From:	Ken Eklund
To:	Benton Public Comment
Subject:	I oppose LU-24-027: reference articles and opinions in the press - 2 of 12
Date:	Thursday, May 8, 2025 2:33:03 PM
Attachments:	writerguy-cube2.png 2 Landfill Failures - PUB 009.pdf

CAUTION: This email originated from outside of the organization. Do not click links or open attachments unless you recognize the sender and know the content is safe.

This is the first part of a CHEJ pdf on landfills that is too big to email in one piece. – K



Ken Eklund, writerguy

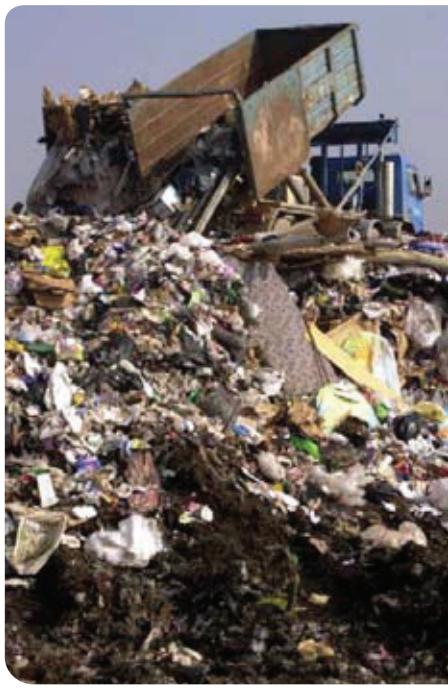
37340 Moss Rock Dr
Corvallis OR 97330
408.623.8372

Creator of
World Without Oil
Ed Zed Omega
FutureCoast
and other storymaking games



Landfill Failures
The Buried Truth

FactPack – P009





Center for Health, Environment & Justice
P.O. Box 6806, Falls Church, VA 22040-6806
703-237-2249 chej@chej.org www.chej.org

Landfill Failures
the Buried Truth

Center for Health, Environment & Justice
FactPack - PUB 009

August 2019

Copyright 2019 by Center for Health, Environment & Justice. All rights reserved. For Permission to reprint, please contact CHEJ. Printed in the U.S.A.

P.O. Box 6806 Falls Church, VA 22040-6806 703-237-2249 chej@chej.org www.chej.org

Center for Health, Environment & Justice
P.O. Box 6806 • Falls Church, VA 22040 • Phone: 703.237.2249 • Fax: 703.237.8389 • www.chej.org

Mentoring a Movement

Empowering People

Preventing Harm

About the Center for Health, Environment & Justice

CHEJ mentors the movement to build healthier communities by empowering people to prevent the harm caused by chemical and toxic threats. We accomplish our work by connecting local community groups to national initiatives and corporate campaigns. CHEJ works with communities to empower groups by providing the tools, strategic vision, and encouragement they need to advocate for human health and the prevention of harm.

Following her successful effort to prevent further harm for families living in contaminated Love Canal, Lois Gibbs founded CHEJ in 1981 to continue the journey. To date, CHEJ has assisted over 15,000 groups nationwide. Details on CHEJ's efforts to help families and communities prevent harm can be found on www.chej.org.

Table of Contents

Introduction to Landfill Problems

- The Basics of Landfills: How They Are Constructed and Why They Fail – *Environmental Research Foundation* 1
- The Normal Landfill Environmental Research Site; What Happens to Waste in Landfills - *USGS* 3
- Solid Waste Landfill Technology: A Documented Failure – *Blue Ride Environmental Defense League* 4
- New Evidence that All Landfills Leak – *Rachel's Environment & Health News* 5
- Plastics Part 2: Why Landfill Linters Always Fail – *Rachel's Environment & Health News* 7
- Leachate Collection Systems: The Achilles' Heel of Landfills – *Rachel's Environment & Health News* 9
- The Catch-22s of Landfill Design – *Rachel's Environment & Health News* 11

Landfill Liner & Leachate Problems

- Emerging Contaminants at a Closed and Operating Landfill in Oklahoma – *Groundwater Monitoring And Remediation* 12
- Updated Review of the "Flawed Technology" of US EPA Subtitle D MSW Landfilling – *G.Fred Lee and Anne Jones-Lee* 13
- Flawed Technology of Subtitle D Landfilling of Municipal Solid Waste – *G. Fred Lee and Anne Jones-Lee* 15
- Detecting Failure of Subtitle D Landfilling Systems – *G. Fred Lee* 19
- Assessing the Potential of Minimum Subtitle D Lined Landfills to Pollute: Alternative Landfilling Approaches – *G. Fred Lee and Ann Jones-Lee* 23
- Impact of Municipal and Industrial Non-Hazardous Waste Landfill on Public Health and the Environment: An Overview – *G. Fred Lee and Ann Jones-Lee* 24
- Plastic Dump Liners Have Been Slow in Coming – *Wall Street Journal* 28
- Unexpected Leakage Through Landfill Liners – *Science News* 30
- Document Shows Landfill Operator Fined for Design Failures – *Hawaii News Now* 32
- Health Effects Associated with the Disposal of Solid Waste in Landfills – *Swiss School of Public Health* 33
- Effect of Aging on the Leachate Characteristics From Municipal Solid Waste Landfill – *Naveen, Sivapullaiah, & Sitharam* 44
- Landfill Leachate Released to Wastewater Treatment Plants and other Environmental Pathways Contains a Mixture of Contaminants including Pharmaceuticals – *USGS Toxic Substances Hydrology Program* 50

Landfill Gas Problems

- Landfill Gas Safety and Health Issues – *Agency for Toxic Substances and Diseases Registry* 53
- Landfills Make Mercury More Toxic – *ScienceNews* 58
- Vinyl in Landfills Most Likely to Blame for Toxic Gases – *Greenpeace* 59
- Old PCs Toxic in Landfill Sites – *Galt Global Review* 62
- In Our Backyard: Environmental Racism in Dickinson – *Colorlines* 65
- Landfill Gas-to Energy Project May Release More Greenhouse Gases Than Flaring – *Stewart* 66

News Articles about Local Landfill Problems

- Court Orders Agency to Address Landfill Emissions– *Environment & Energy News* 74

- EPA resolves Clean Water Act violations with Honolulu and Waste Management at Waimanalo Gulch Landfill– *EPA* 76
- Report identifies factors in Advanced Disposal landfill slope failure that left one dead– *Waste Dive* 78
- Waste Management reaches $4.1M settlement over Ohio– *Waste Dive* 81
- DEC Cites High Acres Landfill for Failure to Reduce Odors– *New York Department of Environmental Conservation* 83
- AG Koster releases new expert reports concluding radiation and other pollutants have migrated off-site at Bridgeton Landfill – *Missouri Attorney General* 84
- Carter's Valley Landfill Listed as Possible Site for Radioactivity – *The Rogersville Review* 85
- Australia: Methane gas landfill leak forces residents to evacuate suburb – *World Socialist Website* 87
- Ombudsman's Damning Repot on Landfill Leak – *Inside Waste Website* 90
- Scotland Board Puts End to Landfill Project – *Fay Observer* 92
- State Officials File Suit Over Dump Site Health Hazards – *Salem News* 93
- Bird Flu Virus Can Survive Two Years in Landfill – *HealthDay News* 95
- Nevada Landfill Operator Agrees to $26 Million Plan to Close Landfill Site – *USDO* 96
- Hazardous Waste Landfills: Some Lessons from New Jersey – *Civil Engineering* 98

Academic Studies

- Socio-Environmental and Hematological Profile of Landfill Residents– *Environmental Research and Public Health* 102
- Morbidity and Mortality of people who live close to municipal waste landfills: a multisite cohort study – *Environmental Exposures and Cancer* 114
- Systemic Review of Epidemiologic Studies on health Effects Associated With Management of Solid Waste – *Environmental Health* 124
- Health Effects of Residence Near Hazardous Waste Landfill Sites: A Review of the Epidemiological Literature – *Environmental Health Perspectives* 138
- Risk of Adverse Birth Outcomes in Populations Living Near Landfill Sites – *British Medical Journal* 150
- Largest Ever Study Into Health of Populations Around Landfill Sites Published – *UK Department of Health* 156
- Health Study of New York City Department of Sanitation Landfill Employees – *Journal of occupational and Environmental Medicine* 158
- Relation Between Malodor, ambient hydrogen sulfide and health – *Elsevier Environmental Research* 159

Reference Material

- Annotated Resources on Landfills and Health Effects 160
- Useful Websites on Landfills 166
- Bibliographic Information 167

The Basics of Landfills- How They Are Constructed And Why They Fail

WHAT IS A LANDFILL?

A secure landfill is a carefully engineered depression in the ground (or built on top of the ground, resembling a football stadium) into which wastes are put. The aim is to avoid any hydraulic [water-related] connection between the wastes and the surrounding environment, particularly groundwater. Basically, a landfill is a bathtub in the ground; a double-lined landfill is one bathtub inside another. Bathtubs leak two ways: out the bottom or over the top.

WHAT IS THE COMPOSITION OF A LANDFILL?

There are four critical elements in a secure landfill: a bottom liner, a leachate collection system, a cover, and the natural hydrogeologic setting. The natural setting can be selected to minimize the possibility of wastes escaping to groundwater beneath a landfill. The three other elements must be engineered. Each of these elements is critical to success.

THE NATURAL HYDROGEOLOGIC SETTING:

You want the geology to do two contradictory things for you. To prevent the wastes from escaping, you want rocks as tight (waterproof) as possible. Yet if leakage occurs, you want the geology to be as simple as possible so you can easily predict where the wastes will go. Then you can put down wells and capture the escaped wastes by pumping. Fractured bedrock is highly undesirable beneath a landfill because the wastes cannot be located if they escape. Mines and quarries should be avoided because they frequently contact the groundwater.

WHAT IS A BOTTOM LINER?

It may be one or more layers of clay or a synthetic flexible membrane (or a combination of these). The liner effectively creates a bathtub in the ground. If the bottom liner fails, wastes will migrate directly into the environment. There are three types of liners: clay, plastic, and composite.

WHAT IS WRONG WITH A CLAY LINER?

Natural clay is often fractured and cracked. A mechanism called diffusion will move organic chemicals like benzene through a three-foot thick clay landfill liner in approximately five years. Some chemicals can degrade clay.

WHAT IS WRONG WITH A PLASTIC LINER?

The very best landfill liners today are made of a tough plastic fi lm called high density polyethylene (HDPE). A number of household chemicals will degrade HDPE, permeating it (passing though it), making it lose its strength, softening it, or making it become brittle and crack. Not only will household chemicals, such as moth balls, degrade HDPE, but much more benign things can cause it to develop stress cracks, such as, margarine, vinegar, ethyl alcohol (booze), shoe polish, peppermint oil, to name a few.

WHAT IS WRONG WITH COMPOSITE LINERS?

A Composite liner is a single liner made of two parts, a plastic liner and compacted soil (usually clay soil). Reports show that all plastic liners (also called Flexible Membrane Liners, or FMLs) will have some leaks. It is important to realize that all materials used as liners are at least slightly permeable to

liquids or gases and a certain amount of permeation through liners should be expected. Additional leakage results from defects such as cracks, holes, and faulty seams. Studies show that a 10-acre landfill will have a leak rate somewhere between 0.2 and 10 gallons per day.

WHAT IS A LEACHATE COLLECTION SYSTEM?

Leachate is water that gets badly contaminated by contacting wastes. It seeps to the bottom of a landfill and is collected by a system of pipes. The bottom of the landfill is sloped; pipes laid along the bottom capture contaminated water and other fluid (leachate) as they accumulate. The pumped leachate is treated at a wastewater treatment plant (and the solids removed from the leachate during this step are returned to the landfill, or are sent to some other landfill). If leachate collection pipes clog up and leachate remains in the landfill, fluids can build up in the bathtub. The resulting liquid pressure becomes the main force driving waste out the bottom of the landfill when the bottom liner fails.

WHAT ARE SOME OF THE PROBLEMS WITH LEACHATE COLLECTION SYSTEMS?

Leachate collection systems can clog up in less than a decade. They fail in several known ways: they clog up from silt or mud; they can clog up because of growth of microorganisms in the pipes; they can clog up because of a chemical reaction leading to the precipitation of minerals in the pipes; or the pipes become weakened by chemical attack (acids, solvents, oxidizing agents, or corrosion) and may then be crushed by the tons of garbage piled on them.

WHAT IS A COVER?

A cover or cap is an umbrella over the landfill to keep water out (to prevent leachate formation). It will generally consist of several sloped layers: clay or membrane liner (to prevent rain from intruding), overlain by a very permeable layer of sandy or gravelly soil (to promote rain runoff), overlain by topsoil in which vegetation can root (to stabilize the underlying layers of the cover). If the cover (cap) is not maintained, rain will enter the landfill resulting in buildup of leachate to the point where the bathtub overflows its sides and wastes enter the environment.

WHAT ARE THE PROBLEMS WITH COVERS?

Covers are vulnerable to attack from at least seven sources: 1) Erosion by natural weathering (rain, hail, snow, freeze-thaw cycles, and wind); 2) Vegetation, such as shrubs and trees that continually compete with grasses for available space, sending down roots that will relentlessly seek to penetrate the cover; Burrowing or soil- dwelling mammals (woodchucks, mice, moles, voles), reptiles (snakes, tortoises), insects (ants, beetles), and worms will present constant threats to the integrity of the cover; 3) Sunlight (if any of these other natural agents should succeed in uncovering a portion of the umbrella) will dry out clay (permitting cracks to develop), or destroy membrane liners through the action of ultraviolet radiation; 5) Subsidence--an uneven cave-in of the cap caused by settling of wastes or organic decay of wastes, or by loss of liquids from landfilled drums--can result in cracks in clay or tears in membrane liners, or result in ponding on the surface, which can make a clay cap mushy or can subject the cap to freeze-thaw pressures; 6) Rubber tires, which “float” upward in a landfill; and 7) Human activities of many kinds.

Prepared by: Environmental Research Foundation

THE NORMAN LANDFILL ENVIRONMENTAL RESEARCH SITE WHAT HAPPENS TO THE WASTE IN LANDFILLS?

U.S. Geological Survey Fact Sheet 040-03
August 2003

By Scott C. Christenson and Isabelle M. Cozzarelli

This Factsheet is also available as pdf (949KB).

DO LANDFILLS LEAK?

We call it "garbage" or "trash" but it is "municipal solid waste" to your city government and the waste industry. Municipal solid waste is a combination of non-hazardous wastes from house holds, commercial properties, and industries. The U.S. Environmental Protection Agency (USEPA) reports that the United States produced about 230 million tons of solid waste in 1999, about 57 percent of which is disposed of in landfills (U.S. Environmental Protection Agency, 1999).

Disposal of municipal solid waste in landfills was largely unregulated prior to the 1970s. Most solid waste was deposited in unlined pits. Precipitation and ground water seeping through this waste produces leachate, which is water contaminated from the various organic and inorganic substances with which it comes in contact as it migrates through the waste. Leachate seeping from a landfill contaminates the ground water beneath the landfill, and this contaminated ground water is known as a plume. The normal movement of ground water causes the leachate plume to extend away from a landfill, in some cases for many hundreds of meters. Many studies have shown leachate plumes emanating from old unlined landfills. Estimates for the number of closed landfills in the United States are as high as 100,000 (Suflita and others, 1992).

Federal and state regulations were passed in the 1980s and 1990s to manage disposal of solid waste. Those regulations require that most landfills use liners and leachate collection systems to minimize the seepage of leachate to ground water. Although liners and leachate collection systems minimize leakage, liners can fail and leachate collection systems may not collect all the leachate that escapes from a landfill. Leachate collection systems require maintenance of pipes, and pipes can fail because they crack, collapse, or fill with sediment. The USEPA has concluded that all landfills eventually will leak into the environment (U.S. Environmental Protection Agency, 1988). Thus, the fate and transport of leachate in the environment, from both old and modern landfills, is a potentially serious environmental problem.

SOLID WASTE LANDFILL TECHNOLOGY
A DOCUMENTED FAILURE

HIGH DENSITY POLYETHYLENE LINERS (HDPE) ARE NOT EFFECTIVE BARRIERS TO LANDFILL LEACHATE.

Two major classes of chemicals are responsible for HDPE failure. Aromatic hydrocarbons such as benzene and naphthalene, "permeate excessively and cause package deformation," and halogenated hydrocarbons such as trichlorethylene and methylene chloride can permeate HDPE and cause,"softening, swelling, and part deformation."

Marlex Polyethylene TIB 2 Packaging Properties, Plastics Division, Phillips 66 Company, Bartlesville, OK 74004

The "best demonstrated available technology" for composite liners (clay and plastic) allow leakage rates from .02 to 1.0 gallons per acre per day. This would result in 730 to 36,500 gallons per year from a 100 acre landfill.

Geoservices Inc. Background Document on Bottom Liner Performance in Double-lined landfills and Surface Impoundments, April 1987

LANDFILL CAPS ARE SUBJECT TO NATURAL ELEMENTS AND LEAKAGE

Lightning bolts striking the ground typically five million volts and 2,500 to 220,000 amperes can bore holes in the ground eight inches in diameter and fifteen feet deep. In western North Carolina, an average number of lightning strikes per hundred acres is 2.96 per year.

AT&T Telecommunication Electrical Protection, AT&T Technologies, Inc. 1985

Burrowing animals can move 5.3 tons of soil to the surface per acre per year. "Similar activity would have a dramatic impact on landfill cap integrity..synthetic liners, measured in mils are not likely to impede these same animals." Clay presents little barrier to such animals.

Johnson & Dudderar, WASTE AGE, March 1988, p.108-111

LEAK TESTING OF NEW LANDFILL LINERS REVEALS MAJOR FLAWS

Tests of the new municipal solid waste liner after burial by an Arizona contractor revealed that even with the most careful construction and quality assurance testing at every stage of emplacement, the liners had holes and punctures. ***American City and County, July 1991***

EVEN EPA PREDICTS FAILURE OF THE NEW LANDFILL TECHNOLOGY

"First, even the best liner and leachate collection systems will ultimately fail due to natural deterioration…" ***Federal Register p.33345 August 30, 1988***

BLUE RIDGE ENVIRONMENTAL DEFENSE LEAGUE

PO Box 88 Glendale Springs, North Carolina 28629 ~ Phone 336-982-2691 ~ Fax 336-982-2954 ~ Email BREDL@skybest.com October 2002

www.BREDL.org

Rachel's Environment & Health News
#316 - New Evidence That All Landfills Leak
December 15, 1992

Starting in the 1970s and continuing throughout the 1980s, U.S. Environmental Protection Agency [EPA] funded research which showed that burying household garbage in the ground poisons the groundwater. On several occasions, EPA spelled out in detail the reasons why all landfills leak. (For example, see RHWN #37, #71, and #116)

Then in late 1991, after several years of deliberation, EPA chief William Reilly issued final landfill regulations that allow the continued burial of raw garbage in landfills. (See RHWN #268.) EPA's 1991 regulations require an expensive landfill design: two liners in the ground and an impervious plastic cover over the landfill after it has been filled with garbage. This is "state of the art" technology, the very best that modern engineers can build. However, EPA officials still expect such landfills to fail and eventually poison groundwater.

As early as 1978, EPA knew why all landfills eventually leak. The main culprit is water. Once water gets into a landfill, it mixes with the garbage, producing a toxic leachate ("garbage juice"), which is then pulled downward by gravity until it reaches the groundwater. Therefore, the goal of landfill designers (and regulators) is to keep landfills dry for the length of time that the garbage is dangerous, which is forever.

Now a 1992 report from a California engineering-consulting firm, G. Fred Lee & Associates, has examined recent scientific studies and has confirmed once again why modern "dry tomb" landfill technology will always fail and should always be expected to poison groundwater.[1]

The new report, authored by Fred Lee and Anne Jones, reviews recent evidence--much of it produced by government-funded research--that landfill liners leak for a variety of reasons; that leachate collection systems clog up and thus fail to prevent landfill leakage; that landfill leachate will remain a danger to groundwater for thousands of years; that even low-rainfall areas are not safe for landfill placement; that gravel pits and canyons are particularly dangerous locations for landfills; that maintaining a single landfill's cap for the duration of the hazard would cost hundreds of billions, or even trillions, of dollars; that groundwater monitoring cannot be expected to detect landfill leakage; that groundwater, once it is contaminated, cannot be cleaned up and must be considered permanently destroyed; and that groundwater is a limited and diminishing resource which modern societies grow more dependent on as time passes.

A 1990 examination of the best available landfill liners concluded that brand-new state-of-the-art liners of high density polyethylene (HDPE) can be expected to leak at the rate of about 20 gallons per acre per day (200 liters per hectare per day) even if they are installed with the very best and most expensive quality-control procedures.[2] This rate of leakage is caused by pinholes during manufacture, and by holes created when the seams are welded together during landfill construction. (Landfill liners are rolled out like huge carpets and then are welded together, side by side, to create a continuous field of plastic.) Now examination of actual landfill liners reveals that even the best seams contain some holes.

In addition to leakage caused by pinholes and failed seams, new scientific evidence indicates that HDPE (high density polyethylene, the preferred liner for landfills) allows some chemicals to pass through it quite readily. A 1991 report from University of Wisconsin shows that dilute solutions of common solvents, such as xylenes, toluene, trichloroethylene (TCE), and methylene chloride, penetrate HDPE in one to thirteen days. Even an HDPE sheet 100 mils thick (a tenth of an inch)--the thickness used in the most expensive landfills) is penetrated by solvents in less than two weeks.

Another problem that has recently become apparent with HDPE liners is "stress cracking" or "brittle fracture." For reasons that are not well understood, polyethylenes, including HDPE, become brittle and develop cracks. A 1990 paper published by the American Society for Testing Materials revealed that HDPE liners have failed from stress cracks in only two years of use. Polyethylene pipe, intended to give 50 years of service, has failed in two years. Lee and Jones sum up (pg. 22), "While the long-term stability of geomembranes (flexible membrane liners) in landfills cannot be defined, there is no doubt that they will eventually fail to function as an impermeable barrier to leachate transport from a landfill to groundwater. Further, and most importantly at this time, there are no test methods, having demonstrated reliability, with which to evaluate long-term performance of flexible membrane liners."

Recent scientific studies of clay indicate that landfill liners of compacted clay leak readily too. For example, a 1990 study concludes,

[I]F A NATURALLY OCCURRING CLAY SOIL IS COMPACTED TO HIGH DENSITY, THEREBY PRODUCING A MATERIAL WITH VERY LOW HYDRAULIC CONDUCTIVITY, AND IF IT IS MAINTAINED WITHIN THE SAME RANGES OF TEMPERATURE, PRESSURE, AND CHEMICAL AND BIOLOGICAL ENVIRONMENT, IT WOULD BE EXPECTED TO FUNCTION WELL AS A SEEPAGE BARRIER INDEFINITELY. IN WASTE CONTAINMENT APPLICATIONS, HOWEVER, CONDITIONS DO NOT REMAIN THE SAME. THE PERMEATION [PENETRATION] OF A COMPACTED CLAY LINER BY CHEMICALS OF MANY TYPES IS INEVITABLE, SINCE NO COMPACTED CLAY OR ANY OTHER TYPE OF LINER MATERIAL IS EITHER TOTALLY IMPERVIOUS OR IMMUNE TO CHEMICAL INTERACTIONS OF VARIOUS TYPES

The 1992 study by Lee and Jones is an excellent resource for anyone wanting to understand why landfills always fail. In their footnotes, they cite 18 other studies of landfill problems that they themselves have authored, so their expertise is unquestionable, their information reliable, their arguments solid.

There has been sufficient scientific evidence available for a decade to convince any reasonable person that landfills leak poisons into our water supplies, and are therefore anti-social.

The question remains: what will it take to convince government--specifically EPA--to base policy on its own scientific studies and its own understanding?

The new EPA administrator is Carol M. Browner, an avowed environmentalist from Florida. Asked to describe Ms. Browner's style, John Sheb, head of Florida's largest business trade association, said: "She kicks the door open, throws in a hand grenade, and then walks in to shoot who's left. She really doesn't like to compromise."

Maybe Ms. Browner could start with a wake-up grenade in the Office of Solid Waste.

--Peter Montague

=====

[1] G. Fred Lee and Anne R. Jones, MUNICIPAL SOLID WASTE MANAGEMENT IN LINED, "DRY TOMB" LANDFILLS: A TECHNOLOGICALLY FLAWED APPROACH FOR PROTECTION OF GROUNDWATER QUALITY (El Macero, Calif.: G. Fred Lee & Associates, March, 1992). Available from: G. Fred Lee & Associates, 27298 East El Macero Drive, El Macero, CA 95618-1005. Phone (916) 753- 9630. 67 pgs.; free.

[2] Rudolph Bonaparte and Beth A. Gross, "Field Behavior of Double- Liner Systems," in Rudolph Bonaparte (editor), WASTE CONTAINMENT SYSTEMS: CONSTRUCTION,

REGULATION, AND PERFORMANCE [Geotechnical Special Publication No. 26] (New York: American Society of Civil Engineers, 1990), pgs. 52-83.

CLARIFICATION: RIGHTS OF CORPORATIONS

Last week we suggested the need for a Constitutional amendment declaring that a corporation is not a natural person and is therefore not protected by the Bill of Rights and the 14th amendment to the Constitution. Such an amendment would level the playing field somewhat, giving communities and individuals a greater chance of controlling anti-social corporate behavior. As we noted in earlier newsletters (RHWN #308, #309), corporations are now literally out of control. Shareholders cannot control them; boards of directors cannot control them; workers cannot control them; in a competitive world market, even managers have lost control. In some cases, of course, management doesn't care about the environment or the community. But even when managers, as individuals, want to do the right thing, the logic of corporate growth and short-term gain often dictates choices that do not serve the environment or the community. Since corporate behavior is at the root of nearly all environmental problems, stripping corporations of some of their rights (such as the Constitutional protections guaranteed to individual citizens, which the Supreme Court extended to corporations in 1886), would help communities assert control over corporate behavior. Merely DEBATING such an amendment would get people thinking about power in the modern world, asking who has a legitimate right to control what. Ask yourself: who ever gave private corporations the right to manufacture and sell products that can destroy the planet as a place suitable for human habitation? In suggesting such a Constitutional amendment, we omitted reference to the original source of the idea, author Richard Grossman.

For historical background on control of corporations, get: Richard Grossman and Frank T. Adams, TAKING CARE OF BUSINESS; CITIZENSHIP AND THE CHARTER OF INCORPORATION (Cambridge, Mass.: Charter, Inc., 1992). For a copy, send $4.00 plus a self-addressed, stamped envelope containing 52 cents postage to: Charter, Inc., P.O. Box 806, Cambridge, MA 02140.
--Peter Montague

Descriptor terms: corporations; constitution; us; landfilling; landfill liners; leachate collection systems; groundwater; epa; waste disposal technologies; high density polyethylene; waste treatment technologies; msw;

Rachel's Environment & Health News is a publication of the Environmental Research Foundation, P.O. Box 160, New Brunswick, NJ 08903-0160; Phone: (732) 828-9995; Fax (732) 791-4603; E-mail: erf@rachel.org; http://www.rachel.org. Unless otherwise indicated, Rachel's is written by Peter Montague.

Rachel's Environment & Health News
#217 - Plastics -- Part 2: Why Plastic Landfill Liners Always Fail
January 22, 1991

In the landfill business, government and industry say plastic liners are going to save the day. For example, U.S. Environmental Protection Agency (EPA) and industry both argue that incinerator ash can be safely "disposed of" in a double-lined ash "monofill." A "monofill" is a landfill that contains only ash, no raw garbage. Like any other landfill, the basic design is a bathtub in the ground. The bottom of the bathtub is formed by a huge sheet of plastic. In an expensive landfill, you have two sheets of plastic separated by about two feet of sand and gravel--thus creating one bathtub inside another bathtub. Therefore, a doublelined ash monofill is a landfill (which is really just a polite word for a dump) in the form of a bathtub created by two plastic liners, containing incinerator ash and nothing else.

The theory behind the monofill is that ash contains only small amounts of aggressive organic chemicals that might eat a hole in the plastic liner, so the plastic liner will remain intact and protect us against the lead and cadmium and other toxic metals contained in the ash. (See RHWN #92.) As always, the key question is: what is the duration of the hazard and what is the duration of the protection provided by the plastic liner? (The "cap" or umbrella covering a landfill will also be made of the same plastic, so a landfill is really a "baggie" in the ground, containing toxins. What is the lifetime of this baggie? How long will it protect us?)

What is the duration and nature of the hazard from metals in incinerator ash? As we saw earlier (in RHWN #92) incinerator ash is rich in toxic metals. For example, it typically contains anywhere from 3000 parts per million (ppm) to 30,000 ppm of lead. U.S. Environmental Protection Agency Region (Boston), and the Harvard University School of Public Health have recommended a cleanup action level of 1000 ppm for lead in soil--in other words, they recommended that remedial action, as would be needed at a Superfund site, should be undertaken wherever lead in soils exceeds 1000 ppm.[1] In recommending the 1000 ppm action level, EPA and Harvard wrote, "While we believe a greater margin of safety would be achieved with an action level of 500 ppm, we think it necessary to set priorities for remedial activity." (What they meant was that there are so many places in urban America where there is 500 ppm lead in soil that EPA would be overwhelmed with work if 500 ppm were set as the threshold for remedial action--so 1000 ppm is a more "realistic" cleanup action level even though it's not as safe as the nation's children really need it to be.)

Given that EPA Region I and the Harvard School of Public Health have recommended that Superfund-type cleanup be initiated whenever soils contain more than 1000 parts per million (ppm) of lead, we know immediately that every ash monofill will have to be cleaned up at some time in the future because all incinerator ash contains more than 1000 ppm lead. (Ash also contains dangerous amounts of other toxic metals-- cadmium, arsenic, chromium, and perhaps others, so lead is not the only reason why a cleanup might be needed.) Therefore, when we create ash monofills we know we are creating Superfund sites that our children will pay for--either in damage to their brains and nervous systems, or in enormous outlays of money--or both.

Because lead and cadmium and other metals never degrade into anything else, but remain toxic forever, the duration of the hazard is perpetual, everlasting, eternal. The danger will never go away.

The incineration industry, and its acolytes in government, argue that the plastic liners will protect us and our children forever. Unfortunately, this idea is based on a misunderstanding (or more likely an intentional misrepresentation) of what happens to plastics as they get older. Plastics are not inert; they do not stay the same as time passes. They change. They come apart spontaneously.

A recent book by Deborah Wallace, Ph.D., describes this process well. [2] The book is about the dangers of plastics in fires, but in telling the story of "Why today's fires are so dangerous," (the answer is because burning plastics give off toxic gases that kill people who breathe them), Dr. Wallace included a section on the makeup of plastics at the molecular level, which helps us understand why all plastics eventually fall apart.

The building blocks of plastics are found in natural gas, coal, and wood, but the major source is oil. Oil (like coal and natural gas) is a mixture of molecules of different sizes and structures. To separate out the different molecules, crude oil is distilled in an oil refinery. The oil is boiled and smaller, lighter molecules are separated from the larger, heavier molecules. The heavier molecules are then "cracked" to break up the large, heavy molecules into smaller, lighter molecules.

The result of this distillation and cracking is organic chemicals, which is the name for chemicals containing carbon and other elements (chiefly hydrogen, oxygen, and nitrogen). These organic chemicals form the building blocks of pesticides, glues, and plastics. Other chemicals (such as chlorine and lead) are added to give the raw materials new characteristics (strength, stiffness, color, and so forth).

After the building blocks are manufactured, they are turned into plastic resin by a process called polymerization. A polymer is a large, organic, chain-like molecule made of repeated units of smaller molecules. Polymerization usually requires heating the raw materials in the presence of helper chemicals called catalysts, until the building blocks form long chains. Even with the catalysts, a great deal of heat is used in the polymerization process. "Because of this heat, the long chains, even during manufacture, may decompose slightly and have defect points along them," Dr. Wallace explains. The defect points are in the chemical bonds, which absorb the energy used in the manufacturing process. The law of conservation of energy states that the amount of energy in a system after the reaction is the same as the amount of energy before the reaction. The large amounts of energy (heat) thus must go somewhere; they go into the bonds between the atoms of the plastic and are stored there. But nature does not favor this gain of energy--nature favors low energy chemical bonds, and high energy bonds tend to release their energy by breaking spontaneously. These are defect points. Although polymer scientists have striven to reduce the number of defect points, they have not been able to completely eliminate them from synthetic polymers.

Dr. Wallace continues, "The physical and chemical defects that are produced by ordinary processes in the manufacture and use of plastics demonstrate the fragile and unstable character of these long chains of molecules that are joined by high energy chemical bonds. When the resin is further processed to become the finished marketable product, additional defect points are created because the product is again heated and handled."

As time passes, plastics decompose--their molecules come apart spontaneously--beginning at the defect points. Polymer scientists refer to this decomposition as "aging." All plastics "age" and there is nothing that can be done about it. Within a few years (at most a few decades), all plastics degrade, come apart, and fail. They become brittle, lose their strength, crack, break into fragments. At that point, any protection the plastic may have afforded against the toxic dangers lurking in an ash monofill is gone. By that time, the people who created the ash monofill will have taken their profits and left town, but the deadly residues they leave behind--the ash--will remain to plague the community forever, poisoning the community's children with toxic lead and other metals.

The only affordable solution to this problem is a simple one: prevent the creation of incinerator ash.

--Peter Montague

=====

[1] P.L. Ciriello and T. Goldberg, "Lead-contaminated Soil Cleanup

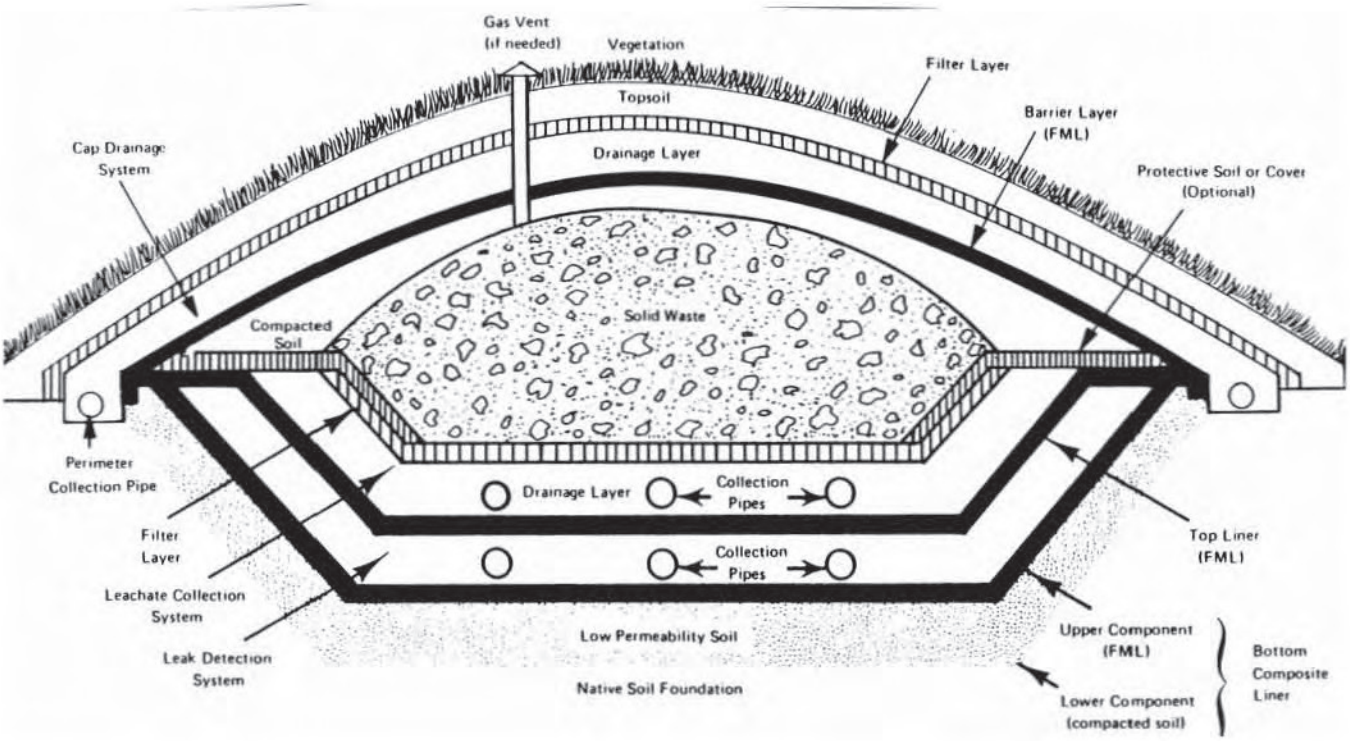
Draft Report" which appears as Appendix E in: Agency for Toxic Substances and Disease Registry, THE NATURE AND EXTENT OF LEAD POISONING IN CHILDREN IN THE UNITED STATES: A REPORT TO CONGRESS (Atlanta, Ga: Agency for Toxic Substances and Disease Registry, Public Health Service, U.S. Department of Health and Human Services [1600 Clifton Rd. -Mail Stop E-33, Atlanta, Ga 30333; phone (404) 639-0730], July, 1988). Free while supplies last."

[2] Deborah Wallace, IN THE MOUTH OF THE DRAGON (Garden City Park, NY: Avery Publishing Group [120 Old Broadway, Garden City Park, NY 11040; phone (516) 741-2155], 1990). $17.95.

Descriptor terms: epa; landfilling; plastic liners; harvard university school of public health; studies; remedial action; ash monofills; heavy metals; deborah wallace; polymerization; leaks;

Rachel's Environment & Health News is a publication of the Environmental Research Foundation, P.O. Box 160, New Brunswick, NJ 08903-0160; Phone: (732) 828-9995; Fax (732) 791-4603; E-mail: erf@rachel.org; http://www.rachel.org. Unless otherwise indicated, Rachel's is written by Peter Montague.

Rachel's Environment & Health News
#119 – Leachate Collection Systems: The Achilles' Heel Of Landfills
March 7, 1989



A landfill is a bathtub in the ground, and a bathtub can leak two ways: it can leak through a hole in the bottom (failure of its bottom liner), or it can fill up with fluid and spill over its sides. Either way, it's bad news. The basic problem is the fluid. If a landfill begins to fill up with fluid, the weight of the fluid puts pressure on the bottom of the landfill, increasing the likelihood of bottom liner failure, so any fluid inside a landfill is a potential source of trouble.

To prevent fluid from causing problems, every modern landfill has a system for draining liquids out of the landfill. This is called a leachate collection system. What is leachate? Think of a landfill as being like a drip coffee maker. The dry coffee is the garbage, the water you pour in the top is rainwater, and the dark, brewed coffee dripping out the bottom is leachate. You might want to drink coffee, but you definitely do not want to drink leachate: it has many toxic and dangerous characteristics. It is badly polluted with chemicals and with micro-organisms (bacteria and viruses) that would make you sick.

The picture below represents a closed landfill; the heavy dark line represents the plastic baggie (bottom liner and top cover) that is supposed to keep leachate from entering the environment. The round circles between the two bottom liners represent collection pipes which have many holes drilled along their length (making these pipes resemble a swiss cheese); they are supposed to collect any leachate that flows to the bottom of the landfill. In theory, these pipes carry off the leachate to a wastewater treatment plant, where the leachate is processed to remove the toxic chemicals. (At the wastewater treatment plant, some of the chemicals are released into the air, and the remaining ones are collected [they're now in a mud-like sludge] and they are sent to another landfill somewhere.)

One of the least-studied aspects of landfill design is how to make a leachate collection system that will work for many decades (much less many hundreds of years). The fact is, leachate collection systems can clog up in less than a decade and, when that happens, fluids begin to build up inside the landfill—a dangerous situation, as we have noted above.

Leachate collection systems fail in several known ways. First, they can clog up from silt or mud. Second, they can clog up because of the growth of microorganisms in the pipes. Third, they can clog because of a chemical reaction leading to the precipitation of minerals in the pipes; anyone who has boiled a pot of "hard" water and seen the whitish crusty residue in the bottom of the pot knows what "precipitated chemicals" look like. Fourth, the pipes themselves can be weakened by chemical attack (acids, solvents, oxidizing agents, or corrosion) and may then be crushed by the tons of garbage piled above them.

The book, AVOIDING FAILURE OF LEACHATE COLLECTION AND CAP DRAINAGE SYSTEMS, by Jeffrey Bass, discusses these four failure mechanisms. The first problem (silt) can sometimes be avoided, or at least reduced, by installing a "filter layer" above the leachate collection system. The filter layer may be made up of gravel or of a rug-like plastic material called "geotextile." Since the oldest leachate collection systems

date from the early 1970s, humans have very little experience with the long-term performance of leachate collection systems. The hope is that a "filter layer" will solve the siltclogging problem, but after many decades the entire filter layer itself may clog. Only time will tell.

The growth of microorganisms seems to be an uncontrollable problem. The conditions for growth of slime-forming microorganisms are not well understood. Even if they were understood, we could not control chemical and physical conditions (temperature, pH, etc.) at the bottom of a landfill because of the thousands of tons of wastes heaped up in the landfill.

The problem of chemical precipitation also appears to be uncontrollable. The chemical conditions that lead to precipitation may be knowable, but again the conditions in the leachate collection system cannot be controlled because the system is not accessible once wastes have begun to be dumped into the landfill.

The last problem—chemical attack on the leachate collection pipes, leading to destruction of the pipes themselves—also appears to be an unsolvable problem. Mr. Bass suggests, in best ivory tower fashion, that the way to control chemical attack on the pipes is to select pipes that are resistant to the chemicals that you know will make their way into the landfill. In principal, this is a good idea. But in the real world, how do you know what's going to be put into your landfill next week? Next year? With 1000 brand new chemicals being put into commercial use each year, over the next 10 years, today's leachate collection pipes may come into contact with 10,000 new chemicals that don't even exist today. Any of those chemicals may attack the pipes. In addition, chemicals mixing together inside a landfill will create new chemical combinations that may produce heat or may otherwise attack the pipes.

Mr. Bass's book is misnamed because it seems to suggest that the failure of leachate collection systems can be avoided. However, as the text of Mr. Bass's book makes abundantly clear, if such failures were to be avoided, it would be by dumb luck, not by engineering design. Only a fool trusts dumb luck.

Mr. Bass's book is overpriced at $36.00 from: Noyes Data Corporation, Mill Road, Park Ridge, NJ 07656. No telephone orders accepted.

--Peter Montague

Descriptor terms: landfilling; landfill failure mechanisms; leachate collection systems; msw;

Rachel's Environment & Health News is a publication of the Environmental Research Foundation, P.O. Box 160, New Brunswick, NJ 08903-0160; Phone: (732) 828-9995; Fax (732) 791-4603; E-mail: erf@rachel.org; http://www.rachel.org. Unless otherwise indicated, Rachel's is written by Peter Montague.

Rachel's Environment & Health News
#109 - The Catch-22s Of Landfill Design
December 25, 1988

The waste hauling industry knows that all landfills will eventually leak because their own industry trade journals are now telling the story. WASTE AGE is the main magazine for the waste industry. The editors of WASTE AGE are not sympathetic to environmental groups. For example, it was in WASTE AGE'S columns that you may have read,

"The NIMBY [not in my back yard] syndrome is a public health problem of the first order. It is a recurring mental illness that continues to infect the public.

"Organizations that intensify this illness are like the viruses and bacteria which have, over the centuries, caused epidemics such as the plague, typhoid fever, and polio.

"....It is time solid waste management professionals stopped wringing their hands and started a campaign to wipe out this disease." (WASTE AGE, Mar., 1988, pg. 197.)

Clearly WASTE AGE is no friend of the grass roots environmental movement. Yet it has been publishing articles that say what we've been saying all along: the security and safety of landfills is dependent upon the landfill cap, and the landfill cap is inevitably destroyed by natural forces.

WASTE AGE has run a series of articles over the past two years saying why landfills will inevitably leak, and suggesting that the only solution to the problem is perpetual maintenance of the closed landfill. Since humans have no experience maintaining anything in perpetuity, perpetual maintenance is an untested and unproven, and, one can only say, silly non-solution. If we took it seriously, perhaps we would develop a large army of landfill maintainers whose only job in life will be to maintain the toxic garbage left behind by their parents and their parents' parents and their parents' parents' parents and so on for generation after generation.

Despite the silly suggestion that perpetual maintenance of landfill caps is a way out of our present garbage problem, these articles contain much good information about why landfills leak.

Remember, a landfill is nothing more than a bathtub in the ground (perhaps, in the case of a double-lined landfill, one bathtub inside another). A bathtub will leak if its bottom develops a hole, or it can simply fill up with water (for example, rainfall) and leak over its sides. Either way, a landfill can contaminate the local environment. Therefore, a "cap" is placed over the landfill when the landfill is full. The "cap" is supposed to serve as an umbrella to keep rain out, to keep the bathtub from spilling over its sides.

Writing in WASTE AGE, Dr. David I. Johnson and Dr. Glenn R. Dudderar of the Michigan State University Department of Fisheries and Wildlife, have argued,

"There is evidence that the engineered integrity of a cap will not be maintained over the landfill's extended life." (This is somewhat fancy language for "All landfills will eventually leak.")

Johnson and Dudderar go on to say, "Regulations may require bonding for five to 20 years. Yet from a biological and geophysical point of view this time period is a totally inadequate maintenance requirement." (Translation: It may take nature more than 20 years to destroy a landfill cap, but nature has all the time in the world, so you'd better be prepared to maintain a landfill for the long haul--forever.)

Catch 22 #1: A landfill cap is intended to be impermeable--to keep water out. This means water is supposed to run off the surface. But this, in turn, invites soil erosion. "But in the runoff process, cap soil will be carried with the runoff, causing sheet and rill erosion and, ultimately, gullying of the cap." When you get gullies in the cap, it's all over.

Other physical forces working constantly to destroy a landfill cap are freezethaw and wet-dry cycles. Soil shrinkage during dry weather can cause cracks. Rain penetrates the cracks. In winter, rain freezes to ice and expands, widening the cracks. And so on, year in, year out, century after century. The cracks not only let in water, they also provide pathways for plant roots and for burrowing animals.

Catch 22 #2: To minimize soil erosion, and to minimize changes due to wet-dry cycles, you need to establish vegetation on the cap. However, plants maintain their physical stability, and they gather water and nutrients, through roots, which can penetrate a landfill cap, destroying the cap's integrity. Furthermore, plants provide cover (and food) for burrowing animals, which then burrow into the cap, destroying it.

A study of a solid radioactive waste landfill reveals that mice, shrews, and pocket gophers can move 10,688 pounds (5.3 tons) of soil to the surface per acre per year. "Similar activity would have a dramatic impact on landfill cap integrity," Johnson and Dudderar observe. Burrowing animals of concern include woodchucks, badgers, muskrats, moles, ground squirchipmunks, gophers, prairie dogs and badgers. Clay presents little barrier to such animals; "synthetic liners, measured in mils [of thickness], are not likely to impede these same mammals," Johnson and Dudderar observe. Non-mammals are also a problem: crayfish, tortoises, mole salamanders, and "a variety of worms, insects and other invertebrates" can make holes in a landfill cap.

Earthworms alone can have a devastating impact on a landfill cap. Earthworms pass two to 15 tons of soil through their digestive tracts per acre per year. "The holes left as they move through the soil to feed increase water infiltration," Johnson and Dudderar comment. They give evidence that worm channels allowed plant roots to grow to a depth of nine feet in Nebraska clay soils.

In a section called "The fundamental dilemma," Johnson and Dudderar sum up:

"At this point you may well say: 'If we plant, we're encouraging plant and animal penetration of the clay cap. If we don't plant, we get erosion or freeze-thaw destruction of the cap.'

"Unfortunately, that is one of the fundamental dilemmas left us by the normal processes of change in the natural world, be they the progressive conversion of a grassy field to a forest or the utilization of cracks in concrete sidewalks by ants and dandelions.

"This same successional development process, so intensively studied in the ecological literature, will detrimentally affect long-term landfill integrity." So there you have it, right from the pages of Waste Age: the forces of nature, left to themselves, will destroy landfill caps, the key element intended to prevent landfills from leaking.

What hope is there? Perpetual care. A perfectly silly idea. What reasonable hope is there? None whatsoever. All landfills will eventually leak. Happy new year.

For further information, see: David I. Johnson, "Caps: The Long Haul," WASTE AGE March, 1986, pgs. 83-89; David I. Johnson, "Capping Future Costs," WASTE AGE August, 1986, pgs. 77-86; David I. Johnson and Glenn R. Dudderar, "Can Burrowing Animals Cause Groundwater Contamination?" WASTE AGE March, 1988, pgs. 108-111; see also David I. Johnson and Glenn R. Dudderar, "Designing and Maintaining Landfill Caps for the Long Haul," JOURNAL OF RESOURCE MANAGEMENT AND TECHNOLOGY, Vol. 16 (April, 1988), pgs. 34-40. Dr. Johnson [phone 517/353-1997] and Dr. Dudderar [phone 517/353-1990] are with Department of Fisheries and Wildlife, Michigan State University, East Lansing, MI 48824.

Emerging Contaminants at a Closed and an Operating Landfill in Oklahoma

by William J. Andrews, Jason R. Masoner, and Isabelle M. Cozzarelli

Abstract

Landfills are the final depositories for a wide range of solid waste from both residential and commercial sources, and therefore have the potential to produce leachate containing many organic compounds found in consumer products such as pharmaceuticals, plasticizers, disinfectants, cleaning agents, fire retardants, flavorings, and preservatives, known as emerging contaminants (ECs). Landfill leachate was sampled from landfill cells of three different age ranges from two landfills in Central Oklahoma. Samples were collected from an old cell containing solid waste greater than 25 years old, an intermediate age cell with solid waste between 16 and 3 years old, and operating cell with solid waste less than 5 years old to investigate the chemical variability and persistence of selected ECs in landfill leachate of differing age sources. Twenty-eight of 69 analyzed ECs were detected in one or more samples from the three leachate sources. Detected ECs ranged in concentration from 0.11 to 114 µg/L and included 4 fecal and plant sterols, 13 household\industrial, 7 hydrocarbon, and 4 pesticide compounds. Four ECs were solely detected in the oldest leachate sample, two ECs were solely detected in the intermediate leachate sample, and no ECs were solely detected in the youngest leachate sample. Eleven ECs were commonly detected in all three leachate samples and are an indication of the contents of solid waste deposited over several decades and the relative resistance of some ECs to natural attenuation processes in and near landfills.

Introduction

There are 90,000 to 100,000 closed municipal landfills and about 3100 operating landfills (Zero Waste America 2011) in the United States. The closed landfills, many of which are unlined and poorly capped, may be sources of a large number of organic compounds known as emerging contaminants (ECs) to surrounding groundwater and surface water. ECs consist of household and industrial compounds in wastes and consumer products that include fecal and plant sterols, pharmaceuticals, food additives, soaps and detergents, solvents, cleaning agents, fire retardants, plasticizers, perfumes, and pesticides. ECs, although they generally occur in small concentrations in water (<1 mg/L), may singly or in aggregate cause health problems for humans and wildlife ingesting water containing these compounds.

In 2008, approximately 135 million tons of municipal solid waste (MSW) was deposited in landfills in the United States, making landfilling the most common method of MSW disposal (U.S. Environmental Protection Agency 2009). Landfills are the final depositories for a large number of anthropogenic organic compounds, including ECs (Slack et al. 2005). Pharmaceutical compounds may occur in concentrations of approximately 8.1 mg/kg in typical MSW (Musson and Townsend 2009). Having been discarded in landfills, ECs may be degraded/metabolized, adsorbed to solids, or dissolved in leachate (Musson and Townsend 2009). Anaerobic conditions in landfills and nearby groundwater receiving organic-rich leachate from landfills (Cozzarelli et al. 2011) are likely to slow metabolism/breakdown of organic compounds in leachate and groundwater compared to aerobic conditions that are more common in shallow groundwater (Bedient et al. 1997). In groundwater downgradient from an abandoned unlined landfill near Elkhart, Indiana, detergent metabolites, plasticizers, disinfectants, fire retardants, pharmaceuticals, and an antioxidant were detectable at concentrations in the low parts-per-billion range (Buszka et al. 2009). Huset et al. (2011) reported on detection of 24 fluorochemicals in landfill leachates, primarily short-chain (C4-C7) carboxylates or sulfonates associated with paper, textiles, and carpets.

Leaching of organic chemicals from both old and modern landfills to groundwater and surface water is a potentially important environmental problem, with such chemicals potentially being toxic, estrogenic, and carcinogenic to both terrestrial and aquatic organisms (Cozzarelli et al. 2011; Huset et al. 2011; Matejczyk et al. 2011). Some reports have indicated that mixtures of dilute concentrations of ECs in water may deleteriously affect human health, as had been

Ground Water Monitoring & Remediation
© 2011, National Ground Water Association. Published 2011. This article is a U.S. Government work and is in the public domain in the USA.
doi: 10.1111/j1745–6592.2011.01373.x

Updated Review of the "Flawed Technology"
of US EPA Subtitle D MSW Landfilling

G. Fred Lee, PhD, PE, BCEE, F.ASCE and Anne Jones-Lee, PhD

June 7, 2010

The current US EPA Subtitle D landfilling regulations, adopted in 1992, were crafted under the hand of litigation settlement. They were not developed through considered input of and evaluation by the experienced technical community or with scrupulous peer review for the ability of the regulatory specifications to ensure true protection of public health and environmental quality for as long as the landfilled wastes would represent a threat. In fact, during the Subtitle D development process, the US EPA repeatedly indicated that the proposed landfilling regulations would not be protective of groundwater quality over the period that the wastes in the prescribed "dry tomb" (plastic-sheeting and compacted soil-lined) landfill could be a threat. Indeed, the US EPA noted that the "dry tomb" landfills as prescribed and allowed by the regulations could be expected to fail to prevent production of landfill leachate and the migration of that leachate to groundwater. It was clear from the outset that the Subtitle D regulations represented a fundamentally flawed technology. The fundamental flaws of the Subtitle D specifications have not been overcome in the implementation of the regulations over the past 18 years since it adoption.

In the early 1990s Drs. G. Fred Lee and Anne Jones-Lee developed an extensive overview discussion of public health and environmental quality problems that can be caused by landfilling of municipal and industrial solid wastes under the applicable US EPA Subtitle D regulations. The review, which was posted on their website [www.gfredlee.com], was based on their professional experience in reviewing the impacts of proposed and existing landfills, their university research on landfill liner integrity issues, their search and review of the professional literature, and the provisions, requirements, allowances, and implementation of Subtitle D regulations. It included an overview of a number of key deficiencies in Subtitle D with regard to landfill siting, design, construction, operation, closure, and post-closure monitoring and maintenance for the protection of public health and environmental quality for as long as the wastes in the landfill represent a threat to public health, water resources, air quality, and the interests of those in the sphere of influence of a landfill. In addition to highlighting regulatory shortcomings, the review also discussed key elements that need to be incorporated into the landfilling of non-recyclable solid waste components in order to more reliably protect public health, environmental quality, and the interests of those in the sphere of influence of a landfill. It also included substantial references to, and internet links for, professional literature where additional information on the issues discussed could be obtained. Based on their experience and findings, they described the Subtitle D regulations in their review as advancing and enabling a "Flawed Technology" that falls far-short of protecting groundwater and surface water quality from pollution by municipal and industrial solid waste leachate (garbage juice) for as long as the landfilled wastes will be a threat.

Periodically over the past two decades, Lee and Jones-Lee have updated their "Flawed Technology" review with new information on the topics discussed and the addition of discussion of new issues that have come to light since the previous update. In June 2010, Drs. Lee and

Jones-Lee again updated their "Flawed Technology" review, and incorporated an additional nine pages of text and references. The updated, now 94-page, review is available as:

Lee, G. F., and Jones-Lee, A., "Flawed Technology of Subtitle D Landfilling of Municipal Solid Waste," Report of G. Fred Lee & Associates, El Macero, CA, December (2004). Updated June (2010). http://www.gfredlee.com/Landfills/SubtitleDFlawedTechnPap.pdf

In addition to improved clarity of presentation, the June (2010) updated review includes several new or expanded sections on a variety of issues including:

- additional statements by the US EPA acknowledging the inevitability of failure of landfill liner systems,
- monitoring stormwater runoff from landfills and hazardous chemical sites,
- unregulated, potentially hazardous and otherwise deleterious chemicals in municipal solid wastes,
- Subtitle D or equivalent landfills in other countries, including in a new proposed landfill in Alberta, Canada,
- the inappropriate development of a landfill atop a fractured rock, sole-source aquifer system in an area that is subject to intense seismic (earthquake) activity,
- the inadequacy of information published by SWANA on bioreactor landfills,
- the potential for leachate and landfill gas produced in construction and demolition (C&D) waste landfills to pollute groundwater and lead to offsite explosions.

The abstract and table of contents for the June (2010) update of the "Flawed Technology" review is attached.

The authors anticipate continuing to update this review periodically as new information and experience comes to light. Therefore, if you identify topics that are not covered in this review, or if you have comments or questions about this review, please contact G. Fred Lee at gfredlee@aol.com.

Flawed Technology of Subtitle D Landfilling of Municipal Solid Waste

G. Fred Lee, PhD, PE, BCEE, F.ASCE and Anne Jones-Lee, PhD
G. Fred Lee & Associates
27298 E. El Macero Drive, El Macero, CA 95618
Phone: (530)753-9630 Email: gfredlee@aol.com, www.gfredlee.com
Updated June 2010

Abstract

This report presents a review of the information available pertinent to public health and environmental quality protection issues for proposed and existing Subtitle D landfills. Based on this review it is concluded that this type of landfill will at most locations cause groundwater pollution by landfill leachate and be adverse to the health, welfare and interests of nearby residents and property owners/users. As discussed, there is normally significant justification for those near a proposed Subtitle D landfill to oppose the development of the landfill and the existence of an operating Subtitle D landfill.

Typically landfilling regulations require that,
(a) the solid waste facility shall not pose a substantial endangerment to public health or safety or the environment;
(b) the solid waste facility shall not cause an environmental nuisance.
Frequently in review of a proposed landfill, the regulatory agency staff do not adequately or reliably evaluate the potential for a proposed landfill to endanger public health, safety and the environment, and cause nuisance on adjacent properties.

Subtitle D landfills have the potential to generate leachate (garbage juice) that will pollute groundwater with hazardous and deleterious chemicals that are a threat to human health and the environment for thousands of years. These landfills have the potential to generate landfill gas that will contain hazardous and obnoxious chemicals for a long period of time well beyond the current minimum 30-year funded postclosure period. Specific deficiencies in the siting, design, operation, closure and postclosure care provisions for Subtitle D landfills include:

- a single composite landfill liner that will eventually fail to prevent leachate pollution of groundwater,
- a landfill cover that will eventually allow rainfall to enter the landfilled wastes which will generate leachate that will pollute groundwater,
- a grossly inadequate groundwater monitoring system that has a low probability of detecting leachate-polluted groundwater before it leaves the landfill owner's property,
- inadequate postclosure funding for landfill monitoring, maintenance and remediation of polluted groundwater for as long as the wastes in the landfill will be a threat,
- inadequate buffer lands between where wastes will be deposited and adjacent properties, which will result in adverse impacts on nearby property owners/users from landfill releases, including odors, dust, vermin, and noise and lights from landfill activities,
- decreased property values for owners of nearby properties.

In addition, at some locations there is an environmental justice issue associated with the development of a landfill that will be adverse to minority communities.

Flawed Technology of Subtitle D Landfilling of Municipal Solid Waste

Table of Contents

Abstract i
Table of Contents ii
Tables and Figures iv
Acronyms and Definitions v

Flawed Technology of Subtitle D Landfilling of Municipal Solid Waste

Overview of Landfilling Regulations 1
Qualifications to Provide Comments 2
Evolution of Subtitle D Landfills 3
Leachate Generation Potential Will Continue for Thousands of Years 8
Effect of Climate on Leachate Generation 8
Subtitle D Landfill Design Will Not Protect Groundwater for as Long as Leachate Can Be Generated 9
Expected Performance of Subtitle D Landfill Liner System 10
Liner Failure Inevitable 11
NRC Committee Report 13
Desiccation Cracking of Liner 14
Cation Exchange-Related Failure 14
Permeation through the Liner 15
*Diffusion can be Important*1 16
Potential Problems with Geosynthetic Clay Liners 16
Leachate Collection and Removal System Problems 19
Plugging of Leachate Collection Systems 20
Unreliable Evaluation of the Long-Term Integrity of Landfill Covers 20
Leak-Detectable Covers 22
Alternative Cover Design 22
Landfill Cover Area Reuse 24
Closing Unlined Landfills 24
Landfills at Superfund Sites 25
Unreliable Groundwater Monitoring 27
Initial Liner Leakage Can Produce Narrow Plumes of Leachate-Polluted Groundwater 28
Monitoring of Some Fractured Rock Aquifers Nearly Impossible 32
Regulatory Agency Should Evaluate Ability of Groundwater Monitoring System to Detect Initial Groundwater Pollution 35
Potential Change in Direction of Groundwater Flow 35
Evaluation of Leachate Density 36
State's Responsibility to Require Reliable Groundwater Monitoring 36
Responsibility for Long-Term Monitoring 36
Frequency of Groundwater Monitoring 37
Vertical Migration of Leachate Polluted Groundwater in Wells 37
Unreliable Information on Detection of Landfill Liner Failure 37
Impact of Seismic Activity on Integrity of Landfill Containment Systems 38
Landfill Gas and Airborne Emission Problems 38
Threat of Landfill Gas to Wildlife 41

Table of Contents (cont.)

Landfill Odor Control Problems and Impacts 41
Landfill Dust Control Problems 43
Stormwater Runoff Pollution Impacts/Control 43
Monitoring Stormwater Runoff from Hazardous Chemical Sites 45
Inadequate Stormwater Runoff Parameter Monitoring 46
Safe Drinking Water Act Source Protection Issues 47
Inadequate Postclosure Monitoring and Maintenance 48
Hazardous versus Nonhazardous Waste Classification 51
Inadequate Waste Screening for Prohibited Wastes 52
Hazardous Characteristics of MSW 53
Construction and Demolition Waste Landfilling 57
PCBs in Caulk in Older Buildings 58
Hazards of Living/Working near Landfills 62
Recommended Approach 63
Landfill Siting Issues 64
Justified NIMBY 64
Inadequate Buffer Lands 65
Other Impacts of Landfill Releases and Activities 66
Vermin-Disease Vectors 66
Noise Pollution 66
Light Pollution 67
Stormwater Flooding Problems 67
Decreased Values of Nearby Property 67
Host Fees 68
Impact on the Three Rs 68
Environmental Justice Issues 68
Professional Ethics Issues 68
Improving Landfilling of MSW 69
Siting 69
Design 69
Closure 69
Monitoring 69
Landfill Gas Collection 69
Maintenance 69
Funding 70
Improving Public Health and Environmental Protection from Inadequately Developed Landfills 70
Need for Improved Hydrogeological Characterization 71
Subtitle D Landfills in Other Countries 72
Comments on Environment Alberta July 1, 2009 Draft Standards for Landfills 72
Offsite Groundwater, Water Supply Well, and Surface Water Monitoring 73
Hazardous Waste Landfilling 74
Addressing the Flawed Technology of Subtitle D Landfilling 75
Fermentation leaching of MSW 76
References 77

Tables and Figures

Tables

Table 1 – Causes of Liner Failure 11
Table 2 - Adverse Impacts of "Dry Tomb" Landfills on Adjacent/Nearby Property Owners/Users 66

Figures

Figure 1 – Single Composite Liner Landfill Containment System 4
Figure 2 – Factors Affecting Landfill Cover Integrity 21
Figure 3 – Pattern of Landfill Leakage-Groundwater Contamination from unlined Landfills 29
Figure 4 – Pattern of Landfill Leakage-Groundwater Contamination from Lined Landfills 30
Figure 5 – Zones of Capture of Standard Monitoring Wells Must Overlap to Detect Leakage from Lined Landfills 31
Figure 6 – Double Composite Liner Landfill Containment System 33
Figure 7 - Chemical Analysis Output for a Typical Environmental Sample 47
Figure 8 - Comparison of Pattern of Landfill Gas Generation over Time at Classical Sanitary Landfill and "Dry Tomb" Landfill 50
Figure 9 - Impact of Moisture on Landfill Gas Formation 51
Figure 10 – Chemical Sources for California Coastal Water 57

Detecting Failure of Subtitle D Landfill Liner Systems

G. Fred Lee, PhD, PE, DEE
G. Fred Lee & Associates, El Macero, California
November 1999

Periodically landfill applicants and some regulators who want to prove that today's Subtitle D landfills are protective will assert that there are no recorded failures of Subtitle D landfills. This is an issue that I have addressed previously in my report, "Detection of the Failure of Landfill Liner Systems," (1996) which is available from my web site, www.gfredlee.com, in the Landfill section.

The statement about "no recorded failures" of Subtitle D landfills is likely correct. I don't know of any recorded failures. However, as discussed in my review, except under extremely sloppy construction and highly lucky groundwater monitoring, the failure of Subtitle D landfills at this time would not be expected to be detected. This is the result of several situations.

First, Subtitle D landfills have only been used for a few years. It should take about 25 years for leachate that passes through holes in the flexible membrane liner to pass through the clay liner.

Second, as discussed in the paper, "Deficiencies in Subtitle D Landfill Liner Failure and Groundwater Pollution Monitoring," (1998) which is also available in the Landfill section of my web site, the typical groundwater monitoring program allowed by regulatory agencies for Subtitle D landfills involving the use of monitoring wells at the point of compliance, which have zones of capture of about one foot, but which are spaced hundreds of feet apart, means that there must be widespread, general failure of the liner system before these monitoring wells can be expected to detect failure.

The initial failure of the liner system will not be through general leakage throughout the bottom of the landfill, but will be through holes, rips, tears, or points of deterioration in the plastic sheeting flexible membrane liner. As discussed by Cherry in 1990, the initial liner failures will produce finger-like plumes of leachate that will have a high probability of passing between the monitoring wells and not being detected by them.

As discussed in my comprehensive review of the deficiencies in the Subtitle D landfilling approach, "Assessing the Potential of Minimum Subtitle D Lined Landfills to Pollute: Alternative Landfilling Approaches," (1998), which is also available from my web site, based on the properties of the wastes allowed in Subtitle D landfills and the characteristics of the liner systems and groundwater monitoring systems, there is no question about the fact that for Subtitle D landfills sited at geologically unsuitable sites where the base of the landfill is connected through a vadose zone to usable groundwaters, it is only a matter of time until those groundwaters are polluted by landfill leachate, rendering them unusable for domestic and many other purposes. This is not a debatable issue.

Many of the components of the wastes in Subtitle D landfills will be a threat to pollute groundwaters forever. The liner systems being allowed at best only postpone when groundwater pollution occurs. The

groundwater monitoring systems being allowed are largely cosmetic in detecting off-site groundwater pollution before widespread pollution occurs. Anyone who claims otherwise either doesn't understand the basic issues involved, or is deliberately distorting the readily available information on these issues.

Additional Information on Reliability of Groundwater Monitoring at Subtitle D Landfills

In response to my recently summarizing the fundamentally flawed nature of Subtitle D landfilling of municipal solid wastes in protecting public health and the environment for as long as the waste in a Subtitle D landfill will be threat, a "landfill engineer" suggested that the typical groundwater monitoring well array that is used at Subtitle D landfills will detect leachate-polluted groundwater before off-site adjacent property pollution of groundwater occurs due to dispersion of the leachate-polluted groundwater plume. While dispersion plays a role in determining the ability of a monitoring well array to detect a leak from a small area source, it cannot be relied on to insure with a high degree of reliability that the typical groundwater monitoring well array that is being used today at Subtitle D landfills will detect groundwater pollution when it first reaches the point of compliance for groundwater monitoring. Dispersion can be an important factor for slow-moving groundwater pollution plumes at considerable distances from the source. However, contrary to the "landfill engineer's" suggestion, the situation in monitoring around a leaking tank is not the same as the typical monitoring situation at Subtitle D landfills. It is my experience that rarely are monitoring wells near a leaking tank somewhat randomly spaced hundreds to a thousand or so feet apart along the down groundwater gradient edge of the tank, as they are with Subtitle D landfills.

Detection of Leaks from Underground Tanks Versus Detecting Landfill Liner Leaks

When investigating leaking underground storage tanks, the potential source of the leak, i.e., the tank and its associated plumbing, are confined to a small area. To determine whether a tank has leaked sufficiently to pollute groundwaters, it is necessary to define, through the use of three monitoring wells, the direction of groundwater flow. Once this direction has been defined, then the placement of monitoring wells to detect leaks is usually straightforward for relatively homogeneous aquifer systems. However, for landfills, which can occupy hundreds to a thousand or more acres, the initial leakage point is unknown. Therefore, it is not possible to strategically locate monitoring wells downgradient which would reliably detect the leak when it first reaches the point of compliance for groundwater monitoring.

In accord with Subtitle D regulations, the point of compliance can be no more than 150 meters from the down groundwater gradient edge of the landfill, and must be on the landfill owner's property. Since there are no restrictions on landfilling to the edge of the property, I have repeatedly seen landfills with waste deposition areas within a few feet of the adjacent property line. Further, in some states, such as California, the point of compliance for Subtitle D landfill groundwater monitoring is the down groundwater gradient edge of the waste deposition area. This means that there can be little distance between where leaks can occur along the down groundwater gradient edge of the landfill, and the point of compliance for groundwater monitoring. While dispersion might be important for helping to detect leaks from the up groundwater gradient side of the landfill for slow-moving groundwater pollution plumes, it is of limited value in detecting leaks on the down groundwater gradient side of the landfill.

Dr. Cherry and his associates at the University of Waterloo examined the lateral dispersion that occurs in a relatively homogeneous aquifer system from a two-foot-long line source of a tracer. This group found that the two-foot-wide source had spread to about ten feet within 150 meters of the source. This means that monitoring wells would have to be spaced no more than 10 to 20 feet apart in order to reliably detect down groundwater gradient side of the landfill leaks. With monitoring wells spaced at least hundreds of feet apart at distances less than 150 meters from the down groundwater gradient edge of the landfill, there is appreciable distance between the monitoring wells, where substantial leachate plumes could pass without being detected.

It is inappropriate to suggest that detecting leaks from underground storage tanks is similar to detecting liner leaks from municipal landfills. The two situations are obviously significantly different.

Detecting Leaks from Landfills Sited above Fractured Rock Aquifer Systems

There are many Subtitle D landfills sited above fractured rock aquifer systems where it is impossible to reliably monitor landfill liner leakage, even if the monitoring wells are spaced only a few feet apart. Under most of these types of situations dispersion will not overcome the fundamental problems of monitoring the eventual failure of the landfill liner system.

Support of Dr. Cherry's Conclusions on the Unreliability of Groundwater Monitoring at FML-Lined Landfills

The work of Dr. John Cherry and his associates at the University of Waterloo has been supported by a number of competent hydrogeologists with whom I have worked, in review of the potential of proposed Subtitle D landfills to pollute groundwaters, as well as the ability of a proposed groundwater monitoring well array to detect this pollution in accord with Subtitle D requirements, when the pollution first reaches the point of compliance for groundwater monitoring.

Detecting Leaks in Fast and Slow-Moving Plumes

For fast-moving plumes in homogenous aquifer systems, dispersion will not necessarily be adequate to significantly improve the reliability of the typical Subtitle D monitoring well array. There are many places within a landfill footprint where leaks could occur and not be detected at the point of compliance for groundwater monitoring. For slow-moving plumes, there are important questions about whether the monitoring system will be maintained and operated when these plumes reach the point of compliance for groundwater monitoring. With no assured post-closure funding after 30 years, there is no assurance that groundwater monitoring systems will still be maintained and operated when they are needed, when the slow-moving plume with its dispersion reaches the point of compliance for ground water monitoring.

Recommended Approach for Permitting of Landfills

It has been my recommendation at landfill permitting hearings, that rather than assuming that arbitrarily spaced groundwater monitoring wells will reliably detect landfill liner leaks in accord with Subtitle D requirements, i.e., when the leachate-polluted groundwater first reaches the point of compliance for groundwater monitoring, the landfill applicant should be required to provide reliable information on the

monitoring well spacing, considering the site-specific characteristics of the geology-hydrology of the aquifer system that will be polluted when the Subtitle D liner system fails to prevent significant leakage of leachate through the liner. The burden of proof for the reliability of the groundwater monitoring system should be on the landfill applicant and not the public whose groundwater could be polluted if the arbitrarily developed groundwater monitoring system fails to detect the leachate-polluted groundwater at the point of compliance. It should be the responsibility of the landfill applicant to define, based on the site-specific characteristics of the aquifer, the monitoring well array needed to have a 95% probability of detecting one to two-foot-long rips, tears, or points of deterioration in the landfill FML liner at the point of compliance for groundwater monitoring, when the leachate-polluted groundwater first reaches this point.

Adopting this approach would quickly show what is well understood, that today's groundwater monitoring systems at many Subtitle D landfills are cosmetic and provide little in the way of reliable monitoring of leachate-polluted groundwaters before widespread liner deterioration occurs. At many Subtitle D landfills, the leaks through the liners will likely first be detected in off-site production wells, rather than by the groundwater monitoring system.

Assessing the Potential of Minimum Subtitle D Lined Land lls to Pollute: Alternative Land lling Approaches

G. Fred Lee, PhD, PE, DEE and Anne Jones-Lee, PhD
G. Fred Lee & Associates, 27298 E. El Macero Drive, El Macero, CA 95618
Ph: 530-753-9630; Fx: 530-753-9956; em: gfredlee@aol.com

March 1998

Abstract

The US EPA Subtitle D regulations specify as a minimum, MSW land lls be lined with a single composite liner which is part of a leachate collection and removal system. Upon reaching the land ll capacity, a low-permeability cover is installed. A groundwater monitoring system is used to detect liner failure during the 30-year mandated post-closure care period. The waste in a minimum Subtitle D Adry tomb@ land ll will be a threat to pollute groundwaters by leachate, effectively forever. The land ll liner and cover have a nite period of time when they can be expected to function effectively to keep moisture out of the land ll that generates leachate and to collect leachate formed within the land ll. The groundwater monitoring systems typically used with monitoring wells having zones of capture of about one foot on each side, spaced hundreds of feet apart, have low probabilities of detecting land ll liner failure that leads to groundwater pollution before off-site pollution occurs. The 30 years of mandated post-closure care is an in nitesimally small part of the time that the waste in a minimum Subtitle D Adry tomb@ land ll will be a threat to generate leachate that can pollute groundwater. Fundamentally, the minimum Subtitle D MSW land ll is a technologically awed approach that, at best, only postpones when groundwater pollution occurs for those land lls sited at geologically unsuitable sites, i.e. those without natural groundwater quality protection. The US EPA Subtitle D regulations also fail to address the justi able NIMBY associated with active life releases (odors, dust, blowing paper, etc.) from the land ll to the surrounding area. This paper discusses the de ciencies in minimum Subtitle D land lling of MSW and provides guidance on alternative land lling approaches that can protect public health, groundwater resources, environment and the interests of those within the sphere of in uence of the land ll.

Impact of Municipal and Industrial Non-Hazardous Waste Land lls on Public Health and the Environment: An Overview

G. Fred Lee, Ph.D., P.E., D.E.E. and Anne Jones-Lee, Ph.D.
G. Fred Lee & Associates
El Macero, CA 95618
(530) 753-9630

Prepared for California Environmental Protection Agency's Comparative Risk Project, May (1994).

Executive Summary

Classical unlined sanitary land lls are well-known to release large amounts of hazardous and otherwise deleterious chemicals to nearby groundwater and to the air, via leachate ("garbage juice") and land ll gas. It is known that such releases contain a wide variety of potential carcinogens and potentially toxic chemicals that represent a threat to public health. However, little quantitative information exists on the total hazard that land lls represent to those who live or otherwise use properties near the land ll. Epidemiological studies of the "exposed" populations near land lls and Superfund sites have not detected a clearly discernable increase in the incidence of cancer in those populations. This is to be expected because of the insensitivity of epidemiological methods for detecting small increases in cancer incidence in limited populations over the normal lifetime cancer risk for the US population of one cancer in three people. It would be rare that a suf cient number of individuals near Superfund site land lls would experience an average increased cancer risk of 1 in 1,000.

The leachate from MSW land lls is a highly concentrated "chemical soup," so concentrated that small amounts of leachate can pollute large amounts of groundwater rendering it unsuitable for use for domestic water supply. In addition to potential carcinogens and highly toxic chemicals, MSW leachate contains a variety of conventional pollutants that render a leachate-contaminated groundwater unusable or highly undesirable due to tastes and odors, reduced service life of appliances (e.g., dishwashers, hot water heaters, plumbing), fabric (clothes), etc. Furthermore, both gas and leachate from MSW land lls contain many organic chemicals that have not been characterized with respect to speci c chemical content or their associated public health or other hazards. These "non-conventional pollutants" include more than 95% of the organics in MSW leachate.

There are more than 65,000 chemicals in US commerce today; about 1,000 new chemicals are being developed each year. Of those chemicals, only about 200 are regulated and measured in studies of MSW land ll leachate-contamination. Given the highly concentrated nature of MSW land ll leachate, that a large portion of the organics in MSW leachate are of unknown character and hazard, and that a comparatively few chemicals are regulated, it should not be assumed that the fact that a leachate-contaminated groundwater meets all drinking water MCL's (maximum contaminant lev-

els) means that the water should be considered safe to consume. Furthermore, once a groundwater is contaminated by MSW land ll leachate of the type produced in today's Subtitle D land lls, it and the associated aquifer cannot be cleansed so as to render a water that can be considered reliable for consumption and certain other uses. The contaminated portion of the aquifer must be abandoned for future use as a domestic water supply source and for conjunctive use storage of surplus surface waters for use during drought periods. Therefore, it is prudent public health and water resource management policy to assume that any contamination of groundwater by MSW land ll leachate represents a signi cant threat to public health and the environment and should cause termination of the use of the water for domestic water supply purposes.

Land ll gas emissions also contain large amounts of obnoxious and otherwise deleterious chemicals that are highly detrimental to nearby property owners and users. The methane in land ll gas releases, while odorless, poses a threat of explosions in enclosed structures and contributes to the greenhouse gases that promote global warming. Both methane and C02 in land ll gas can also be highly detrimental to vegetation on the land ll cover and near the land ll. The obnoxious odors that are emitted from MSW land lls can persist for a mile or more from the land ll. Such odors provide a tracer for non-odorous as well as odorous hazardous chemicals in gaseous emissions. Because of the large amounts of non-conventional pollutants in land ll gas, the detection of land ll odors on offsite properties should warn of a signi cant public health threat. Odors and other adverse conditions created by land ll operations cause property values to decrease within a mile or so of the land ll.

New Subtitle D regulations prescribe a "dry tomb" land lling approach in which untreated MSW is placed in plastic-sheeting- and compacted-soil-lined land lls in an attempt to isolate the wastes from water for as long as the wastes will be a threat. Evaluation of the character of the systems incorporated relative to physical, chemical, and biological processes as they occur in such systems, and the nature of the materials placed in them shows the "dry tomb" land lling approach to be a awed technology that will not protect the public health, or groundwater and air resources under and above the land ll and adjacent properties. At best, it will only postpone the leakage of leachate and gas to adversely affect public health and environmental quality.

MSW in a "dry tomb" land ll will be a threat to public health, groundwater resources, and the environment forever. The effectiveness of Subtitle D land ll liner systems in preventing leachate migration is compromised after installation, and will deteriorate over time allowing increasing amounts of leachate to pass through the liner into the groundwater system hydraulically connected to the bottom of the land ll.

The US EPA and states' Subtitle D groundwater monitoring approach of using vertical monitoring wells spaced hundreds to a thousand or more feet apart at the groundwater monitoring point of compliance is grossly inadequate for detecting incipient groundwater pollution from lined land lls. Unlike leakage from unlined land lls in homogeneous hydrological settings, the initial leakage from plastic sheeting-lined Subtitle D land lls will be through holes, tears, or imperfections in the sheeting. Such point-source leakage results in the emanation of " ngers" of leachate-contaminated groundwater which are a few feet wide at the point of compliance for groundwater monitoring. Vertical monitoring wells have effective zones of capture of leachate-contaminated groundwater of only about one foot around the wells. With the spacing of such wells allowed, the US EPA Subtitle D groundwater monitoring approach will not detect groundwater pollution, much less incipient land ll

leakage, before widespread groundwater pollution has occurred.

The municipal solid waste stream of today and of the future potentially contains less industry-de ved hazardous chemicals than the classical sanitary land ll. However, it does, and will continue to, contain large amounts of highly hazardous and otherwise deleterious chemicals that will render groundwaters contaminated by such leachate unusable for domestic water supply purposes.

RCRA set forth a minimum post-closure care period of 30 years; that period was also used by the US EPA in implementing Subtitle D regulations. However, 30 years is an imperceptibly small, and insigni cant part of the total time that MSW in Subtitle D "dry tomb" land lls will be a threat to public health, groundwater resources, and the environment. Insuf cient funds are being collected from waste generators and set aside to meet the inevitable and unending needs for post-closure care monitoring and maintenance, and groundwater and land ll remediation for Subtitle D land lls. The Subtitle D land lling approach and requirements adopted by the US EPA are super cial and only serve as a stop-gap measure for managing MSW. They enable today's society to continue to enjoy solid waste "disposal" without the responsibility and expense of preventing them from causing future problems. This is being enjoyed at the expense of future generations' public health, groundwater resources, and welfare.

Contrary to claims made by the US EPA in implementing Subtitle D land ll regulations in October 1991, Subtitle D land ll requirements do not address the justi able "NIMBY" concerns and problems associated with the active life of land lls or the post-closure care impacts on those who own or use properties within several miles of the land lls. In not recognizing the potential signi cance of non-conventional pollutants, the nature of processes within the land lls, the nature and limitations of the liner systems and monitoring approaches, and the perpetual threat of contaminants in land lls, the US EPA Subtitle D and state regulations do not protect public health or groundwater resources for as long as the wastes represent a threat. Since Subtitle D land lls only postpone groundwater pollution, and for many land lls, gas emission problems, Subtitle D land lls do not signi cantly alleviate the threat of land ll gas and leachate to those who own or use properties within the sphere of in uence of the land ll. The "dry tomb" land lling approach should be recognized as "temporary" storage for MSW that will ultimately require exhumation and treatment of the wastes unless groundwaters hydraulically connected to them are to be abandoned as water resources.

More protective alternatives to US EPA Subtitle D "dry tomb" land lls are available to address both the near-term and long-term threats that such land lls represent to public health, groundwater resources and the environment, as well as to the welfare of those within the sphere of in uence of the land ll. The additional costs for such approaches are insigni cant compared to the long-term costs that will have to be paid by future generations for today's waste management mistakes. One such alternative is a fermentation/leaching "wet-cell" approach. In brief, that approach includes the recycling of land ll leachate in a double-composite-lined land ll that contains shredded MSW followed by a decade or so of clean-water washing (leaching) of the solid waste to produce non-polluting residues. The lower composite "liner" serves not for last-resort containment, but rather as a lysimeter leak detection system for the upper-composite liner. Associated with that waste treatment/management concept is required the setting aside of suf cient funding in a dedicated trust fund derived from increased disposal fees to exhume the wastes when leakage through the upper-composite liner

cannot be stopped. To address justi able active-life NIMBY concerns and problems, it is necessary that the land ll be sited with an adequate land ll owner-owned land buffer of at least one mile about the outer reaches of the land ll. The land ll buffer would be used to dilute the adverse impacts of the land ll, such as odors, seagulls, etc. that occur with today's land lling operations. The estimated initial cost of this approach is about 10 to 15 cents/person/day more than that paid for solid waste management in Subtitle D land lls. Expenditures of this amount will not only address justi able NIMBY issues of today's land lls, but also signi cantly improve the protection of future generations from adverse impacts of gaseous and leachate emissions. Further information on each of these issues is provided in this report and in references contained therein.

ProQuest

THE WALL STREET JOURNAL.

Plastic dump liners have been slow in coming

Bailey, Jeff. **Wall Street Journal**. (Eastern edition). New York, N.Y.: Nov 14, 1996. pg. A4, 5 pgs

Abstract (Summary)

Five years after federal rules were rolled out aimed at requiring environmental protecting plastic liners under garbage dumps, the liners are installed at only about one third of the nation's dumps, a consultant's study found. What's more, the EPA is gearing up to allow increasing varieties and amounts of industrial wastes, some of them formerly channeled to hazardous-waste-only disposal sites, to go to regular trash dumps.

Copyright Dow Jones & Company Inc Nov 14, 1996

Five years after federal rules were rolled out aimed at requiring environment-protecting plastic liners under garbage dumps, the liners are installed at only about one third of the nation's dumps, a consultant's study found.

What's more, the Environmental Protection Agency is gearing up to allow increasing varieties and amounts of industrial wastes, some of them formerly channeled to hazardous-waste-only disposal sites, to go to regular trash dumps.

In addition to raising environmental concerns, these two developments are angering waste-handling companies that compete against dumps, particularly trash and hazardous-waste incinerators that already have much higher operating costs.

The Integrated Waste Services Association, which represents operators of more than 100 big trash-to-energy plants, objects to what it considers unequal treatment. The waste-burning plants are just beginning a $400 million retrofit to comply with Clean Air Act regulations, and some have been suffering because a glut of disposal capacity has driven disposal prices downward in some big markets.

"It's not fair," said Maria Zannes, president of the Washington-based association. "These guys get all the breaks."

The study was conducted by Environmental Information Ltd., a Minneapolis consulting and publishing concern. The firm has accepted funding from hazardous-waste handlers to perform other studies, but funded this study entirely on its own, said Jeff Smith, a senior associate.

According to the study, only 960 of the nation's 2,931 active dumps have synthetic liner systems.

The liner-installation shortfall arose as the EPA delegated to states the implementation of dump rules, and allowed the states to exempt many disposal facilities from any synthetic-liner requirement. Most commonly exempted were dumps in some remote areas, those that take smaller volumes of waste, and, those in arid climates where low rainfall reduces the likelihood that water contaminated by waste would seep into groundwater.

But some large and active dumps, particularly those owned by municipalities, continue to accept waste into unlined areas because the rules allowed "vertical expansion" to continue on top of older, unlined dump areas.

This shows how even a simple environmental safeguard -- itself far from an absolute protection against fouling groundwater -- ends up being watered down as the EPA, states, local government and the waste industry all get involved in the implementation of federal rules.

To be sure, the biggest and busiest dumps in the U.S. tend to have synthetic liner systems, which include piping to extract and treat garbage juice known as leachate.

Browning-Ferris Industries Inc., the nation's No. 2 dump operator, said 80 of its 82 active U.S. trash dumps have such liner systems. WMX Technologies Inc., No. 1 among dump operators, said it has synthetic liners in all of its dumps horizontally expanded since 1993 -- about 80% of its more than 100 U.S. sites. Some of the remaining 20%, though not all, also have such liners.

It's not only the big dumps that are of concern. Many of the nastiest Superfund cleanup sites, born during the dump-it-anywhere days before regulations, were in fact small facilities.

Adding a synthetic liner costs $25,000 or more an acre at dumps, according to the EPA, while cleaning up even small contaminated dump sites can costs millions of dollars. "The EPA and states seem to prefer a pound of cure to an ounce of prevention,"

Environmental Information's Mr. Smith said.

The EPA itself doesn't keep track of how many dumps have synthetic liners, leaving that to states. "I'm not shocked," said Bob Dellinger, acting director of the agency's municipal and industrial solid-waste section, of the study's finding about the lack of synthetic liner systems. Mr. Dellinger said the EPA expected about 800 dumps to qualify under the "small, dry and remote" exemptions, and that many of the other dumps without liners are probably still piling trash on top of older, unlined areas.

Proximity to groundwater and the mix of wastes that go into a dump are considered by many waste experts to be as important -- or more so -- than whether a site has a synthetic liner. Mr. Dellinger said the rules and various exemptions were designed to require liners at dumps that pose greater threats.

Credit: Staff Reporter of The Wall Street Journal

Indexing (document details)

Subjects:	Waste disposal, Landfill, Industrial wastes, Hazardous substances, Federal regulation, Environmental protection
Companies:	Environmental Protection Agency, EPA
Author(s):	Bailey, Jeff
Document types:	News
Publication title:	Wall Street Journal. (Eastern edition). New York, N.Y.: Nov 14, 1996. pg. A4, 5 pgs
Source type:	Newspaper
ISSN:	00999660
ProQuest document ID:	10454388
Text Word Count	687

Copyright © 2008 ProQuest LLC. All rights reserved.

Unexpected leakage through landfill liners.Janet Raloff. ***Science News*** 135.n11 (March 18, 1989): pp164(1). (757 words)

Full Text:COPYRIGHT 1989 Science Service, Inc.

Unexpected Leakage Through Landfill Liners

For years, the standard way to dispose of hazardous chemicals was to bury them in landfills. Intended as permanent resting places, most of these graves incorporated a bathtub-shaped liner of compacted clay to keep water -- and buried toxic wastes -- from escaping. While clay does limit water leaks fairly well, new field research shows it fails to block the major route by which many toxic chemicals, such as organic solvents, escape.

The researchers say this finding carries grave implications not only for the safety of hazardous-waste landfills begun prior to 1985, but also for the adequacy of current techniques of containing landfill leaks and toxic chemicals spilled on land.

Water provides the two primary means by which pollutants move from landfills. Through a "vehicular" pathway, water can carry dissolved wastes as it flows from areas of high pressure, such as pools collected on the inside of a landfill, to regions of low pressure, such as drier soils underneath. A second pathway uses water quite differently -- as a potentially fixed "conduit" through which dissolved contaminants "diffuse" from regions where their concentrations are higher to areas where they are lower.

Today, notes Richard Johnson, an environmental scientist at the Oregon Graduate Center in Beaverton, engineers work at controlling the vehicular pathway only. Until recently, the standard approach was to line landfills with "impermeable" clay barriers -- ones designed to leak no more than 89 gallons of water per acre daily, according to Environmental Protection Agency (EPA) engineer Kenneth Skahn of Washington, D.C. Diffusion control was all but ignored, Skahn says, because of a prevailing attitude that "diffusion really will never be much of a factor" in landfill leaks. Unfortunately, Johnson says, this attitude fostered a false sense of security.

Johnson's research, reported in the March ENVIRONMENTAL SCIENCE AND TECHNOLOGY, shows significant toxic-chemical diffusion into the barrier of a five-year-old, clay-lined hazardous-waste landfill in Sarnia, Ontario. As expected, there was wide variability in contaminant mobility, with the most water-soluble pollutants moving fastest. Chloride ions, for example, had penetrated about 28 inches into the clay floor. Less water-soluble organic chemicals spent more of their time preferentially clinging to carbon in the clay. Acetone and ketones, among the more water soluble of these organics, traveled only about 5 inches -- three to 20 times farther than would be expected for far less soluble solvents, like benzene and toluene.

Owing to the unusual depth of this landfill's natural clay floor -- about 130 feet -- no contaminant broke through this barrier. However, Johnson says, if the clay's thickness had been more typical of hazardous-waste landfills -- perhaps 3 feet -- his data suggest the more mobile contaminants might have broken through in just five years, and slower ones, like benzene, in 70 years.

So closely do these field data mirror theory, Johnson says, "that if I know what a contaminant's solubility is, and the [barrier's] organic carbon content, I can now predict how fast a chemical will [diffuse through]."

Comments Donald H. Gray, a civil engineer at the University of Michigan in Ann Arbor, "There are

important implications here for the design and construction of containment envelopes around hazardous-waste landfills." The new findings show that once water permeability is well controlled, diffusion becomes the dominant exit route for interred wastes.

Since 1985, EPA has banned landfilling of solvents -- like benzene -- and required that new hazardous-waste landfills use multiple barriers of clay and synthetic materials. Less water-permeable than clay, plastics also provide a major barrier to diffusion. Thus, Johnson says, the real concern is with landfills built before 1985. EPA's Robert Landreth says agency officials don't know how many U.S. hazardous-waste landfills rely on clay barriers, but a good guess might be "more than 10 and less than 50." Johnson says a more likely estimate is "at least hundreds."

The new findings are relevant also to current containment efforts, says Walter Weber, a colleague of Gray's at the University of Michigan. Today, engineers commonly cordon off chemical spills in soil and leaking landfills by digging a thick trench around them, preferably down to a natural clay deposit, and filling the trench with a slurry of clay and soil. Once it hardens, the slurry wall becomes relatively impermeable to water. However, this barrier -- often the only one surrounding the toxic chemicals -- offers little protection from diffusion, Weber notes. So he and Gray are studying ways to increase its carbon content -- currently by incorporating fly ash -- to slow the diffusion of trapped organics.

Source Citation: Raloff, Janet. "Unexpected leakage through landfill liners." Science News 135.n11 (March 18, 1989): 164(1).

Gale Document Number:A7483323

HAWAII NEWS NOW

Document shows landfill operator fined for design failures

Posted: Jan 27, 2011 3:03 AM EST

Updated: Jan 27, 2011 3:45 AM EST



By Ben Gutierrez - bio | email

KAPOLEI (HawaiiNewsNow) - A document has come to light, showing that the operator of the Waimanalo Gulch landfill and the city were fined $424,000 last year for design failures at the landfill.



Carroll Cox

The fine was in a notice of violation issued in May 2010, which contended that Waste Management and the city failed to follow design specifications for a liner that was supposed to cover waste, and built the west berm of the landfill too high. According to the notice, the liner was of a lower quality than specified.

Carroll Cox, of the environmental group EnviroWatch, noted that the company had paid an even bigger fine. "That comes on the heels of a $2.8 million dollar fine that they paid earlier, for earlier violations. So this is just a constant dripping, so to speak, of one big problem after the other," Cox said.



The huge fine was assessed in 2006; according to the notice of violation, the design process involved in the latest fine began the same year.

Cox contends that the failure to follow the design contributed to the problems that arose when floodwaters went through the landfill and spread refuse and medical waste along the Leeward Oahu coast. "I think I would probably not be here doing this interview, and we wouldn't see the people of Ko Olina, who are rightfully outraged," said Cox. "We wouldn't have the general public querying this one big question: How did medical waste get into the environment, get into the ocean?"

Ko Olina residents were present at a Kapolei Neighborhood Board meeting Wednesday night to discuss the problems at the landfill. Meantime, the city announced Wednesday that the landfill would reopen Friday to allow city crews to dispose of backlogged waste. It will reopen to the general public next week Wednesday.

Cox says the document also points to continuing problems at Waste Management, which have been only made worse by the heavy rain.

"What they are really facing now is having to work in the mud now, in that area. Not just from that storm, but also from water that had gotten behind the liner, and gotten into the cell and presenting a bigger problem," Cox said.

The city's Environmental Services Department said the fine had been settled with the state Health Department. But Cox said it's no longer just an environmental cost, but a cost to taxpayers, because of the fines.

Copyright 2011 Hawaii News Now. All rights reserved.

WorldNow All content © Copyright 2000 - 2011 WorldNow and KHNL/KGMB, a Raycom Media station. All Rights Reserved.
For more information on this site, please read our Privacy Policy and Terms of Service.

DOI 10.1007/s00038-013-0496-8

REVIEW

Health effects associated with the disposal of solid waste in landfills and incinerators in populations living in surrounding areas: a systematic review

Amalia Mattiello · Paolo Chiodini · Elvira Bianco · Nunzia Forgione · Incoronata Flammia · Ciro Gallo · Renato Pizzuti · Salvatore Panico

Received: 26 March 2013 / Revised: 26 June 2013 / Accepted: 10 July 2013 / Published online: 26 July 2013
© Swiss School of Public Health 2013

Abstract
Objectives Potential health hazards for the environment and people living nearby landfills and incinerators are claimed to be related to several methods of waste management. Independent systematic review of the scientific literature is a key procedure to support the lay public and policy makers to achieve informed decisions.
Methods The study design and potential biases of papers retrieved in this comprehensive literature search were analyzed.
Results The most consistent result is that the risks of congenital anomalies and hospitalization due to respiratory disease are likely to be real nearby special waste landfills. From the very little information on exclusively urbanwaste depots it is reasonable to say that correct management of landfill does not increase the risk of these health effects. It is confirmed that historically incinerators are an important source of pollution and harm for the health of populations living nearby; however, changes in technology are producing more reassuring results.
Conclusions A moderate level of confidence is possible in limited areas of knowledge, implying the need to overcome the limitations of current studies about exposure assessment and to control confounders at the individual level.

Keywords Incinerator · Landfill · Environmental exposure · Environmental diseases · Population health

This article is part of the special issue "Environment and Health Reviews".

Electronic supplementary material The online version of this article (doi:10.1007/s00038-013-0496-8) contains supplementary material, which is available to authorized users.

A. Mattiello · N. Forgione · I. Flammia · S. Panico
Azienda Ospedaliera Universitaria Federico II Naples, Naples, Italy

P. Chiodini · C. Gallo
Department of Mental Health and Preventive Medicine, Second University of Naples, Caserta, Italy

E. Bianco
Azienda Sanitaria Locale Avellino, Avellino, Italy

R. Pizzuti
Epidemiological Observatory, Campania Region, Naples, Italy

S. Panico (✉)
Dipartimento di Medicina Clinica e Chirurgia, Federico II University, Via Pansini, 5, 80131 Naples, Italy
e-mail: spanico@unina.it

Introduction

Management of solid waste disposal is a priority issue in the organization of modern societies. In spite of the increasing recycling activities, landfills and incinerators are widely used to manage the final phase of waste disposal. Potential health hazards for the environment and people living nearby are claimed to be related to waste management, which is known to release potentially harmful substances although in small quantities and at very low levels. Many uncertainties surround the assessment of health effects, and the need for independent systematic reviews of the current scientific information is urgent in order to provide the lay public and policy makers with reliable lines of scientific knowledge. A number of reviews are already available (Vrijheid 2000; Hu and Shy 2001; Rushton 2003; Dolk and Vrijheid 2003; Department for

Environment, Food and Rural Affairs (DEFRA) 2004; Franchini et al. 2004; Michaels and Monforton 2005; Minichilli et al. 2005; Linzalone and Bianchi 2007; World Health Organization (WHO) 2007; Russi et al. 2008; Signorelli et al. 2008; Giusti 2009; Porta et al. 2009). The reviews underline the difficulties in interpreting data from primary studies because of the lack of accurate exposure information and control of potential confounders. This problematic interpretation further complicates a scenario where risk communication is poorly manageable, risk perception is greatly biased, and conflicting interests become the dominant issues for discussion, implying huge difficulties in managing public health issues affecting the safety of communities. This review updates the evaluation of evidence (19 more papers on landfills and 13 on incinerators included in the tables in the "Electronic supplementary material") derived from the literature on the health effects of landfills and incinerators in people living in their proximity and discusses the degree of uncertainty associated with the risk estimates, thereby providing researchers, citizens, and institutions with an updated independent piece of evidence. This process has been promoted by the Italian authorities after the dramatic garbage management failures in Campania, an Italian area where the safety of communities has been put in danger by very bad organization and the presence of several illegal landfills; the resultant potential health hazards in some areas of Campania are associated with higher mortality rates for various diseases in comparison with those in other regional areas (Altavista et al. 2004; Comba et al. 2006; Martuzzi et al. 2009; Fazzo et al. 2008, 2011).

Methods

The scientific literature was scrutinized through computerized literature searches using PubMed, Embase, Web of Science, and the Cochrane Library from 1 January 1983 to 1 June 2012. The search strategy consisted in the use of various combinations, in line with the specific database language, of the terms "incinerat* OR "refuse disposal" OR "refuse disposals" OR landfill*", "population* OR habitant*", "environmental exposure", "environmental disease"; the search was subsequently improved using more restrictive terms related to both exposure to disposal sites and disease outcomes. Primary publications on the health effects of landfills and/or incinerators on the population living in the proximity were the subject of this systematic review. Other types of papers (systematic reviews, biomonitoring of toxic agents in the proximity of waste disposal sites, environmental impact estimation) were consulted in order to integrate all the available scientific information for the interpretation of the results. The search was completed using the references identified in the retrieved papers and any highlighted by the working group. A total of 201 relevant papers were identified, 101 on landfills and 100 on incinerators. The papers were screened for eligibility by two independent reviewers; disagreements were resolved by discussion. Out of 100 papers on landfills, 71 were excluded (1 systematic review, 1 duplicate paper, 1 focused on occupational exposure, 34 biological studies, 34 other non-relevant types of papers); therefore 29 papers were evaluated (4 cohort studies, 8 case–control studies, 17 ecological studies). Out of 100 papers on incinerators, 69 were excluded (2 systematic reviews, 1 duplicate paper, 1 focused on occupational exposure, 29 biological studies, 36 other non-relevant types of papers); therefore 31 papers were evaluated (2 cohort studies, 9 case–control studies, 17 ecological studies, 3 cross-sectional studies). The list of excluded papers is reported in Appendix A (Electronic supplementary material).

Information on study subjects (number, age, gender, country), exposure assessment, outcome assessment, estimated effects, and potential bias were independently abstracted by three observers using a predefined format, and disagreements were resolved by discussion. Characteristics of the studies are reported in Appendices B and C (Electronic supplementary material) for landfills and incinerators, respectively. The tables therein are arranged by outcome.

To assess the size and direction of potential biases an evaluation scale is proposed that envisages exposure assessment, outcome assessment, and confounding control (Table 1). For each item the null value (0) indicates that no influence on the estimation is likely, a positive sign that the effect estimates could be less (+) or more (++) overestimated, and a negative sign that the effect estimates could be less (−) or more (− −) underestimated. As for exposure assessment, underestimation is considered according to the study designs; conversely for outcome and confounding assessment, overestimation is considered (Porta et al. 2009; WHO 2007; Franchini et al. 2004; Giusti 2009). The results of this evaluation were discussed among three authors (SP, EB, and PC) and the grade was assigned according to the majority rule in case of inconsistencies.

An attempt to define the relationship between the process (landfill/incinerator) and the various diseases in terms of potential cause–effect evaluation was performed according to Porta et al. (2009), using the International Agency for Research on Cancer (IARC) criteria for carcinogenesis (IARC–WHO, 2013). The results of this evaluation were discussed among three authors (SP, EB, and PC) and the relationship was assigned according to the majority rule in case of inconsistencies.

Table 1 Qualitative assessment of internal validity of the reviewed studies

Item	Risk of bias	Evaluation criteria
Exposure	−	If defined by both the distance from the site and some measurement of polluting substances
	− −	If defined only by the distance from the site or by an exposure area
	0	Use of individual data
Outcome	0	If reported from cancer registries or direct measure of incidence
	+	If reported by death registries
	++	If reported by hospital discharge forms or detected through questionnaires
Confounding	0	Use of individual data
	+	Control at a population level (including deprivation index)
	++	No control

Results

Studies on communities living near landfills

Twenty-nine papers on the health effects in communities living in the proximity of landfills were evaluated. One of the major issues in the evaluation was the difficulty in distinguishing between solid urban waste and other types of wastes. There is not yet a standardized definition of the various types of wastes. The terms dangerous, special, toxic, industrial, and commercial are not uniformly used in different countries and over time periods. Moreover, the types of wastes disposed in a landfill may have changed over time. The outcomes considered in the papers were all cancers, birth defects, respiratory diseases, and total mortality. In some papers multiple outcomes were evaluated.

Cancer

The relationship between landfills and cancer has been evaluated in seven studies (5 ecological, 1 cohort, and 1 case–control)

Colorectal A cohort study carried out in Finland compared the incidence of colorectal cancer in a community in the proximity of a landfill containing industrial and urban wastes to that in a control cohort (Pukkala and Pönkä 2001). No difference was found, but the low number of cases and the lack of adjustment for confounders, beside age and sex, make the results less reliable. An ecological study in Australia evaluated mortality and incidence in populations living nearby a landfill containing urban special and dangerous wastes, both liquid and solid, did not find any risk excess, but again involved a low number of cases (Williams and Jalaludin 1998).

Liver In an ecological study that analyzed mortality in a community living in an Italian area containing a landfill, an incinerator, and a refinery, liver cancer mortality was not different in populations living at various distances from the sites, after adjustment for age and deprivation index and separately by sex (Michelozzi et al. 1998). In another Italian study a potential risk was found in males, but no adjustment was made and information on outcomes cannot be related to the distance from the landfills (Minichilli et al. 2005). A Canadian case–control study found no significant trend in populations living at various distances from an urban waste landfill, adjusting for some confounders (Goldberg et al. 1999). Multiple comparisons on 30 cancer sites and the low number of cases suggest that caution be adopted in interpreting these results. A Brazilian ecological study of urban landfills in Sao Paolo found no difference comparing people living at less and more than 2 km from several sites (Gouveia and Ruscitto do Prado 2010a).

Bladder A large national ecological study, carried out in the UK, analyzed the incidence of bladder cancer in populations living at various distances from a landfill site (Jarup et al. 2002) and did not detect any association, nor when only special wastes were considered. Two other studies were unable to detect any association (Williams and Jalaludin 1998; Gouveia and Ruscitto do Prado 2010a).

Larynx A significant decrease of mortality rates as the distance from the sites increased was reported in Italy, but with low numbers (Michelozzi et al. 1998). Another study in Canada did not detect any association (Williams and Jalaludin 1998).

Lung None of the three evaluated studies was able to detect any association (Williams and Jalaludin 1998; Michelozzi et al. 1998; Pukkala and Pönkä 2001).

Kidney Two studies found a modest non-significant increase in risk (Michelozzi et al. 1998; Goldberg et al. 1999).

Lymphomas Only one study (Goldberg et al. 1999) found a significant association, whereas those by Williams and Jalaludin (1998) and Michelozzi et al. (1998) did not.

Leukemia Two studies in children (Jarup et al. 2002; Gouveia and Ruscitto do Prado 2010a) and four in adults (Williams and Jalaludin 1998; Michelozzi et al. 1998; Jarup et al. 2002; Gouveia and Ruscitto do Prado 2010a) were unable to detect any association.

Brain No association was found in a UK study (Jarup et al. 2002). An increased risk only in males living in the proximity of the landfill was detected in a US study (Williams and Jalaludin 1998), limited by low numbers of cases.

Other cancers In a previously described study no association was found for breast, uterus, prostate, stomach, and skin cancers (Williams and Jalaludin 1998). Goldberg found an increased risk for pancreatic cancer but not for prostate (Goldberg et al. 1999). Another study found an increased risk for skin and pancreatic cancers only in males (Pukkala and Pönkä 2001).

Birth defects and reproductive disorders

Out of the 22 studies analyzing the relationship between these disorders and the presence of landfills, 13 are ecological, 2 cohort, and 7 case–control.

Birth defects in general

Six studies found statistically significant associations (Fielder et al. 2000, 2001; Elliott et al. 2001, 2009; Palmer et al. 2005; Vrijheid et al. 2002), but five other studies (Morris 2003; Dummer et al. 2003b; Boyle et al. 2004; Kloppenborg et al. 2005; Gouveia and Ruscitto do Prado 2010a) did not. In the UK an ecological study of residential distance from a site, the risk of congenital malformations was higher; however, that risk was also detected by analyzing data before the opening of the landfill (Fielder et al. 2000). A national UK study analyzed congenital anomalies and low birth weight in populations living at different distances from a large number of waste sites (19,196) (Elliott et al. 2001). A statistically significant association was found (RR 1.05), but it disappeared for urban solid waste (RR 0.99) when analyzed separately from toxic waste (RR 1.08) (Elliott et al. 2009). A Danish national ecological investigation found no association in comparing people living at different distances from the sites (Kloppenborg et al. 2005). Evaluating the rates before and after the opening of 24 landfills in Wales, Palmer et al. (2005) found a significant increase over time. Among residents of areas close to 15 landfills in Brazil no association was detected comparing rates of people living at less than 2 km and the whole city, after adjustment for sex and age (Gouveia and Ruscitto do Prado 2010a). Another UK study reported on a landfill where all kinds of wastes (urban solid, industrial, and special) were transferred, and compared three areas close to site and 26 distant areas (Fielder et al. 2001). After the opening of the site a significant risk increase in the closest areas was found, but the authors cautiously interpreted the findings owing to poor accuracy and incompleteness of data. A Scottish investigation found no association in residents at less than 2 km from the site compared with those at more after adjustment for age and deprivation index (Morris 2003). A multicenter case–control study (EUROHAZCON), carried out in five countries (Belgium, Denmark, France, Italy, and the UK), found a significant increase in congenital malformations in people living nearby sites containing dangerous substances (Vrijheid et al. 2002). Caution is suggested in interpreting the results owing to the difficulty in correctly classifying the sites according to their dangerousness. A previous investigation on dangerous waste landfills had found conflicting results (Geschwind et al. 1992). In a UK retrospective cohort study stratifying by three time periods and four types of landfills, Dummer et al. (2003b) found no association. A similar lack of association was found in a study on urban solid wastes in Northern Ireland (Boyle et al. 2004).

Non-chromosomal birth defects

The EUROHAZCON case–control study detected an increase in risk of non-chromosomal birth defects in people living at less than 3 km from landfills containing both urban solid and industrial or toxic wastes (Dolk et al. 1998). In this study a statistically significant increased risk was found in the subgroups of neural-tube defects (OR 1.86), malformations of the cardiac septa (OR 1.49), and anomalies of great arteries and veins (OR 1.81).

Nervous system birth defects

In a UK retrospective cohort study in which data were stratified by three time-periods and four types of landfills, congenital anomalies were significantly higher close to urban solid waste landfills (Dummer et al. 2003b), whereas a previous study had not found this relationship (Croen et al. 1997). Another study confirmed the association for a landfill containing toxic substances (Marshall et al. 1997).

Cardiovascular defects, hypo- and epispadias, oral defects

Statistically significant higher risk of hypo- and epispadias was detected in children living close to industrial toxic wastes (Geschwind et al. 1992). For cardiovascular and oral anomalies no such risk was found in another investigation (Croen et al. 1997).

Down syndrome

No association was found for Down syndrome in the analysis of 6,829 sites (Jarup et al. 2007).

Sirenomelia and cyclopia

The two studies on this malformations analyzed four cases of sirenomelia and four of cyclopia (Castilla and Mastroiacovo 2008; Orioli et al. 2009). The identification of a possible cluster of sirenomelia has to be interpreted cautiously in the light of this very low number of observations.

Low birth weight

A retrospective cohort study in Alaska took into account several confounders and classified sites according to dangerousness, finding a risk nearby the sites with intermediate and high dangerous levels (Gilbreath and Kaas 2006). An ecological study in the UK, part of the EUROHAZCON on mixed sites, found a small significant risk increase in residents at less than 3 km, evaluating seven areas close to ten sites (Morgan et al. 2004). A case control study in Quebec found a small increase in risk which persisted after adjustment for several confounders; however, it did not find any association with preterm births (Goldberg et al. 1995). As reported in a previous section a nationwide UK study reported an increase, with no distinction between the types of waste disposed (Elliott et al. 2001). Only an ecological UK study, described above, found no association (Fielder et al. 2000).

Respiratory diseases

A retrospective Finnish study on a site containing urban and industrial wastes reported an increase of asthma incidence (Pukkala and Pönkä 2001), and an ecological investigation in the UK found an increase in hospitalization for respiratory diseases, again dealing with a waste site also containing industrial wastes (Fielder et al. 2001). In another retrospective US cohort study the results suggested an increased rate of hospitalization for asthma and respiratory diseases (Ma et al. 2007).

Total mortality

Three ecological studies reported on this association: no association was reported in one (Williams and Jalaludin 1998), whereas in two there was some indication of a positive association (Fielder et al. 2001; Minichilli et al. 2005). However, in the study by Williams and Jalaludin (1998) the detected risk was consistent with that reported before the opening of the site; in the other studies there is no indication of the distance from the site. No association was found in a US cohort study (Gensburg et al. 2009).

Studies of communities living near incinerators

Thirty-one papers on the health effects in the communities living in the proximity of incinerators were evaluated. The following outcomes were considered: cancers (15), birth defects (10), respiratory diseases (5), cardiovascular diseases (1), total mortality (1), and skin disease (1). In some papers multiple outcomes were evaluated.

Cancer

Fifteen studies analyzed the relationship between incinerators' activity and cancer. Most studies are ecological or case–control and only one is based on a retrospective cohort.

All cancers Three ecological (Elliott et al. 1996; Goria et al. 2009; Federico et al. 2010) and one retrospective cohort study (Ranzi et al. 2011) evaluated the association between incinerators and all cancers in adults. In a UK ecological study the incidence increased; however, no adjustment for relevant confounders was performed and the authors claimed to be cautious in their interpretation (Elliott et al. 1996). In an Italian study no association was reported in the four geographical areas analyzed (Federico et al. 2010), whereas another Italian cohort study reported an increase in all-cancer mortality (RR 1.47) in women exposed to elevated levels of heavy metals (>2 ng/m^3) (Ranzi et al. 2011). In a modeling risk estimation study a linear relationship was found, but limitations in study design and patient selection imply problems of interpretation (Goria et al. 2009). In an ecological study no excess risk of cancer mortality was found in children aged less than 5 years (Gouveia and Ruscitto do Prado 2010b), but according to analyses coming from a companion study to that of Elliott et al. (1996) the influence of population migration might influence the results owing to poor accuracy of the case findings (Knox 2000). Overall, the evidence appears weak and conflicting.

Non-Hodgkin lymphomas Three ecological studies and one cohort study found no association (Elliott et al. 1996, Federico et al. 2010; Gouveia and Ruscitto do Prado 2010b; Ranzi et al. 2011), whereas two case–control studies and one ecological study found a positive association with dioxin levels (Viel et al. 2000; Floret et al. 2003; Viel et al. 2008a), especially in women (Viel et al. 2008a); however, some exposure measurement errors may misestimate the effects. An ecological Italian study reported higher Standardized Mortality Ratio (SMR) between 1986 and 1992 for non-Hodgkin lymphomas (not for Hodgkin lymphomas) in a municipality where an incinerator had operated until 1985 (Biggeri and Catelan 2005).

Sarcoma and soft tissues Six ecological (Elliott et al. 1996; Viel et al. 2000; Floret et al. 2004; Biggeri and Catelan 2005; Viel et al. 2008a; Federico et al. 2010), two case–control (Comba et al. 2003; Zambon et al. 2007), and one cohort studies (Ranzi et al. 2011) provide data. No association was shown in five (Elliott et al. 1996; Floret et al. 2004; Biggeri and Catelan 2005; Federico et al. 2010; Ranzi et al. 2011). The other studies reported: (a) significant risk increase associated with living less than 2 km from the site, but based on five cases and with a very wide confidence interval (Comba et al. 2003); (b) significant risk increase by level and duration of exposure, especially in women (Zambon et al. 2007); (c) risk increase but at exposure levels higher than those detectable in more modern incineration technologies (Viel et al. 2000, 2008a). The evidence of risk due to an old-generation plant is convincing.

Breast No association was found in a case–control and a cohort study (Viel et al. 2008b; Ranzi et al. 2011). A small association was found in a study designed to compare different ways of modeling exposure and confounding, and the results are strongly limited by this study objective (Goria et al. 2009).

Lung Two ecological studies and one case–control study reported a risk excess in people living close to the emission site (Elliott et al. 1996; Biggeri et al. 1996; Parodi et al. 2004). In the studies carried out in Italy, there might be an exposure misclassification because other pollution sources were present but not identified (Biggeri et al. 1996; Parodi et al. 2004). More recent investigations, with better exposure measurement, found no association (Federico et al. 2010; Gouveia et al. 2010b; Ranzi et al. 2011).

Colorectal An increased risk with distance from the site was reported in the UK, but the authors cautiously suggest possible overestimation due to poor control of confounding factors (Elliott et al. 1996). No risk was found in an ecological study in Italy, with a good outcome measurement (Federico et al. 2010). In the same region another cohort study found higher mortality in men and higher incidence in women, but the increased risk was found at heavy metal exposure levels of 1–2 ng/m^3 and not at higher levels (Ranzi et al. 2011).

Liver Recent studies found no association (Federico et al. 2010; Gouveia et al. 2010b; Ranzi et al. 2011). A less recent investigation in the UK had found a significant risk increase associated with smaller distances from the sites (Elliott et al. 1996). A subsequent analysis of this data and including a histological evaluation of cancer cases confirmed the findings. (Elliott et al. 2000). A Brazilian study carried out in rural deprived areas found an association, but its validity is diminished by flaws in the study design (Goria et al. 2009).

Larynx Three ecological studies and one cohort study found convincing associations (Elliott et al. 1996; Federico et al. 2010; Gouveia et al. 2010b; Ranzi et al. 2011)

Leukemia An Italian ecological study found a modest risk increase in residents between 2 and 3.5 km from the site, but not at shorter distances; the authors suggest that this risk is hardly linkable with the distance from the site (Federico et al. 2010). No association was found in a cohort study in adults in Italy (Ranzi et al. 2011) and in an ecological study in children in Brazil (Gouveia et al. 2010b). A UK ecological study in children under 16 years found a risk increase but with a mixed exposure (incinerator and industrial combustion) (Knox 2000).

Stomach An ecological study found a significant risk increase associated with the distance from the site, but control of confounding factors was poor (Elliott et al. 1996). An Italian cohort study reported a risk increase for women exposed to heavy metal levels of 1–2 ng/m^3, but not for those exposed to higher levels (Ranzi et al. 2011).

Bladder No association was found either in a UK ecological study (Elliott et al. 1996) and in an Italian cohort study (Ranzi et al. 2011).

Cerebral, myeloma, lymphatic system, prostate Only one study reported on these cancers (Ranzi et al. 2011); no association was found between incidence and mortality for these diseases and exposure to heavy metals in populations living nearby two incinerators.

Birth defects and reproductive disorders

Ten studies were evaluated (Lloyd et al. 1988; Jansson and Voog 1989; Williams et al. 1992; ten Tusscher et al. 2000; Cresswell et al. 2003; Dummer et al. 2003a; Tango et al. 2004; Cordier et al. 2004; Vinceti et al. 2008; Cordier et al.

2010): eight ecological, one case–control, and one retrospective cohort study. The results are often inconsistent; however, the paper by Cordier is relevant for interpretation because confounders were controlled for on an individual basis, through a questionnaire (Cordier et al. 2010).

Orofacial defects No risk increase was found for cleft palate by a Swedish study (Jansson and Voog 1989), whereas both in France and the Netherlands a risk increase was detected (ten Tusscher et al. 2000; Cordier et al. 2004). However, the site analyzed in the Dutch study was open to many chemical substances (ten Tusscher et al. 2000).

Urinary tract defects The French study by Cordier showed a risk increase (around double after adjustment) for congenital urinary tract defects when women, resident within 10 km from 21 active incinerators, were exposed to atmospheric dioxin and dioxin deposits in the ground during the first months of pregnancy (Cordier et al. 2010). The authors also suggest a possible role of the dioxin in contaminating locally produced food. These data together with those for renal dysplasia require special attention.

Other congenital anomalies Two studies reported a modest risk increase of spina bifida, cardiac defects, and renal dysplasia in the areas proximal to the incinerator (Dummer et al. 2003a; Cordier et al. 2004). No significant association was found for low birth weight and reproductive defects (Tango et al. 2004), chromosomal and non-chromosomal anomalies (Cresswell et al. 2003), spontaneous abortion and other studied reproductive outcomes (Vinceti et al. 2008). Occurrence of twin and female births were increased (Williams et al. 1992; Lloyd et al. 1988).

Respiratory diseases

Two studies reported a decrease in respiratory function and an increase in respiratory wheezing in children living in the proximity of an incinerator (Hsiue et al. 1991; Miyake et al. 2005). Increased prevalence of chronic respiratory symptoms was detected in other studies comparing populations resident at various distances from the site (Lee and Shy 1999; Shy et al. 1995). In an Italian retrospective cohort a higher respiratory disease mortality was found in men exposed to heavy metals levels of 0.5–1 ng/m^3; however, no risk was detected in individuals exposed to higher levels (Ranzi et al. 2011). In the same investigation no difference was found for total mortality and hospitalization for respiratory diseases.

All-cause mortality and cardiovascular diseases

Ranzi found that total mortality in women was associated with the presence of an incinerator at any level of exposure to heavy metals, and an increase in cardiovascular disease mortality in women, in hospitalization for chronic cardiac insufficiency and acute myocardial infarction in men in the mid-category exposure (0.5–1 ng/m^3) to heavy metals, but not for the highest (higher than 2 ng/m^3) (Ranzi et al. 2011).

Skin diseases

A Japanese study found no association with atopic dermatitis (Lee and Shy 1999), but a reporting bias and poor control of confounding factors indicate a unsatisfactory quality of the paper.

Discussion

The evaluation of the possible health effects has to be done taking into account two relevant issues: (a) in the majority of the papers on landfills it is virtually impossible to distinguish the role of urban solid from other types of waste coming from different sources; (b) the evolving technology of modern incinerators, with improved control of dioxin and heavy metals emission, may enhance the inconsistencies of the results. Because of these constraints any conclusion has to be viewed in the light of variability and some uncertainty in the results. Nevertheless, this review appears to have new important information if compared with the latest published systematic review (Porta et al. 2009).

Landfills

For total mortality evidence is insufficient to indicate a role of urban solid waste; moreover, the lack of control of important confounding factors in most papers is a real issue. For cancers the inadequate level of evidence already reported in previous reviews (Porta et al. 2009) is supported by more recent data (Gouveia et al. 2010a). More intriguing are the results on birth defects and reproductive disorders. An effect is detectable for toxic wastes, as pointed out by old and more recent papers, but this is much less clear when only urban solid wastes are considered. The evaluation of 9,565 landfills in the UK in which Elliott et al. (2009) distinguished between deposits of non-special from special or unknown waste confirmed an effect of the latter and no evidence of harm from the former. The environmental impact evaluation performed by the INTARESE group in three European countries (Italy, Slovakia, and the UK) on residents living at less than 2 km from a landfill with mixed waste estimated an excess risk of 1.96 newborns with defects in the period 2001–2030 (Forastiere et al. 2011). It is reasonable to conclude that the risk of

congenital anomalies is likely to be real. Within the framework of a correct management of landfill of strictly urban waste, the risk of these defects is less likely, indicating that solid waste should be very accurately selected before being thrown in a landfill.

Incinerators

Papers dealing with the health effects of incinerators active in the years 1969–1996 consistently report a detectable risk of some cancers in the populations living nearby. The good quality studies confirm these data, as pointed out in other reviews (Franchini et al. 2004; Linzalone and Bianchi 2007; Porta et al. 2009). The large UK study by Elliott et al. (1996) on 72 incinerators found a risk excess for all cancers, stomach, colorectal, liver, lung, and non-Hodgkin lymphomas; other studies carried out in Italy, France, and the UK indicate some suggestive but not consistent results for non-Hodgkin lymphomas and soft tissue sarcomas (Elliott et al. 1996; Viel et al. 2000; Comba et al. 2003; Floret et al. 2004; Zambon et al. 2007; Viel et al. 2008a; Federico et al. 2010; Ranzi et al. 2011). One study that did not detect any association is quite interesting for a number of reasons (Ranzi et al. 2011): the investigation was carried out on a technologically advanced plant which had undergone a number of improvements; the observations were based on a complex model of dispersion as an estimate of exposure; morbidity and mortality were quite accurately evaluated. The paper also provides an interesting analysis comparing emissions at different time periods relative to a different technology: the ratios of concentrations of released substances in 2008 compared with the period 1994–1996 are 0.214 for total suspended particulate, 0.20 for mercury and cadmium, and 0.0001 for dioxins [polychlorinated dibenzo-*p*-dioxins (PCDD) and polychlorinated dibenzofurans (PCDF)]. These data suggest a dramatic change in the amount of dangerous emissions and the need for accurate monitoring of pollution. In the comparison between older and newer observations, the results for cancer incidence and mortality are largely not consistent.

Attention should be paid to the risk excess for urinary tract defects as reported in a well-designed study by Cordier et al. (2010), even if other studies are inconsistent. Orofacial defects are reported to be associated with exposure to special waste incinerators, whereas no risk is found for reproductive disorders such as spontaneous abortion (Vinceti et al. 2008).

A first general comment is that, historically, incinerators have been consistently indicated as an important source of pollution and harm for the health of populations living nearby the sites. Studies on biomarkers support this: populations exposed to emissions more than others have higher biological levels of released substances (Gonzalez et al. 2000; Reis et al. 2007). Where an incinerator had been the only source of pollution in a defined area for many years in the past, the harmful effects on the health have been consistently detected in a later period (Viel et al. 2000). Second, where a health impact of the change of technology has been reported (as for the Italian study by Ranzi et al. 2011) the results appear reassuring; however, this implies new challenges for the evaluation of environmental impact on health in other societal environments. New objectives of evaluation are needed: (a) the size of incinerators, accurate measurement of nanoparticles; (b) markers of "minor", but not less important health outcomes (respiratory symptoms, annoyance of the residents, stress-induced risk conditions). The evaluation of the aforementioned conditions in public health should include both incinerators and landfills owing to their association with the quality of life of residents during the time of exposure (de Wet et al. 2011).

Main methodological issues

Environmental epidemiology of waste disposal suffers from limitations conducive to inadequate or contrasting results: because most disease are "rare" in populations, a large number of individuals have to be observed for a long time period to identify a potential determinant, and studies carried out in small communities for a limited number of years lack statistical power; specific attention is often given to communities where exposure is "visibly" higher compared with others, thereby emphasizing the effect; exposure is mostly not based on individual measurements or accurate modeling of differences in population groups; potential concomitant causes of harm to health should be measured and controlled for in the analyses as confounders such as the socioeconomic conditions; the lack of information on individual risk factors competitive for many diseases such as smoking, dietary habits, alcohol use, and occupation, is mostly common. This large variety of conditions impaired the calculation of summary estimates of risks through meta-analyses.

Cause–effect relationship

A summary table (Table 2), using the IARC criteria for cause–effect evaluation, as described in the methods (IARC–WHO) is proposed. Although this classification is applied to evaluate the causal role of potential carcinogens, it allows us to compare the conclusions proposed by us with those by Porta et al. (2009), the latest comprehensive systematic review performed before ours. Only two categories (*limited* and *inadequate*) have been used because of the insufficient design of the evaluated studies that suffer from poor exposure measurement, outcome definition, and

Table 2 Evaluation of the evidence according to IARC criteria for evaluated diseases

Health effect	Level of evidence	
	Landfills	Incinerators
All cancers	Inadequate	Limited
Stomach	Inadequate	Inadequate
Colorectal	Inadequate	Inadequate
Liver	Inadequate	Inadequate
Larynx	Inadequate	Inadequate
Lung	Inadequate	Inadequate
Soft tissues sarcoma	Inadequate	Limited
Kidney	Inadequate	Inadequate
Bladder	Inadequate	Inadequate
Lymphomas	Inadequate	Inadequate
Leukemia	Inadequate	Inadequate
Brain	Inadequate	Inadequate
Children's cancers	Inadequate	Inadequate
Other cancers	Inadequate	Inadequate
All birth defects and reproductive disorders	Limited	Limited
Neural tube defects	Limited	Inadequate
Orofacial defects	Inadequate	Limited
Genitourinary tract defects	Limited	Limited
Abdominal wall defects	Inadequate	Inadequate
Gastrointestinal defects	Inadequate	Inadequate
Cardiac defects	Inadequate	Inadequate
Low birth weight	Limited	Inadequate
Respiratory diseases or symptoms	Limited[a]	Inadequate
Cardiovascular diseases	Inadequate	Inadequate
Skin diseases	Inadequate	Inadequate

[a] Data confined to industrial waste

adjustment for confounding factors. Nevertheless, we have important hints. The category *limited* is used for some disease, indicating points-of-attention for etiology, the estimation of risks, and their management in public health. One reassuring point is that we should appreciate the continuous improvement in research design and analysis of the relevant investigations. The choices on the mode of waste disposal management are not "neutral"; powerful political and economic interests play a great role "like the choices on energy production, mode of transportation or greenhouse gas emission" and often stand "predominant over the epidemiological evidence" (Forastiere et al. 2008). Within this framework—similarly to other public health decisions taken on a scientific basis—in order to overcome issues of conflicts of interest in scientific production and to avoid the construction of false reassurances or deplorable uncertainties (Michaels and Monforton 2005), it is advantageous to rely on independent systematic reviews where transparency of methods and rigorous evaluation criteria can be checked by the readers.

Acknowledgments We thank Vanna Pistotti for library search strategies and Francesco Forastiere, Pietro Comba, Ennio Cadum, Andrea Ranzi, Carla Ancona, and Fabrizio Bianchi for comments and suggestions. The authors declare their full responsibility for the production, analysis, and interpretation of the results and the conclusions of the systematic review. This review has been made possible through a grant from the Regione Campania Authority addressed by the Center for Disease Control of the Italian Ministry of Health.

Conflict of interest The authors declare no conflict of interest.

References

Altavista P, Belli S, Bianchi F, Binazzi A, Comba P, Del Giudice R, Fazzo L, Felli A, Mastrantonio M, Musmeci L, Pizzuti R, Svarese A, Trinca S, Uccelli R (2004) Mortalità per causa in un'area della Campania con numerose discariche di rifiuti. Epidemiol Prev 28(6):311–321

Biggeri A, Catelan D (2005) Mortalità per linfoma non Hodgkin e sarcomi dei tessuti molli nel territorio circostante un impianto di incenerimento di rifiuti solidi urbani. Campi Bisenzio (Toscana, Italia) 1981–2001. Epidemiol Prev 29(4–5):156–159

Biggeri A, Barbone F, Lagazio C, Bovenzi M, Stanta G (1996) Air pollution and lung cancer in Trieste, Italy: spatial analysis of risk as a function of distance from sources. Environ Health Perspect 104:750–754

Boyle E, Johnson H et al (2004) Congenital anomalies and proximity to landfill sites. Ir Med J 97(1):16–18

Castilla E, Mastroiacovo P et al (2008) Sirenomelia and cyclopia cluster in Cali, Colombia. Am J of Med Genet Part A 146(20):2626–2636

Comba P, Ascoli V, Belli S, Benedetti M, Gatti L, Ricci P, Tieghi A (2003) Risk of soft tissue sarcomas and residence in the neighborhood of an incinerator of industrial wastes. Occup Environ Med 60:650–683

Comba P, Bianchi F, Fazzo L, Martina L, Menegozzo M, Minichilli F, Mitis F, Musmeci L, Pizzuti R, Santoro M, Trinca S, Martuzzi M (2006) Cancer mortality in an area of Campania (Italy) characterized by multiple toxic dumping sites. Ann NY Acad Sci 1076:449–461

Cordier S, Chevrier C, Robert-Gnansia E, Lorente C, Brula P, Hours M (2004) Risk of congenital anomalies in the vicinity of municipal solid waste incinerators. Occup Environ Med 61:8–15

Cordier S, Lehebel A et al (2010) Maternal residence near municipal waste incinerators and the risk of urinary tract birth defects. Occup Environ Med 67(7):493–499

Cresswell PA, Scott JES et al (2003) Risk of congenital anomalies near the Byker waste combustion plant. J Public Health Med 25(3):237–242

Croen LA, Shaw GM, Sanbonmatsu L, Selvin S, Bufflers PA (1997) Maternal residential proximity to hazardous waste sites and risk for selected congenital malformations. Epidemiology 8:347–354

de Wet T, Plagerson S, Harpham T, Mathee A (2011) Poor housing, good health: a comparison of formal and informal housing in Johannesburg, South Africa. Int J Public Health 56:625–633

Department for Environment, Food and Rural Affairs (DEFRA) (2004) Review of environmental and health effects of waste

management: municipal solid waste and similar wastes, UK 2004. DEFRA, London
Dolk H, Vrijheid M (2003) The impact of environmental pollution on congenital anomalies. Br Med Bull 68:25–45
Dolk H, Vrijheid M, Armstrong B, Abramsky L, Bianchi F, Garne E, Nelen V, Robert E, Scott JE, Stone D, Tenconi R (1998) Risk of congenital anomalies near hazardous-waste landfill sites in Europe: the EUROHAZCON study. Lancet 352:423–427
Dummer TJB, Dickinson HO, Parker L (2003a) Adverse pregnancy outcomes around incinerators and crematoriums in Cumbria Northwest England, 1956–1993. J Epidemiol Commun Health 57:456–461
Dummer TJB, Dickinson HO et al (2003b) Adverse pregnancy outcomes near landfill sites in Cumbria, northwest England, 1950–1993. Arch Environ Health 58(11):692–698
Elliott P, Shaddick G, Kleinschmidt I, Jolley D, Walls P, Beresford J, Grundy C (1996) Cancer incidence near municipal solid waste incinerators in Great Britain. Br J Cancer 73:702–710
Elliott P, Eaton N, Shaddick G, Carter R (2000) Cancer incidence near municipal solid waste incinerators in Great Britain. Part 2: histopathological and case-note review of primary liver cancer cases. Br J Cancer 82:1103–1106
Elliott P, Briggs D, Morris S, de Hoogh C, Hurt C, Jensen TK, Maitland I, Richardson S, Wakefield J, Jarup L (2001) Risk of adverse birth outcomes in populations living near landfill sites. Br Med J 323:363–368
Elliott P, Richardson S, Abellan JJ, Thomson A, de Hoog C, Jaruo L, Briggs DJ (2009) Geographic density of landfill sites and risk of congenital anomalies in England. Occup Environ Med 66:81–89
Fazzo L, Belli S, Minichilli F, Mitis F, Santoro M, Martina L, Pizzuti R, Comba P, Martuzzi M, Bianchi F, Working Group (2008) Cluster analysis of mortality and malformations in the Provinces of Naples and Caserta (Campania Region). Ann Ist Super Sanità 44:99–111
Fazzo L, De Santis M, Mitis F, Benedetti M, Martuzzi M, Comba P, Fusco M (2011) Ecological studies of cancer incidence in an area interested by dumping waste sites in Campania (Italy). Ann Ist Super Sanità 47:181–191
Federico M, Pirani M et al (2010) Cancer incidence in people with residential exposure to a municipal waste incinerator: an ecological study in Modena (Italy), 1991–2005. Waste Manag 30(7):1362–1370
Fielder HMP, Poon-King CM et al (2000) Assessment of impact on health of residents living near the Nant-y-Gwyddon landfill site: retrospective analysis. Br Med J 320(7226):19–22
Fielder HMP, Palmer SR et al (2001) Addressing environmental health concerns near Trecatti Landfill Site, United Kingdom. Arch Environ Health 56(6):529–553
Floret N, Mauny F, Challier B, Arveux P, Cahn JY, Viel JF (2003) Dioxin emissions from a solid waste incinerator and risk of non-Hodgkin lymphoma. Epidemiology 14:392–398
Floret N, Mauny F et al (2004) Dioxin emissions and soft-tissue sarcoma: results of a population-based case-control study. Rev Epidemiol Sante Publique 52(3):213–220
Forastiere F, Badaloni C et al (2011) Health impact assessment of waste management facilities in three European countries. Environ Health Glob Access Sci Sour 10(1):53
Forastiere F, Perucci CA (2008) Rifiuti, prove scientifiche e decisioni politiche: quale ruolo per l'epidemiologia. Epidemiol Prev 32(1):5–7
Franchini M, Rial M, Buiatti E, Bianchi F (2004) Health effects of exposure to waste incinerator emissions: a review of epidemiological studies. Ann Ist Super Sanita 40(1):101–115
Gensburg LJ, Pantea C et al (2009) Mortality among former Love Canal residents. Environ Health Perspect 117(2):209–216
Geschwind SA, Stolwijk J, Bracken M, Fitzgerald E, Stark A, Olsen C, Melius G (1992) Risk of congenital malformations associated with proximity to hazardous waste sites. Am J Epidemiol 195:1197–1207
Gilbreath S, Kaas PH (2006) Adverse birth outcomes associated with open dumpsites in Alaska native villages. Am J Epidemiol 164:518–528
Giusti L (2009) A review of waste management practices and their impact on human health. Waste Manage (Oxford) 29:2227–2239
Goldberg MS, Goulet L, Riberdy H, Bonvalot Y (1995) Low birth weight and preterm births among infants born to women living near a municipal solid waste landfill site in Montreal, Quebec. Environ Res 69:37–50
Goldberg MS, Siemiatyck J, DeWar R, Dèsy M, Riberdy H (1999) Risk of developing cancer relative to living near a municipal solid waste landfill site in Montreal, Quebec, Canada. Arch Environ Health 54:291–296
Gonzalez CA, Kogevinas M, Gadea E, Huici A et al (2000) Biomonitoring study of people living near or working at a municipal solid-waste incinerator before and after two years of operation. Arch Environ Health 55(4):259–267
Goria S, Daniau C et al (2009) Risk of cancer in the vicinity of municipal solid waste incinerators: importance of using a flexible modelling strategy. Int J Health Geogr 8:31
Gouveia N, Ruscitto do Prado R (2010b) Spatial analysis of the health risks associated with solid waste incineration: a preliminary analysis. Rev Bras Epidemiol 13(1):3–10
Gouveia N, Ruscitto do Prado R (2010a) Health risks in areas close to urban solid waste landfill sites. Rev Saude Publica 44(5):1–8
Hsiue TR, Lee SS, Chen HI (1991) Effects of air pollution resulting from wire reclamation incineration on pulmonary function in children. Chest 100:698–702
Hu SW, Shy CM (2001) Health effects of waste incineration: a review of epidemiological studies. J Air Waste Manag Assoc 51:1100–1109
International Agency for Research on Cancer (IARC)–WHO. http://monographs.iarc.fr/ENG/Preamble/currentb6evalrationale0706.php. Accessed 22 July 2013
Jansson B, Voog L (1989) Dioxin from Swedish municipal incinerators and the occurrence of cleft lip and palate malformations. Int J Environ Stud 34:99–104
Jarup L, Briggs D, de Hoogh C, Morris S, Hurt C, Lewin A, Maitland I, Richardson S, Wakefield J, Elliott P (2002) Cancer risks in populations living near landfill sites in Great Britain. Br J Cancer 86:1732–1736
Jarup L, Morris S, Richardson S, Briggs D, Cobley N, de Hoog C, Gorog K, Elliot P (2007) Down syndrome in births near landfill sites. Prenat Diagn 27:1191–1196
Kloppenborg SCh, Brandt UK, Gulis G, Ejstrud B (2005) Risk of congenital anomalies in the vicinity of waste landfills in Denmark; an epidemiological study using GIS. Cent Eur J Public Health 13:137–143
Knox E (2000) Childhood cancers, birthplaces, incinerators and landfill sites. Int J Epidemiol 29:391–397
Lee JT, Shy CM (1999) Respiratory function as measured by peak expiratory flow rate and PM10: six communities study. J Expo Anal Environ Epidemiol 9(4):293–299
Linzalone N, Bianchi F (2007) Incinerators: not only dioxins and heavy metals, also fine and ultrafine particles. Epidemiol Prev 31(1):62–66
Lloyd OL, Lloyd MM, Williams FL, Lawson A (1988) Twinning in human populations and in cattle exposed to air pollution from incinerators. Br J Ind Med 45:556–560
Ma J, Kouznetsova M, Lessner L, Carpenter D (2007) Asthma and infectious respiratory disease in children—correlation to residence near hazardous waste sites. Paediat Resp Rev 8:292–298

Marshall EG, Gensburg LJ, Deres DA, Geary NS, Cayo MR (1997) Maternal residential exposure to hazardous wastes and risk of central nervous system and musculoskeletal birth defects. Arch Environ Health 52(6):416–425

Martuzzi M, Mitis F, Bianchi F, Minichilli F, Comba P, Fazzo L (2009) Cancer mortality and congenital anomalies in a region of Italy with intense environmental pressure due to waste. Occup Environ Med 66(11):725–732

Michaels D, Monforton C (2005) Manufacturing uncertainty: contested science and the protection of the public's health and environment. Am J Public Health 95(Suppl 1):S39–S48

Michelozzi P, Fusco D, Forastiere F, Ancona C, Dell'Orco V, Perucci CA (1998) Small area study of mortality among people living near multiple sources of air pollution. Occup Environ Med 55:611–615

Minichilli F, Bartolacci S, Buiatti E, Pallante V, Scala D, Bianchi F (2005) Studio di mortalità intorno a sei discariche di rifiuti in Toscana. Epidemiol Prev 29(5–6) Suppl:53–56

Miyake Y, Yura A, Misaki H, Ikeda Y, Usui T, Iki M, Shimizu T (2005) Relationship between distance of schools from the nearest municipal waste incineration plant and child health in Japan. Eur J Epidemiol 20:1023–1029

Morgan OWC, Vrijheid M et al (2004) Risk of low birth weight near EUROHAZCON hazardous waste landfill sites in England. Arch Environ Health 59(3):149–151

Morris SE, Thompson AOW et al (2003) No excess risk of adverse birth outcomes in populations living near special waste landfill sites in Scotland. Scottish Med J 48(4):105–107

Orioli IM, Mastroiacovo P, Lopez-Camelo JS, Saldarriaga W, Isaza C, Aiello H, Zarante I, Castilla E (2009) Clusters of sirenomelia in South America. Birth Defects Res A Clin Mol Teratol 85(2):112–118

Palmer SR, Dunstan FDJ et al (2005) Risk of congenital anomalies after the opening of landfill sites. Environ Health Perspect 113(10):1362–1365

Parodi S, Baldi R, Benco C, Franchini M, Garrone E, Vercelli M, Pensa F, Puntoni R, Fontana V (2004) Lung cancer mortality in a district of La Spezia (Italy) exposed to air pollution from industrial plants. Tumori 90:181–185

Porta D, Milani S et al (2009) Systematic review of epidemiological studies on health effects associated with management of solid waste. Environ Health 8:60

Pukkala E, Pönkä A (2001) Increased incidence of cancer and asthma in houses built on a former dump area. Environ Health Perspect 109:1121–1125

Ranzi A, Fano V, Erspamer L, Lauriola P, Perucci CA, Forastiere F (2011) Mortality and morbidity among people living close to incinerators: a cohort study based on dispersion modeling for exposure assessment. Environ Health. 24(10):22

Reis MF, Sampaio C, Brantes A, Aniceto P, Melim M, Cardoso L, Gabriel C, Simão F, Segurado S, Miguel JP (2007) Human exposure to heavy metals in the vicinity of Portuguese solid waste incinerators. Int J Hyg Environ Health 210(3–4):447–454, 439–446, 455–459

Rushton L (2003) Health hazards and waste management. Br Med Bull 68:183–197

Russi MB, Borak JB, Cullen MR (2008) An examination of cancer epidemiology studies among populations living close to toxic waste sites. Environ Health 26:7–32

Shy CM, Degnan D, Fox DL, Mukerjee S, Hazucha MJ, Boehlecke BA, Rothenbacher D, Briggs PM, Devlin RB, Wallace DD, Stevens RK, Bromberg PA (1995) Do waste incinerators induce adverse respiratory effects? An air quality and epidemiological study of six communities. Environ Health Perspect 103:714–724

Signorelli C, Riccò M, Vinceti M (2008) Inceneritori e rischi per la salute umana: lo stato dell'arte. Ann Ig 20:251–277

Tango T, Fujita T, Tanihata T, Minowa M, Doi Y, Kato N, Kunikane S, Uchiyama I, Tanaka M, Uehata T (2004) Risk of adverse reproductive outcomes associated with proximity to municipal solid waste incinerators with high dioxin emission levels in Japan. J Epidemiol 14:83–93

ten Tusscher GW, Stam GA et al (2000) Open chemical combustions resulting in a local increased incidence of orofacial clefts. Chemosphere 40(9–11):1263–1270

Viel JF, Arveux P, Baverel J, Cahn JY (2000) Soft-tissue sarcoma and non-Hodgkin's lymphoma clusters around a municipal solid waste incinerator with high dioxin emission levels. Am J Epidemiol 152:13–19

Viel JF, Daniau C, Goria S, Fabre P, de Crouy-Chanel P, Sauleau EA, Empereur-Bissonnet P (2008a) Risk for non Hodgkin's lymphoma in the vicinity of French municipal solid waste incinerators. Environ Health 7:51. doi:10.1186/1476-069X-7-51

Viel JF, Clément MC, Hägi M, Grandjean S, Challier B, Danzon A (2008b) Dioxin emissions from a municipal solid waste incinerator and risk of invasive breast cancer: a population-based case-control study with GIS-derived exposure. Int J Health Geogr 7:4

Vinceti M, Malagoli C et al (2008) Adverse pregnancy outcomes in a population exposed to the emissions of a municipal waste incinerator. Sci Total Environ 407(1):116–121

Vrijheid M (2000) Health effects of residence near hazardous waste landfill sites: a review of the epidemiological literature. Environ Health Perspect 108(suppl I):101–112

Vrijheid M, Dolk H et al (2002) Hazard potential ranking of hazardous waste landfill sites and risk of congenital anomalies. Occup Environ Med 59(11):768–776

WHO, Regional Office for Europe, Copenhagen (2007) Population health and waste management: scientific data and policy options. In: Mitis F, Martuzzi M (eds) Report of a WHO workshop Rome, Italy, 29–30 March 2007. WHO Regional Office for Europe, Copenhagen

Williams A, Jalaludin B (1998) Cancer incidence and mortality around a hazardous waste depot. Aust N Z J Publ Health 22(3 Suppl):342–346

Williams FL, Lawson AB, Lloyd OL (1992) Low sex ratios of births in areas at risk from air pollution from incinerators, as shown by geographical analysis and 3-dimensional mapping. Int J Epidemiol 21:311–319

Zambon P, Ricci P, Bovo E, Casula A, Gattolin M, Fiore AR, Chuiosi F, Guzzinati S (2007) Sarcoma risk and dioxin emissions from incinerators and industrial plants: a population-based case-control study (Italy). Environ Health 6:19

Effect of aging on the leachate characteristics from municipal solid waste landfill

B.P. Naveen[i], P.V. Sivapullaiah [ii] and T. G. Sitharam [iii]

i) Ph.D Student, Department of Civil Engineering, Indian Institute of Science, Bangalore 560012, India.
ii) Professor, Department of Civil Engineering, Indian Institute of Science, Bangalore 560012, India.
iii) Professor, Department of Civil Engineering, Indian Institute of Science, Bangalore 560012, India.

ABSTRACT

Leachate emanating from solid waste deposited in landfill possess dissolved or an entrained environmentally harmful substances. They consist of soluble organic and inorganic compounds as well as suspended particles. These leachates also have a distinguishing characteristic in that they are highly variable and contain significantly elevated concentrations of undesirable material derived from the waste. Depending on whether leachate flow increases (during rainy season) and decreases (during dry/summer season) can change the composition. The concentration of waste change dramatically changes over the life of the landfill due to chemical degradation and biological decay of organic matter present. Consequently, the physical characteristics also vary considerably depending on the age of the waste. This paper brings out the effect of aging on the leachate characteristics from a municipal solid waste located at the Terra Firma Biotechnologies Ltd situated at Gundlahalli village in Doddaballapur taluk, near Bangalore. For the sake of comparison the leachates from two different parts of the site one from the location where old waste was dumped and another from the location where the waste was dumped relatively recently during the same period. Thus the two leachate samples from the same site representing different stages degradation of waste were collected to represent leachate from old waste and another from relatively fresh waste. The samples were analyzed for various physicochemical parameters to estimate its pollution potential. The results showed that most of the parameters examined in the leachate samples such as colour, conductivity, hardness, BOD, COD, TOC were found higher in the fresh leachate than aged leachate. In addition, low BOD/COD ratio of <0.1 in aged leachate and BOD/COD ratio of 0.33 in fresh leachate are observed. This shows that the major portion is organic matter which is not quickly biodegradable in the leachate from Terra Firma Biotechnology. The compost site is non-engineered solid waste landfill, which has neither bottom liner system nor any leachate collection and treatment system. Hence, leachate may percolate through subsoil causing pollution to ground water and surface water resources. Further the properties of soil below can change due to changing composition of the pore fluid.

Keywords: Aging, BOD, COD, Leachate, Municipal Solid Waste.

1. INTRODUCTION

Leachate is a contaminated liquid that drains through the bottom of the solid waste disposal facilities such as landfills. Its composition varies widely depending on the composition of waste as well as the age of waste. It contains number of dissolved and suspended materials. After municipal solid waste landfill site is closed, landfill will continue to produce contaminated leachate and this process can last for 30-50 years which can have significant environmental impact when released untreated into the environment(Peter et al., 2002). Quality of leachate is site-specific and even at a single landfill site the quality of leachate is strongly variable. Variability caused by many factors such as rainfall regime, geology, landfill age, composition of solid waste, physico-chemical conditions at the landfill (Zgajnar et al., 2009).

Within the land fill waste mass, biodegradable waste includes food waste, green waste and certain wastes arising from commercial and industrial sources. This kind of waste will easily decompose within the first few months of disposal. Non biodegradable waste like paper, wood and plastics also yield organic compounds to leachate, but only in small percentage over long periods of time. The majority of inorganic compounds are readily soluble and the ions released usually appear within a short time. Heavy metals contained in the solid waste are usually released slowly into the leachate and the process may take up to several years. Moreover, there is a complex interplay between leaching of ionic species and the maturity of the solid waste landfill site. This affects the compositional characteristics of the leachate (Renou et al., 2005).

As landfill passes through different phases of its life cycle, the leachate composition also varies widely

through the successive aerobic, acetogenic, methanogenic and stabilization stages. The degradation process of the waste in a landfill passes through different phases. The first phase which is normally short is characterized by the aerobic degradation of organic matter, CO2 is produced and the temperature of waste can increase up to 80^0C, this can affect the later stage of leachate production. In this phase, leachate contributes moisture during compaction as well as from precipitation through the buried waste (Kjeldsen et al., 2002). The amount of leachate leaving the landfill is limited due to the water holding by the waste, until the leachates reaches the collection system and is drained to the collection basin(Armstrong and Rowe,1999). This stage usually lasts only a few weeks and consequential phase appears when the oxygen is depleted, the degradation continues anaerobically. The anaerobic degradation process consists of two major fermentation phases, the acidogenic phase generating young, biodegradable leachate and the methanogenic phase, generating old, stabilised leachate (Bhala et al., 2012).

Young leachate from the early acidogenic phase contains large amounts of readily biodegradable organic matter. The complex organic compounds are fermented anaerobically, yielding mainly soluble organic acids such as free volatile fatty acids (VFAs), amino acids, other low molecular weight compounds and gases like H_2 and CO_2 (Harmsen, 1983). The concentration of VFAs can be quite significant, representing 95% of the TOC, leading to low pH (less than 5). BOD5/COD will have high ratio values of 0.5-0.7 indicate large amounts of biodegradable organic matter (Granet et al., 1986). COD values are 3,000-60,000 mg/l (Aisien et al., 2010). During this phase the metals are more soluble because of lower pH and the bonding with the VFAs, leading to relative high concentrations of Fe, Mn, Ni and Zn (Harmsen, 1983).

Old leachate will be in the methanogenic phase with lower concentration of VFAs (Chain and Dewalle, 1976). This is due to their conversion into methane and carbon dioxide (CO2) as gaseous end products during this second fermentation period. VFAs and other readily biodegradable organic compounds in the leachate decreases, the organic matter in the leachate becomes dominated by refractory compounds, such as humic like compounds and fulvic acid like substances (Chian and Dewalle,1976). Thus BOD5/COD will have low ratio values, most often close to 0.1, is a characteristic value for stabilised leachates. The dark colour in leachate is mainly due to humic substance. The decrease of VFAs results in an increase in pH. A characteristic pH value for stabilised leachate is close to 8 (Granet et al., 1986). The concentration of metal ions is in general low due to the decreasing solubility of many metal ions with increasing pH. In case of lead, it forms very stable complexes with the humic acids (Harmsen, 1983). Due to the effect of the shifting pH on metal-ions, reduction of sulphate to sulphide during methanogenic phase, this increases the precipitation of metals ions.

Generally, leachate strength get reduces with time due to biological breakdown of organic compounds and precipitation of soluble elements like heavy metals. With increasing age of leachate production, the organic compounds decrease more rapidly than the inorganic compounds. Hence, the ratio of total volatile solids to total fixed solids decreases with the age of the landfill (Robinson and Gronow, 1993)

The aim of our study is to bring out the effect of aging on the leachate characteristics from a municipal solid waste of Terra Firma Biotechnologies Ltd situated at Gundlahalli village in Doddaballapur taluk, near Bangalore. Two leachate samples were collected at different locations from the same site representing different stages of degradation of waste. Further the leachate contamination potential has been assessed based on the concept of leachate pollution index (LPI).

2 SITE DESCRIPTION

Terra Firma Biotechnologies Ltd(TFBL) is situated at Gundlahalli village, 18 km from Doddaballapur taluk of Karnataka state,India. TFBL receives about 1,000 tons of MSW daily from BBMP while remaining 400 tons of MSW is collected from hotels, IT parks..etc. The MSW collected is treated through composting, biomethanation and landfill facility. The first leachate (sample-1) originated from the old part of the landfill as show in fig 1.



Fig. 1 Leachate location from the Old part of the Landfill

The second leachate (sample-2) was sampled at the same landfill but it is active part of the landfill as show in fig 2.



Fig. 2. Leachate location from the fresh dump site

3. SAMPLING AND ANALYSES

A municipal solid waste leachate sample was collected in the month of April from the Terra Firma Biotechnologies Ltd in Bangalore. Glass bottles were used to collect leachate samples for chemical analyses, whereas, samples preserved for BOD and COD tests were collected in polyethylene bottles covered with aluminium foils. A few drops of concentrated nitric acid were added to the leachate sample collected for heavy metals analysis to preserve the samples. The samples were then transported in cooler boxes at temperature below 5°C, and transported immediately to the laboratory. Sample of leachate were stored in refrigerator at 4°C before proceeding for the analysis. The analysis is carried out according to standard methods for examination of water and wastewater unless otherwise stated (APHA, 1998).

3.1 Determination of Physico-chemical parameters

Table 1. Method of determination of Physico-chemica parameters

Parameters	Method of determiantion
pH	pH meter
Conductivity, µS/cm	Conductivity meter
TDS, mg/l	TDS meter
COD, mg/l	Open reflux method
BOD_3 , mg/l	Winkler's method
Sulphate, mg/l	Titration
Chloride, mg/l	Titration
Calcium, mg/l	EDT titration
Alkalinity, mg/l	EDT titration
Sodium, mg/l	flame photometer method
Potassium , mg/l	flame photometer method
Nitrate,mg/l	Spectrophotometer method
Heavy metal	Absorption Spectrophotometer

4 RESULTS AND DISCUSSION

The physico-chemical properties of both leachates are presented in Table 2.

Table 2. Leachate characteristic of TFBL

Details	Sample-1	Sample-2
pH	7.38	5.7
Colour	Brownish	Dark Black
Odour	Very High	Medium
Temperature,ºC	29	29
Conductivity, µS/cm	2750	1050
Turbidity (NTU)	470	80
TDS, mg/l	1375	310
COD, mg/l	498	4960
BOD_5, mg/l	40	1680
Sulphate, mg/l	42	30
Chloride, mg/l	960	2300
Calcium, mg/l	159	680
Hardness, mg/l	26000	30000
Alkalinity, mg/l	-Nil-	2500
Iron, mg/l	5.28	6.61
Copper, mg/l	0.001	0.223
Silver, mg/l	0.785	0.192
Chromium, mg/l	BDL	BDL
Cadmium, mg/l	0.026	0.015
Lead, mg/l	0.252	0.145
Zinc, mg/l	48	0.2
Nickel, mg/l	0.074	BDL
Sodium, mg/l	260	508
Potassium , mg/l	200	508
Nitrate,mg/l	82.73	8.91

The Sample-1 leachate originating from the old landfill had typical properties of leachate from landfill in the methonogenic phase (Kjeldsen et al., 2002). High pH, low concentration of organic matter and typically very low BOD_5/ COD ratio (<0.1), indicating low biodegrability potential.

On the other hand, leachate from the active part of the landfill (sample-2) was significantly more polluted, it contained high concentrations of chlorides, sulphate, calcium and its pH was lower (5.7) indicate that the landfill is at the end of the acidic anaerobic phase (waste buried in the landfill is about 4 years) and it will proceed to another phase i.e. methanoenic.

The sample -2 leachate is a strongly odoured black coloured liquid when it comes from a landfill site. The

smell is acidic and offensive because of sulfur, hydrogen and nitrogen rich organic species such as an organosulfur compound As it becomes oxygenated it tends to turn brown because of the presence of Iron salts in solution and in suspension. It also quickly develops a bacterial flora often comprising substantial growths of Sphaerotilus.

Concentrations of metals were low in both leachates samples except for Fe and Zn. Generally heavy metals appear in the municipal solid waste from Batteries, consumer electronics, ceramics, light bulbs, house dust and paint chips, lead foils such as wine bottle closures, used motor oils, plastics, and some inks and glass. Concentration of heavy metals in a landfill is generally higher at earlier stages because of higher metal solubility as a result of low pH caused by production of organic acids. It is now recognized that most trace elements are readily fixed and accumulate in soils, and because this process is largely irreversible, repeated applications of amounts in excess of plant needs eventually contaminate a soil and may either render it non-productive or the product unusable. Although plants do take up the trace elements, the uptake is normally so small that this alone cannot be expected to reduce appreciably the trace element. It is interesting to note that the zinc levels are very high in leachate from old waste compared to leachate from fresh waste. However the concentrations of iron is about the same in the both the leachate samples.

4.1 Indications from BOD and COD values

The BOD/COD ratio can used to indicate the age of the waste fill. Relatively BOD levels decrease with age faster than COD due to rapid disintegration of bio degradable waste. Thus generally the ratio of BOD/COD will decrease with age and can be used to indicate the age of the waste.. Any waste water, having its BOD_5/COD ratio more than 0.63 can be considered to be quite controlled to biological treatment.

Table 3. Age of waste based on BOD & COD values of leachate (Hui, 2005).

BOD5/COD	Age of fill	COD
≥ 0.5	Young (< 5yr.)	>10,000
0.1-0.5	Medium(5yr -10yr)	500-10,000
<0.1	Old(>10 yr)	<500

From table 3, it shows that BOD_5 was 1290 mg/l and the value of COD was 13400 mg/l. The ratio of BOD_5/COD is 0.09 for sample-1 leachate. The value of BOD_5/COD can characterize the age of the landfill according to the leachate constituents (Table 3). The value of COD and BOD_5/COD from Table 3 shows that the leachate (sample-1) in this study was collected from the landfill with a age of more than 10 years and (sample-2) leachate found to be in medium age between 5 and 10 years.

5. LEACHATE POLLUTION INDEX CONCEPT

LPI provides an efficient method for evaluating the leachate contamination potential. The leachate pollution index (LPI) and it is formulated based on the Delphi technique. The LPI is a quantitative tool by which the leachate pollution data of the landfill sites can be reported uniformly. LPI formulation process involves selecting variables, deriving weights for the selected pollutant variables, formulating their sub indices curves, and finally aggregating the pollutant variables to arrive at the LPI (Kumar and Alappat, 2003).

LPI process involves: Selection of pollutant variables, Pollutant weights are assigned, formulating their sub indices curves and aggregating the pollutant variables to arrive at the LPI.

The LPI is calculated using the following equations:

$$LPI = \sum_{i=1}^{n} WiPi \qquad (1)$$

Where LPI= the weighted additive LPI, Wi= the weight for the ith pollutant variable, Pi = the sub index score of the ith leachate pollutant variable, n= number of leachate pollutant variables used in calculating LPI.

However, when the data for all the leachate pollutant variables included in LPI are not available, the LPI can be calculated using the concentration of the available leachate pollutants. In that case, the LPI can be calculated by the equation:

$$LPI = \frac{\sum_{i=1}^{m} WiPi}{\sum_{i=1}^{m} Wi} \qquad (2)$$

Where m is the number of leachate pollutant parameters for which data are available, but in that case, $m<18$ and $\Sigma W<1$ contamination from the pollutant to the overall leachate pollution.

LPI values were calculated for leachate sample of Terra Firma site. Tables 4 show the calculations for LPI values of leachate samples in Terra Firma site.

Table 4. LPI for the landfill leachate (sample-1)

Pollutant, mg/l	Sample 1	W_i	P_i	(P_iW_i)
pH	7.38	0.055	5	0.275
TDS	1375	0.050	8	0.40
BOD_5	40	0.061	55	3.36
COD	498	0.062	80	4.96
TKN	831	0.053	95	5.035
AN	1	0.051	100	5.10
Iron	5.28	0.044	5	0.22
Copper	0.001	0.050	5	0.25
Nickel	0.074	0.052	5	0.26
Zinc	48	0.056	5	0.28
Lead	0.252	0.063	5	0.31
Chromium	0.011	0.064	10	0.64
Chlorides	960	0.048	5.3	0.2544
Final LPI value = 13.22				

Table 5. LPI for the landfill leachate (sample-2)

Pollutant, mg/l	Sample 2	W_i	P_i	(P_iW_i)
pH	5.7	0.055	5	0.275
TDS	310	0.050	8	0.40
BOD_5	1680	0.061	55	3.36
COD	4960	0.062	80	4.96
TKN	485	0.053	95	5.035
AN	350	0.051	100	5.10
Iron	6.61	0.044	5	0.22
Copper	0.223	0.050	5	0.25
Nickel	0.001	0.052	5	0.26
Zinc	0.2	0.056	5	0.28
Lead	0.145	0.063	5	0.31
Chromium	0.001	0.064	10	0.64
Chlorides	2300	0.048	5.3	0.2544
Final LPI value = 16.11				

The results indicate that the leachate sample has high LPI value and therefore, has relatively more contamination potential. Terra Firma leachate sample can therefore pose threat to the environment and human health and hence, measures and continuous monitoring must be ensured. This threat potential does not seem to be reducing even with increase of the leachate.

It is interesting to note that the LPI of both the leachates is not much different. While pollution threat from Leachate 1 (from old waste) is less from BOD and COD, its threat is mainly due to high concentrations of Zinc, TDS and Total Kjeldahl Nitrogen (TKN). On the contrary the pollution threat from fresh leachate arises mainly form high BOD, COD and chloride levels. However the threat exists from leachates from both fresh waste and aged leachate.

6. CONCLUSIONS

1. Based on the physico-chemcial analysis the leachate from the active part (fresh waste) of the landfill, it has been inferred that anaerobic acidic phase is established.
2. The leachate from the closed part showed typical characteristics of leachates generated during the methanogenic phase of the landfill life phase.
3. Based on BOD_5/COD ratio suggested that the leachate (sample-1) (closed part of landfill) from the landfill with the age more than 10 years and (sample-2) leachate (fresh waste) found to be in medium age.
4. The LPI is a quantitative tool by which the leachate pollution data of the landfill sites can be reported uniformly. High LPI values indicate that the leachates generated from landfill site are not yet stabilized even after 10 years, resulting in high pollution threat. While pollution threat from Leachate 1 (from old waste) is less from BOD and COD, its threat is mainly due to high concentrations of Zinc, TDS and TKN. On the contrary the pollution threat from fresh leachate arises mainly form high BOD, COD and chloride levels.

REFERENCES

1) APHA (1998), Standard Methods for Examination of Water and Waste water , 19th edition, American Public Health Association, Washington, DC. Brock T.D. and Madigan M.T.Biology of Microorganisms. *5th edition.Prentice Hall International inc* 641 - 644.
2) Armstrong, M.D., and Rowe,R.K, (2009): Effect of landfill operations on the quality of municipal solid waste leacahte, *In international Waste Management and Landfill Symposium,* proc. Sardinia99, S Margherita di pula, Cagliari, Italy,.81-88.
3) Barlaz, M.A., Ham, R.K., and Shaefer, D.M. (2012): Methane Production form Municipal Refuse: A review of Enhancement Techniques and Microbial Dynamics,CRC *Crit. Rev. Environ. Contr*,19, 6,557.
4) Chain.E.S.K and Dewalle.E.B (1976), Sanitary landfill leachate and their treatment, *Journal of Environmental Engineering Division, ASCE*, 108(EE2), 411.
5) Granet.C, Courant.N, Millot. N, Rousseau and Navarro. N (1986), Diagnostic detrailabilite dex lixivials: definition d'une methodologie,L'Eau et l' Industrie. Janvier.
6) Harmsen.J, (1983), Identification of organic compounds in leachate from a waste tip, *Journal of Water Research*, 17(6), 699-705.
7) Hui, T.S. (2005), Leachate Treatment by Floating Plants in Constructed Wetland Master's Thesis,*Universiti Teknologi Malaysia,* Malaysia.
8) Kjeldsen, P., Barlaz, M.A.,Rooker, A.P., Balun, A., Ledin, A and Christen, T.H.(2002): Present and long-term composition of MSW landfill leachate: a review,*criti Rev Environ Sci Technol,*32:297-336.
9) Kumar, D., and Alappat, B.J (2003). A technique to quantify

landfill leachate pollution, *Proc., 9th Int. Landfill Symp*. 243-244.

10) Peter .K, Morton A. B, Alix P. R, Anders B, Anna. L, and Thomas H.C,(2002), Present and Long-Term Composition of MSW Landfill Leachate: A Review, Critical Reviews in Environmental Science and Technology, 32(4), 297-336

11) Renou,S J.G. Givaudan, S. Poulain, F. Dirassouyan and Moulin.P, (2008), Landfill leachate treatment: Review and opportunity, Journal of Hazardous Materials, 150, 468-493.

12) Robinson,H.D & Gronow. J.R.(1993), A review of landfill leachate composition in the *UK, Proc. Sardinia* 1, CISA, 821-83.

13) ZgajnarGotvajnA,Ti˘slerTandZagorc-Kon˘canJ(2009),Comparisonofdifferenttreatmentstrategiesforindustriallandfillleachate.*JHazardMater*162:1446–1456.

USGS science for a changing world

Environmental Health - Toxic Substances Hydrology Program

Landfill Leachate Released to Wastewater Treatment Plants and other Environmental Pathways Contains a Mixture of Contaminants including Pharmaceuticals

Signup

New scientific research from the U.S. Geological Survey (USGS) details how landfill leachate, disposed from landfills to environmental pathways, is host to numerous contaminants of emerging concern (CECs).

Landfills are the final repository for a heterogeneous mixture of liquid and solid waste from residential, industrial, and commercial sources, and thus, have the potential to produce leachate—a liquid waste product that consists of a diverse mixture of chemicals as precipitation or applied water moves through the waste. Landfills are often not the final repository for leachate which can be discharged to surface waters following onsite or offsite wastewater treatment.



Sample bottels like these filled with leachate were analyzed for contaminants of emerging concern (CECs) including pharmaceuticals, industrial chemicals, household chemicals, steroid hormones, and plant/animal sterols. Photo Credit: Dana W. Kolpin, USGS

In this national-scale study, scientists provide an assessment of CECs in landfill leachate disposed offsite that has undergone treatment or storage processes (final leachate) at landfills across the United States to gain a greater understanding of this potential contaminant source to the environment. This study follows and advances previous USGS research of leachate prior to onsite treatment, storage processes, and offsite disposal (fresh leachate).

In this study, final leachate samples from 22 landfills were collected and analyzed for 190 CECs including pharmaceuticals, industrial chemicals, household chemicals, steroid hormones, and plant/animal sterols. The sampling network included municipal and private landfills with varying landfill waste compositions; geographic and climatic settings; ages of waste, waste loads, and leachate production; and leachate management strategies.

Scientists determined that final leachate samples contained 101 of the 190 chemicals analyzed for the study, with chemicals present in every final leachate sample collected at levels ranging from as low as 2 nanograms per liter (ng/L) to as high as 17,200,000 ng/L. The most frequently detected CECs were lidocaine (local anesthetic, found in 91 percent of samples), cotinine (nicotine breakdown product, 86 percent), carisoprodol (muscle relaxant, 82 percent), bisphenol A (component for plastics and thermal paper, 77 percent), carbamazepine (anticonvulsant, 77 percent), and N,N-diethyltoluamide (DEET, insect repellent, 68 percent).

A detailed comparison of CEC concentrations between final leachate in landfills included in this study and the previous study of fresh leachate indicated that levels of CECs were significantly less in final leachate compared to those observed in fresh leachate samples. Nevertheless, final leachate still contained a complex mixture of CECs at concentrations that may be potential cause for concern if released to the environment.

This research is part of continuing USGS efforts to quantify the contribution of contaminants in leachate released from landfills to various pathways that ultimately lead to the environment. Use of landfills as a means of waste disposal will likely

increase as the global population continues to increase. Despite advancements in recycling, source reduction, and composting, the amount of municipal solid waste discarded in U.S. landfills increased from 150 million tons in 1985 to 165 million tons in 2010. The study is intended to inform landfill managers, stakeholders, and regulators about chemicals present in landfill leachate disposed offsite to environmental pathways.

The study was supported by the USGS Toxic Substances Hydrology Program.



In some cases USGS scientists collected leachate samples from manhole access points like this one. Photo Credit: Dana W. Kolpin, USGS

References

Masoner, J.R., Kolpin, D.W., Furlong, E.T., Cozzarelli, I.M., and Gray, J.L., 2015, Landfill leachate as a mirror of today's disposable society--Pharmaceuticals and other contaminants of emerging concern in final leachate from landfills in the conterminous United States: Environmental Toxicology and Chemistry, doi:10.1002/etc.3219 (Advanced Web release).

Masoner, J.R., Kolpin, D.W., Furlong, E.T., Cozzarelli, I.M., Gray, J.L., and Schwab, E.A., 2014, Contaminants of emerging concern in fresh leachate from landfills in the conterminous United States: Environmental Science--Processes and Impacts, v. 16, no. 10, p. 2335-2354, doi:10.1039/C4EM00124A.

More Information

- For more information contact Dana W. Kolpin, USGS Iowa Water Science Center, or Jason R. Masoner, USGS Oklahoma Water Science Center
- Frequently Asked Questions about this Science Feature Article
- USGS Technical Announcement: Storage and Treatment of Liquid Waste from Landfills Doesn't Remove All Contaminants, Including Pharmaceuticals
- USGS Emerging Contaminants in Landfill Leachate
- Pesticide Contamination and Environmental Exposure Investigation

Related Science Features

- New Study Documents Crop Bactericide, Nitrapyrin, in Iowa Streams
- Distinct Microbiomes Identified in Landfills Throughout the United States
- Chemicals Found in Treated Wastewater are Transported from Streams to Groundwater
- Pharmaceuticals and Other Chemicals Common in Landfill Waste
- Chemicals from Land-Applied Biosolids Persist in Soil
- Complex Mixture of Contaminants Persists in Streams Miles from the Source
- Hormones in Land-Applied Biosolids Could Affect Aquatic Organisms
- Biosolids, Animal Manure, and Earthworms: Is There a Connection?
- Household Chemicals and Drugs Found in Biosolids from Wastewater Treatment Plants

More Science Features

CHAPTER

3 Landfill Gas Safety and Health Issues

This chapter provides information about health and safety issues associated with landfill gas—specifically, possible explosion and asphyxiation hazards and issues related to odors emanating from the landfill and low-level chemical emissions. It also contains information about health and safety issues associated with landfill fires (which may or may not be the direct result of landfill gas). This chapter also describes the tools that can be used to help environmental professionals respond to community health concerns. It provides information about what is known and unknown about the short-term and long-term health effects associated with landfill gas emissions, which can be mixtures of hundreds of different gases.

When reading this chapter, keep in mind that if people are not being exposed to landfill gases, no adverse health effects are expected. Exposures occur only if the landfill is producing harmful levels of gases *and* if the gases are migrating from the landfills *and* reaching people. Responding to community concerns about the possible health impacts of known or potential landfill gas emissions can often be difficult. Data (at the point of exposure) are needed to fully evaluate exposures, and these data are often limited or not available (see Chapter Four).

How are people exposed to landfill gas?

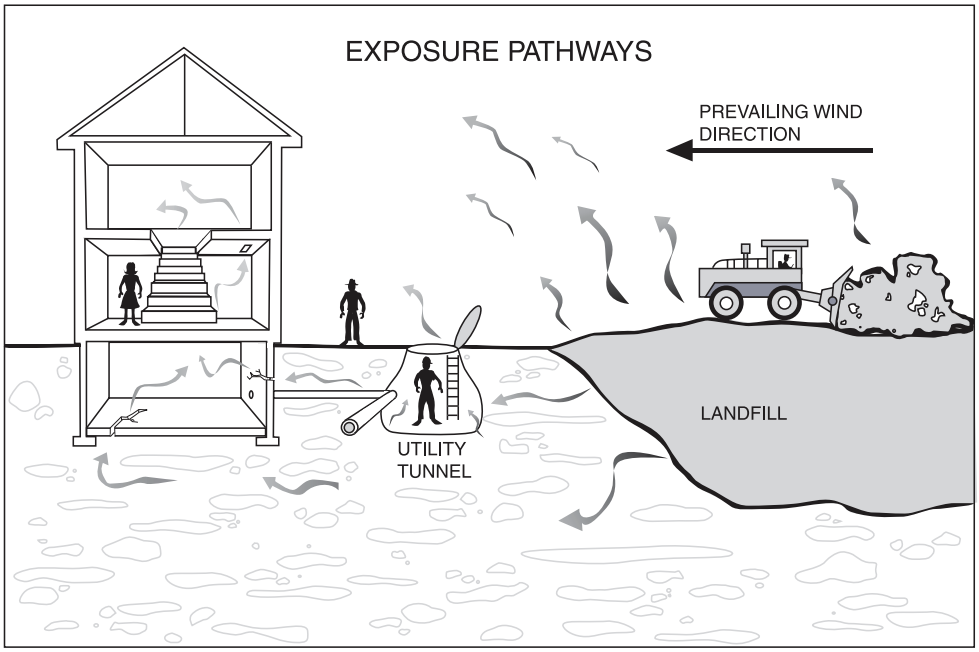
People may be exposed to landfill gases either at the landfill or in their communities. As discussed in Chapter Two, landfill gases may migrate from the landfill either above or below ground. Gases can move through the landfill surface to the ambient air. Once in the air, the landfill gases can be carried to the community with the wind. Odors from day-to-day landfill activities are indicative of gases moving above ground. Gases may also move through the soil underground and enter homes or utility corridors on or adjacent to the landfill. Figure 3-1 illustrates the movement of landfill gases and potential exposure pathways. The levels of gases that migrate from a landfill and to which people are exposed are dependent on many factors, as described in Chapter Two. Landfill gas collection and control systems have the greatest impact on gas migration and exposures. If a collection or control system is in place and operating properly, migration and exposures should be minimal.

Explosion Hazards

Landfill gas may form an explosive mixture when it combines with air in certain proportions. This section provides information about:

- The conditions that must be met for landfill gas to pose an explosion hazard.
- The types of gases that may potentially pose explosion hazards.
- What can be done to assess whether a landfill is posing an explosion hazard.

Figure 3-1: Potential Exposure Pathways to Landfill Gas



When does landfill gas pose an explosion hazard?

The following conditions must be met for landfill gas to pose an explosion hazard:

- ***Gas production.*** A landfill must be producing gas, and this gas must contain chemicals that are present at explosive levels.
- ***Gas migration.*** The gas must be able to migrate from the landfill. Underground pipes or natural subsurface geology may provide migration pathways for landfill gas (see Chapter Two, "What factors affect landfill gas migration?"). Gas collection and treatment systems, if operating properly, reduce the amount of gas that is able to escape from the landfill. (See Chapter Five.)
- ***Gas collection in a confined space.*** The gas must collect in a confined space to a concentration at which it could potentially explode. A confined space might be a manhole, a subsurface space, a utility room in a home, or a basement. The concentration at which a gas has the potential to explode is defined in terms of its lower and upper explosive limits (LEL and UEL), as defined at right.

Lower and Upper Explosive Limits (LEL and UEL)
The concentration level at which gas has the potential to explode is called the explosive limit. The potential for a gas to explode is determined by its lower explosive limit (LEL) and upper explosive limit (UEL). The LEL and UEL are measures of the percent of a gas in the air by volume. At concentrations below its LEL and above its UEL, a gas is *not* explosive. However, an explosion hazard may exist if a gas is present in the air between the LEL and UEL and an ignition source is present.

From:	Ken Eklund
To:	Benton Public Comment
Subject:	I oppose LU-24-027: reference articles and opinions in the press - 1 of 12
Date:	Thursday, May 8, 2025 2:33:10 PM
Attachments:	writerguy-cube2.png 1 PUB-063-Landfills.pdf 3 Mailbag We might as well change those signs.pdf 4 Coffin Butte Benton County hears more opposition to landfill expansion.pdf 5 Benton County commission unanimously rejects Coffin Butte landfill expansion plan.pdf 6 Republic Services pulls appeal on Coffin Butte landfill expansion.pdf 7 As I See It Assessing our trash future.pdf 8 "Complex chemical stew" Leachate concerns in Corvallis.pdf 9 Letter What is source of the gaseous smell .pdf

CAUTION: This email originated from outside of the organization. Do not click links or open attachments unless you recognize the sender and know the content is safe.

Benton County Planning Commissioners
c/o Planning Division 4500 SW Research Way, Corvallis, OR 97333
May 8, 2025
#dumppress

RE: Please Deny LU-24-027, the Conditional Use Permit Application Regarding Landfill Expansion

Dear Chair Fowler and Members of the Benton County Planning Commission:

I'm realizing that Planning Commission members haven't necessarily seen the various press articles and print opinions about Coffin Butte Landfill, and so I've gathered together some of the main ones from the last four years and am attaching them here and to succeeding emails as necessary. These articles of course cover many of the same issues that have come up in public testimony, namely, PFAS, leachate, methane, EPA and DEQ investigations and actions, labor issues, Republic cover-ups of problems and information, misleading and dubious information about the economics of the landfill, and so on.

The PDFs each begin with a number, so that you can read them in chronological sequence; 1 = oldest.

Thank you for your attention,

Ken Eklund



Ken Eklund, writerguy

37340 Moss Rock Dr
Corvallis OR 97330
408.623.8372

Creator of
World Without Oil
Ed Zed Omega
FutureCoast
and other storymaking games

Landfills
Trashing the Earth





Center for Health, Environment & Justice
P.O. Box 6806, Falls Church, VA 22040-6806

Landfills
Trashing the Earth

Center for Health, Environment & Justice

April 2016



Copyright 2016 by Center for Health, Environment & Justice. All rights reserved. For Permission to reprint, please contact CHEJ. Printed in the U.S.A.

P.O. Box 6806 Falls Church, VA 22040-6806 703-237-2249 chej@chej.org www.chej.org

Center for Health, Environment & Justice
P.O. Box 6806 • Falls Church, VA 22040 • Phone: 703.237.2249 • Fax: 703.237.8389 • www.chej.org

Mentoring a Movement

Empowering People

Preventing Harm

About the Center for Health, Environment & Justice

CHEJ mentors the movement to build healthier communities by empowering people to prevent the harm caused by chemical and toxic threats. We accomplish our work by connecting local community groups to national initiatives and corporate campaigns. CHEJ works with communities to empower groups by providing the tools, strategic vision, and encouragement they need to advocate for human health and the prevention of harm.

Following her successful effort to prevent further harm for families living in contaminated Love Canal, Lois Gibbs founded CHEJ in 1981 to continue the journey. To date, CHEJ has assisted over 15,000 groups nationwide. Details on CHEJ's efforts to help families and communities prevent harm can be found on www.chej.org.

Table of Contents

Chapter		Page
1	Introduction	1
2	Different Types of Landfills	3
3	How Landfills Work	8
4	Problems with Landfills	11
5	The Flow of Waste	25
6	Communities Fighting Back	28
7	Taking Action	33
8	Regulations and the Permitting Process	38
9	Troublesome Alternatives	42
10	Real Solutions: Zero Waste	45
11	Myths and Counter Arguments	50
	Appendix: Annotated Bibliography	53
	References	61

Chapter 1
Introduction

Today, every American will generate 4.4 pounds of trash. Of your junk mail, orange peels, paper towels, plastic wrappers, take-out containers, band-aids, newspapers and water bottles, almost 55% goes to a landfill. In 1960, only two-thirds of that amount – 2.68 pounds – went to the dump. Landfills contaminate the water and poison the air, yet the "need" for them continues to expand. Landfills have grown unabated for the past fifty years as capacity has soared to accommodate ever-increasing amounts of trash. In order to bring a halt to this garbage explosion, we must believe that zero waste is achievable – no landfills, no incinerators, just a holistic approach to the lifecycle of every item.

Zero waste is an idea that encompasses many environmental tenets (recycling, reusing, composting, reducing, conserving, etc) in order to fulfill its goal of eliminating the waste stream. But for this seemingly impossible concept, it's not the end result that matters as much as the reach for it. Stretching to achieve zero waste – doing all that we can to reduce garbage at its source – is the ultimate objective of the zero waste concept. We must strive for the impossible to reach the edge of possibility. By aiming for zero waste, we will achieve substantial garbage reduction and realize we don't have to settle for a lesser "solution" like burning trash. If in the end, when every imaginable step has been taken and all possibilities extinguished, some garbage remains, then landfilling may be used. But we need to see such unsavory action as an absolute last resort rather than an easy fix; otherwise, we'll never truly deal with our trash load, and landfills will remain the common response.

Stopping a proposed landfill or landfill expansion in your community is a critical first step toward redefining the management of our waste. We do not need more landfills. **All landfills will eventually fail, polluting the environment and placing people at risk.** If your community is willing to fight for your right to clean air and water, history has shown that you can succeed in opposing a proposed landfill. It will not be quick or easy, and it requires a great deal of planning

and organization, but we believe in your ability to win and protect your health, the health of your family, and your neighbors.

The best way to win is to organize your community. By organizing, we mean bringing people together for a common purpose and for mutual support to get the power needed to influence the outcome of a local issue. Power is obtained in two ways, either by engaging and organizing people or by spending money. Most community groups have little money and are often battling huge corporations, who can always outspend citizen groups. That's why we encourage activists to stress the "people power" side when organizing.

The first step, however, is deciding to get involved yourself. Maybe it's because of your children, or because of the way you were treated at a public meeting, or maybe you decided that you're just not going to take it anymore. The next step is to get more people involved. The best way to do this is with face-to-face contact and communication. Talk to your friends and family and have them talk with their friends and family. Go door-to-door in your neighborhood, host your own community meeting or speak at churches, clubs, schools, etc.

As you engage your neighbors, you'll want to work together to define what you, as a community, want to accomplish. This will lead to forming an organization that has its primary focus to address the issue that brought you and your neighbors together. Together you'll want to define your goals, both short term and long term. Be realistic in setting your goals. Pick goals that you can win. One or two are enough; don't choose more than three or four.

There are four basic steps to achieving your goals:

1. Organize a community group
2. Decide what you want
3. Find out who can give you what you want
4. Develop strategies that target the decision-makers so that they give you what you want

Once you've organized into a group, defined your goals, and identified who can give you what you want, you'll need to develop strategies that target the decision makers so that they have no choice but to do what you want. This does not come about easily. Government and political officials are influenced by many factors and forces and you will quickly realize that to be successful, you have to create more pressure on the politicians and government officials than anyone else.

For advice on how to form a successful community-based group, see CHEJ's Organizing Handbook available for free from CHEJ or from our website at http://chej.org/wp-content/uploads/Organizing%20Handbook%20-%20PUB%20059.pdf.

The purpose of this guidebook is to serve as a resource for people opposing a new landfill or landfill expansion. It provides an overview of landfill design, regulations, and the reasons that landfills are inherently flawed. We have included information to assist you in organizing your community to fight the landfill, and some alternatives to our current waste management system.

We hope that this guidebook makes your own struggle a little easier. As you fight for justice, remember that many people have won these struggles. Until we move away from a society where waste is 'out of sight, out of mind,' these fights will continue.

Chapter 2

Different Types of Landfills

A landfill is a depression in the ground for the disposal of unwanted materal considered "waste." Landfills that do not contain covers are called open dumps. If the trash is covered to keep rodents, people and wind from dispersing the material, then the site is called a sanitary or municipal landfill.

A site that still operates and accepts waste is considered an active landfill. Conversely, a landfill that is filled to capacity and no longer accepts waste is referred to as a closed landfill.

Even though only one type of landfill is denoted as "hazardous waste," in truth, all of the landfills listed in Table 1 can contain toxic chemicals that threaten the air, water, and the public's health. Municipal Solid Waste (MSW) landfills hold electronics which, especially when crushed, leak out their poisonous components of lead, mercury, and cadmium. Construction and Demolition (C&D) landfills emit hydrogen sulfide (a compound which smells like rotten eggs), and store paint, lacquers, and wood preservatives which contain harmful chemicals like arsenic (SLee 2006, USEPA 1995a, Turley 2006). Industrial landfills are home to heavy metals and organic compounds like pesticides and polychlorinated biphenyl (PCBs) which can pollute surface water (USEPA 2010b). Hazardous Waste landfills also pose health risks: in 2014 there were 3,779 hazardous waste facilities which needed to take "corrective action" – requiring action to clean up contamination (USEPA 2014). Across the board, landfills are harmful additions to a community.

Municipal Solid Waste (MSW) is what we generally call garbage. It consists of:

- Durable items (appliances, tires, batteries)
- Nondurable items (newspapers, books, magazines)
- Containers and packaging
- Food waste
- Yard trimmings
- Various organic waste from non-production sources (homes, businesses, institutions) (USEPA 2006)

Recycling, composting, zero waste – all are environmentally-friendly alternatives to landfills. See Chapter 10 for more information on these **realistic** solutions.

Table 1: Types of Landfills	
Municipal Solid Waste	Primarily accepts items categorized as MSW (see box on page 3). Additionally, these landfills accept a limited amount of *household hazardous waste*, such as batteries, paint, florescent light bulbs and drain cleaners. These landfills also take "special" waste such as municipal wastewater sludge, coal ash waste, and incinerator ash.
Industrial	Industrial landfills deal with hazardous and non-hazardous waste from commercial production sources. These can include the waste generated by factories, mills, agricultural operations, logging and mining.
Construction & Demolition	C&D landfills are exclusively for waste generated during the construction, renovation and demolition of buildings, roads and bridges. C&D landfills contain bulky items such as concrete, wood, asphalt, metals and bricks. These landfills also contain mixed hazardous waste found in buildings such as asbestos, PVC, mercury switches, lead paint, batteries, and electronics..
Hazardous Waste	Hazardous waste landfills contain non-liquid waste which is classified as hazardous under *Subtitle C* of the Resource Conservation and Recovery Act (USEPA 2008). These landfills have more stringent regulations, monitoring systems and inspections than municipal solid waste landfills.
Post-Disaster	While disasters have always generated large amounts of waste, the amount of waste generated by Hurricanes Katrina in Louisiana and Sandy in New York/New Jersey highlighted the issues around landfills in disaster areas. Many types of debris, including chemicals, oil, personal property, building rubble, soil, trees, ash, and charred wood require quick disposal in large quantities. In times of crisis, it remains crucial that citizens and municipalities work with state environmental agencies to make sure that debris is disposed of in a safe manner.
Superfund	Some landfills have been granted Superfund status, meaning that they are contaminated with hazardous waste and considered a risk to human health and the environment. Many Superfund sites are former landfills, including over ten percent of the *411 Most Dangerous Superfund Sites* listed by the Center for Public Integrity (CPI 2007). Superfund landfill sites are not limited to hazardous waste landfills, but include MSW and other types of landfills that have significantly contaminated the soil, water and air.

Brief History of Landfills in the United States

"Historically, the goal of municipal solid waste and industrial 'nonhazardous' waste management has been to get the waste out of sight in the least costly manner."

- Dr. G. Fred Lee (2005)

Pre-1960s: Open Dumps

Landfills are one of the oldest waste disposal methods. Waste has long been deposited on low-value areas away from urban areas, such as wetlands. Starting in the late nineteenth century, land began to be excavated prior to dumping

waste (Lee 2005). Most municipal solid waste was then either burned or allowed to decompose in open dumps. Generally, these landfills worked well because only biodegradable waste was disposed in them, allowing soil bacteria to break the waste down in a relatively short period of time.

Starting in the 1950s, landfill operators began to place a layer of soil over the waste at the end of the day. When landfills were closed, additional soil was placed as a cover, upon which buildings or parks were built. While this eliminated some public health concerns – odors, vermin, etc. - it did little to address the increasing problems of soil and water contamination (Lee 2002).

The 1960s: The First Government Regulations

With the advent of plastics, pesticides and petroleum products, landfills became more toxic and difficult to maintain (Lee 2002). This waste decomposes at a much slower rate than biological matter. Moreover, the chemicals contained in these types of waste (or the chemicals released when they break down) create air, soil and water pollution when they are emitted with landfill gases or mix with rainwater and leach into the soil (Montague 1989).

The discovery of these contamination problems around landfills in the 1960s brought about major changes in landfill design in concert with the first federal law for solid waste, the 1965 *Solid Waste Disposal Act*. The bill focused on improving the efficiency of disposal, providing states and municipalities with financial assistance and creating federal standards for building and maintaining safer landfills (Fletcher 2005).

Though the technology continued to evolve, landfill design remained problematic. In the mid-1970s, the concept of the "secure" or *double-lined landfills* emerged. Here, two liners are separated from each other by 1-2 feet of sand or gravel. To boost popular appeal, they have also been called "scientific" landfills. However, history continues to provide evidence that all landfills, even 'secure' scientific ones, eventually fail.

Creation of the USEPA

After the creation of the Environmental Protection Agency (EPA) in 1970, the federal government continued to issue landfill regulations. The Resource Conservation and Recovery Act (RCRA) (usually pronounced "wreck-rah") passed by Congress in 1976 as an amendment to the Solid Waste Disposal Act, created the framework for regulating waste (USEPA 2006). RCRA also banned industrial and commercial sources from putting large amounts of industrial waste into MSW landfills, such as 55-gallon drums of chemical solvents (Lee 2002).

Assorted amendments to RCRA continued to increase landfill safety measures, siting rules and government regulation of waste. The Hazardous and Solid Waste Amendments of 1984 signified a move toward preventing future cleanup problems. The amendments prohibited the disposal of untreated hazardous waste, implemented stronger leachate (liquid runoff from waste) collection requirements, and set deadlines for the closure of facilities not meeting standards (Fletcher 2005). At the same time, mounting concerns about air pollution spurred decreased rates of MSW incineration. Fewer landfills, less burning and more trash helped to grow the burgeoning recycling industry (USEPA 2007).

The 1990's: Subtitle D

As the percentage of MSW sent to landfills peaked in 1990, the EPA continued to refine RCRA (USEPA 2007). A set of regulations for MSW disposal referred to as "Subtitle D," created partly in response to lawsuits against the EPA, went into

effect in October of 1993. The hallmark of this legislation is the concept of "dry tomb" landfilling.

Since groundwater contamination occurs when water mixes with waste, dry tomb landfills are designed to isolate waste with a liner and cap, thus preventing pollution (Lee 2005). The minimum standard for a landfill under Subtitle D requires both a plastic and a compacted clay liner (Lee 2002). These "dry tomb" landfills are now the most common type of landfill built in the U.S. Since biodegradable waste breaks down much slower due to the lack of moisture and oxygen, and the composition of waste in landfills shifted to long-lasting items, such as plastics, the decomposition of "dry tomb" landfills has greatly slowed (Freudenrich 2000).

Additional Subtitle D provisions state that MSW landfills must have liners, leachate collection systems, groundwater monitoring and corrective action (Fletcher 2005). Similar to Superfund, the corrective action program works with current landfill operators to clean up contamination released into the environment (USEPA 2007a).

In 1996, the government began regulating emissions of certain chemicals and compounds in large landfills under the Clean Air Act (Fletcher 2005). Other subsequent minor changes to landfill policy are discussed later in Chapter 8.

The 21st Century: Alternatives?

The design of landfills has not changed drastically in recent years, nor have new liner systems prevented leaks in aging liners. CHEJ's Landfill fact pack, *Landfill Failures: The Buried Truth*, elaborates on landfill designs and their downfalls (available from CHEJ and at www.chej.org). Initially, municipal solid waste "alternatives" focused on waste prevention, recycling and energy production from the gases (mainly methane) emitted by landfills. However, the latter two also pose environmental risks, as discussed later.

More recently, the concept of zero waste has been introduced, which offers a sustainable and safe solution to landfills. Its advantages and benefits can be found in Chapter 10: *Real Solutions – Zero Waste*.

Facts and Figures on MSW

There is a clear downward trend in the number of landfills in the U.S. (see Figure 1). In 2012

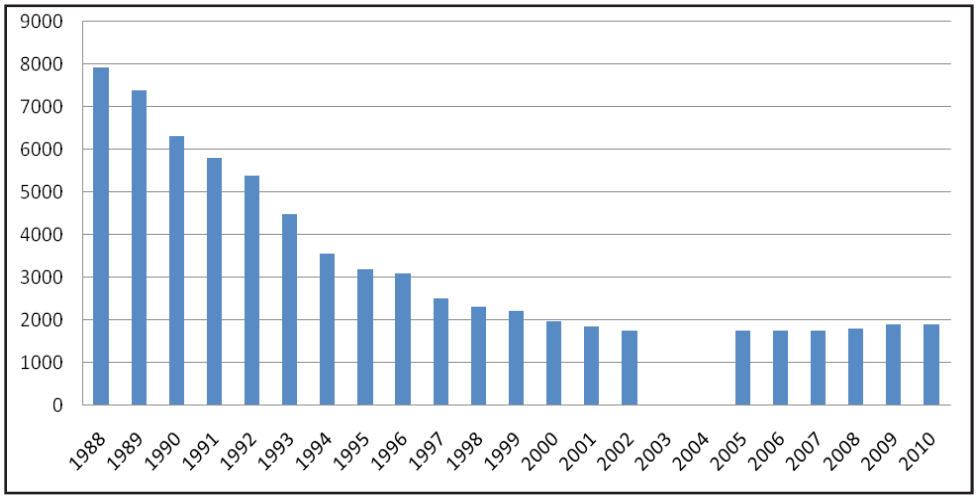


Figure 1: Number of Landfills in the United States, 1988-2010 (USEPA 2010)
Note: Data unavailable for 2003-2004

there were only 1,908 landfills, compared to 7,924 in 1988 (USEPA 2014a). Unfortunately, fewer landfills do not mean less waste. The remaining landfills are larger than before, since the amount of garbage produced over the past half century has almost doubled since 1960 (USEPA 2014a).

In 2012, U.S. consumers produced approximately 4.38 pounds of MSW per person per day, totaling almost 251 million tons, compared to only 88 million tons in 1960! While "recovery" – recycling and composting – helps to divert waste away from landfills, close to 55% of the waste still ends up going to landfills, with another 11.7% being incinerated (USEPA 2014a).

Commercial waste (generated by stores, office buildings, apartment complexes and institutions) accounts for approximately 40% of all MSW. Private corporations usually manage commercial waste, and are increasingly contracting with municipalities to manage residential MSW as well (McCarthy 2000).

Newer landfills are much larger than in the past. This is primarily due to the difficulties in siting new landfills and the consolidation of the waste industry. The Southeast United States contains the most landfills – more than all in the Midwest and Northeast combined. As the number of landfills declines, MSW continues to travel increased distances before landfill disposal. Urban areas, especially those in the Northeast, export garbage to landfills in the Southeast.

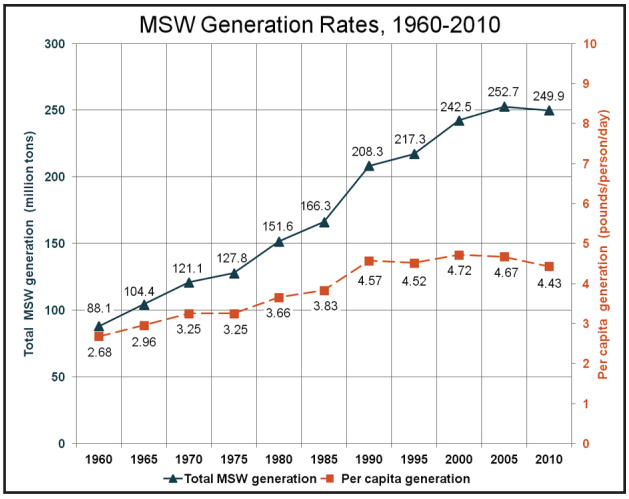


Figure 2: MSW Generation Rates 1960-2010 (US EPA 2009)

The National Solid Wastes Management Association asserts that the U.S. currently has the landfill capacity to last roughly 20 years. However, certain states including Alaska, Connecticut, Delaware, North Carolina, New Hampshire, and Rhode Island have less than five years worth of available space left (NSWMA 2010).

GENERAL RESOURCES ON LANDFILLS

- A list of common household hazardous wastes: http://www.longwood.edu/assets/safety/epalchhw_brochure.pdf
- Industrial Landfills: http://www3.epa.gov/epawaste/nonhaz/industrial/
- C&D Landfills, see: https://www.epa.gov/landfills/industrial-and-construction-and-demolition-cd-landfills
- HazardousWaste Landfills: https://www.epa.gov/hwpermitting/hazardous-waste-management-facilities-and-hazardous-waste-management-units#landfills
- EPA website about disaster debris: http://www3.epa.gov/epawaste/conserve/imr/cdm/debris.htm
- EPA Superfund information: http://www.epa.gov/superfund/
- Wasting Away - Center for Public Integrity: http://www.publicintegrity.org/environment/health-and-safety/wasting-away
- RCRA Orientation Manual: http://www2.epa.gov/hwgenerators/resource-conservation-and-recovery-act-rcra-orientation-manual
- History of Waste Management timeline: http://beginwiththebin.org/resources/for-education

Chapter 3

How Landfills Work

In its most basic form, a landfill is simply a "bathtub" in the ground. A municipal solid waste landfill is designed so that waste is placed on the ground in a pot, spread in layers, compacted to the smallest practical volume, and covered with soil at the end of each day (USEPA 1995).

Most landfills built today are designed based on the "dry tomb" concept, as specified in Subtitle D of the RCRA. The basic setup of a modern "dry tomb" landfill can be seen in Figure 3.

Bottom Liner System

The bottom liner system of a landfill is in effect the "tub" that separates the contents of the landfill from the soil around it. The liner system is the main barrier against soil and water contamination from garbage, leachate, and landfill gas.

The liners for MSW landfills are usually 30-100 millimeters thick and made of a durable synthetic plastic (polyethylene, high-density polyethylene (HDPE), or polyvinyl chloride).

Under Subtitle D, landfills are now typically required to have an additional layer of compacted clay soil underneath the plastic liner. There may also be an additional fabric mat (geotextile mat) surrounding the plastic liner to guard against tearing from surrounding rock (Freudenrich 2000).

Cells

Waste is stored in a series of "cells" within the landfill. Each cell contains one day's trash, which has been compacted and covered in soil. The amount of trash in a cell is usually 2,500 tons, which is then compacted by bulldozers, balers, rollers and other equipment to 1,500 pounds per cubic yard (Freudenrich 2000).

Storm Water Drainage System

Plastic drainage pipes and storm liners are used to keep out and remove rainwater. The collected water is channeled to drainage ditches and ponds around the base of the landfill. The water is tested

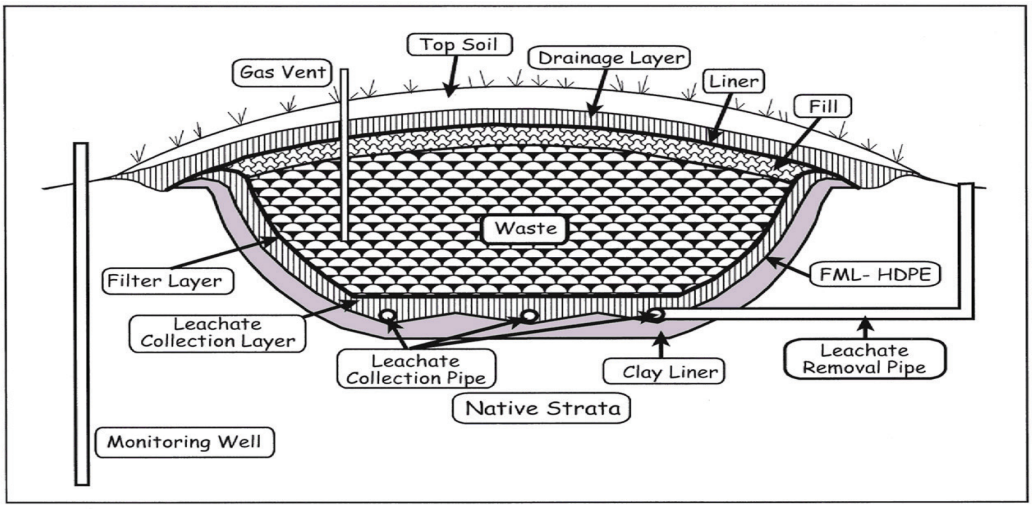


Figure 3: Single Liner Landfill Containment System (Lee 2004)

for chemicals and is pumped off-site once soil sediments have settled.

Leachate Collection & Monitoring System

Despite measures to prevent water from entering the landfill, some water always gets inside. The water moves through the garbage, mixing with contaminants (chemicals, metals, waste products of decomposition) and forms "leachate".

In order to collect leachate, modern landfills contain a leachate collection system between the composite (clay and plastic) liner and the waste cells (see Figure 3). Beneath the waste is a filter layer, designed to keep the waste from migrating downward but allowing leachate to move freely. The leachate collection system is between the filter layer and the plastic sheeting. Leachate moves through a porous material, such as gravel, and slides off the plastic sheeting to collection pipes (Lee 2005).

The collection pipes lead out to a removal pipe. The removal pipe pumps or sprays ("aerates") leachate into a collection pond outside the landfill. There, leachate is tested for contaminants and then treated, returning the solids to the landfill.

One concern about aerating the leachate is that volatile chemicals in the leachate will evaporate into the air and become airborne. This may pose health risks to residents living nearby.

Landfill Gas Collection System

The decomposition of waste by bacteria produces landfill gas, composed primarily of methane and carbon dioxide. Its production depends upon a number of factors, including the type of waste, moisture content in the landfill, amount of oxygen present and temperature (ATSDR 2001).

In compliance with the Clean Air Act, "large" landfills (those with a capacity at or above 2.5 million cubic meters) that emit at least 50 metric tons of non-methane organic chemicals (NMOCs) per year must have a landfill gas collection system, which reduces NMOC emissions by 98 percent. This series of pipes snakes through the landfill, and collects landfill gas. The gas is either released (vented) or burned. In some cases, the gas is captured and burned as an energy source. NMOCs typically represent 1 percent of landfill gas. Included in NMOCs are toxic volatile organic compounds (VOCs) and hazardous air pollutants (HAPs) such as benzene,

toluene, ethyl benzene and vinyl chloride (USEPA 2008e). Additional information on landfill gas can be found in *Chapter 4: Problems with Landfills*, under the subsection entitled "Landfill Gas and Air Emissions."

Cover/Cap

For an operating landfill, a covering of six inches of soil is placed on the top of the day's compacted waste. This covering aims to keep animals and insects from getting into the landfill, and to keep garbage from escaping.

When a landfill is closed, it is first covered with a layer of soil (fill), followed by a low-permeability polyethylene (plastic) sheeting. On top of the cap lies a one to two foot high porous drainage layer. Up to a foot of topsoil covers the drainage layer to promote vegetation growth and prevent erosion (Lee 2005).

Groundwater Monitoring System

Groundwater monitoring wells are placed around the perimeter of the landfill, usually several hundred feet apart (Lee 2015). At these stations, pipes are sunk deep enough to reach the groundwater. The groundwater is then periodically sampled for temperature, pH levels and the presence of leachate chemicals.

Chapter 4

Problems with Landfills

All landfills lead to environmental pollution. Even a landfill that complies with every EPA law and regulation will, by the nature of its design, emit harmful gases and leachate into the water, soil and air. Landfill waste takes hundreds, if not thousands, of years to completely decompose.

As the waste degrades, so do the liners and caps meant to contain them. The leachate and gas collection systems, and monitoring wells will need maintenance and upkeep, for which there is no funding after 30 years post-closure. Each new truckload of garbage dumped into a landfill leads to an unknown amount of environmental pollution, expensive remediation costs, and health threats to those who live and work near the site and everyone affected by the wider issue of global climate change.

These, and the following issues underscore the need for serious consideration of the zero waste principle, a safer answer to the alarming problem of our waste and landfills.

Exposure Pathways

People are exposed to chemicals in landfills through four basic routes of exposure – air (breathing), skin absorption (direct contact), consumption (ingesting drinking water or food contaminated by chemicals) or from the mother via the placenta (while a fetus) or from breast milk. Figure 4 below offers a simple visual of these pathways.

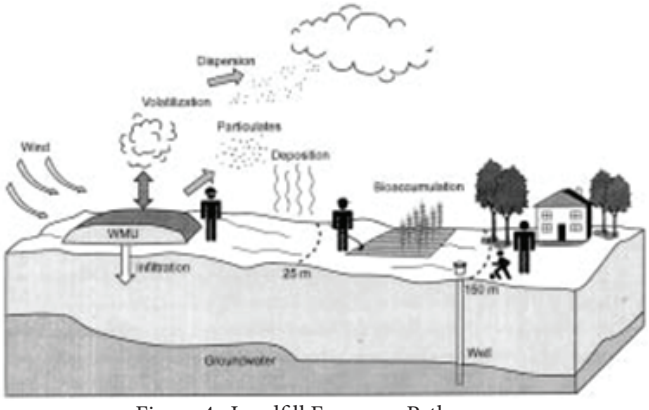


Figure 4: Landfill Exposure Pathways

Design Problems

Subtitle D landfills are designed to seal off waste from contaminating the surrounding air and water. However, most organic materials require air and water to decompose into nutrient-rich matter, which can then be reclaimed by the land and fertilize it. This leads to a classic catch-22 scenario: open landfills contaminate the environment more easily than closed ones, but closed, dry landfills slow down organic (and non-organic) waste decomposition, thus producing gas and leachate over a prolonged time-span. This is not to imply that unlined, open dumps are a better alternative to Subtitle D landfills. Rather, these modern landfills, even more than their predecessors, are fundamentally problematic.

Liner Failures

Liners are placed at the bottom of the landfill to contain waste and separate it from the surrounding soil and groundwater. They are usually made of durable synthetic plastic, in combination with compacted clay soils. Though liners are designed to avoid breakage, deterioration and punctures, industry experts and the EPA acknowledge that leakage is inevitable after a certain number of years (USEPA 1988).

After the Leak: Effects of a Flawed Liner

The Dewey Loeffel toxic dump in Nassau, New York operated from 1952 until 1968. It was only in 1980, however, that state officials discovered the landfill had been leaking PCBs into local waterways and Nassau Lake, a fishing and recreational haven that now lies devoid of activity. The fish are unsafe to eat, and residents are scared to even dip their toes in the water. With cleanup still being bogged down by General Electric, the primary user of the dump, the prospect of a speedy recovery for the region is dim; the landfill serves as a stark reminder of the potential impact of faulty liners (Cooney 2010, Gardiner 2002).

All liners are permeable to some degree and are often punctured with pinholes caused by the manufacturing and welding process (Montague 1992). Uneven soil or sharp rocks underneath the liner can tear the plastic or cause stress to the clay liner. Additionally, household products, including vinegar, alcoholic beverages, margarine, and household cleaners, can permeate through the plastic liner, degrade it, soften it, or make it brittle and cause it to crack (Pellerano 2005). Depending on the composition of the waste, leachate can be comprised of many chemical contaminants. Unfortunately, even with an intact liner, many of these contaminants can migrate into the surrounding soil. Organic chemicals, such as chlorinated solvents, benzene, and vinyl chloride, have been found to readily pass through a fully functional liner relatively quickly (Haxo 1988).

The clay and plastic liners should have surface-to-surface sealed contact. When this occurs, even if the plastic sheeting is cracked, initial leakage into the clay layer will be limited. However, if the clay and plastic liners are not in direct contact, such as when the plastic sheet develops a fold, leachate can flow out through the hole and widely disperse across and through the clay liner, eventually contaminating groundwater (Lee 2005). Such liner failures and subsequent water contamination are quite common. For instance, a survey of Virginia landfills in 2003 found contaminated groundwater in the monitoring wells of 62% of the sites (deFur 2003).

New Doesn't Mean Safe

An example of a faulty liner occurred in a Toms River Chemical landfill in Dover, New Jersey in 1979. There, just three months after the landfill opened, Department of Environmental Protection officials found that the double-lined landfill cells were leaking between 60 to 131 gallons of leachate per day (Montague 1982a).

Leachate Collection and Monitoring System Failures

When rainwater or other precipitation mixes with waste, leachate is formed. Though landfill operators seek to minimize leachate generation by covering waste daily, this is only effective up to a point. In theory, once a landfill is capped, water can no longer enter, and thus a landfill ceases to generate new leachate. However, as discussed more in later chapters, landfill caps always allow a certain amount of moisture into the landfill, thus continuing to create leachate.
If a landfill liner fails, the leachate collection system cannot work as designed. Leachate is supposed to move to the bottom of the landfill and slide off the plastic liner to collection pipes. However, if a liner has cracks or holes, the leachate can drain outside of the landfill, rather than being funneled into the collection system (Lee 2005).

Even if the liner is currently intact, the leachate collection system can still fail. Drainage and collection pipes can become clogged by silt or microorganisms, weakened by chemicals, or crushed by overlying waste and soil. Leachate pumps that drain collected leachate out of the landfill can also fail, allowing leachate to build up and leak. All of these circumstances cause leachate to pool at the bottom of the landfill, placing additional pressure on the liner, and eventually leading to a failure in which leachate is released into the soil (Montague 1989). Some states have regulations requiring landfill operators to notify nearby residents when a leachate leak occurs (deFur 2003). However, this provision is useless if leaks are not identified.

Collection system failures are difficult to detect and often require extensive testing, which can be expensive and time consuming with no guarantee of success. For example, a lack of leachate flow through the collection system can be misinterpreted as an end to leachate generation, when in fact a pipe may be blocked. If a landfill does not have manholes connecting the collection pipes, there is no physical way to find out if the collection system is intact. TV cameras and specialized "snaking" tools can be used to find a blockage and clear it, or a chemical tracer can be added to the waste to see if it reaches the collection system, but both of these methods require extra money that landfill operators may not be willing to spend.

Groundwater detection or monitoring systems are intended to identify liner and leachate collection system failures. Monitoring wells can only detect leaks if the leachate passes by one of the monitoring wells surrounding the landfill. A typical plume of leachate in sand, gravel or silt soils is between 10 and 20 feet wide (Lee 2005). Thus, if monitoring wells are placed 200 feet apart,

Landfill Failures – In Their Own Words

For the past 20 years, research on Subtitle D modern landfills has continually concluded that all liners eventually fail.

When adopting the Subtitle D regulations, the Environmental Protection Agency wrote in the 1988 draft regulations (USEPA 1988):

Even the best liner and leachate collection system will ultimately fail due to natural deterioration.

The U.S. Geological Survey wrote in 2003 (Christenson):

Modern landfills are designed to minimize contamination of ground water, but modern landfills eventually may leak contaminants in the environment.

as per government regulation (requirements range between 100 to 200 feet depending on the state), and each well monitors a one-foot area, even a 20-foot wide flume could easily pass between wells without detection (see Figure 5).

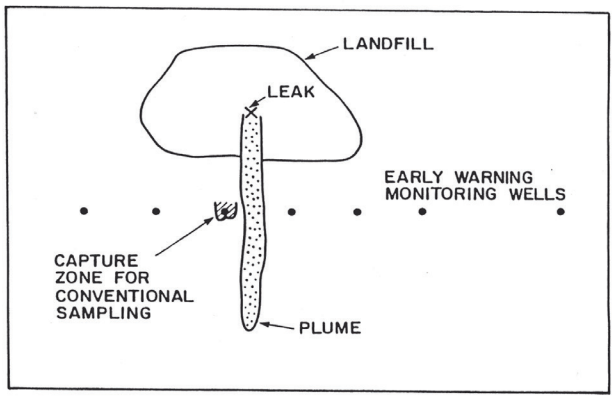


Figure 5: Leaking Leachate Escapes Detection (Lee 2004)

Leachate and other pollutants also pose a threat to groundwater upon leaving the landfill. Spills can occur while handling leachate, and the ponds that hold leachate, usually lined with HDPE sheeting, can leak and contaminate groundwater. In addition, ponds for storm water can flood and contaminate surface and goundwater (Lee 2005).

Due to the unreliability of groundwater monitoring, some states, such as Michigan, require landfills to contain a double-plastic liner, with a leak-detection system between the two layers. The very fact that these leak-detection systems catch failures from the upper liner illustrates the vulnerabilities of liners and importance of locating leaks before groundwater contamination occurs (Lee 2002).

Leachate Problems

"A landfill is a bathtub in the ground, and a bathtub can leak two ways: it can leak through a hole in the bottom (failure of its bottom liner), or it can fill up with fluid and spill over its sides. Either way, it's bad news." - Peter Montague (1989)

Toxic Leachate

When moisture filters through a landfill and mixes with decomposing organic waste, plastics, batteries, electronics, diapers, cleaners and a multitude of other items, the leachate formed can contain bacteria, heavy metals and other carcinogenic compounds. Even assuming that no items classified as "hazardous waste" by RCRA end up in a municipal landfill (an *extremely* improbable assumption), the combination of water with chemicals from many household products can create toxic leachate.

Leachate can contain a variety of chemical contaminants, depending on the specific waste disposed of in the landfill. Table 2 shows the types of chemicals present in a MSW landfill. The toxicity of leachate in landfills is due in part to the prevalence of industrial and commercial chemicals and toxic products, such as vinyl (also known as polyvinyl chloride or PVC) plastic. PVC is found in pipes and vinyl siding, in addition to everyday products, such as shower curtains, food containers, vinyl flooring, cosmetic packaging, and many kids' toys. PVCcontains plasticizer molecules that easily seep out into the leachate (Meriowski 1999).

The majority of plasticizers are phthalates or heavy metals such as lead and cadmium, both of which the National Toxicology Program classifies as a human carcinogen (ATSDR 2003). When leachate includes these chemicals, it becomes toxic. The Environmental Protection Agency estimates that in 2012, 870,000 tons of PVC went to landfills (USEPA 2014a).

Another major source of toxicity in leachate comes from discarded electronic items. Table 3 lists some of the hazardous chemicals found in such waste. In 2012, 2.42 million tons of unwanted consumer electronics were discarded in landfills, estimated at 1.5% of the municipal solid waste

stream (USEPA 2014a). Electronic waste, or *e-waste,* encompasses not just computers, but a broad range of devices, including refrigerators, washers, dryers, air conditions, cellular phones, televisions, foluorescent lamp bulbs, and personal stereos. Cathode ray tubes (CRTs) found in computer monitors, televisions and other display devices, contain significant amounts of lead and heavy metals. While appliances containing CRTs are classified as hazardous waste, they often end up in MSW landfills.

A computer monitor or television screen contains an average of 4 to 8 pounds of lead. When monitors are crushed in landfills, the lead is released and, as an EPA publication notes, can "leach out under conditions typical of municipal landfills" (USEPA 2000). Consumer electronics have been estimated to account for 40% of lead and 70% of heavy metals found in landfills (Scanlon 2001).

Table 2: Sample of Chemicals Found in MSW Landfill Leachate

Chemical	Sources	Health Risks
Cobalt	Magnets, cutting tools, alloys, colored glass or ceramics	Heart and lung damage, dermatitis
Ammonia	Fertilizers, household cleaners	Skin, mouth, lung and throat irritation
Arsenic	Wood preservatives, pesticides, sawdust	Skin discoloration, blood vessel damage, abnormal heart rhythm, cancer
Lead	Cathode ray tubes, batteries, metal pipes, old paints	Brain and kidney damage, muscle weakness, decreased mental abilities
Mercury	Electronics, thermometers, batteries	Brain and kidney damage, lung damage, skin rashes
Toluene	Paint, lacquers, adhesives, fingernail polish, paint thinners	Fatigue, weakness, confusion, memory loss, nausea
Benzene	Plastics, resins, nylons, rubbers, dyes, lubricants, pesticides, detergents	Anemia, leukemia, bone marrow damage, immune system damage
Di (2-ethylhexyl) phthalate (DEHP)	Plastic products like tablecloths, floor tiles, upholstery, dolls, shoes, rainwear	High, prolonged levels may cause liver damage

Note: This table represents some of the typical chemicals found in leachate. The composition of waste and its decomposition time can cause leachate composition to vary greatly from landfill to landfill.

Source: Kjeldsen (2002), ASTDR (2004b, 2004c, 2007b, 2007,1999a, 2000a, 2007a, 2002a) (in order of chemicals listed, top to bottom)

Table 3: Select Chemicals Found in Landfill Leachate from Electronic Waste		
Chemical	**Sources**	**Health Risks**
Cadmium	Plastics in computers	Kidney disease, lung damage, fragile bones
Chromium (VI)	Anti-corrosion agent in steel computer parts	Allergic reactions, bronchitis, respiratory problems, DNA damage
Lead	Glass panels in screens and monitors	Severe brain and kidney damage, miscarriage, high blood pressure, anemia
Mercury	Circuit breakers, switches, other electronic equipment	Brain and nervous system damage, kidney problems, ulcers, high blood pressure
Polybrominated Diphenyl Ether (PBDE)	Flame retardant additive in plastics and textiles	Liver and thyroid problems
Polychlorinated Biphenyls (PCBs)	Though banned by Congress in 1977, PCBs exist in older electrical equipment	Negative effects on the liver and endocrine system; skin and eye problems; impaired immune system; neurological effects in children; low birth weight; reproductive organ damage; cancer
Source: ATSDR (2008, 2007, 2004a, 2000, 1999, 1999a), Scanlon (2001)		

Unfortunately, heavy metal contaminants do not break down into inert forms, but rather continually contaminate the surrounding soil and water (Lee 2004). Furthermore, treatment systems for leachate are often unable to remove heavy metals (Anthony 2001).

A study done in the early 1990s on the toxicity of MSW leachate found that all samples were acutely toxic; three of four were genetically toxic, and two of four contained concentrations of US EPA priority pollutants exceeding standards for drinking water. Based on their results, the authors concluded that leachate from MSW landfills was as acutely and chronically toxic as that of hazardous waste landfills (Schrab 1993).

Just the mere inclusion of MSW landfill sites on the Superfund National Priorities List indicates that dangerous toxic contamination does occur at these landfills. Superfund sites are the worst of the worst among toxic contamination sites in the country. MSW landfills that are on the Superfund list include the Marine Corps Logistics Base landfill in Georgia, Operating Industries, Inc. landfill in California, and the "Hastings Groundwater Contamination" landfill in Nebraska (Wang 2009). In EPA Region I (Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont), 17 out of the 117 Superfund sites were once municipal solid waste landfills (USEPA 2010e). According to the EPA, approximately 20% of all Superfund sites are MSW landfills (USEPA 2015).

Toxic Leachate and Groundwater Contamination

"It is prudent public health policy to assume that any contamination of groundwaters by MSW landfill leachate represents a hazardous situation to the public health of those who consume the waters, even if the concentrations of all regulated contaminants measured in the groundwater are below the drinking water standards."
- Dr. Fred Lee (1994)

Though the public health risks of toxic leachate remain largely unknown, it is important to remember that all chemicals can be toxic to human health, depending on the concentration and duration of exposure. There are over 84,000 chemicals used in the manufacturing and processing of everyday products, and fewer than 200 of them are measured when testing groundwater for leachate contamination (USEPA 2010a, Lee 2010). Groundwater near landfills may have thousands of chemicals at unknown concentrations, yet if the tested chemicals for established drinking water standards are at low enough levels, water is considered "safe". Furthermore, different chemical contaminants have differing health effects, and people drinking contaminated water may be exposed to different concentrations.

In addition to risks from chemicals, landfills also contain biological contaminants. Landfill waste includes fecal matter from diapers, septic tanks and pet manure. While bacteria and viruses found in fecal matter have a short lifespan, cyst-forming protozoa can survive and mix into the leachate (Sulfita 1992). These risks may be small, but they cannot be ignored.

When leachate-contaminated groundwater discharges to surface waters, such as springs, aquatic life can be impacted. Toxic chemicals can bioaccumulate (become concentrated) in the aquatic life, and as the fish are eaten, move up the food chain, which impacts people who live outside of the immediate proximity of the landfill. Other negative effects of leachate contaminated water include aesthetic problems (odor, discoloration, etc.) and a shortened lifespan of appliances, plumbing and washed clothes (Lee 1994).

While studies have not definitively "proven" a link between leachate-contaminated groundwater and health problems (see Appendix A), the known health effects of many contaminants found in groundwater from leaking landfills highlight the need to employ a precautionary approach. Why place the public at risk, knowing that all landfills will eventually leak, when safer alternatives (recycling, compost, etc.) exist?

Holding Ponds and Leachate Disposal

Leachate disposal can take many forms. Many times leachate is collected and sent to wastewater treatment plants to be treated, though this can adversely impact the plant due to the high levels of ammonia found in leachates (Abbas 2009).

Another disposal option involves letting the leachate stand in a holding pond for a period of time so that microbacteria can breakdown the chemical compounds. Leachate collection systems funnel the leachate to pipes, which then deposit the waste runoff into a pond. These open air ponds also allow the leachate to evaporate into the air, thereby reducing its volume and creating a more solid sludge that is then dumped back into a landfill, or even burned (Abbas 2009). These volatile chemicals are released into the air as another source of air pollution.

Upon arriving at the holding pond, the leachate may be sprayed out of the pipe and through the air. Spraying the leachate causes its volatile components - compounds which can be toxic – to evaporate quickly and pollute the surrounding air.

Besides sitting in holding ponds, leachate may also be transported to another part of the landfill where it is then sprayed over the trash (ESD 2007). Besides not solving the issue of leachate, the spraying of the leachate creates air pollution that can affect nearby residents.

None of the leachate disposal methods discussed above truly address the issue before them: what to do with leachate in the long run. Leachate, even if reduced in volume or treated by a wastewater facility, still leaves behind a residue that must be dealt with (Abbas 2009). As with the landfill itself, these are temporary fixes for a long-term problem.

Landfill Gas and Air Emissions

Unfortunately, leaking leachate is not the only problem plaguing landfills. Gas emissions are always released during the decomposition of waste. In addition to being an odor nuisance, these greenhouse gases can contain toxic contaminants harmful to the health of those who breathe the surrounding air. Like liners and leachate collection systems, measures to contain gas emissions are moderately successful at best. Fugitive emissions from landfills continue post-closure. Today's waste will contribute to global climate change and air pollution for many years into the future.

Landfills emit gasses for three reasons (ATSDR 2001):

- Bacteria break down organic waste, releasing methane and carbon dioxide.
- Certain chemicals in landfills are *volatized* when they break down, changing from a liquid or a solid into vapor.
- Certain chemicals combined in a landfill react with each other to form a gas.

Of the three, the first category – decomposition – represents the largest proportion of landfill gas generation. Decomposing organic waste produces methane and carbon-dioxide. Each gas compromises 40-60% of the total emissions, depending on the make-up of the waste. Methane is only produced by anaerobic (oxygen-independent) bacteria, so very dense landfills which allow little oxygen access to its waste may produce more methane than carbon dioxide. Other factors influencing the amount of gas emissions include moisture content (more water leads to more bacteria which leads to more gas) and the temperature (warmer landfills promote bacterial growth).

Landfill gas is usually produced under the surface of the landfill. It then tries to move away from the landfill, in a process called *landfill gas migration*. The gas will take the path of least resistance, which is generally upward. This is especially the case with gases lighter than air, such as methane. However, if the landfill is very compact, the methane may migrate sideways to other parts of the landfill or out of the landfill entirely, where it can then move upward. Landfill gas migration has been observed for distances of over 1500 feet (ATSDR 2001). Gases which are heavier than air, such as carbon dioxide, will collect in channels beneath the surface of the landfill.

Landfill gases often permeate out of the top covering of soil on open landfills, leading to air pollution. Due to the questionable long-term success of landfill caps, closed landfills can also allow the escape of landfill gas. After a landfill is capped, grass and other vegetation are usually planted on the surface to prevent erosion. However, landfill gas often seeps through the cracked cover or cap of a landfill. If carbon dioxide continues to be released, it can prevent the plant roots from taking up oxygen. Landfills with faulty caps are often characterized by large swaths of non-vegetated land as a result of landfill gas (Lee 1994).

Landfill Gas and Climate Change

One of the biggest concerns with landfill gases are their contribution to global climate change. Both methane and carbon dioxide are greenhouse gases (GHGs), a term which refers to gases that absorb heat emanating from the earth's surface and then radiate a portion of that energy back down to earth, thereby increasing the surface temperature more so than if the gases were not present. Global warming is attributed in part to this greenhouse gas effect. Municipal Solid Waste landfills were responsible for 17% of anthropogenic (human-caused) methane emissions in 2009, making such landfills the third largest anthropogenic source of methane (USEPA 2012).

Estimates on how much landfills contribute to global greenhouse gas production vary greatly, based on the percentage of gas produced by landfills that is captured through gas collection wells. However, as solid waste planning expert Peter Anderson writes "there is virtually no field data on the amount of fugitive gas emissions from landfills," so the EPA claim that 75% of landfill gas is captured may be grossly overestimated (Anderson 2007).

"Large" (at or above 2.5 million cubic meters for capacity) landfills are not required to have a gas collection system in place for the first five years of active waste storing (or, if the landfill closes within two years, then two years after initial garbage collection). Moreover, after a landfill closes permanently, "the [gas] collection and control system must have been in continuous operation a minimum of 15 years" – a time period that includes gas collection during active waste storing – and NMOCs emission rates need only be below 50 metric tons per year before the gas collection system can be removed. There are significant portions of time that the landfill emits greenhouse gases unchecked. "Small" landfills, or those that emit less than 50 metric tons of non-methane organic compounds (NMOCs) per year, aren't even required to have gas collection systems (USEPA 1996). The Agency for Toxic Substances and Disease Registry (ATSDR) estimates that the peak gas production occurs five to seven years after the waste was dumped.

However, Lee asserts that this model is based on un-bagged, homogenous waste which interacts with moisture (Lee 2005). In reality, dry tomb landfills are sealed off from moisture and waste is often contained in plastic bags. When plastic bags eventually decay, likely decades after the lifespan of the gas collection system, the waste will break down and release gas into the soil (Lee 2002). The Intergovernmental Panel on Climate Change (IPCC) estimates that over the lifetime of a landfill, the gas recovery rate is merely 20% (Bogner 2007).

If 80% of the lifetime emissions from a landfill are released into the atmosphere, finding landfill alternatives seems imperative as citizens, scientists and governments seek to address the issue of global climate change.

Landfill Gas, Air Quality and Public Health

Air pollution from landfills remains a more local, though no less important, concern. Chemicals, even in small amounts, can be transmitted out of the landfill into the air and soil with fugitive methane and carbon dioxide emissions. This places residents of the surrounding community at risk to toxic exposure (Lewis 1998). Captured landfill gas, often vented straight into the air, also places residents at risk. Many landfills do not have high enough stacks to adequately dilute these gaseous pollutants through dispersion. Thus, much of the polluted air remains near the landfill site (Raloff 1999).

Low levels of organic compounds are present in landfill gases, including a number of hazardous air pollutants (HAPs) and volatile organic

compounds (VOCs). Table 4 shows common volatile organic compounds found in landfill gas. According to the EPA, these include suspected and probable carcinogens such as toluene, benzene, chloroform, carbon tetrachloride, vinyl chloride (much of which originates from PVC), perchloroethylene, and methylene dichloride (USEPA 1995). Even though these chemicals make up a small portion of landfill emissions, most can have toxic effects at very low levels.

Odors and Particulate Matter

The extent of health effects from landfill gases depends on the toxicity of the chemicals and the extent of exposure. Methane is a major contributor to the formation of ozone, which can cause or aggravate respiratory conditions (ATSDR 2001). Landfill odors can be overpowering for those living and working within a mile of a landfill, especially where a landfill has been built with insufficient buffer land surrounding it (Lee 2005). Odors are likely caused by landfill gases like sulfides (which produce the rotten egg smell), ammonia, and certain NMOCs, such as vinyl chloride (ATSDR 2001). In addition to causing headaches, nausea and sleep disturbances, strong odors can trigger asthma attacks.

Landfill dust is created when waste is dumped, when the daily cover is removed or added, and from truck traffic. The presence of this dust could create a nuisance or possible health threat to property owners nearby. Substantial amounts of litter can blow off the top of open landfills on a windy day (Lee 2005).

Moreover, landfill odors serve as a reminder of the economic and psychological implications of living near a landfill – including lower property values and social stigma. In a study in Pennsylvania, landfills negatively affected property values for almost a 2-mile radius, farther and more significantly than roads or factory farms (Ready 2003).

Table 4: Common Volatile Organic Compounds Found in Landfill Gas
(Number of times found in 46 landfills)

Trichlorofluomethane (46)	Carbon tetrachloride (37)
Benzene (45)	1,2-dichloroethene (37)
Trichloroethene (44)	Chloroform (36)
Vinyl chloride (42)	1,1-dichloroethane (33)
Toluene (40)	1,1-dichloroethene (32)
Tetrachlorethene (39)	Ethyl benzene (31)
1,1,1-trichloroethane (38)	
Methylene chloride (37)	Chloromethane (30)
1,2 dichloroethane (37)	

Source: EPA (1990)

Burning Landfill Gas

Landfill gas may also contain various heavy metals, such as mercury. Mercury is a potent neurotoxin (nerve poison). Mercury in its elemental form is present in many products, including thermometers, the currently popular incandescent light bulbs, and batteries (Raloff 2001). When these products are disposed of in landfills, microbes in the landfill can convert the mercury to its highly poisonous methyl mercury form (Lindberg 2001).

A 2001 study found that high concentrations of methyl mercury, 1,000 times higher than any concentration of methyl mercury ever found in ambient air, were present in the water vapor condensed from landfill gas in Florida (Raloff 2001). This study indicated that landfills are likely

a major source of methyl mercury in air and rain.

Flaring (burning) landfill gas can destroy methyl mercury, but not inorganic (elemental) mercury. Mercury is released from products when crushed in the landfill and it can easily dissolve in leachate and contribute to water and soil contamination (NEWMOA 2006). The major route of exposure to methyl mercury for most Americans is from eating contaminated fish or shellfish, but people living in areas surrounding landfills or other industry may be affected from associated air and water pollution.

Exposure to high levels of mercury in all its forms can cause permanent damage to the brain, kidneys, and developing fetus (passed from an exposed mother). There is also evidence that methyl mercury may damage the cardiovascular system in both adults and children (NRC 2000).

Flaring landfill gas can also release dioxins and furans, which are by-products of burning plastics such as PVC, polychlorinated biphenyls (PCBs), and brominated flame retardants (BFRs). Dioxin, a name given to a family of chemical compounds, is one of the most dangerous chemicals produced by humans. Its most toxic form, tetrachlorodibenzo-p-dioxin or TCDD, is a known human carcinogen (NTP 2005). Exposure to dioxin is also associated with reproductive and developmental health problems and can impair the immune system (Birnbaum 2003).

Landfill gas has the potential to cause serious physical injury due to its high level of combustibility. Fires in landfills can occur spontaneously, placing landfill employees and nearby residents at additional risk for toxic exposure. FEMA estimates that an average of 8,400 landfill fires occur each year (FEMA 2002). Landfill fires also generate dioxin and dioxin-like compounds, and could be a large source of such compounds (USEPA 2006b). Regardless, the fact that landfill fires produce such noxious byproducts enhances their danger and underlines their seriousness (USEPA 2006b).

Working at a Landfill

Some studies have also found associations between working in a landfill and various health problems. One study found those employees who worked at a large municipal landfill experienced higher rates of work-related dermatologic, neurological, hearing and respiratory symptoms, and sore/itchy throats than off-site employees (Gelberg 1997). Another study of landfill workers in Virginia found elevated work-related dermatological, neuromuscular, respiratory, hearing, and gastrointestinal symptoms and injuries (Kitsantas 2000).

The fatality rate for sanitation workers has been up to ten times higher than the national job fatality rate (IBT 2008).

Landfill Gas Migration

Landfill gas can also migrate into the ground through porous soil, fractured rock and other pathways (ATSDR 2001). Gases which migrate through the soil can enter buildings through cracks in the foundation or basement. If leaked landfill gas (composed mainly of methane) mixes with oxygen and builds up in a small space (utility pipe corridors, crawl spaces, basements, etc.), it can cause an explosion. Though rare, these explosions can result in property damage, serious physical injury or death. A study by the USEPA identified 40 methane migration-related explosions and fires between 1967 and 1984 (USEPA 1990).

Asphyxiation can also occur if either methane or carbon dioxide accumulates in small spaces (USEPA 1990). Carbon dioxide is denser than air, so it can remain in a location even after the space has been opened to outside air circulation. High carbon dioxide concentrations can result in a range of serious physical symptoms – headaches, dizziness, rapid heartbeat, difficulty breathing, unconsciousness and even death.

Cover/Cap Failure

"A dry tomb landfill will, through leachate and gas releases, be a threat to public health and the environment forever."– Dr. G. Fred Lee (2005a)

When a landfill is closed, a cover of plastic sheeting or clay is used to "cap" it. According to dry tomb design, water that filters down through the vegetation to reach the cap should slide off to the sides and into the nearby soil. However, in addition to problems occurring from faulty installation, many different failures can occur with a landfill cap, including, as adapted from Montague (1982):

- Cracking of the cap due to settlement of waste and drying
- Collapse of the cap due to settling of waste
- Pooling of water in depressions
- Erosion due to weather
- Burrowing animals, trees and plant roots penetrating the cap
- Deterioration of the plastic
- Problems when structures or parks are built on top

In accordance with Subtitle D regulations, monitoring of the landfill cover occurs for 30 years after closure. This usually consists of visually looking at the vegetation and filling in any obvious cracks or depressions with additional soil. However, there is no monitoring of the actual cap, which is the layer preventing moisture from reaching the waste and becoming leachate.

If the cracks occur after the 30 year post-closure monitoring period, an increase in leachate would not be detected, posing a public health risk (Lee 2005).

When the cap inevitably deteriorates, the moisture which enters helps speed up decomposition of waste in formerly "dry" cells. This generates landfill gas that may have been dormant for years, which can migrate into the soil, groundwater and air.

Capped landfills are often viewd as ideal locations for new housing developments, schools, and parks. However, the risks of soil, water and air contamination remain high and development should be limited if not avoided. For example, agricultural activity (including gardening) should not occur, since gas emissions can damage crops (Lee 2005).

The Difficulty in Proving Adverse Health Effects

Few studies have detected, with certainty, increases in adverse health effects in populations living around landfills. This is due primarily to the limited ability of epidemiological studies and other methods to accurately assess the health impact of exposure to toxic chemicals leaking from landfills. Nonetheless, there have been a good number of studies that have identified increased risks in populations living near landfills.

Health studies are notorious for not 'proving' harm from a landfill. Small populations of affected people, the long latency period that occurs before many cancers manifest, and privacy concerns are just a few of the challenges communities encounter when trying to show a statistically significant, and thus credible, connection between health problems and landfill proximity (Montague 1989a).

In 1995, a study was published on cancer rates in people living near a municipal solid waste

landfill located in a densely populated area in Montreal, Quebec (Goldberg 1995). Due to the fact that the area derived drinking water from other sources, the main exposures of concern for nearby residents were derived from the landfill's release of gas into the air and soil, noise, diesel fumes, and dust. Exposure risk was characterized by proximity to the landfill. Elevated risks for cancers of the stomach, liver and intrahepatic bile duct, trachea, bronchus, and lung were found for males living closest to the site. Additionally, in one of the "proximal exposure subzones," prostate cancer was elevated. In women, rates of stomach and breast cancer were lower than expected. According to the authors, a previous study had also indicated increased low birth weight for children born to mothers living near the site. In both studies, however, it was not possible to definitively link the excess cancer and reproductive effects to the landfill gas (Goldberg 1995).

A study of residents living near 38 landfills with soil gas migration in New York State in the years 1980-1989 found some evidence of elavated cancer incidence rates. Most of the landfills included in the study were constructed prior to 1970 and were not lined or capped and only 22 had gas collection systems. At the time of the study, none of the landfills were active (open). Results showed increased incidence of bladder cancer and leukemia for females living within 250 feet of the landfill boundary. However, lack of data on smoking, presence of other contaminants, and length of residence created uncertainty in the strength of association between the landfill and cancer rates (Lewis 1998).

In 2000, an exploratory study evaluated the severity and frequency of respiratory symptoms occurring over a 12-month period among residents of Staten Island, NY who reported having asthma, severe breathing, or other respiratory conditions. Responses indicated that residents who lived adjacent to the Fresh Kills municipal solid waste landfill and those from the north-shore (seven miles from the landfill) had differing health problems, with landfill residents reporting higher rates of certain odors and eye, nose and throat irritation. The authors concluded that further investigation of respiratory illnesses should be conducted, as the study showed high rates of respiratory-related symptoms and conditions (Berger 2000). For more health studies, see Appendix A.

Health Studies of Populations Living Near Landfills

Studies have been published that have found a link beween living near landfills and adverse health outcomes. Many of the studies are annotated and included in Appendix A. Several of these studies are briefly described below.

A study in Great Britain compared populations living within 1.2 miles of 9565 landfill sites, to those living farther away, in an effort to determine the risk of birth defects in relation to living in close proximity to a landfill. The study examined data from hazardous waste, municipal waste, and unknown waste sites. The authors found slight increased risks for neural tube defects, abdominal wall defects, and low and very low birth weight. They also concluded that, "findings for special [hazardous] waste sites did not differ from those for non-special sites" (Elliot 2001).

Another study in Cumbria, northwest England examined the risks of stillbirth and neonatal death for mothers living near landfill sites. For the period 1970-1993, a small but significant increase in risk of "other congenital anomalies of the nervous system" was found in mothers living near domestic waste landfill sites. This finding was consistent with other research, but a causal effect could not be inferred and the possibility that the results occurred by chance could not be ruled out (Dummer 2003). More studies are listed in Appendix A of this guide.

Chapter 5

The Flow of Waste

Transfer Stations

After garbage is collected from the street, it is often taken to a transfer station. There the garbage collection trucks "tip" their waste load onto the "tipping floor," and drive off. The garbage is then swept into a lower level compartment, compacted into tight bales of trash, and loaded into tractor-trailers or rail cars. These vehicles then transport the garbage to distant landfills, or other waste disposal facilities such as incinerators (Gornto 2010).

Transfer stations may process large amounts of waste for an urban area. Community concerns around transfer stations include odors, noise and emissions from heavy truck traffic (McCarthy 2007). Communities are right to be worried; health studies conducted in New York City and London have show elevated levels of particulate matter (miniscule bits of liquid or solids such as smoke, water, dust, and other pollutants) near waste transfer stations. Airborne particulate matter (PM) is considered a type of air pollution and has been shown to harm the respiratory system. A recent study in Erith, London found that the PM from a transfer station there contained trace amounts of metals like lead, and concluded "WTS [waste transfer station] activity should be considered a potential health risk to the nearby residential community" (Godri 2010).

For more information about transfer stations, view CHEJ's *Waste Transfer Stations* fact pack: http://chej.org/assistance/publications/135-waste-transfer-stations-fact-pack/

Exporting Urban Garbage to Rural Areas

In 1994, the Supreme Court overturned flow control laws, which had allowed municipalities to designate where solid waste generated within their jurisdiction was taken. This was generally used to guarantee MSW (and thus profit) for specific disposal sites, which had been paid for by revenue bonds. Opponents argued that it created local monopolies and violated interstate commerce clauses of the Constitution (McCarthy 1995).

While the pros and cons of flow control laws continue to be debated, the outcome of the 1994 ruling has contributed to three trends in waste management:

- A shift from many small local landfills to a few large regional disposal sites.
- Consolidation of waste management companies.
- Increased distance between MSW collection and disposal, often across state lines.

Private waste management companies may choose to ship waste to their own facility, even at a greater distance, than pay to dispose locally in a landfill owned by a competitor (McCarthy 2000). In 2005, over 42 million tons of MSW crossed state lines, over 17% of all generated waste. Most travels from urban areas to rural landfills: New York City sends its waste to Pennsylvania and Virginia, Chicago exports garbage to Wisconsin and Illinois (McCarthy 2007). As a result, lower-income rural communities often shoulder a disproportional share of the environmental burden and health risks associated with landfills.

Sending Trash Abroad

Most municipal waste generated in the U.S. stays within our borders.[1] However, exporting items abroad for recycling is a growing trend. This is especially true for electronics and certain plastics, which are sent to developing countries. Whether these exported electronics are actually recycled or dumped is a question (see Silicon Valley Toxics Coalition). If these electronics get dumped, this is unacceptable. Other countries often have less stringent guidelines about handling hazardous items than here in the U.S., placing workers at risk of toxic exposure.

The issue of e-waste disposal is burgeoning. Global e-waste generation balloons every year by roughly 40 million tons. The United Nations Environment Programme released a report in 2010 forecasting a 500% increase in e-waste for India, compared to 2007. Places like Nigeria, Brazil, China, and Mexico would also see sharp increases (UNU 2010). E-waste from the U.S. exported abroad is a contributor to this growing problem, but things are changing. The EPA has assisted in the identification and disruption of the illegal collection, recycling, export, import, and shipping of e-waste (USEPA 2014b). Starting in 2012, 240 tons of illegally-traded e-waste was seized and 40 companies were criminally investigated (USEPA 2014b).

Profiting from Garbage

Before being brought to a landfill or recycling center, garbage must be collected and sometimes stored. These services can be provided by the local government, a private firm contracted by the government, or a private firm that has contracted to residents (LGEAN 2003). In the late 1960s to early 1970s, the "corporatization of garbage" (Rogers 2005) led to large national companies replacing thousands of small private waste management providers (Hickman 2000). These large waste management companies have been in fierce competition ever since, frequently merging and buying each other to become even larger. This has resulted in a virtual takeover of the waste management market by a small number of large, private firms.

Waste management firms make money in direct proportion to the amount of waste that gets thrown away and make the most money when garbage is placed in landfills, as opposed to composted or otherwise diverted. Their pursuit of profit is clearly reflected in their priorities today. It is much more appealing to these companies to invest in landfill technology such as bioreactors, which allow them to fit more garbage in each landfill, than in waste reduction strategies (Rogers 2005).

1 With a few exceptions involving agreements between states and Canadian provinces

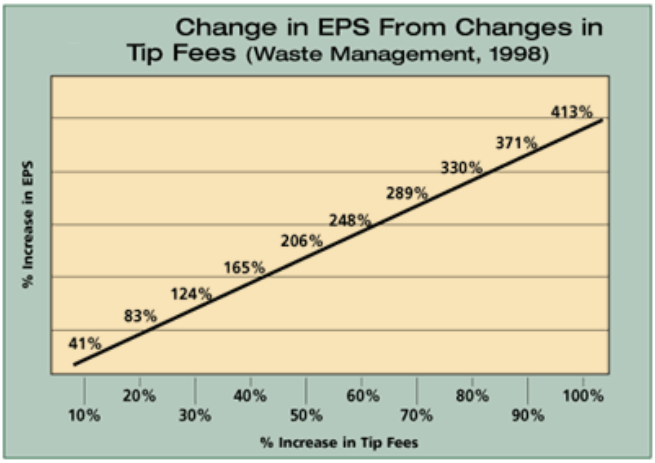


Figure 7: WMI Changes in Earnings Per Share From Increased Tip Fees

Case Study: Waste Management, Inc.

In 2015, out of 100 firms dealing with MSW, the top ten comprised 83.6% of industry revenue at $44.6 billion. Waste Management was first on the list at just under $14 billion, while Republic Services came in second at $8.8 billion (Waste360 2016). These firms take an integrated approach, operating not just landfills, but local garbage collection, recycling, transfer stations, and transportation, often across state lines.

The largest waste management company in the United States is Waste Management, Inc. (formerly WMX) of Houston, Texas. A massive global corporation, Waste Management offers collection, transfer, disposal, recycling, and "renewable" energy services. They operate 390 collection operations, 300 transfer stations, 267 active landfill disposal sites, 120 recycling plants, 17 waste-to-energy plants (burning garbage), and 113 "beneficial-use landfill gas projects" (burning landfill gas) (WMI 2011, 2013, 2014).

Despite efforts to market their company as "green", the abuses of Waste Management are longstanding and pandemic. The corporation has a documented history of ignoring environmental laws, monopolizing the waste disposal industry in communities and then raising prices, placing landfills and transfer stations in low-income and/or minority neighborhoods, and lobbying the federal government on environmental policies.

The corporation has 75 current sites on the Federal Superfund register (in addition to 3 proposed and 9 removed sites). Also, according to the center for Responsive Politics, WM spent over $12.2 million in lobbying between 1998-2014, and almost $4.5 million in campaign contributions during the same period (CRP 2016, 2015). Waste Management was inducted into the Corporate Accountability International (formerly INFACT) Hall of Shame in 1996, "because of its long history of manipulating policy affecting the environment and public health, while engaging in practices that are detrimental to both" (Infact 1998).

For information and local news articles about Waste Management, Inc, visit the Stop Waste Management at: http://www.stopwmx.org/waste-management/

Chapter 6

Communities Fighting Back

As evident from the preceding chapters, landfills are unsustainable, unreliable, unsafe, and provide false "solutions" to our increasing waste stream. Fighting their construction is the first step towards moving to a zero waste approach, and as the following case studies show, resistance to landfills is fiercely alive.

Big Run Landfill, Kentucky

Group
Citizens of Boyd County Environmental Coalition, Inc. (CBCEC)
http://www.citizensofboydcountyenvironmentalcoalition.com/

Background
Managed by EnviroSolutions Inc. (ESI), Big Run Landfill recieved its permit for construction in 2001, started operating in 2004, and was granted a second permit for expansion a year later. One of the busiest sites on the East Coast, the landfill takes in more waste than any other landfill in the state. At an average of 3,298 tons per day, the amount of waste brought in by the company reached 1.5 million tons in 2014. During that year, 90.25% of the total waste collected was imported via railroad from out of state.

Environmental Concerns
For the citizens living within and around Boyd County, receiving excessive amounts of waste from other states apart from Kentucky causes much concern. In most cases, odors and gases emitted from landfill waste are substantial enough to draw complaints from the community. But in this case, when the majority of the waste within the landfill comes from out of state and continuously adds to the problem, the effects are magnified - creating a much bigger need for control.

There were 135 complaints filed against Big Run in 2013. That same year, the landfill suffered a major trash landslide, which affected 8 acres of land on-site. Since then, complaints about odors originating from Big Run have increased greatly - a total of 593 complaints were filed during 2014.

Community Organizing
In efforts to protect the community and show opposition to the landfill, CBCEC has filed a number of complaints, as well as requested the Boyd County Fiscal Court to reduce the volume of imported MSW to the landfill. They have also asked the Division of Air Quality (DAQ) to reconsider a 2:1 dilution ratio, in place of the 7:1 ratio set by the Kentucky Department of Environmental Protection.

Working with Ohio Valley Environmental Coalition and the Appalachian Mountain Advocates, CBCEC filed a lawsuit in June 2015 against ESI on the premise that the permit granting Big Run expansion in 2005 was unconstitutional.

Keeping in touch with the community through their Facebook page, the coalition posts about current happenings in regards to nearby landfills and environmental health, as well as reminders about what members can do to alert authorities of the continued impact of Big Run on their community. They encourage members to call and report odors to the DAQ. According to CBCEC's Facebook, there were 3,211 calls made in 2015 alone.

Current Status
An agreement was reached in November 2015 between CBCEC, the Fiscal Court of Boyd County, and River City Disposal LLC with goals to decrease the size of the landfill, as well as create a safer environment for the community. Under this agreement, the importation of MSW by rail will cease to be a part of the company's operation by July 2016, as Big Run is no longer allowed to accept sewage wastes from areas outside of Boyd and surrounding counties. The agreement also allows county and CBCEC personnell to visit the landfill and inspect ongoing operation in order to verify compliance.

Increased environmental protection systems will also be put into place. There will be fence line monitoring for hydrogen sulfide and methane, as well as the further develpment of a project resulting in better air quality. ESI has partnered with Enerdyne Inc., a company that specializes in the creation of gas control and collection systems, in hopes of capturing the waste gas produced by the landfill.

Complaints from community members have decreased since the creation of the agreement as the surrounding environmental conditions are slowly improving. Though still working towards their ultimate goal of closing the Big Run landfill, this agreement was a huge victory for CBCEC.

Sunshine Canyon Landfill, California

Group
North Valley Coalition of Concerned Citizens (NVC)
http://www.nodump.com/

Background
Owned by Republic Services Inc., Sunshine Canyon Landfill (SCL) is a giant city/county landfill built on top of the L.A. city and county border. Over the years, both city and county sides have been closed and reopened, due to the division in governing power. The City closed its dump between 1991-1999, followed by an expansion in 2006. The County side reopened for expansion in 1995, and over a decade later in 2009, both city and county sides were combined into the giant landfill it is today. Having to take trash from Lopez Canyon when it closed in 1996, Sunshine Canyon has become one of the largest sites in the nation.

Community Concerns
A plan called Renew L.A. was established in 2005, which called for a limitation on the amount of trash the landfill would be allowed to accept -

hoping to decrease intake by 600 tons per day. However, as of August 2015, it received an average of 8,300 tons of MSW per day - still much more than what Renew L.A. had planned.

Since the opening of the combined city/county landfill in 2009, there have been 8,410 complaints reported against SCL, to both the South Coast Air Quality Management District (SCAMQD) and the landfill itself. 1,795 of those complaints were filed in 2015 alone.

With 2015 seeing the highest number of complaints so far, a group of parents, whose children attend Van Gogh St. Elementary school, came forward during a meeting led by the Community Advisory Committee (SCL-CAC) to address this ongoing issue at Sunshine Canyon. Located only two miles from the landfill, the school is unavoidably exposed to odors from the landfill, and parents are concerned about the lasting effect it will have on the children. Two other schools are located within a two mile radius of the landfill, which causes concern for not only this group of parents, but for the rest of the community as well.

Community Organizing

North Valley Coalition provides technical advice about SCL, as well as advises groups in their efforts to combat the landfill. With the help of NVC, the group of parents from Van Gogh have been gathering data in support of the closure of SCL by looking into past records to find any evidence of noncompliance by the landfill.

A meeting was organized by North Valley Coalition in February 2016, which addressed the health concerns due to living near the landfill. During this meeting, the Van Gogh parents requested an analysis report of the 2013 air sampling data from AQMD, in order to see which toxins they are being exposed to in the air, and how severe those toxins can be to their health. As of late, this has been their biggest focus.

Some members of NVC are also part of the SCL-CAC, a committee comprised of concerned members of the communities surrounding the landfill. Other members of this committee include Republic Services, SCAQMD, and the Los Angeles Unified School District (LAUSD). In order to keep updated with activities associated with the landfill, SCL-CAC holds meetings to discuss current administration and assure compliance. Also, any concerns by community members are addressed during these meetings.

Current Status

SCL is currently participating in a pilot program to test effectiveness of Environmental Products, Inc.'s (EPI) ExtendedEnviro cover. This is in place of the 9 inches of soil used as daily cover material. With hopes to control odors, blowing litter, vectors, fires, and scavenging, the implementation of this geosynthetic cover started in 2015.

Since 2009, the systems for gas control/collection at Sunshine Canyon have continuously been upgraded. Republic has also recently implemented a landfill gas-to-energy (LFGTE) project at SCL, in partnership with DTE Biomass Energy and Aria Energy. The goal of this project is to convert the gas generated by the landfill and turn it into a more renewable energy source. This project is estimated by EPA to immensely decrease carbon emissions of the landfill.

Though the L.A. school district has placed air filters within the Van Gogh's air conditioning system, this does nothing to prevent or reduce exposure to toxins when the children are outside. Members of NVC and the Van Gogh group continue to monitor Sunshine Valley by attending SCL-CAC meetings in hopes that one day, the battle against SCL will end in a victory, as Lopez Canyon did over two decades ago.

Scotland County Landfill, North Carolina

Group
Scotland County of Tomorrow (SCOT)
http://www.nomegadump.org/

Background
In 2007, North Carolinian chapters of Blue Ridge Environmental Defense League (BREDL) and their allies successfully pushed for a statewide moratorium on new, huge garbage landfills called "mega dumps." However, this was only a temporary fix. In early 2010, after the moratorium had lifted, it was proposed that a closed landfill be expanded in Scotland County, North Carolina, near its border with the town of Maxton. This mega dump would help produce revenue for the struggling county. Strong and vocal opposition from both Scotland County of Tomorrow (SCOT) and the Maxton Board of Commissioners squashed the proposition.

Community Organizing
As a chapter of BREDL, SCOT was able to use many of its resources in order to effectively organize their opposition. In March, SCOT hosted a meeting with Neil Seldman, the President of Institute for Local Self Reliance, to talk about environmentally-friendly alternatives to the landfill, such as recycling hubs. SCOT sent copies of this video to local leaders. They also circulated material on the landfill through their website, as well as made posters showing where the landfill would be located, and leaflets asking where commission candidates stood to get votes in the primary. Maxton held a forum in which sixteen people spoke against the landfill, including other BREDL chapter members. The Maxton Commissioners voted unanimously to send a resolution in opposition to the landfill.

Current Status
Their efforts came to fruition in early June, 2010. The Scotland County Board of Commissioners voted unanimously to pass a resolution that officially ended any chances for the regional landfill. They also went a step farther, calling for a ban on any future landfill proposals in the county. Scotland County's fight was the first test for the state after it had passed its Municipal Solid Waste Act of 2007. It was a great success and should give hope to future landfill battles in North Carolina (Calhoun 2010, BREDL 2010).

Pottstown Landfill, Pennsylvania

Group
Alliance for a Clean Environment (ACE)
http://www.acereport.org/

Background
Pottstown has six landfills in a 35-mile radius, the highest concentration in the state. The Pottstown Landfill is an old, unlined forty-acre landfill operated by Waste Management. The site accepted hazardous waste from other states and counties and 17 kinds of radiation were found in leachate testing in 2005.

As early as the 1980's, the Pennsylvania Department of Environmental Protection (DEP) verified that toxic gases were traveling through the soil and into residents' homes. Yet, the DEP did not investigate this, or a host of other resident complaints about air and water quality.

Community Organizing
ACE members are an example of strong, successful grassroots organizing. They refused to share their neighborhood with a landfill that polluted their soil, air and water, and fought extremely diligently to close the landfill down.

ACE's tactics included distributing fliers about the landfill throughout the town, press releases, and attending every meeting possible with the town, county, local commissioners, zoning board, economic development council, etc. Members

made it clear that they wanted the landfill closed, and would not accept a compromise on the issue.

In addition, ACE reached out to community leaders, finding allies who supported their efforts in local politicians, businesses and a hospital. Like the group in Marin County, ACE held workshops and public forums on the issue, educating residents and keeping the landfill problems in the public spotlight even when there seemed to be little progress on the issue.

ACE used the health problems in their community as a platform in fighting the landfill. They focused on the toxic chemicals present in the landfill gas, making maps that indicated disease patterns pointing to the landfill as a primary cause. When Waste Management proposed building a pipeline and selling the landfill gas to a PVC plant on the other side of the town, ACE members organized a massive opposition to defeat the proposal.

Current Status

After twelve years of organizing, ACE declared a victory in 2004 when the DEP denied Waste Management's expansion permit. Since the landfill was at capacity, this meant that it needed to be closed. The DEP had previously never denied Waste Management a permit in its history; so much of this groundbreaking victory can be credited to the hard work of ACE.

ACE members continue today to monitor the closing procedures of the landfill. They are advocating for the filtering of leachate before it reaches the sewer line and drains into the local watershed, testing of drinking water wells within a fifteen mile radius for leachate contamination, and a new cap which will help prevent toxic air emissions.

Chapter 7

Taking Action

Organizing To Win Around Landfills

Every day, people facing threats to their health and environment speak out. They look for proof that a landfill leaks, or seek to undertake a health study to link emissions from an incinerator to cancer, or find evidence that a polluting company has a bad environmental record. However, simply speaking the truth about landfills, incinerators, toxic products or previous violations won't stop the poisoning of our bodies and the environment.

The truth is, it is only a start. In order for things to change, the truth has to be understood by a large group of people who then use this knowledge to fuel their efforts to win justice. The truth won't stop the poisoning, but mobilizing and organizing will.

According to Webster's dictionary, organizing is "uniting in a body or becoming systematically arranged." Organizing to protect our communities from environmental harm means pulling together a large enough, diverse enough, active enough group of people to convince the government and corporations that they have to stop making people sick with negligent waste practices.

Organizing is how we restore the balance between the rights of people to safe environments and healthy communities, and the rights of corporations to profit. We will never have as much money as the BIG Companies. We will never be able to afford their Madison Avenue media campaigns or their twenty-four hour access to elected officials. But we can build our own power to overcome their influence. We can do this by organizing to demonstrate the strength of our numbers and the righteousness of our demands.

Successful organizing happens when a group of people find visible ways to use the truth to wake up the conscience of a larger group. In an era where politics is defined by scandals and sound bytes, organizing can remind the American people that political life is supposed to be about self-government, justice and the common good.

After years of doing it, we've come to the conclusion that organizing is more of an art

than a science. At the same time, there are some basic rules for organizing that usually hold true. These rules are not always applicable, but they are right often enough that you should consider them if you start to get organized around an environmental issue in your community.

Basic Organizing Rules

Power determines the outcome.
If two or more groups care about an issue, and one of them has a lot more power, that group will get what it wants, no matter what the facts are or who will be hurt.

Our power comes from people, while corporations' and government's power comes from money.
Communities need to use strategies that depend on people's creativity, courage and caring. The corporations and government will use strategies that depend on things that can be paid for, like experts and lawyers.

Polluters and government agencies write the rules so they can win using experts and lawyers, which are their strength.
You can assume going in that if you play exactly according to the rules of their game, you will lose most of the time, whether you are at the slot machines in Atlantic City or the hearing process of your state environmental agency. Create your own rules instead.

To win, communities need to work harder than polluters and government agencies do.
Landfill operators and environmental agencies are doing what they do because they are paid. They have done it before, and they know most of the facts before the fight even starts. You are opposing them because you believe your health and your community are at risk. This gives you an unmatched motivation for working harder than they do.

These rules may seem harsh because they are. Sometimes things turn out to be easier than these rules would lead you to expect. But when your community is at stake, it is important to start out vigilant, alert and ready to face the challenges ahead.

Experience has taught us that organizing is not easy. Recognizing this should help you to be forgiving of each other and yourselves. We are trying to build a democratic society without adequate blueprints and models, so our trial-and-error method has to leave room for experimentation and mistakes. Recognizing how necessary organizing is should help you to be inclusive and persistent. There are no magic facts. There are no perfect heroes to give perfect speeches that will convince the polluters to stop polluting. There is only the dogged determination of people working together to protect their own health, their family's health and the health of their communities. This is why we organize.

Ten Key Steps To Organizing

1. Talk and Listen
If you are one, two or three individuals without an organization, you'll need to talk with other people in your community to build a group. If you are already part of an organization, then your next step is to talk to the people in your organization about initiating a campaign around a landfill issue in your community. Brainstorm a list of groups and individuals whose interests are most directly affected by the landfill, and then determine who you need to talk with first.

Who are the people that are most directly affected? Who are the leaders in that neighborhood? What other organizations are involved in protecting the community's health?

You can work out the answers to these questions in a brainstorming exercise at an early meeting

with your group. Brainstorm a list of the groups of people whose self interests are most directly affected, then figure out who has contacts with these groups or individuals.

2. Create and Distribute Fact Sheets
Create an attractive, easy-to-read and accurate fact sheet to educate the community about the problems and how these problems relate directly to their lives. A simple one-page fact sheet will serve the purpose.

3. Recruit People, One at a Time
Recruiting will help you build the relationships, resources and critical mass to act effectively for change. Reach out to a wide range of local groups to build the broadest possible coalition. It will be much more difficult for decision-makers to ignore your concerns if your campaign represents a wide cross-section of your community. All recruiting is a form of door knocking. If you are trying to organize a neighborhood, the doors line the streets. If you are trying to build a different kind of group or coalition, the doors may spread all over town and you may need appointments to open them.

There are several ways to make knocking on doors easier. First, come up with a 'rap'— "I am..." "We are..." "This is..." "We want..." "You can..." Also, consider circulating a petition. Not only will the petition help you get the names and addresses of community supporters and show community support to those in power, it also begins the process of getting the people you are talking with involved in the issue. Make sure to listen closely to the concerns of the people you are talking with and link the landfill problems to their interests and concerns.

4. Hold Meetings That Make People Want to Come Back and Bring Their Friends
People will come to a meeting if:

- They have made a commitment to come
- They have a role or responsibility in the meeting
- They have an immediate and specific self-interest in the work of the organization
- They have past, positive experiences with similar meetings

To have a successful meeting, your recruitment efforts must satisfy the first and third of these conditions. The second and fourth conditions will depend on how you run the meeting. There are several different kinds of meetings to suit different purposes.

House Meetings - This is the kind of meeting many groups hold when they are first forming. The meeting is held at a member's house and the style is informal. One of the biggest benefits of this kind of meeting is the greater comfort level among members.

Planning Meetings - Leaders or other key decision makers within the group get together to set their agenda, review the work that has been done, and plan activities. Planning meetings should not be decision-making meetings, but rather they should establish the agenda and process by which decisions will be made at a general membership meeting, or define a plan to carry out an activity that has already been decided upon by the membership.

General Membership Meetings - These meetings are important to ensure that all members of the organization share the responsibility for decision making and carrying out the activities of the organization. The time and location should always be chosen to accommodate the maximum number of people. The meeting should always start with an agenda, and when possible, get the agenda out to people prior to the meeting in the form of a flier (this will also serve as a reminder for the meeting). Make sure you pass around a sign-in sheet to collect names and addresses of

those who attended so you can contact them in the future. People will come to the next meeting if they enjoyed the first one, if it started and ended on time and was not a bore, if it produced concrete results, if it was lively and exciting, and if it delivered what was promised.

5. Set Goals

It is critically important to have long-term, intermediate and short-term goals to help members understand where they are going and the steps they have mastered along the way. Ask yourselves: What do we want? What is our bottom line? Do we want to deny the permit for a new landfill or landfill expansion? This could be your long-term goal.

Next, identify different strategies and tactics that will lead you to your goal, such as getting your city or county council to extend the public comment period or require a more extensive environmental impact assessment of the proposal. This could be your intermediate or short-term goal.

Groups that successfully oppose landfill expansions often actively support broader issues of waste in their community. Consider advocating a zero-waste policy (see Chapter 10), and expanding municipal recycling and composting programs. If you defeat a landfill proposal, but the waste from your community is sent to a landfill or incinerator in someone else's community, is it really a victory?

Within your group, it is important to come to a consensus on how much you are willing to compromise. For example, your group could choose to accept a landfill if the operators agreed to a double liner, monitoring for 50 years post closure (instead of 30) or leak-detection systems in the cover. We believe that all landfills will eventually leak, regardless of technology. However, you should discuss within your group how, if corporations or government agencies offer them, to approach these compromises, helping to avoid group divisiveness later down the road.

6. Identify Your Targets

Once you have identified what it is that you want, the next step is to identify who can give it to you. Pinpoint the actions and the people that have the power to help you reach your goal. The people who could impede the achievement of your goal are often referred to as the targets of the campaign. This does not mean that they are evil or bad. It simply means that because they have the power to give you what you want. It makes sense to focus your attention and actions on them. The target of your campaign must always be a person or persons. You can't fight City Hall because City Hall is a building, but you can target the person with the power at City Hall to get others to act.

To help your group identify your targets, answer these three questions.

- Who is responsible for the situation you want to change?
- Who can make the changes you want to happen?
- How can you convince them to act on your issue?

7. Research Is an Essential Tool

Research is a tool, not an end product. You need to do research to gather enough information to achieve your goals, not to know absolutely everything there is to know. Research should tell you who has the power to give you what you want and should help you figure out what arguments your targets will probably use against you. Once you know this, you can create counter arguments. This guide will provide general information, but research on your specific local issue needs to be undertaken as well.

8. Take Direct Action

An action is any step you take to advance your group's goals. Petitions, letter-writing campaigns and educational meetings are all actions that advance your group's goals. A direct action is the most dramatic type of action, involving confrontation and demands. Direct action begins after your efforts at education, information sharing and persuasion are ignored. Use direct action when your group is ready to confront a decision maker with its frustrations and to make specific demands. Direct actions move your organization outside the established rules for meetings and discussion. It takes your group into a forum in which you make the rules and where elected representatives and corporate executives are less sure of themselves and how to handle the situation.

Before taking direct action, however, understand the rules surrounding such confrontations. Confer with lawyers or local law enforcement on the legality of your proposed direct action, so that you know exactly what you are doing. Direct action is not for everyone, and your whole group doesn't have to be involved. Make sure those who want to participate are aware of the possible consequences. A direct action often provides the necessary pressure to force your target to act on your group's issue.

9. Target the Media

Who are the media decision-makers who need to be convinced that your story should be covered? What will it take to convince them? In most media outlets, the decision-makers are the editors, and the way you get to them is to spoon-feed them a story they can use without much work.

It is important to develop a media strategy for your campaign that you can constantly refine and develop. But don't be fooled into believing that the media is the only way to get your story out.

Keep creating your own media through fact sheets, cable access television programs, newsletters, call-ins to radio talk shows, letters to the editor, statements at public hearings, barbecues, rallies, auctions, concerts and videotapes.

Also, don't hesitate to use social media to create pressure. Create a FaceBook page or Twitter account to keep people up to date with your group and the status of the issue you're fighting.

- Add us on Facebook: https://www.facebook.com/CHEJfans/
- Follow us on Twitter: https://twitter.com/chej

10. Celebrate the Victories and Keep Applying Pressure

Savor the victories no matter how large or small. A meeting with the City Council is a small victory and denial of a permit is a larger victory. Celebrate all victories because it helps members to see that you are moving forward and winning. No one wants to join a losing organization.

For more information pertaining to organizing, see the following handbooks written by CHEJ:

- *Fight to Win: The Leadership Handbook* *http://chej.org/assistance/publications/002-fight-to-win-leadership-handbook/*
- *Organizing Handbook* *http://chej.org/wp-content/uploads/Organizing-Handbook-PUB-059.pdf*

Chapter 8

Regulations and the Permitting Process

Who Regulates Landfills

Solid waste is primarily regulated by state and local governments. However, legislation passed by Congress (such as RCRA) and EPA-issued guidelines provide minimum standards for landfill management (USEPA 2006). It is important to note that these guidelines are the *mimimum* - you and your community are encouraged to lobby your local leaders and state agencies for more comprehensive regulations.

The following is a brief overview of two important landfill regulations.

RCRA Subtitle D

The key piece of legislation affecting modern landfills is Subtitle D of the Resource Conservation and Recovery Act (RCRA), first implemented in 1976. RCRA has been amended several times, and the EPA developed and adopted the Subtitle D requirements in 1991, with requirements being phased in by 1997 (McCarthy 2000).

Estimated Annual EPA Cost: $330 million (McCarthy 2000)[2]

RCRA affects new landfills or landfill expansion projects, but has little impact on existing sites. Though the number of landfills in the US continues to decline, existing landfills are expanding, thus falling under RCRA regulations.

Location: Landfills must meet certain standards before being sited on flood plains, wetlands, seismic fault zones or near airports (birds are attracted to landfills and can pose a risk to air traffic) (USEPA 2006). It is important to note that landfills are not *prohibited* from being built in these high-risk areas, but merely subject to stricter regulation.

Design: Subtitle D regulations are based on the "dry tomb" approach to landfilling, in which waste is isolated in a plastic-sheet and clay-lined landfill. The regulations require landfills to have a

2 Comparison Cost: Though costs can very wildly, estimates put the average cost of a Superfund cleanup between $25 million and $30 million (NHDES 2008)

.06-inch thick high-density polyethylene (plastic) liner on top of two feet of compacted clay soils. These landfills must also have a leachate collection system (Lee 2002).

Operation: Landfill operators are required to cover the waste daily with soil, control landfill gas emissions and prevent unauthorized access to the site (USEPA 2006).

Groundwater Monitoring: Subtitle D contains a variety of specific requirements intended to protect against environmental contamination, specifically of groundwater. Landfills must have a groundwater monitoring system in place to detect leachate leaks. Unfortunately, as described earlier, groundwater monitoring systems often fail to detect leachate leakage (see Chapter 4).

Corrective Action: If a landfill is found to be leaking into the soil and groundwater, the operator of the landfill must take *corrective action* to clean up the contamination. Corrective action denotes a process of assessment (find the source of contamination), investigation (determine compounds involved, severity of contamination, health risks), interim measures (contain the contamination temporarily to alleviate adverse health effects), planning and implementation of a clean-up method, and monitoring the landfill afterwards to guarantee no harm befalls the environment or humans (USEPA 2010c).

Closure and Post-Closure Care: Operators are required to collect and monitor landfill gas and continue maintenance of the landfill for 30 years after its closure (Lee 2002).

Financial Assurance Criteria: Before building a landfill or expanding an existing site, the owners and operators must prove that they have the financial resources to maintain the landfill, perform corrective action as needed, and conduct closure and post-closure activities for 30 years (USEPA 2006). One of the consequences of this statute is that it favors large landfill companies (such as Waste Management).

Critiques of RCRA

Since RCRA limits the amount of hazardous waste that can be disposed of in a MSW landfill, it implies that MSW landfills are not toxic. However, as discussed previously, leachate from MSW landfills often contains hazardous chemicals which are a threat to public health and the environment. Despite the RCRA focus on defined hazardous waste, the risks of MSW leachate (which may or may not contain hazardous chemicals) should not be overlooked (Lee 2002). Subtitle D does not require any sort of minimum buffer zone between a landfill site and adjacent properties, placing the surrounding community at risk when contamination eventually occurs.

Subtitle D, first passed in 1976, was phased in by 1997, making current Subtitle D landfills at least 19 years old. However, many of the problems associated with aging liners have not yet occurred in these landfills. Proponents note that groundwater contamination has not been found in Subtitle D landfills. However, in addition to the unreliability of groundwater monitoring systems, unless the site was very poorly constructed, it is unlikely that leachate would even pass through the clay soils for 25 years (Lee 2002).

While leak-detectable covers for landfills exist, they are not required by Subtitle D. The plastic-sheeting cap on a landfill will eventually deteriorate, creating polluting leachate. By allowing operators to visually monitor caps, Subtitle D legislation encourages a lowest-cost approach which fails to take adequate measures for cover maintenance (Lee 2002).

After the first 30 years of a landfill closure, there is no guarantee of funding for any clean-up needed

because of leachate contamination. It is possible that a properly installed and non-punctured liner could prevent groundwater pollution from leachate through the 30-year post-closure period. Thus, a liner could begin to show signs of aging and leakage after the landfill owner ceases to be responsible for it. However, holding private companies or even public agencies responsible for remediation costs will prove difficult, if not impossible. A 2001 audit report by the US EPA Inspector General affirms this, stating that:

"Many landfills may need more than 30 years of post-closure care. However, most of the state agencies in our sample had not developed a policy and process to determine whether post-closure care should be extended beyond 30 years, and there is no EPA guidance on determining the appropriate length of post-closure care." (USEPA 2001)

As landfill engineering expert Dr. Fred Lee writes, "this situation virtually assures that there will be future "Superfund" sites at today's municipal Subtitle D landfills" (2002).

While Subtitle D made strides towards improving landfill construction and operation, there are many areas that could be improved. When new landfills are built, citizens need to advocate above and beyond Subtitle D for best technologies to protect public health and the environment from landfill pollution.

Clean Air Act, Section 111

In 1996, the EPA began to regulate air pollution from landfills under the Clean Air Act, requiring that MSW landfills must "control emissions to the level achievable by the best demonstrated system of continuous emission reduction, considering costs, non-air quality health, and environmental and energy impacts" (USEPA 1996). This regulation applies to landfills that meet the following criteria (USEPA 1999):

- Built, expanded or remodeled since 1991
- Have a capacity of at least 2.5 million cubic meters
- Emit at least 50 metric tons per year of non-methane organic compounds (NMOCs), such as benzene, toluene and vinyl chloride

The annual cost of implementing this regulation is $94 million (McCarthy 2000).

As of 2014, 1,000 US landfills meet these criteria (USEPA 2014c). These landfills must have a gas control system in place which reduces landfill gas emissions by 98 percent. Interestingly, the EPA chose not to base the criteria on green house gas emissions, but NMOCs. While it is important to regulate NMOCs, it seems that a more comprehensive regulation system would include both types of emissions.

For more information on landfill regulations:
- EPA: *Laws and Regulations for Waste:* http://www2.epa.gov/regulatory-information-topic/waste
- EPA: *Air Regulations for MSW Landfills*: https://www3.epa.gov/ttn/atw/eparules.html

The Permitting Process

When opposing a new landfill or expansion, it is important to be aware of the opportunities for public participation for you and your group. While each situation is different, we have laid out a general chronology of the permitting process for landfills.

Pre-application meetings
The permit applicant (i.e. the landfill operator) is required to hold a public meeting at least 30 days before filing for a RCRA permit (USEPA 2006). Though they are required to advertise in

the affected community, these meetings are often poorly-publicized with low attendance. It is likely that your group did not learn about the proposal until after the permit was filed.

Public comments

After the operator files the permit, the permitting agency (such as the local board of commissioners) sends a notice to everyone who attended the meeting that the application is available for public review. The permitting agency will decide to provisionally grant or deny the permit. Once the decision has been made, a public comment period of at least 45 days begins. The agency must also prepare a fact sheet about their decision. You can request a copy of it, and the original application, from the agency.

Members of your group can submit written concerns and suggestions to the agency. The permitting agency is required to respond to all "significant" comments raised (though the definition of "significant" is open to interpretation) (USEPA 2006).

Public hearings

Your group can request a public hearing during the comment period by submitting written notice of your opposition (or support) for the agency's decision. The agency may also decide to hold public hearings, giving at least 30 days notice (USEPA 2006). These are extremely important opportunities for you and your group to speak out against a proposed landfill and show the agency (and the media) the degree of public opposition.

Regulatory agencies and landfill operators often seek out landfill consultants to testify as to the viability of the proposed landfill. However, if these independent consultants give negative feedback on the proposal, they risk not being hired for future work by the same companies and agencies. As a result, expert consults tend to be extremely supportive of proposed landfills (Lee 2002). Remember – you need to create your own rules for the struggle, focusing on a strong grassroots opposition rather than technical details.

Final decision

Once the comment period closes, the agency will issue a final decision. If it is not in your favor, don't give up! Re-evaluate your group's goals and tactics, and determine how you want to proceed with this new obstacle.

Chapter 9

Troublesome Alternatives

There is no "away" place where our garbage can collect without harming anyone. Our ability to safely dispose of waste is flawed. When fighting a landfill in your community, we encourage you and your group to explore alternatives to landfilling, such as the zero waste concept mentioned earlier. A few of these alternatives involve new types of landfills, and are often touted by industry, government agencies, the media and sometimes even environmental groups as "clean" and "safe" options. Yet, it is critical to remember, **there are no good landfills**. They may break down waste faster, or produce gas for energy, but they will eventually fail and contaminate the surrounding water, soil and air.

Don't settle for the 'lesser of two evils.' Remember your group's goals, and be wary of "greenwashing" tactics, i.e. a company's portrayal of its practices as being environmentally friendly when in reality, they are not. Any risk to the health of your community is too much.

Bioreactors, Mechanical Biological Treatment, and Leachate Recycling

Some landfills are being created as or converted to "bioreactor" or "wet cell" landfills. This involves the introduction of moisture to the landfill, typically by "recycling" leachate that has been drained from the landfill. In theory, the moisture in the landfill speeds up the breakdown of waste in the landfill, which increases available space.

Bioreactors are often advocated because it reduces the cost of leachate management, but in reality, it creates a situation where, if the groundwater is contaminated, the cleanup costs far exceed any savings (Lee 2004a). The recycling of leachate increases the toxicity of the leachate, which can then contaminate groundwater in more potent forms than if the leachate wasn't reused (Jones-Lee 2000). The additional moisture also adds to the rate of methane formation (Anderson 2007). In addition, much of the garbage in landfills is contained in plastic bags, which significantly reduces the speed of waste breakdown. While "wet cell" methods could be a viable alternative

if waste is shredded *and* additional groundwater pollution controls are utilized (such as secure liner designs and perpetual and comprehensive groundwater monitoring), at this point bioreactors are generally not a safer alternative to dry tomb landfilling (Lee 2010a).

Energy Recovery

As the concern over global climate change continues to mount, the EPA and several states have actively supported landfill-gas-to-energy (LFGTE) projects as a way to reduce greenhouse gas emissions. For instance, the EPA touts their Landfill Methane Outreach Program (LMOP), which "promotes the use of landfill gas as a renewable, green energy source" (USEPA 2008b). Landfill gas is 40% to 60% methane. Gas is extracted using wells, blowers or a vacuum system, and processed to generate energy in the form of either electricity (via internal combustion engines or gas turbines) or heat (via boilers) (Ewall 2007). As of July 2012, there were 576 LMOP projects in the U.S., with 540 of those being MSW landfills (USEPA 2012).

Given the overall low rate of landfill gas collection discussed previously, LFGTE projects remain troublesome. If only a small portion of methane from landfill gas is actually being captured, and the LFGTE unit uses a highly polluting internal combustion engine, which releases carbon dioxide into the atmosphere, the greenhouse gas reduction is minimal at best. In a report to the California Air Resources Board on landfills and greenhouse gas production, Peter Anderson (2007) asserts that only 1% of the methane sequestered by LFGTE projects can be considered a greenhouse gas offset, writing that:

"Landfill-gas-to-energy is a non-productive approach that fails to overcome the fact that, especially in a world concerned with climate change, land disposal alone, or all the other options to manage discards, creates the enormous volumes of methane that are among the most significant contributors to anthropogenic greenhouse gas emissions." (Anderson, 2007)

Burning natural gas is not considered a "green" energy project, yet it releases less pollution per unit of energy produced than burning landfill gas, which is viewed as a "renewable" energy source (Ewall 2008). Since landfill gas is often marketed as a "green" alternative, states can use it to meet their Renewable Portfolio Standard (the required percentage of electricity generated from renewable sources). Landfill operators are thus given incentives to produce as much gas as possible. This may also mean delaying the covering of the landfill to allow more moisture to enter the landfill (and thus generate more methane during decomposition), exposing the community to increased rates of odors and toxic chemicals (Ewall 2008).

Combusting landfill gas for energy can be dangerous. The EPA regulations state that when landfill gas mitigation techniques are in place, 98% of emissions are reduced. Even overlooking the problematic nature of gas collection, that still leaves 2% of the toxic gas emitted into the atmosphere. When certain non-methane organic compounds in the gas (such as chlorine, fluorine or bromine) are burned in the presence of methane, dioxins and furans are formed. Dioxins can form at low temperatures (200 °C to 400 °C), such as when the gases are cooling down after the combustion process (Ewall 2007). A review of 20 studies on dioxin releases found that on average, LFGTE projects released more dioxin than shrouded flaring (burning gas without trying to convert it to energy) of landfill gas (Caponi 1998).

Finally, LFGTE projects tacitly imply that there are no other ways to reduce methane production in landfills, and operators must simply make the best of a bad situation. Alternatives, including the removal and composting of organic matter before waste is sealed, can also reduce the amount of methane produced from landfills. Moreover, truly "green" and renewable energy options, such as solar and wind power, should be pushed as alternative energy options instead of LFGTE projects (Ewall 2007).

Incineration

The burning of waste is arguably even more dangerous to the environment and public health than landfills. Incinerators release dioxins, mercury, heavy metals, acid gases (which lead to acid rain), particulate matter (which compromises lung function) and greenhouse gases. Even incinerators which meet pollution control standards still create ash, which is classified as hazardous waste. In addition, no air pollution controls are 100% effective. Overall, incinerators waste more energy than they produce (Tangri 2003).

Incineration is not a solution to landfills, nor vice versa. Rather, we should work for alternatives which divert materials away from landfills or incinerators and actually reduce the waste stream.

For a detailed analysis of the problems of incineration, we recommend an excellent report by the Global Alliance for Incinerator Alternatives (GAIA) entitled "Why incineration is a very bad idea in Twenty First Century," available at: http://www.no-burn.org/why-incineration-is-a-very-bad-idea-in-the-twenty-first-century.

Chapter 10

Real Solutions: Zero Waste

"Waste is tangible evidence of economic inefficiency and lost resources."
– Neil Tangri, GAIA, 2003

While throwing away an item (or burning it) will always have health and environmental repercussions, alternatives exist. Though landfills are currently the least expensive option for disposing of waste, their true cost is rarely taken into consideration. Consider the thousands of dollars spent on the cleanup of Superfund landfills, the health care bills for those with cancer or respiratory ailments, or the loss of property values for nearby homeowners. And what is the value of clean air and water? Certainly more than the limited economic benefit a community receives from taxes and a handful of new jobs at a local landfill.

We encourage you and your group to become advocates for a comprehensive approach to managing waste. This prevents your opponents from accusing you of NIMBY-ism[3] and gives your group more leverage and legitimacy in the eyes of elected officials. Some of the most successful groups we've seen, have not only defeated landfill proposals, but led to improved commercial recycling and composting facilities, passed waste-reduction ordinances in their municipalities, and created a public discourse on the problems (and solutions) to issues of waste. You and your group have the potential to create a more sustainable future for your community – we look forward to hearing how you act on it!

3. Literally, "Not In My BackYard", this term has negative connotations and denotes a belief where people only protest an action when it affects them directly, rather than being concerned with the broader problem.

An Introduction to Zero Waste

Zero waste is a systemic approach to eliminating, rather than managing, waste. It is not just community based actions – reducing, reusing, and recycling – but includes industrial responsibility to design products and packaging in sustainable ways. It targets every stage in the lifecycle of a product, from design to disposal, resource extraction to recycling (NWNZT 2003). The overarching philosophy of zero waste imagines our industrial system as a closed-loop system, in which everything is reused and recycled into future uses (Connett 2001).

At first, the concept of zero waste seems impossible to wrap your head around, but it really is possible. Communities around the world have passed zero-waste ordinances, from California to Nova Scotia to New Zealand (GRRN 2007). These local municipalities are using zero waste as a guiding principle, and are achieving tangible results – increased recycling rates, new jobs from recovery industries and better air quality (Connett 2001).

For a wealth of information on zero waste, including sample policies and strategies for working with elected officials, visit the Grassroots Recycling Network (GRRN) site: http://www.grrn.org/zerowaste/. For the worldwide perspective, see Global Alliance for Incinerator Alternatives (GAIA) on the zero waste campaign, visit: http://www.no-burn.org/section.php?id=91 .

Source Reduction

The U.S. is the epitome of a consumer society. Since the 1950s, our consumption rates have skyrocketed – and so have our trash rates. For a nation with 5% of the world's population, we have already consumed 30% of the earth's resources. Interestingly enough, and perhaps most telling, our happiness as a nation has declined ever since consumerism became our country's focus (Leonard 2007). Our current pattern of "buy-use-throw" is impractical and unsustainable, which is why one of the most important components of zero waste is source reduction. This is pretty straightforward – consume less, and thus throw away less.

On a consumer level, this entails not just reducing the amount of stuff we use, but reusing existing items. Source reduction can be on a smaller, simpler scale– printing on both sides of a piece of paper, donating used clothing – or be a bigger

5 Tenets of Zero Waste

Redesign Products and Packaging.
Limit resource consumption, toxicity and waste, while recovering materials through reuse, recycling or composting.

Producer Responsibility.
Hold manufacturers responsible for the waste and environmental impact their product and packaging creates, rather than passing that responsibility on to the consumer. Encourage manufacturers to redesign products that reduce material consumption and facilitate reuse, recovery and recycling. (For more information, visit http://www.upstreampolicy.org/.)

Invest in Infrastructure, Not Landfills.
Have communities use the tax base to invest in new recycling and compost facilities rather than landfills - the technological advances of the 1990s can easily support the diversion of 90% of society's discards.

End Taxpayer Subsidies for Wasteful and Polluting Industries.
Remove tax subsidies that make using virgin resources for raw materials the least expensive option. Assign economic penalties to landfill operators for the emissions, contamination and public health risks they create.

Create Jobs and New Businesses from Discards.
Separating and processing recyclables employs ten times more jobs on a per-ton basis than landfills (ILSR 2006).

- adapted from "Beyond Recycling! Zero Waste… Or Darn Near" by Eric Lombardi (EcoCycle. '01)

commitment, such as not owning a car. This saves money for both consumers - who buy less stuff, and municipalities - who have less waste they must pay to dispose of (USEPA 2008c).

One way that communities can encourage source reduction is by developing "pay-as-you-throw" programs (PAYT). These programs charge each resident or business for trash collection based on how much they throw away. This has been shown to be very effective; not surprisingly, people respond well to financial incentives. When Austin, Texas implemented a PAYT program in 1997, recycling rates increased 11 percent in just over a year (CWMI 2001). Municipalities across the country, small and large, have similar success stories.

A final piece of source reduction focuses on industry. Manufacturers can create products which require less packaging, create less waste during production, and have a longer lifespan (USEPA 2008d).

For a creative and clever presentation of consumerism in the United States, watch Annie Leonard's "The Story of Stuff" at www.storyofstuff.com.

Recycling

Source reduction is not always possible, such as when an item has reached the end of its lifespan. It is important to have recycling programs set up in your community to handle waste that would otherwise be sent to landfills. Sometimes recycling remakes the same product (such as paper), and sometimes it creates completely different items. Your plastic containers could be made into park benches or carpets and your glass bottles could be an ingredient of a paved road.

A Special Note on Electronics Recycling

Recycling of electronic waste is the safest and most cost effective strategy for dealing with the problems created by obsolete technological items. Valuable materials can be harvested for reuse, reducing the amount of disposed hazardous waste. Unfortunately, the recycling of e-waste remains an expensive proposition for both consumers and local governments. Too often, e-waste recycling exposes workers to dangerous levels of toxic chemicals, or is exported overseas, where cheap labor and lax environmental laws exist.

The European Union has introduced Extended Producer Responsibility (EPR) for dealing with e-waste. EPR dictates that producers must work to find less-toxic alternatives for their products, labeling e-waste and improving recycling capabilities. Costing only 1-3% of retail cost, EPR holds industry responsible for the solutions (Scanlon 2001). While some US computer manufacturers have made limited promises to improve electronic recycling, toxic e-waste continues to fill landfills at a growing rate.

For more information on electronic recycling and how to safely dispose of e-waste:

- Electronics Take Back Coalition: www.electronicstakeback.com
- Silicon Valley Toxics Coalition: www.svtc.org
- Greenpeace: www.greenpeace.org/international/campaigns/toxics/electronics
- EPA eCycling Program: www.epa.gov/recycle/

Unfortunately, just because recycling is a good thing doesn't mean that it is always cost-effective. Putting waste in a landfill is often more affordable for municipalities than diverting items to a material recovery facility (MRF) to be sorted. Once at the MRF, items become commodities, with prices that fluctuate based on market forces. If the costs for a MRF operator to transport brown glass to the manufacturing site are higher than the price they will receive, it is unlikely they will continue to recycle brown glass. According to the EPA, recycling programs diverted 60.8 million tons of material away from the waste stream in 2008. However, 135.0 million tons still went to landfills (USEPA 2014a).

Recycling is a fast growing sector with many opportunities for new jobs. Unions, such as the International Brotherhood of Teamsters, have focused organizing and recruitment efforts on workers in material recovery industries (IBT 2015). A study by the National Recycling Coalition found that recycling creates 1.25 million jobs (five times the number of jobs in waste disposal), which pay approximately $3,000 above the national average wage (Beck 2001).

You can support recycling on two levels. First, learn what you can recycle in your community and maximize it. Look around your community – where are these opportunities to recycle at work or school, places of worship, and on the street corners? Brainstorm how to make recycling more convenient. Most people support recycling, but aren't willing to carry their waste with them until they find an appropriate receptacle. Some offices and schools have actually found that they saved money when participating in a recycling program, since they paid less for disposing less waste.

As a consumer, try to buy recycled products when possible. Look for items that contain "post-consumer" content. Encourage your workplaces, schools, religious institutions, libraries, and government offices to purchase items with recycled content.

Composting (commercial level)

The removal of biodegradable waste from the waste stream is an important step towards reducing the harmful environmental and health effects of landfills. In addition to simply having less waste to landfill, the removal of organic matter limits the production of the methane gas (a by-product of anaerobic decomposition).

In the 1999 Landfill Directive, the European Union required member states to reduce the amount of organic waste going to landfills by 75% by 2006, with additional benchmarks for further reduction (CEU 1999). As of 2005, 12 nations had submitted plans, with most already having met the goals, or on target to do so (CEC 2005).

Composting involves diverting lawn trimmings, food and other biodegradable items from the waste stream and allowing them to decompose. This is becoming an increasingly vital alternative, since the dry tomb landfill design limits the breakdown of organic matter. While compost bins in individual homes are valuable, it is unlikely that they have the capacity to reduce the waste stream in an area. Thus, it remains important that local municipalities take on the composting of organic matter on a large scale.

A few points to stress when speaking to local leaders (SCDHEC 2002):

- Composting reduces the amount of waste generated and extends the life of landfills
- Less waste reduces the threat of groundwater contamination and hazardous air emissions
- Composting can help meet local and state waste reduction goals
- Facilities create profit for local communities through the sale of soil and mulch

Some communities have no composting programs, some have drop-off sites for yard trimmings, others have weekly curbside collections for yard and food waste. What can and cannot be included also varies greatly. Find out about the options available in your area. Tell your mayor and local elected officials that you would like to see an improved commercial composting program in your community.

Composting may also include "biosolids" from wastewater treatment plants. Such places treat contaminated water to reduce contaminants, but they produce solid or semi-solid residue or sludge ("biosolid") that then needs to be disposed of. This sludge can be rich in nutrients, but it also contains toxic chemicals that are not removed by the treatment process. Toxic chemicals get into waste water when small business and light industry dump their waste chemicals into the same sewage system that residential homes use. Consequently, this sludge cannot be used as fertilizer, no matter what EPA and others say about how "safe" it is to use. The disposal of waste water sludge is regulated by 40 CFR Part 503 of the EPA.

For additional resources:

- Cornell Waste Management Institute: http://cwmi.css.cornell.edu/composting.htm
- EPA Composting Home Page: http://www.epa.gov/compost/
- EPA State and Regional Composting Programs: http://www.epa.gov/wastes/conserve/composting/index.htm

Working with municipal governments to enact alternatives

In order to fight landfills and reduce the waste produced by your community, it is crucial to work with local agencies and elected officials. This may seem daunting, but remember, they are there to serve you and your community members. Besides, your asking for changes might be the catalyst needed to start some real change! Use the organizing guidelines discussed previously to shape your strategy and approach.

Some helpful resources for working with municipalities:

- EPA - Comprehensive Procurement Guidelines for 'buy-recycled' programs: http://www3.epa.gov/epawaste/conserve/tools/cpg/
- California Integrated Waste Management Board - "Incentive Programs for Local Government Recycling and Waste Reduction:" http://www.calrecycle.ca.gov/publications/Detail.aspx?PublicationID=914
- Greenpeace (UK) - "How to comply with the Landfill Directive without incineration:" http://www.greenpeace.org.uk/media/reports/how-to-comply-with-the-landfill-directive-without-incineration

Chapter 11

Myths and Counterarguments

Below are a number of arguments or "myths" raised by landfill supporters and counterarguments to these "myths." These statements apply equally to hazardous or municipal waste; some counterarguments specifically address landfills, but others apply equally to other land disposal methods.

Myth: "Landfills are a "safe" way to dispose of trash."

Counterarguments:

- Even when built with today's technology, all landfills will fail after a certain amount of time.
- Current federal regulations do not provide enough protection against problems that may occur during and after a landfill is closed.
- Many researchers consider municipal solid waste landfills to have the same health effects and cancer risk as hazardous waste landfills.
- Today's common "dry tomb" landfills are considered "storage" for waste, rather than appropriate disposal solutions. Most waste in modern landfills cannot break down quickly due to landfill design or because the product is not biodegradable.
- Years after they are closed, many landfills will become Superfund sites.

Myth: "It's State-of-the-Art Technology."

Counterarguments:

- This really means, "This is the best we can do now." It's not a good solution and there is no guarantee of safety.
- The technology used for most landfills has not changed drastically in the last couple of decades and they continue to fail.
- "State-of-the-art" landfills have no track record, so what proof is there that they will be any better?
- That's what was said about the "double lined" landfill, yet they also fail.
- Is this the time to build more landfills? Isn't it better to use safer alternatives?

Myth: "The aquifer is already polluted; a little more won't hurt anything."

Counterarguments:

- As a society, we can't afford to "write off" aquifers.
- We want the aquifer cleaned up.
- Let's not make it any worse. There's no reason to continue doing so.
- If we take that attitude on all contaminated aquifers, we are in deep trouble.
- If people are drinking water from this aquifer, you already have a sensitized population; don't make it worse.
- We have a right to clean water for our children.
- We have a moral responsibility to do something. If someone has cancer you do not just let the person die, you do something!

Myth: "Not many people will be affected."

Counterarguments:

- In many cases now, this is no longer true. There are numerous landfills in densely populated, urban centers.
- In the case of more rural locations, rural aquifers are often the drinking water source for many cities. Animals and crops–food for cities–are raised on rural water sources.
- The lives of exposed populations are just as important as those of everyone else.
- It is equally important to protect the environment and the public.

Myth: "What else can we do with waste? What is the alternative?"

Counterarguments:

- We should reduce waste at the source. Less waste means less need for disposal space.
- Safe alternatives to landfilling do exist (See Chapter 10).
- We are smart enough to realize landfilling does not work.
- Include tax on final products to cover costs of proper disposal, recovery and recycling. If costs become too high, let the free market reflect this. It is okay if some products die, rather than people. Stop making products that produce toxic waste.

Myth: "If you shut down the landfill, we have to close and take our jobs elsewhere."

Counterarguments:

- Jobs are not lost permanently. They change.
- Landfilling is not labor intensive.
- Wherever the company goes, workers are still needed; skilled workers may be transferred to new locations.
- Plants can change practices, sometimes with large savings; industrial revenue bonds are available to help reduce costs.
- Most threats are just bluffs.
- Jobs are not worth the cost of sick children.
- Workers can get sick too.

Myth: "You are politically motivated."

Counterarguments:

- Right, but so what? These decisions are mainly driven by politics.
- If government and industry handled waste responsibly, residents would not become upset.
- Political participation, especially on decisions that affect people's lives, is a basic American right.
- Decisions are made by politicians, not scientists or engineers.

Myth: "We are the experts, not you. We know what we are doing."

Counterargument:

- We know how to read too. We have

common sense. Who are the real experts, anyway? Experts gain expertise gradually. Few have any real answers and most make mistakes.
- People who live there know the land.
- Experts disagree because science/ engineering is so uncertain, so what do the experts really know?
- We have proven we know our stuff. We are experts too–experts on our community!

Myth: "There is no direct scientific evidence that landfills cause health problems."

Counterargument:
- And there is no evidence that they **do not** cause health problems.
- Why must the burden of proof fall to us to prove harm exists? With people's health at stake, we should enforce the precautionary principle, and say that the burden of proof falls to the industry to show that no harm exists!
- Many scientific studies have found a link bewteen living near landfills and adverse health outcomes as compiled in the Appendix

Myth: "Zero Waste is impossible and impractical."

Counterarguments:
- Many things once deemed 'impossible' have become a reality; look at flying, computers, and vaccinations.
- How do you know it is impossible if you do not try?
- It is not about literally making zero waste; it is about setting an incredibly high bar so that we try our absolute best to grasp it, and in the process achieve new heights in waste reduction and recycling. It is about viewing landfills as a dire last resort rather than a quick fix, and seeing what we can accomplish if we act like there are no landfills.
- The chemical industry did not think it could drastically reduce dioxin levels, but here we are now, with a 90% decrease in dioxin levels. Who is to say we cannot do that with waste?

Appendix

Annotated Resources on Landfills and Health Effects

Though it may seem obvious to communtiy members that their health problems are associated with living near a landfill, few formal studies have supported this link. Most research has focused on studies of people living near hazardous waste sites, rather than municipal landfills. We have included some of these studies, recognizing that many MSW landfills contain a percentage of hazardous waste.

Though these can serve as helpful tools in supporting your argument, there are always errors within experimental study designs which can lead to skewed results. There is no way to be one hundred percent certain of the materials in a landfill, just as there is no way to definitively "prove" that health problems are a result of landfill proximity. We encourage you to use these studies as a tool in your fight. However, it is ultimately your organizing and advocacy that will make the most impact, rather than any health study.

1. **Shibata, T., Wilson, J. L., Watson, L. M., Nikitin, I. V., A., Ane, R. L., & Maidin, A. (2015). Life in a landfill slum, children's health, and the Millennium Development Goals.** *Science of The Total Environment*, **536, 408-418.**

   This study, conducted in Indonesia, evaluated the living and working conditions of those living in landfill slum. Through face-to-face interviews with the population, researchers analyzed the demographic and population characteristics, as well as ambient air and MSW contamination. Results of this study concluded that children from the landfill slum were more likely to suffer from diarrhea and acute respiratory infections.

2. **Mattiello, A., Chiodini, P., Bianco, E., Forgione, N., Flammia, I., Gallo, C., . . . Panico, S. (2013). Health effects associated with the disposal of solid waste in landfills and incinerators in populations living in surrounding areas: A systematic review.** *International Journal of Public Health Int J Public Health*, **58(5), 725-735.**

This report compiles the results of 60 relevant papers within literature that describe health problems related to landfills and incinerators. Researchers found that through their review, the most consistent result was found to be the occurrence of congenital anomalies, as well as increased rates of hospitalization, due to residency near waste landfills.

3. **Cabral, M. et al. Low-level environmental exposure to lead and renal adverse effects: A cross-sectional study in the population of children bordering the Mbeubeuss landfill near Dakar, Senegal.** *Human Experimental Toxicology* **(2012) 31:1280-1291.**

   This article examines the effect of lead exposure on children living near a landfill in Senegal. Soil and air samples collected near the landfill indicated metal contamination. The authors designed a study that examined multiple factors that indicated lead contamination in humans. The study concluded that the landfill poses a significant health risk for children. The biomarkers used to indicate the presence of lead showed high levels of lead absorption. An excess production of reactive oxygen species in specific organs may be involved in lead-induced renal injury. The authors suggest that these environmental problems be considered as part of future development programs in poor countries.

4. **De Felice, B. et al. Telomere shortening in women residents close to waste landfill sites.** *Gene* **(2012) 500:101-106.**

   This study examines the effect of environmental pollution from illegal landfills on pregnant women in Campania, Italy. Specifically, the study looks at the effect on telomere length which has implications for early onset of age-related diseases. The authors determined that the pollution caused by illegal dumping has resulted in higher oxidative stress, shorter telomere length and lower telomerase activity, which are known determinants of cell senescence and aging-related meiotic dysfunction in women.

5. **Heaney, C. D., Wing, S., Campbell, R. L., Caldwell, D., Hopkins, B., Richardson, D., & Yeatts, K. (2011). Relation between malodor, ambient hydrogen sulfide, and health in a community bordering a landfill.** *Environmental Research***, 111(6), 847-852.**

   This study looked at the health and quality of life of a community of North Carolina residents affected by exposure to numerous waste facilities. For ten months in 2009, participants of this study used methods of self-reporting to keep track of irritant and physical symptoms they experienced due to exposure from living near a landfill. Results found that experience of malodor was common to those who live near waste sites, and that it negatively impacts the well-being of those populations.

6. **Mari, M., Nadal, M., Schuhmacher, M., & Domingo, J. L. (2009). Exposure to heavy metals and PCDD/Fs by the population living in the vicinity of a hazardous waste landfill in Catalonia, Spain: Health risk assessment.** *Environment International,* **35(7), 1034-1039.**

   This study examines a population in Catalonia, Spain which is exposed to heavy metals from a hazardous waste landfill. Researchers specifically looked at the health effects associated with air inhalation, soil and dust ingestion, as well as dermal absorption. With their results, they concluded that concentrations of metals found within the area were relatively higher in the nearest village to the landfill- indicating closer proximity to a landfill equals higher exposure to the pollutants released by said landfill.

7. **Porta, D. et al. Systemic Review of Epidemiological Studies on Health Effects Associated with Management of Solid Waste**. *Environmental Health* **(2009) 8:60-73.**

   This paper provides an overview of the studies in the published literature that evaluated the adverse health effects

associated with different waste management methods including landfills. The authors also scored the reported effects in order to derive useable excess risk estimates for health impact assessment. The study design and potential biases in effect estimates were evaluated for each study included in the review. The authors found that for populations living with 2 kilometers of landfills, there was limited evidence of congenital anomalies and low birth weight with an excess risk of 2 percent and 6 percent, respectively. The excess risk tended to be higher when sites handled toxic waste. Many of the studies suffered from various limitations that are described in the review. Despite this, the authors concluded with a moderate degree of confidence that "we have derived some effect estimates that could be used for health impact assessment."

8. Kouznetsova, M., et al. Increased Rate of Hospitalization for Diabetes and Residential Proximity of Hazardous Waste Sites. *Environmental Health Perspectives* **(2007) 115(1): 75-79.**

This study investigated whether residence near persistent organic pollutants (POPs)-contaminated hazardous waste sites increased rates of hospitalization for diabetes. The authors examined adult diabetes patients 25-74 years of age in New York State from 1993-2000. After controlling for major potential confounders, the study found a statistically significant increase in the rate of hospitalization for diabetes among patients residing in ZIP codes containing POPs-contaminated waste sites versus patients in "clean" sites. These results do not prove a cause and effect relationship; however, this study provides further support for the association between diabetes and exposure to environmental contaminants.

9. Kuehn, C.M., et al. Risk of Malformations Associated with Residential Proximity to Hazardous Waste Sites in Washington State. *Environmental Research* **(2007) 103: 405-412.**

This study examines the relationship between malformations occurring in infants and maternal residential proximity to hazardous waste sites in Washington State. Maternal residence of infants born with malformations from 1987-2001 was compared to maternal residence of infants who were randomly selected and who were born without malformations during this same time period. The authors found that infants born within 5 miles of a hazardous waste site had an increased risk of malformations compared to infants born more than 5 miles away from a hazardous waste site.

10. Gilbreath, S and Philip Kass. Adverse Birth Outcomes associated with open dumpsites in Alaska Native Villages. *American Journal of Epidemiology* **(2006) 164(4): 518-528.**

This study evaluates adverse birth outcomes in infants whose birth records indicate that the mothers lived in villages with dumpsites that were potentially hazardous to public health. The authors found that mothers who lived in villages with intermediate and high hazard dumpsite has a higher proportion of low birth weight infants than did mothers in the control group. More infants born to mothers who lived in the intermediate and high hazard villages suffered from intrauterine growth retardation.

11. Palmer, S. et al. Risk of congenital anomalies after the opening of landfill sites. *Environmental Health Perspectives* **(2005) 113(10): 1362-1365.**

This study was conducted to investigate whether there was an increased risk of births with congenital malformations for mothers living near 24 landfill sites in Wales that opened between 1983 and 1997. Expected rates of congenital anomalies were compared to those of mothers living within 2 km of the sites, before and after opening of the landfills. Results showed risk of congenital anomalies for mothers living near the landfills increased when the sites were opened. However, the data could not establish a causal link between the landfills and the malformations because of a variety of biases that may have confounded the relationship. Nonetheless, the increase in risk associated with the opening of sites requires continued surveillance.

12. Morgan, O., Vrijheid, M., Dolk, H. Risk of low birth weight near EUROHAZCON hazardous waste landfill sites in England. *Archives of Environmental Health* **(2004) 59(3): 149-151.**

This study evaluated risk of low birth weight near 10 English hazardous waste sites used in a previous study of congenital anomalies (see entry #14 below). The authors found a small but not statistically significant increase in risk of low birth weight within 3 km of sites. The findings of this study suggests that previously reported results for congenital anomalies should not be extrapolated to a wider range of reproductive effects but instead evaluated separately for each outcome.

13. Dummer, T., Dickinson, H., Parker, L. Adverse pregnancy outcomes near landfill sites in Cumbria, northwest England, 1950-1993. *Archives of Environmental Health* **(2003) 58(11): 692-697.**

This study evaluated the risks of stillbirth or neonatal death for mothers living near landfills. All stillbirths, neonatal deaths, and lethal congenital anomalies occurring among 287,993 births to mothers in Cumbria, northwest England during the period 1950-1993 were studied. For the period 1970-1993, a small but significant increase in risk of "other congenital anomalies of the nervous system" was found in mothers living near domestic waste landfill sites. This finding was consistent with other researchers, but a casual effect could not be inferred and the possibility that the results occurred by chance could not be ruled out.

14. Vrijheid et al. Chromosomal congenial anomalies and residence near hazardous waste landfill sites. *Lancet* **(2002) 359: 320-322.**

This study revealed that there is an increased risk of chromosomal anomalies in people who live close to hazardous waste landfills. Adjustments were made for maternal age and socioeconomic status. The results of this study suggest that an increase in the risk of chromosomal anomalies is similar to that found for non-chromosomal anomalies.

15. Elliot, P. et al. Risk of adverse birth outcomes in populations living near landfill sites. *British Medical Journal* **(2001) 323: 363-368.**

Between 1982 and 1997, a study was conducted to investigate the risk of adverse birth outcomes associated with residence near landfill sites. Individuals living 2 km from one of 9565 landfill sites throughout Great Britain were sampled. This has been the largest study of associations between residence near landfill and adverse birth outcomes thus far. It was concluded that residents near landfill sites are at risk of having children with congenital anomalies and low birth weight, however, further studies are needed to explain these findings.

16. McNamee, R., Dolk, H. Editorial: Does exposure to landfill waste harm the fetus? *British Medical Journal* **(2001) 323: 351-352.**

This editorial addresses issues concerning the article entitled "Risk of adverse birth outcomes in populations living near landfill sites" by Elliot et al. in the August 2001 edition of the British Medical Journal (see entry #15 above).

17. Pukkala, E and Antti Ponka. Increased incidence of cancer and asthma in houses built on a former dump area. *Environmental Health Perspectives* **(2001) 109(11): 1121-1125.**

This study evaluated the health of people who moved into twelve blockhouses in Helsinki, Finland that were built on a former dumpsite. Cancer and other chronic diseases were evaluated. The authors found a statistically significant increase in cancer for both sexes. The relative risk increased slightly with the number of years lived in the area. They also found increases in asthma and chronic pancreatitis. The authors concluded that the "possibility of a causal association between the dump exposure and incidence of cancer and asthma cannot be fully excluded." Nonetheless, the city council decided to demolish all houses in the dump area.

18. Berger, S., Jones P., White, M. Exploratory analysis of respiratory illness among persons living near a landfill. *Journal of Environmental Health* **(2000) 62.6: 19.**

Due to concern expressed by residents in two Staten Island, NY communities, the authors of this study evaluated the severity and frequency of respiratory symptoms occurring over a 12-month period among self-identified residents with asthma, severe breathing, or other respiratory conditions. Responses indicated that residents who lived adjacent to the landfill and those from the north-shore (seven miles from the landfill) had differing health problems, with landfill residents reporting higher rates of certain odors and eye, nose and throat irritation. The authors concluded that further investigation of respiratory illnesses should be conducted, as the study showed high rates of respiratory-related symptoms and conditions.

19. Vrijheid et al. Health effects of residence near hazardous waste landfill sites: a review of epidemiologic literature. *Environmental Health Perspectives* **(2000) 108: (Suppl. 1) 101-112.**

This review is an evaluation of current literature on the adverse health effects due to residence near landfill sites. It is difficult to make a conclusion about direct causes for adverse health effects and risks of landfills in general are hard to quantify. Of the studies reviewed, all proved to have insufficient exposure information. This article suggests that research of exposure to landfill sites needs to take a more interdisciplinary approach. Furthermore, epidemiologic and toxicologic studies need to be conducted for individual chemicals and chemical mixtures in order to understand what their effects may be on a population living near a landfill.

20. Knox, EG. Childhood cancers, birthplaces, incinerators and landfill sites. *International Journal of Epidemiology* **(2000) 29: 391-397.**

A study conducted in Great Britain between 1974 and 1987 found that children living near incinerators, both municipal and medical, were at more risk of getting cancer than those children living near landfill sites. This study targeted the sensitivity of children to carcinogenic emissions, but it failed to take into account the association of additional toxic sources in the vicinity. This study also did not account for the migration of families from areas of high toxicity to areas of low toxicity before, during, or after a child's birth.

21. Goldberg, M. et al. Risks of developing cancer relative to living near a municipal solid waste landfill site in Montreal, Quebec, Canada. *Archives of Environmental Health* **(1999) 54:291-296**

The study examines the effect of a municipal solid waste landfill in Montreal, Quebec, Canada on male residents' potential for developing cancer. Men who lived near the Miron Quarry municipal solid waste landfill were compared to individual who lived in more remote locations. Elevated risks were observed for cancers of the pancreas, liver, and prostate in individuals living nearest to the site. A high risk was found for pancreatic cancer and non-hodgkin's lymphomas in residents living downwind from the site. The authors concluded that men living near the landfill site may have been and may continue to be at excess risk of cancers of the liver, kidney, pancreas, and non-hodgkin's lymphomas.

22. State of New York Department of Health, Center for Environmental Health. Investigation of cancer incidence near 38 landfills with soil gas migration conditions: New York state, 1980-1989, 1998. Available from: New York State DOH, 2 University Place, Albany, NY 12203-3399. Phone: 1-800-458-1158.

Thirty-eight landfills throughout the state of New York were selected for a study to find out if people living near certain landfills had an increased risk of cancer compared to people living elsewhere. This study evaluated cancer incidence among people living around these 38 landfills between 1980 and 1989. All cases of leukemia, non- Hodgkin's lymphoma, liver, lung, kidney, bladder and brain cancer were identified and located on a map. Although this study had many limitations, it still found that women living near the landfills had a higher incidence of bladder cancer and leukemia. In comparison, men did not show an increased risk of any type of cancer despite their proximity to a landfill.

23. Dolk, H. et al. Risk of congenital anomalies near hazardous-waste landfill sites in Europe: the EUROHAZCON study. *Lancet* **(1998) 352: 423-427.**

This study examined seven regional registers of congenital anomalies in five different countries in Europe to determine if exposure from hazardous chemicals at landfills increased the risk of birth defects. Twenty-one sites were examined overall and among those sites mothers within a 3 km radius showed a significantly raised risk of having children with congenital anomalies. The results of this study were adjusted for maternal age and socioeconomic status. However, this study's findings are limited by a lack of information on exposures.

24. Berry, M., and Bove, F. Birth weight reduction associated with residence near a hazardous waste landfill. *Environmental Heath Perspectives* **(1997) 105(8): 856-861.**

Twenty-five years of birth certificate information (1961-1985) was collected in order to examine the relationship between birth weight and mother's residence near the Lipari Landfill located in New Jersey. The results indicated that there was a significant impact to infants born to residents who lived near the landfill during the time they would have been at greatest risk of exposure to hazardous chemicals. Many factors, including maternal health, cigarette and alcohol consumption during pregnancy, and socioeconomic status were not available for this study.

25. Goldberg, M. et al. Incidence of cancer among persons living near a municipal solid waste landfill site in Montreal, Quebec. *Archives of Environmental Health* **(1995) 50(6): 416-424.**

In a Canadian study, researchers from the Public Health Department in Montreal evaluated cancer incidence rates in people living around the Miron Quarry municipal landfill. Thirty-five volatile organic chemicals were identified in the landfill gases sampled, including known human carcinogens. When evaluating cancer incidence rates among persons living near the landfill, it was concluded that there might have been increased risks for certain cancers, such as stomach, liver, lung, prostate, and cervix uteri. The researchers also concluded that there were too many unknown factors to make any conclusions as to whether cancer incidence and proximity to the landfill were directly related.

26. Shaw, G. et al. Congenital malformations and birth weight in areas with potential environmental contamination. *Archives of Environmental Health* **(March/April 1992) 47: 147-154.**

Due to the public's increasing concern about reproductive damage as a result of exposure to environmental contamination, a study was conducted to determine if mothers living near contaminated sites were at a greater risk of having children with congenital malformations. This study did not reveal lower birth weight or increased risks for most malformations among women who lived in contaminated areas. It did, however, show an elevated risk for infants with malformations of the heart and circulatory system.

27. Upton, A. et al. Public health aspects of toxic chemical disposal sites. *Annual Review of Public Health* **(1989) 10:1-22.**

This article provides a summary and overview of past health studies conducted around toxic waste disposal sites. The results of 16 published epidemiological studies of residential exposures to toxic waste sites are summarized in this report, many of which are landfills operated by local, state or federal agencies. Although many weaknesses were identified in this review, several adverse health impacts were also identified. These included decreased weight at birth, increase in the frequency of congenial malformations, increase in the occurrence of certain forms of cancer, decrease in the growth and maturation of children, and increased prevalence of central nervous system symptoms. Overall, this article provides evidence that health problems associated with exposure to toxic waste disposal sites are underestimated and poorly studied.

28. Hertzman, C. et al. Upper Ottawa Street landfill site health study. *Environmental Health Perspectives* **(1987) 75:173-195.**

As of 1987, there were few health studies conducted that found health problems in communities living around landfills that were published in the medical or scientific literature. To this day, there is still a lack of conclusive studies giving evidence that adverse health effects are caused by landfills alone. In a study conducted by Clyde Hertzman et al. a number of health problems in workers and residents living near the Upper Ottawa Street Landfill in Hamilton, Ontario were identified. A few of the problems found with the highest credibility included clusters of respiratory, skin, narcotic, and mood disorders. Evidence is presented in their study that supports the hypothesis that vapors, fumes or particulate matter emanating from the landfill site, as well as direct skin exposure, may have lead to the health problems found in excess in this particular area.

29. Paigen, B. et al. Growth of children living near the hazardous waste site, Love Canal. Human Biology (June 1987) 59(3): 489-508.

This is the third of a series of three studies that were conducted on children living near the Love Canal landfill. This study examined whether living near a hazardous waste site had an adverse impact on the growth patterns of children. Children are especially vulnerable to environmental contamination and it was hypothesized that exposed children would be smaller in comparison to control groups of children within a similar socioeconomic status. In earlier studies it was found that there was a significant effect between health problems and the closeness of homes near Love Canal, but in this study the difference in stature associated with birth and residence near Love Canal was not statistically significant. These findings suggest that length of exposure to chemicals may be more important to study rather than point of exposure.

30. Goldman, L., and Paigen, B. Low birth weight, prematurity and birth defects in children living near the hazardous waste site, Love Canal. *Hazardous Waste & Hazardous Materials* **(1985) 2(2):209-223.**

This is the second of a series of three studies that were conducted on children living near the Love Canal landfill. This study assessed birth weight, prematurity, gestational age, and birth defects in 239 children who were living in the Love Canal neighborhood before and shortly after birth. Overall the results showed no significant difference in prematurity, but there was an increase in low birth rate and birth defects. The outcomes of this study suggest that low birth weight is a good indicator of adverse health effects caused by exposure to low levels of chemicals.

31. Paigen, B. & Goldman, L. (1985). Prevalence of health problems in children living near Love Canal. *Hazardous Waste & Hazardous Materials, 2***(1), 23-43.**

This is the first of a series of three health studies that were conducted on children living near the Love Canal landfill. This particular study looked at the overall health of children. The parents of 523 Love Canal and 440 control children were given questionnaires. It was found that children that lived near Love Canal had an increased prevalence of seven major health problems including, seizures, learning problems, hyperactivity, eye irritation, skin rashes, abdominal pain, and incontinence. This paper addresses many of the difficulties involved with conducting community health studies and recognizes the limitations of science when there are so many variables to contend with.

References

Abbas (2009), A. and G. Jingsong, L. Z. Ping, P.Y. Ya, W.S. Al-Rekabi, "Review on Landfill Leachate Treatments," *American Journal of Applied Sciences*, April. Available at: http://www.thescipub.com/abstract/?doi=ajassp.2009.672.684

Agency for Toxic Substances and Disease Registry (ATSDR 2008). *Toxicological Profile for Chromium. (Draft for Public Comment)*. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service. Available at http://www.atsdr.cdc.gov/toxfaqs/tf.asp?id=61&tid=17

Agency for Toxic Substances and Disease Registry (ATSDR 2007) *Toxicological Profile for Lead*. U.S. Department of Health and Human Services, Atlanta, GA. Available at: http://www.atsdr.cdc.gov/toxprofiles/tp13.pdf

Agency for Toxic Substances and Disease Registry (ATSDR 2007a). *Toxicological Profile for Benzene (Update)*. U.S. Department of Health and Human Services, Public Health Service, Atlanta, GA Available at: http://www.atsdr.cdc.gov/toxfaqs/tf.asp?id=38&tid=14

Agency for Toxic Substances and Disease Registry (ATSDR 2007b). *Toxicological Profile for Arsenic (Update)*. U.S. Department of Health and Human Services, Public Health Service, Atlanta, GA. Available at: http://www.atsdr.cdc.gov/toxfaqs/tf.asp?id=19&tid=3

Agency for Toxic Substances and Disease Registry (ATSDR 2004). *Interaction Profile for Arsenic, Cadmium, Chromium and Lead*.U.S. Department of Health and Human Services, Atlanta, GA. Available at http://www.atsdr.cdc.gov/interactionprofiles/ip04.html

Agency for Toxic Substances and Disease Registry (ATSDR 2004a). *Toxicological Profile for Polybrominated Biphenyls and PolybrominatedDiphenyl Ethers (PBBs and PBDEs)*.U.S. Department of Health and Human Services, Atlanta, GA. Available at: http://www.atsdr.cdc.gov/toxprofiles/TP.asp?id=529&tid=94

Agency for Toxic Substances and Disease Registry (ATSDR 2004b). *Toxicological Profile for Ammonia*. U.S. Department of Health and Human Services, Public Health Service, Atlanta, GA. Available at: http://www.atsdr.cdc.gov/toxfaqs/tf.asp?id=10&tid=2

Agency for Toxic Substances and Disease Registry (ATSDR 2004c). *Toxicological Profile for Cobalt*. U.S. Department of Health and Human Services, Public Health Service, Atlanta, GA. Available at: http://www.atsdr.cdc.gov/toxfaqs/tf.asp?id=372&tid=64

Agency for Toxic Substances and Disease Registry (ATSDR 2002a). Toxicological *Profile for Di(2-ethylhexyl) phthlate*. Update. U.S. Department of Health and Human Services, Public Health Service, Atlanta, GA. Available at http://www.atsdr.cdc.gov/tfacts9.html

Agency for Toxic Substances and Disease Registry (ATSDR 2001). *Landfill Gas Primer: An Overview for Environmental Health Professionals*. U.S. Department of Health and Human Services, Atlanta, GA. Available at http://www.atsdr.cdc.gov/HAC/landfill/html/intro.html

Agency for Toxic Substances and Disease Registry (ATSDR 2000). *Toxicological Profile for Polychlorinated Biphenyls (PCBs)*. U.S. Department of Health and Human Services, Atlanta, GA. Available at: http://www.atsdr.cdc.gov/toxprofiles/tp17.pdf

Agency for Toxic Substances and Disease Registry (ATSDR 2000a). *Toxicological Profile for Toluene*. Update. U.S. Department of Health and Human Services, Public Health Service, Atlanta, GA. Available at: http://www.atsdr.cdc.gov/toxfaqs/tf.asp?id=160&tid=29

Agency for Toxic Substances and Disease Registry (ATSDR 1999). *Toxicological Profile for Cadmium*. U.S. Department of Health and Human Services, Atlanta, GA. Available at: http://www.atsdr.cdc.gov/toxprofiles/tp5.pdf

Agency for Toxic Substances and Disease Registry (ATSDR 1999a). *Toxicological Profile for Mercury*.. U.S. Department of Health and Human Services, Atlanta, GA. Available at: http://www.atsdr.cdc.gov/toxprofiles/tp.asp?id=115&tid=24

Anderson (2007) P. "Comments to the California Air Resources Board of Landfills' Responsibility for Anthropogenic Greenhouse Gases and the Appopriate Response to Those Facts."The Center for a Competitive Waste Industry, Madison, WI. Available at http://www.competitivewaste.org/documents/LNDFL-LFG-GHG-CA-ARB-5_000.pdf

Anthony (2001) R.V. "Confessions of a Landfill Apologist." *RecycleScene,* California Resource Recovery Association,November. Available at http://www.richardanthonyassociates.com/articles/landfill.html

Belliveau (2004), M. and S. Lester. *Bad News Comes in 3's: The Poison Plastic, Health Hazards and the Looming Waste Crisis*. Center for Health, Environment & Justice, Falls Church, VA and Environmental Health Strategy Center, Portland, ME.

Berger (2000) S., Jones P.A., and M.C. White. "Exploratory Analysis of Respiratory Illness Among Persons Living Near a Landfill." *Journal of Environmental Health* 62(6): 19.

Birmingham (1999), B., Durr, R., Eng, P. and D. Harper. *Environmental Risks of Municipal Non-Hazardous Waste Landfilling and Incineration: Technical Report Summary.* Standards Development Branch, Environmental Sciences and Standards Division, Ontario Ministry of the Environment. Toronto: Queens Printer for Ontario. Available at: http://www.ene.gov.on.ca/envision/techdocs/3795e01.pdf

Birnbaum (2003) L. and W. Farland. "Health Risk Characterization of Dioxins and Related Compounds." In *Dioxins and Health*, Second Edition by Arnold Schecter and Thomas Hasiewicz, John Wiley and Sons, Hoboken, NJ.

Bogner (2007) J., et al "Waste Management." Chapter 10 in, *Climate Change 2007: Mitigation*. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, edited by B. Metz, et al. Cambridge University Press, Cambridge, UK. Available at: http://www.ipcc.ch/pdf/assessment-report/ar4/wg3/ar4-wg3-chapter10.pdf

Blue Ridge Environmental Defense League (BREDL 2010). "BREDL Chapter Spotlight: Scotland County of Tomorrow." Posted 2 July 2010. Accessed 9 August 2010. Available at: http://www.bredl.org/chapters/SCOT.htm

Calhoun (2010), Jennifer. "Scotland Board Puts End to Landfill Project." FayObserver.com. *The Fayetteville Observer*, 07 June 2010. Accessed 9 August 2010. Available at: http://bredl.org/info/2010/FO060710.htm

Caponi (1998) F.R., Wheless, E. & D. Frediani, "Dioxin and Furan Emissions From Landfill Gas-Fired Combustion Units." Published and presented at the annual Air and Waste Management Association Conference, San Diego, CA, June. Available at: http://www.energyjustice.net/lfg/LFG-caponi.pdf

Center for Public Integrity (CPI 2007) "Wasting Away: Most Dangerous Superfund Sites." Last updated 18 May. Available at: http://www.publicintegrity.org/2007/05/18/5623/most-dangerous-superfund-sites

Center for Responsive Politics (CRP 2016). "Waste Management Inc - Summary." Last updated 22 January. Retrieved from https://www.opensecrets.org/lobby/clientsum.php?id=D000000161

Center for Responsive Politics. (CRP 2015). Waste Management Inc - Totals." Last updated 9 March. Retrieved from https://www.opensecrets.org/orgs/totals.php?id=D000000161

Christenson (2003), S.C. and I.M. Cozzarelli. "The Norman Landfill Environmental Research Site: What Happens to the Waste in Landfills?" Fact sheet, U.S. Geological Survey, 040-03, August. Available at http://pubs.usgs.gov/fs/fs-040-03/pdf/fs-040-03.pdf

Commission of the European Communities (CEC 2005). *Report from the Commission to the Council and the European Parliament on the National Strategies for the Reduction of Biodegradable Waste Going to Landfills Pursuant to Article 5(1) of the Directive 1999/31/EC on the Landfill of Waste*. COM (2005) 105 final, Brussels, 30 March. Available at: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2005:0105:FIN:EN:PDF

Committee on the Toxicological Effects of Methylmercury, Board on Environmental Studies and Toxicology, National Research Council (NRC 2000). *Toxicological Effects of Methylmercury.* Washington, DC: National Academy Press. Searchable full text available at: http://www.nap.edu/catalog.php?record_id=9899

Connett (2001) P. and B. Sheehan. "A Citizen's Agenda for Zero Waste: A United States/Canadian Perspective." GrassRoots Recycling Network, Cotati, CA. Available at: http://www.grrn.org/zerowaste/community/activist/citizens_agenda_2_read.pdf

Cooney (2010), M. "Dewey Loeffel and the Toxic Legacy of General Electric," Upstate Earth blog, 10 April. Available at: http://upstateearth.blogspot.com/2010/04/dewey-loeffel-landfill-toxic-legacy-of.html

Cornell Waste Management Institute (CWMI 2001). "Pay as You Throw for Large Municipalities." Final report, Roundtable Four, Cornell Waste Management Institute. Ithaca, NY. Available at: http://cwmi.css.cornell.edu/PAYTreport.pdf

Council of the European Union (CEU 1999). "Council Directive 1999/31/EC of 26 April 1999 on the Landfill of Waste."*Official Journal of the European Communities* 42: L182, 6 July. Available at http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:1999:182:0001:0019:EN:PDF

deFur (2003) P. and S. Shelley. "Landfill and Other Waste Sites in Virginia – Threats to Health and the Environment." Virginia Chapter, Sierra Club. Richmond, VA. Available at: http://www.deq.state.va.us/waste/pdf/landfillsVA.pdf

Dummer (2003) T., Dickinson, H., and L. Parker. "Adverse pregnancy outcomes near landfill sites in Cumbria, northwest England, 1950-1993, *Archives of Environmental Health* 58(11): 692-697.

Elliot (2001) P. "Risk of Adverse Birth Outcomes in Populations Living Near Landfill Sites." *British Medical Journal* 323: 363-368. Available at: http://dx.doi.org/10.1136/bmj.323.7309.363

Ellman (2005) H.Letter to Christopher Gilkerson, Chairperson, No Wetlands Landfill Expansion Group. San Francisco, CA, 7 December. Available at http://www.protectourwetlands.org/links/Gilkersonletter.pdf

Ewall (2008) M. "Factsheet: Landfill Gas." Energy Justice Network, Philadelphia, PA. Available at http://www.energyjustice.net/lfg/factsheet-lfg.pdf

Ewall (2007) M. "Primer on Landfill Gas and "Green" Energy." Energy Justice Network, Philadelphia, PA. Available at http://www.energyjustice.net/lfg

Federal Emergency Management Agency (FEMA 2002). "Landfill Fires: Their Magnitude, Characteristics, and Mitigation." United States Fire Administration, National Fire Data Center. Available at http://www.usfa.dhs.gov/downloads/pdf/publications/fa-225.pdf

Fletcher (2005), S., et al. "Environmental Laws: Summaries of Statues Administered by the Environmental Protection Agency." Report for Congress. Congressional Research Service Report, RL30798, 31 March. Available at https://www.fas.org/sgp/crs/misc/RL30798.pdf

Freudenrich (2000) C. "How Landfills Work." HowStuffWorks, last updated 16 October. Available at http://people.howstuffworks.com/landfill.htm

Gardiner (2002), B. "Plans for Dump are a Big Waste, Town Says," *Times Union*, Albany, New York, 22 January. Available in "Lanfill Failures: The Buried Truth," published by the Center for Health, Environment, & Justice.

Gelberg (1997) K. "Health Study of New York Department of Sanitation Landfill Employees." *Journal of Occupational & Environmental Medicine* 39(11):1103-1110.

Gilkerson (2007) C. "The 'Dump' and Novato's Environmental Choices." Guest opinion, *Novato Advance*, 2 May. Available at: http://www.marinscope.com/archives/guest-opinion-the-dump-and-novato-s-environmental-choices/article_8a74223d-20b6-562e-94c7-9ed298370d28.html

Gilkerson (2006) C. "Dumps Are Not the Answer." Remarks presented at the Marin County 'Counting Down to Zero Waste' workshop, 18 April. Marin County, CA. Available at: http://glin.net/lists/p2tech/2006-03/msg00040.html

Gilkerson (2005) C., et al."Redwood Landfill Land Use Permit." Letter to Supervisor Harold C. Brown, Jr. President, Marin County Board of Supervisor. Novato, CA, 20 December. Available at: http://www.protectourwetlands.org/links/BoardLetter.pdf

Gilkerson (2005a) C. "Landfill Expansion is a Bad Deal." *Marin Independent Journal*, 22 November. Available at http://www.marinij.com/marinvoice/ci_3241817

Goldberg (1995) M.S., Al-Homsi, N., Goulet, L. and H. Riberdy. "Incidence of Cancer Among Persons Living Near a Municipal Solid Waste Landfill Site in Montreal, Quebec." *Archives of Environmental Health* 50(6): 416-424.

Godri (2010) K.J., S.T. Duggan, G.W. Fuller, T. Baker, D.Green, F.J. Kelly, et al. "Particulate Matter Oxidative Potential from Waste Transfer Station Activity," *Environmental Health Perspectives,*Volume 118, Number 4. April. Available at http://ehp03.niehs.nih.gov/article/fetchArticle.action;jsessionid=F84883821A95A898EB63960E4423A911?articleURI=info%3Adoi%2F10.1289%2Fehp.0901303

Gornto (2010), Miles and Michael Kalish, "A Healthy Shade of Green," *Waste Age Magazine*, February 1. Available at http://wasteage.com/Collections_And_Transfer/sustainable-construction-transfer-stations-201002/

GrassRoots Recycling Network (GRRN 2007). "Zero Waste Around the World." Last updated 7 February. Available at: http://www.grrn.org/zerowaste/zw_world.html

Haxo (1988) H.E. and T.P. Lahey. "Transport of Dissolved Organics from Dilute Aqueous Solutions through Flexible Membrane Liners." *Hazardous Waste and Hazardous Materials* 5(4): 275-294.

Hickman (2000) H.L. and R.W. Eldredge. "A Brief History of Solid Waste Management in the United States, 1950-2000."*MSW Management*, January/February. Available at: http://foresternetwork.com/daily/waste/a-brief-history-of-solid-waste-management-in-the-us-1950-2000/

Infact (1998). "Waste Management: Will Corporation by Same Name Play Same Dirty Game?" *People's Annual Report Update*, Boston: Infact.

Institute for Local Self Reliance (ILSR 2006). "Recycling Means Business," Waste to Wealth, Institute for Local Self Reliance, Washington, D.C. Accessed 11 August. Available at https://ilsr.org/recycling-means-business/

International Brotherhood of Teamsters (IBT 2015). Solid Waste and Recycling Division. Retrieved from https://teamster.org/divisions/solid-waste-and-recycling

International Brotherhood of Teamsters (IBT 2008). "Why This Industry is Ripe for Organizing." International Brotherhood of Teamsters, Washington, DC. Available at http://www.teamster.org/divisions/SolidWaste/whyorganize.htm

Jones-Lee (2000) A. and G.F. Lee. "Appropriate Use of Landfill Leachate Recycling in Municipal Solid Waste Landfilling." Proceedings of the Air and Waste Management Associated 93rd national annual meeting, CD-rom paper 00-455, Pittsburgh PA, June. Available at http://www.gfredlee.com/leachatepapsli.pdf

Jones-Lee (1993), A. and F Lee. "Groundwater Pollution by Municipal Landfills: Leachate Composition, Detection, and Water Quality Significance." Proceedings of the '93 Sardinia IV International Landfill Symposium, Sardinia, Italy, pp. 1093-1103, October (1993). Available at http://www.gfredlee.com/lf-conta.htm

Kitsantas (2000) P., Kitsantas, K., R.H. Travis. "Occupational Exposures and Associated Health Effects Among Sanitations Landfill Employees." *Journal of Environmental Health* 63(5): 17.

Kjeldsen (2002), P. and M. Barlaz, A. Rooker, A. Baun, A. Ledin, and T. Christensen. "Present and Long-Term Compositions of MSW Landfill Leachate: A Review," *Critical Reviews in Environmental Science and Technology*, 32(4) 2002. Available at: http://www.tandfonline.com/doi/abs/10.1080/10643380290813462

Lee (2015), G.F. and A. Jones-Lee. "Flawed Technology of Subtitle D Landfilling of Municipal Solid Waste." Report of G. Fred Lee & Associates, El Macero, CA. Updated June (previously issued Dec 2004). Available at http://www.gfredlee.com/Landfills/SubtitleDFlawedTechnPap.pdf

Lee (2010a), G. F. and A. Jones-Lee. "Comments on the O'Brien ARF SWANA Article, 'The Solid Waste Managers' Guide to the Bioreactor Landfill–A 2009 Update,' MSW Management 20(3):14,16 May (2010)," Report of G. Fred Lee & Associates, El Macero, CA, Submitted to MSW Management, June (2010). Available at http://www.gfredlee.com/Landfills/SWANABioreactorCom.pdf

Lee (2005) G.F. and A. Jones-Lee. "Municipal Solid Waste Landfills – Water Quality Issues." Pp. 163-169 in *Water Encyclopedia: Water Quality and Resource Development*, Hoboken, NJ: Wiley. Available at http://www.gfredlee.com/Landfills/WileyLandfills.pdf

Lee (2005a) G.F. and A. Jones-Lee. "Municipal Solid Waste (MSW) Landfill Closure and Postclosure Issues." Report of G.

Fred Lee & Associates El Macero, CA Available at http://www.gfredlee.com/Landfills/LandfillClosureIssRev.pdf

Lee (2004) G.F. and A. Jones-Lee. "Overview of Subtitle D Landfill Design, Operation, Closure and Postclosure Care Relative to Providing Public Health and Environmental Protection for as Long as the Wastes in the Landfill will be a Threat." Report, G. Fred Lee & Associates, El Macero, CA. Available at http://www.gfredlee.com/Landfills/LFoverviewMSW.pdf

Lee (2004a) G.F. "Comments on CIWMB Discussion and Request for Rulemaking Direction to Formally Notice Proposed Regulations for RCRA Subtitle D Program Research, Development and Demonstration Permits." Report of G. Fred Lee & Associates El Macero, CA. Available at http://www.gfredlee.com/Landfills/CIWMB-comments.pdf

Lee (2002) G.F. "Solid Waste Management: USA Lined Landfilling Reliability." G. Fred Lee and Associates. Available at http://www.gfredlee.com/UNpaper-landfills.pdf

Lee (1994) G.F. and A. Jones-Lee. "Impact of Municipal and Industrial Non-Hazardous Waste Landfills on Public Health and the Environment: An Overview," prepared for California EPA Comparative Risk Project, Sacramento, CA, May. Available at http://www.gfredlee.com/cal_risk.htm

Lee (SLee 2006), S. and Q. Xu, M. Booth, T. Townsend, P. Chadik, G. Bitton. "Reduced sulfur compounds in gas from construction and demolition debris landfills," *Waste Management*, Vol. 26 Issue 5.

Leonard, Annie (2007). "The Story of Stuff." Directed by Louis Fox, produced by Free Range Studios. Released December. Available at: http://storyofstuff.com

Lewis (1998), E. et al. "Investigation of Cancer Incidence Near 38 Landfills with Soil Gas Migration Conditions: New York State, 1980-1989." New York State Department of Health, Albany, NY. Available at http://www.savethepinebush.org/Cases/Landfill/NYSDOH_1998_Landfill_Study_report.pdf

Lindberg (2001) S.E., et al. "Methylated Mercury Species in Municipal Waste Landfill Gas Sampled in Florida, USA." *Atmospheric Environment* 35: 4011.

Local Government Environmental Assistance Network (LGEAN 2003). "Solid Waste Management: Environmental Risks and Liabilities for Local Governments" Fact sheet, Local Government Environmental Assistance Network, International City/County Management Association and the Public Entity Risk Institute. Available at file:///C:/Users/chej/Downloads/%7B652C9FD0-445C-479C-B581-934F76EDD095%7D.pdf

Lombardi (2001) E. "Beyond Recycling...Zero Waste or Darn Near." *BioCycle* 42(9): 75-76. Available at: http://www.grrn.org/zerowaste/articles/biocycle_zw_commentary.html

Meriowski (1999) I. and J. Eijlertsson. "Long Term Behavior of PVC Products Under Landfill Conditions." Technical University of Hamburg-Harburg, Germany; Linköping University, Sweden.

McCarthy (2007), J. "Interstate Shipment of Municipal Solid Waste: 2007 Update." Report for Congress, Congressional Research Service, RL34043, 13 June. Available at research.policyarchive.org/18953.pdf

McCarthy (2000), J. "Solid Waste Issues in the 106th Congress." Issue Brief for Congress, Congressional Research Service, IB10002, 27 April. Available at http://www.ncseonline.org/nle/crsreports/waste/waste-27.cfm

McCarthy (1995), J. "Flow Control of Solid Waste: Issues and Options." Report for Congress, Congressional Research Service, 94-265 ENR, 16 May. Available at http://infohouse.p2ric.org/ref/11/10583.htm

Montague (1992), P. "New Evidence That All Landfills Leak." *Rachel's Environment & Health News* 316. Available at http://www.rachel.org/files/rachel/Rachels_Environment_Health_News_813.pdf

Montague (1989), P. "Leachate Collection Systems: The Achilles' Heel of Landfills." *Rachel's Environment & Health News* 119. Available at http://www.rachel.org/files/rachel/Rachels_Environment_Health_News_1026.pdf

Montague (1989a), P. "Landfill Study Finds Low Birth Weight In Babies, Adult Cancers." *Rachel's Environment & Health News* 115. Available at http://www.rachel.org/files/rachel/Rachels_Environment_Health_News_1030.pdf

Montague (1982), P. Testimony before the House Subcommittee on Commerce, Transportation and Tourism of the Committee on Energy and Commerce, Serial NO.97-169, March 31, 1982, 11 pages.

Montague (1982a), P. "Hazardous Waste Landfills: Some Lessons from New Jersey," *Civil Engineering – ASCE* Vol. 52 No. 9, September.

National Waste & Recycling Association (NWRA 2010). "MSW (Subtitle D) Landfills." National Waste & Recycling Association, Washington, D.C. Available at http://www.environmentalistseveryday.org/publications-solid-waste-industry-research/information/faq/municipal-solid-waste-landfill.php

National Toxiocology Program (NTP 2005) "2,3,7,8-Tetrachlorodibenzo-*p*-Dioxin (TCDD); 'Dioxin' CAS No. 1746-01-6."*Report on Carcinogens*, 11th edition. U.S. Department of Health and Human Services, Public Health Service. Available at http://www.hawaiidoh.org/references/NTP%202005.pdf

Northeast Waste Management Officials' Association (NEWMOA 2006). "Summary of Research on Mercury Emissions from Municipal Landfills." Last updated 14 April. Available at http://www.newmoa.org/prevention/mercury/landfillfactsheet.cfm

No Wetlands Landfill Expansion (NWLE 2007). "Comments to the Draft Final Environmental Impact Report (EIR)." Novato, CA. Available at: http://www.protectourwetlands.org/recent-comments-letters/

No Wetlands Landfill Expansion (NWLE 2006). "Green Coalition for Responsible Waste/Resource Management." Novato, CA. Available at: http://www.protectourwetlands.org/green-coalition-for-responsible-wasteresource-management/

Pellerano, M. (1995). The Basics of Landfills. Retrieved from http://www.ejnet.org/landfills/

Porta (Porta 2009), D. and S. Milani, A.I. Lazzarino, C.A. Perucci, F. Forastiere. "Systematic review of epidemiological studies on health effects associated with management of solid waste." *Environmental Health*, Vol 8, 23 December 2009. Available at http://www.ehjournal.net/content/8/1/60

Raloff (2001) J. "Landfills Make Mercury More Toxic." *Science News* 160(1): 4. Available at http://www.phschool.com/science/science_news/articles/landfills_mercury_toxic.html

Ready (2003) R. and C. Abdalla. "The Impact of Open Space and Potential Local Disamenities on Residential Property Values in Berks County, Pennsylvania." Staff Paper 363, Department of Agricultural Economics andRural Sociology, Pennsylvania State University, University Park, PA. Available at http://aese.psu.edu/directory/aic/the-impact-of-open-space-and-potential-local-disamenities-on-residential-property-values-in-berks-county-pennsylvania

Rogers (2005) H. "Titans of Trash." *The Nation*, 19 December. Available at http://www.thenation.com/article/titans-trash/

R.W. Beck, Inc (Beck 2001). "U.S. Recycling Economic Information Study. Final Report." National Recycling Coalition, Washington, DC. Available at: http://infohouse.p2ric.org/ref/19/18327/fullreireport.pdf

San Diego Environmental Services Department (ESD 2007). "Leachate Disposal: Standard Operating Procedure." Waste Reduction & Disposal Division, Environmental Services Department, San Diego. Available at http://www.sandiego.gov/stormwater/pdf/jurmpapp19.pdf

Scanlon (2001), K. *Poison PCs and Toxic TVs and Poison PCs: The Greatest Threat to the Environment You've Never Heard Of*. Californians Against Waste, Materials for the Future Foundation and Silicon Valley Toxics Coalition. Available at: http://svtc.org/wp-content/uploads/ppc-ttv1.pdf

Schrab (1993) G.E., Brown, K.W. and K.C. Donnelly. "Acute and Genetic Toxicity of Municipal Landfill Leachate." *Water, Air, and Soil Pollution* 69(1-2): 99-112.

South Carolina Department of Health and Environmental Control (SCDHEC 2002). "Getting Into the Large-Scale Composting Business." Technical Assistance Guide, Sheet 1, OR-0333, April. Office of Solid Waste Reduction and Recycling, Columbia, SC.

Suflita (1992) J.M., et al 1992 "The World's Largest Landfill." *EnvironmentalScience and Technology* 26(8): 1486-1495.

Tangri (2003) N. *Waste Incineration: A Dying Technology*. Global Anti-Incinerator Alliance/Global Alliance for Incinerator Alternatives (GAIA), Quezon City, Philippines. Available at: http://www.no-burn.org/downloads/Waste%20Incineration%20-%20A%20Dying%20Technology.pdf

Turley (2006), W. "A Watchful Eye:C&D landfill sites are under increasing scrutiny as operators address issues like hydrogen sulfide gas and groundwater contamination." *Construction and Demolition Recycling*, 1 July. Available at: http://www.thefreelibrary.com/A+watchful+eye%3A+C%26D+landfill+sites+are+under+increasing+scrutiny+as...-a0149266989

United Nations University (UNU 2010). "Hazardous e-waste surging in developing countries." *Science Daily*, February 23. Available at http://www.sciencedaily.com/releases/2010/02/100222081911.htm

U.S. Environmental Protection Agency (USEPA 2015). "Presumptive Remedies: CERCLA Landfill Caps RI/FS Data Collection Guide." U.S. EPA. Accessed July 16, 2015. Available at: http://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=P1007WJD.txt

U.S. Environmental Protection Agency (USEPA 2014). "Facility Information," Office of Solid Waste, U.S. EPA. Last updated 23 May. Available at http://www.epa.gov/osw/hazard/correctiveaction/facility/index.htm#2020

U.S. Environmental Protection Agency (USEPA 2014a). "Municipal Solid Waste Generation, Recycling, and Disposal in the United States: Tables and Figures for 2012." USEPA Office of Solid Waste, February. Available at http://www.epa.gov/osw/nonhaz/municipal/msw99.htm

U.S. Environmental Protection Agency (USEPA 2014b). "Moving Sustainable Electronics Forward: An Update to the National Strategy for Electronics Stewardship," Interagency Task Force on Electronics Stewardship, U.S. EPA, August. Available at http://www.epa.gov/sites/production/files/2015-09/documents/moving_sustainable_electronics_forward.pdf

U.S. Environmental Protection Agency (USEPA 2014c). Fact Sheet: Proposed Updates to the New Source Performance Standards for Municipal Solid Waste Landfills. Retrieved from https://www3.epa.gov/airtoxics/landfill/landflpg.html

U.S. Environmental Protection Agency (USEPA 2012). "Basic Information," Landfill Methane Outreach Program, US EPA. Last updated 14 July. Accessed July 19, 2012. Available at http://www.epa.gov/lmop/basic-info/index.html.

U.S. Environmental Protection Agency (USEPA 2010a). "What is the TSCA Chemical Substance Inventory?" New Chemicals Program, US EPA. Update May 17. Available online at http://www.epa.gov/tsca-inventory/about-tsca-chemical-substance-inventory

U.S. Environmental Protection Agency (USEPA 2010b). "Chapter 6: Protecting Surface Water," *Guide for Industrial Waste Management*, Office of Solid Waste, U.S. EPA. Last update 4 January. Available at:http://www.epa.gov/osw/nonhaz/industrial/guide/pdf/chap6.pdf

U.S. Environmental Protection Agency (USEPA 2010c). "Chapter 10: Taking Corrective Action," Guide for Industrial Waste Management, Office of Solid Waste, U.S. EPA. Last updated 4 January. Available at: http://www.epa.gov/osw/nonhaz/industrial/guide/pdf/chap10.pdf

U.S. Environmental Protection Agency (USEPA 2010d). "Sewage Sludge (Biosolids): Introduction." Office of Water, U.S. EPA. Last update July 21. Available at: http://water.epa.gov/polwaste/wastewater/treatment/biosolids/index.cfm.

U.S. Environmental Protection Agency (USEPA 2010e). "Waste Site Cleanup & Reuse in New England: Long Term/National Priorities List Sites," U.S. EPA. Update 19 August. Available at: http://yosemite.epa.gov/R1/npl_pad.nsf/SelectedByType?OpenForm&View=Long%20Term/National%20Priorities%20List%20(NPL)&ViewEnd

U.S. Environmental Protection Agency (USEPA 2008). "Hazardous Waste Land Disposal Units." USEPA Office of Solid Waste and Emergency Response, last updated 3 January. Available at: http://www.epa.gov/hwpermitting/hazardous-waste-management-facilities-and-hazardous-waste-management-units

U.S. Environmental Protection Agency (USEPA 2008a). *eCycling*. US EPA Office of Solid Waste and Emergency Response, last updated 20th February. Available at http://www.epa.gov/epaoswer/hazwaste/recycle/ecycling/

U.S. Environmental Protection Agency (USEPA 2008b). " Landfill Methane Outreach Program (LMOP)." USEPA Office of Air and Radiation, last updated 4th February. Available at: http://www3.epa.gov/lmop/

U.S. Environmental Protection Agency (USEPA 2008c). "Source Reduction and Reuse." US EPA Office of Solid Waste and Emergency Response, last updated 8 January. Available at http://www.epa.gov/recycle/reducing-and-reusing-basics

U.S. Environmental Protection Agency (USEPA 2008d). "Basic Facts: Municipal Solid Waste (MSW)." US EPA Office of Solid Waste and Emergency Response, last updated 3 January. Available at: http://www3.epa.gov/epawaste/nonhaz/municipal/

U.S. Environmental Protection Agency (USEPA 2008e). "Frequently Asked Questions About Landfill Gas and How It Affects Public Health, Safety, and the Environment." US EPA Office of Air and Radiation. Available at: http://www.cityofmidlandmi.gov/DocumentCenter/View/1858

U.S. Environmental Protection Agency (USEPA 2007). "Municipal Solid Waste Generation, Recycling, and Disposal in the United States: Facts and Figures for 2006." US EPA Office of Solid Waste and Emergency Response, EPA-530-F-07-030, November. Available at http://netedu.xauat.edu.cn/sykc/hjx/content/ckzl/9/8.pdf

U.S. Environmental Protection Agency (USEPA 2007a). "Corrective Action." US EPA Office of Solid Waste and Emergency Response, last updated 14 September. Available at http://www3.epa.gov/epawaste/hazard/correctiveaction/

U.S. Environmental Protection Agency (USEPA 2007b). "2006 MSW Characterization Data Tables." US EPA Office of Solid Waste and Emergency Response. Available at http://www.epa.gov/epaoswer/non-hw/muncpl/pubs/06data.pdf

U.S. Environmental Protection Agency (USEPA 2006). *RCRA Orientation Manual*. US EPA Office of Solid Waste and Emergency Response, EPA-530-R-06-003, March. Available at: http://www.epa.gov/sites/production/files/2015-07/documents/rom.pdf

U.S. Environmental Protection Agency (USEPA 2006a). *Solid Waste Management and Greenhouse Gases: A Life-Cycle Assessment of Emissions and Sinks*, 3rd edition. Available at: http://www.epa.gov/climatechange/wycd/waste/SWMGHGreport.html

U.S. Protection Agency (USEPA 2006b). "Background," *An Inventory of Sources and Environmental Releases of Dioxin-Like Compounds in the U.S. for the Years 1987, 1995, and 2000 (Final, Nov 2006)*. U.S. Environmental Protection Agency, Washington, DC, EPA/600/P-03/002F. Update 13 July 2010. Available at: http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=159286

U.S. Environmental Protection Agency (USEPA 2001). "RCRA Financial Assurance for Closure and Post-Closure." Office of Inspector General, Audit Report 2001-P-007. Available at http://www.epa.gov/sites/production/files/2015-12/documents/finalreport330.pdf

U.S. Environmental Protection Agency (USEPA 2000). "What You Need to Know Before Donating or Recycling End of Life Electronics." *WasteWise Update*. US EPA Office of Solid Waste and Emergency Response, EPA-530-N-00-007, November. Available at: http://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=10000N8H.txt

U.S. Environmental Protection Agency (USEPA 1999). "Municipal Solid Waste Landfills, Volume 1: Summary of the Requirements for the New Source Performance Standards and Emission Guidelines for Municipal Solid Waste Landfills." Office of Air Quality Planning and Standards, EPA-453R/96-004, February. Available at http://www.epa.gov/ttn/atw/landfill/lf-vol1.pdf

U.S. Environmental Protection Agency (USEPA 1996). "Standards of Performance for New Stationary Sources and Guidelines for Control of Existing Sources: Municipal Solid Waste Landfills.Final Rule."40 CFR Part 60 *Federal Register* Vol. 61 (49) 9918-9944. Available at http://www.epa.gov/ttn/atw/landfill/fr12mr96.pdf

U.S. Environmental Protection Agency (USEPA 1995). *Compilation of Air Emission Factors Volume 1: Stationary Point and Area Sources,* 5th edition. US EPA Office of Air Quality Planning and Standards, AP-42. Available at http://www.epa.gov/ttn/chief/ap42/

U.S. Environmental Protection Agency (USEPA 1995a). *Construction and Demolition Waste Landfills*. Office of Solid Waste, US EPA, 18 May Draft Report. Available at: http://www3.epa.gov/epawaste/nonhaz/industrial/cd/cdlandfill.htm

U.S. Environmental Protection Agency (USEPA 1990). *Air Emissions from Municipal Solid Waste Landfills – Background Information for Proposed Standards and Guidelines (Draft)*, Office of Air Quality Planning and Standards, U.S. EPA, 12 March Draft Report. Available at: http://www.epa.gov/ttnchie1/ap42/ch02/draft/db02s04.pdf

U.S. Environmental Protection Agency (USEPA 1988). "Solid Waste Disposal Facility Criteria.Proposed Rule." 40 CFR Part 258 *Federal Register* Vol. 53 (168): 33345, 30 August. Available at http://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=10003P3T.txt

U.S. Government Accountability Office (GAO 2010). "Electronic Waste: Considerations for Promoting Environmentally Sound Reuse and Recycling," GAO-10-626. Issued July 12. Available at http://www.gao.gov/products/GAO-10-626

Wang (2009), L. and Y. Hung, N. Shammas. "Handbook of Industrial and Hazardous Wastes Treatment, Volume 2." Taylor & Francis Group, CRC Press. Available at: http://books.google.com/books?id=jOOL8WhKq6UC&pg=PR3&source=gbs_selected_pages&cad=3#v=onepage&q&f=false .

Waste360. (2016). 2015 Waste 100. Retrieved from http://waste360.com/waste-100/2015-waste-100-0

Waste Management, Inc. (WMI 2014). "Fact Sheet for the year ended December 31, 2014." Available at http://phx.corporate-ir.net/External.File?item=UGFyZW50SUQ9MjgyNDMzfENoaWxkSUQ9LTF8VHlwZT0z&t=1

Waste Management, Inc. (WMI 2013). "2014 Fact Sheet." Available at http://phx.corporate-ir.net/External.File?item=UGFyZW50SUQ9MjM5ODMyfENoaWxkSUQ9LTF8VHlwZT0z&t=1

Waste Management, Inc. (WMI 2011). "2011 Fact Sheet." Available at http://phx.corporate-ir.net/External.File?item=UGFyZW50SUQ9MjM5ODMyfENoaWxkSUQ9LTF8VHlwZT0z&t=1

Waste Management, Inc. (WMI 2008a). "Charitable Giving." Available at http://www.wm.com/about/community/charitable-giving.jsp

Waste Management, Inc. (WMI 2007). "Corporate Fact Sheet 2007." Available at: http://media.corporate-ir.net/media_files/IROL/11/119743/FactSheet2007.pdf

Zero Waste New Zealand Trust (ZWNZT 2003). "Wasted Opportunity: A Closer Look and Landfilling and Incineration." Zero Waste New Zealand Trust, Auckland, New Zealand. Available at: https://www.zerowaste.co.nz/assets/Reports/Wastedopportunities.pdf







"CHEJ is the strongest environmental organization today – the one that is making the greatest impact on changing the way our society does business."

Ralph Nader

"CHEJ has been a pioneer nationally in alerting parents to the environmental hazards that can affect the health of their children."

New York, New York

"Again, thank you for all that you do for us out here. I would have given up a long time ago if I had not connected with CHEJ!"

Claremont, New Hampshire

CHEJ

Center for Health, Environment & Justice
P.O. Box 6806, Falls Church, VA 22040-6806

Mailbag: We might as well change those signs

[redacted]

Coming home to our county from north, south, east or west, we see signs that read "Benton County: At your service."

We take pride in our county, especially for our shared goals of sustainability. We work together to reduce waste and to preserve our shared environment.

But garbage haulers entering our county take a different message from those signs. Did you know that, of all the tons of garbage dumped annually at the Coffin Butte Landfill near Adair Village, less than 12% comes from Benton County?

In 2020, Marion, Washington,and Linn counties accounted for more than half of the waste dumped here, with Lincoln County adding another 10% to the pile. That's more than half a million tons of garbage per year, but that's barely half of it. Where did the rest come from? As far away as Clark County, Washington!

Republic Services, the Arizona-based company that operates the landfill, would like us all to make room in Benton County for still more garbage. They've filed an application to radically expand the disposal area right across the top of Coffin Butte Road — a vital emergency route for hundreds of rural residents. Discussions by our county's Solid Waste Advisory Council reveal that taking more waste from the Portland metro area is part of the calculation.

[redacted]

Do we really want to become the destination for more garbage haulers, from an ever-widening area? I'd say no. Otherwise, we might as well change those signs to say, "Benton County: At your disposal."

Joel Geier

Corvallis

ALERT TOP STORY

Coffin Butte: Benton County hears more opposition to landfill expansion



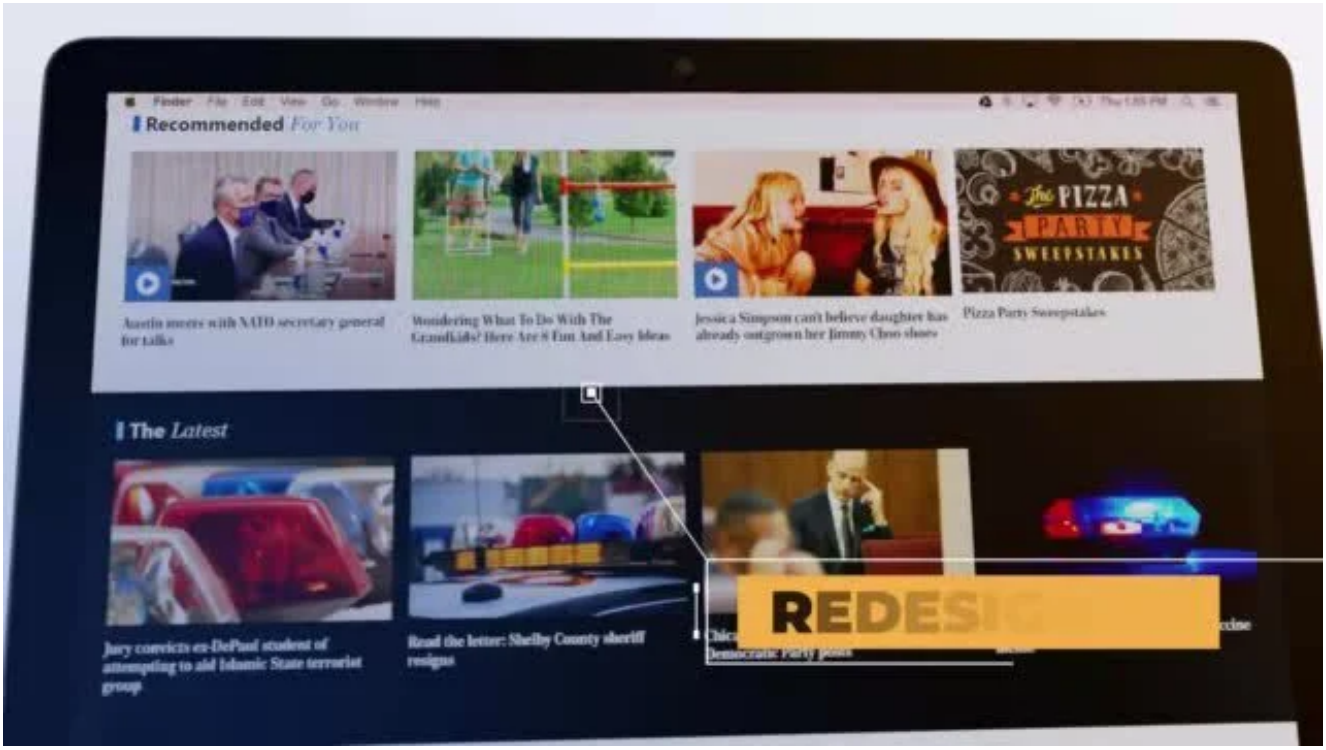
Road access at this corner near the Coffin Butte landfill will be reworked if Republic Services' landfill expansion plans proceed. Motorists would have to use a new northern route via Robison Road or a southern route via Tampico Road to get to Highway 99 because Soap Creek Road (left fork) would no longer connect to the highway.
Andy Cripe, Mid-Valley Media(file 2021)

Jim Day

The Benton County Planning Commission heard almost 2.5 hours of public testimony Tuesday night, Nov. 16 regarding **plans by Republic Services to expand its Coffin Butte landfill**. Residents were nearly unanimous in their opposition to the proposal.

No deliberations or vote took place, with commissioners expected to take those actions at their Dec. 7 meeting. Republic needs a conditional use permit from the

county to move forward.



An update will be happening for our website this week! Here's what things will look like.

A total of 19 individuals testified in the virtual session, with all but one expressing opposition to the proposal. The lone backer was Tyrone Belgarde of Knife River, the company that operates a quarry on the Coffin Butte property.

Those testifying in opposition largely raised similar themes **shared in the 4.5-hour public hearing on Nov. 2**. The length of that session led commissioners to decide to continue the public hearing until this week and allow all who had signed up to testify orally.

. .. .

?[redacted]?

. .....

Key concerns expressed by residents, many of whom live within a mile or less of the landfill, are the closure of Coffin Butte Road, odor and noise issues, the impact of the project on wildlife, water quality and contamination, methane and leachate pollution and whether the expansion is needed. Coffin Butte Road would be "vacated" because it would be covered by the expansion of the landfill pile.

"Republic is not a good partner," said Marge Popp, citing her concerns about its environmental record.

"These issues are complex, life changing and permanent," said Mark Yeager, who previous served on the county's Solid Waste Advisory Council. Yeager also noted, as did many others, that the proposed closing of Coffin Butte Road at Soap Creek Road created an "undue burden."

"We humans are not good at thinking about the future," Ken Hoechlin said. "Republic wants to speed up the methane factory to the max before updated regulations get here. I know you know all this, so I don't understand how all this is happening. There should be someone besides us saying, 'No, oh god, no.' That's why we have the Planning Commission, to stop the process once it goes rogue."

Said Carrie Norris: "There are so many gaps in this plan that I'm frankly astonished that it has gotten this far."

One resident testified mockingly by pretending to be participating in a meeting at which "greedy" Republic Service officials were going over their “talking points.”

A total of 32 people testified in public during the two hearings, with the comment portion of the proceeding consuming more than four hours. Following the public testimony Republic officials and their representatives offered a brief rebuttal of the

testimony, although they noted that their final argument, due by Dec. 6, will be more substantial.

“The Coffin Butte landfill is an important resource in this county that fills a critical need,” said Jeff Condit, an attorney with Miller Nash of Portland. “Republic has an excellent track record at Coffin Butte and has been a good neighbor.”

Should the expansion not move forward, Condit added, local customers would face much higher rates to route trash to the Arlington landfill along the Columbia River. That facility is approximately 200 miles away from Coffin Butte.

One key point of contention that remains unresolved involves Tampico Road. The county wants Republic to improve the road because of the additional traffic it likely would pick up when Coffin Butte Road is closed to through traffic.

Republic officials say a new northern route that would connect the Soap Creek Road/Tampico Road area with Highway 99W via Robison Road would take care of the extra traffic issues. County officials instead prefer that improvements be directed to Tampico, saying that traffic that was no longer able to use Coffin Butte Road was more likely wind up on Tampico than the northern route.

The county preference on Tampico is one of the conditions of approval county staff have recommended be required of Republic to move forward with the project. The Planning Commission will make the final call on any conditions attached to the permit.

In the only vote that has taken place to date the county's Solid Waste Advisory Council recommended on a 5-1 vote that the Planning Commission approve the permit.

- **More Benton County news**

Contact reporter James Day at [redacted] or 541-812-6116. Follow at [redacted] or [redacted].

Here is a look at what’s next on the Coffin Butte Landfill expansion application:

: Republic Services submits its noise study.

: The written record closes for additional public comment.

: Republic submits its final argument.

: The commission meets virtually at 7 p.m. to deliberate and vote on the application. No public testimony will be taken at that time. A link to the session will be posted at in the days leading up to the meeting.

About Coffin Butte

Coffin Butte is a "regional" landfill that generally serves Benton, Linn, Lane, Lincoln, Polk and Marion counties, although it receives 30% of its trash from beyond those six counties. About 12% of the landfill consists of Benton County trash, with another 15% coming from Linn County. The landfill is in north Benton County, just west of Highway 99W near Adair Village.

https://democratherald.com/tncms/asset/editorial/7a5bd9ff-706f-5f75-bc09-8400a2406c84/

BREAKING FEATURED TOP STORY

Benton County commission unanimously rejects Coffin Butte landfill expansion plan

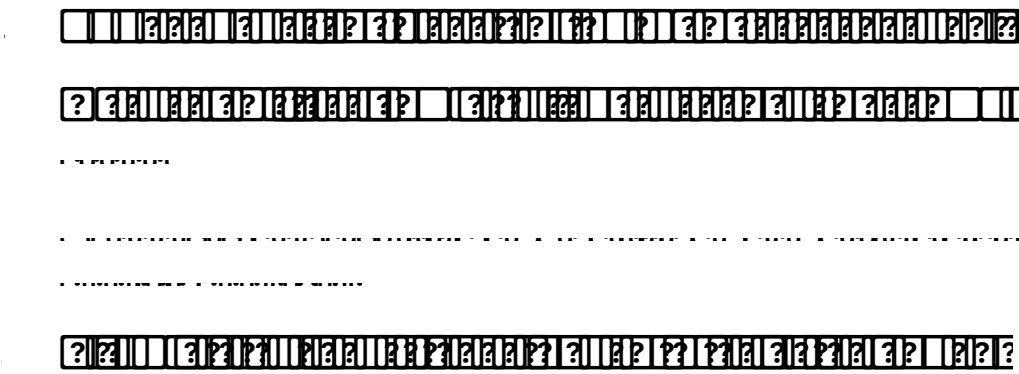


The Benton County Planning Commission has rejected Republic Services' plans to expand the Coffin Butte
Andy Cripe, Mid-Valley Media (File 2021)

Jim Day

The Benton County Planning Commission on Tuesday, Dec. 7 **unanimously rejected a proposal by Republic Services** to **expand its Coffin Butte landfill**.

Chairman Ken Kenaston, who initiated deliberations by reading a lengthy statement, said the proposed closing of Coffin Butte Road would create an “undue burden” on the surrounding neighborhood and that Republic had not effectively answered questions from the community on noise, odor and other public health impacts of the expansion as well as its effects on the environment and wildlife.



The 6-0 vote by the commission at Tuesday night’s virtual session almost assuredly will be appealed, although Republic Services officials chose not to discuss what its future steps will be.

“No comment tonight,” Julie Jackson, the municipal and community relations manager for Republic Services, said in an email Tuesday night seeking Republic’s view of the decision. Attempts to get further comment Wednesday were not successful.

Republic has 14 days to appeal the decision to the Benton County Board of Commissioners. In the meantime the county’s Community Development Department will gather findings based on commissioner deliberations and forward them to the Board of Commissioners as well as members of the community who participated in the process.

The six members of the Planning Commission who voted to reject the Republic application during the 80-minute session were Kenaston, Nick Fowler, Evelyn Lee,

Scott Scorvo, John McEvoy and Jennifer Gervais.

“The unanimous support of the commissioners,” Fowler said, “speaks volumes that this application failed the fundamental test of the conditional use permit.”

Indeed. By the time McEvoy spoke — he was the fifth commissioner to chime in — so much information had been brought forward that McEvoy said “he didn’t feel the need to repeat the points made by others because I am already inclined to vote negatively.”

Republic needed the conditional use permit to expand the current disposal cell south beyond the current route of Coffin Butte Road. The proposal includes the aforementioned closing of Coffin Butte Road with the construction of a private road that would encircle the new disposal area and terminate at a locked gate at Soap Creek Road.

Republic also proposed constructing a new northern route that would link the Soap Creek Road/Tampico Road area to Highway 99W via Robison Road in an effort to replace the highway access lost with the closure of Coffin Butte Road. Residents would continue to have access to Highway 99W via Tampico Road, although many testified that Tampico is less safe than Coffin Butte Road.

Republic plans also included two leachate ponds in the new disposal area. The Phoenix, Arizona-based company said it needs the expansion because the current landfill site will fill up in approximately four years, with the adjacent Knife River quarry not available to accept waste for perhaps another eight to 10 years.

The quarry, Republic officials said, has a potential disposal lifespan of 15 years before it reaches capacity. In all, Republic said, approval of the permit would add 30 years of life to the landfill.

Quality journalism doesn't happen without your help

The application and review process was a lengthy one, with Republic requesting

postponement of the original Sept. 7 date for the public hearing because the trash hauler wanted to modify its proposal.

On Oct. 19 the county's Solid Waste Advisory Council recommended on a 5-1 vote that the Planning Commission approve the application, although members of that board also included reservations about the project in a letter to the planning body.

Commissioners then **held public hearings Nov. 2** and Nov. 16, and more than 30 people testified orally at the two sessions, with dozens more providing written comment. In addition, more than 20 individuals have sent letters to the editor on the subject. Virtually all of the responses — public comment and letters — have come from individuals opposed to the project.

Rejection of the application starts a clock on the possible closure of Coffin Butte and the insertion of a massive question mark into the landfill equation.

"It is very unlikely that the state would approve a new landfill in the Willamette Valley," Benton County Counsel Vance Croney has said.

That means the closure of Coffin Butte would send all of the regional trash more than 200 miles away to the massive Waste Management facility in Arlington along the Columbia River. The extra distance the trucks would have to travel, Croney said, would have an obvious impact on rates.

- **More Benton County news**

Contact reporter James Day at [redacted] or 541-812-6116. Follow at [redacted] or [redacted].

[redacted]

• The Coffin Butte landfill, which is operated by Republic Services of Phoenix, Arizona, occupies 740 acres in northern Benton County near Adair Village. Most of the acreage serves as buffer zones surrounding the landfill. The buffer zones are a mix of wetlands, forested property and farm fields.

• Coffin Butte is a “regional” landfill designed to primarily serve Benton, Linn, Lane, Lincoln, Polk and Marion counties. Approximately 70% of the trash comes from those six counties, with about 12% from Benton and 15% from Linn. About 30% of the trash comes from elsewhere, mainly the Portland area.

• Benton County is in the first year of a 20-year franchise agreement with Republic. Because the county “hosts” the landfill, Republic pays the county $2 million per year.

• Corvallis, Philomath and Albany have franchise agreements with Republic Services that allow the trash hauler to operate in those markets. But the main financial relationship in those agreements is the fees the residents and commercial accounts pay Republic to haul away the trash, recyclables and yard waste.

. .. . .- ... ..

. .. .

https://democratherald.com/tncms/asset/editorial/20f217be-097c-57e6-b0c9-77961ead9771/

BREAKING ALERT TOP STORY

Republic Services pulls appeal on Coffin Butte landfill expansion



The current Coffin Butte landfill extends up the hill to the left in this view looking toward the east. The landf
Learning program on Thursday, Sept. 29.

James Day, Mid-Valley Media (File 2021)

Cody Mann

Republic Services has withdrawn its appeal of a **denied conditional use permit** for the Coffin Butte landfill expansion, according to a news release from Benton County.

The Benton County Board of Commissioners was informed on Tuesday, March 15 that Valley Landfills Inc./Republic Services Inc. withdrew its appeal of the **Planning Commission's denial of the permit** effective last Friday, March 11, according to the release.

Republic Services intends to file a new application for a revised landfill expansion project in the near future, according to a letter sent to the county. Company representatives could not be immediately reached for comment.

The letter was dated March 11 and addressed to Inge Williams, associate planner with Benton County Community Development Department. It was sent by Ryan Lawler, Republic Services area president, who wrote that the decision to withdraw the appeal was made "after careful analysis and consideration of alternatives."

"We will continue to engage with the community, listen to, and incorporate feedback," Lawler wrote. "And we look forward to being part of Benton County's long-term waste management and diversion solutions."

Before this latest development in the bid to expand the landfill, appeal hearings were expected to resume Monday, March 21, which marked the end of a 90-day pause requested by Republic on Dec. 21.

"Coffin Butte Landfill is an extremely important asset to our community," County

Commissioner Nancy Wyse said in a statement. “My fellow commissioners and I were very pleased to hear that Republic is utilizing this opportunity to take more time to re-engage with our community to help shape a more constructive path for the future of solid waste.”

Planning commissioners found that Republic’s proposal would create an “undue burden” on the surrounding neighborhood and that Republic had not effectively answered community questions about noise, odor, air quality and public health impacts as well as effects on the environment and wildlife.

Republic challenged the Planning Commission’s findings, claiming the evidence doesn’t support the commission’s conclusion with regard to odor, air quality or noise, and that the landfill has maintained compliance with Oregon Department of Environmental Quality’s air quality permit regulations.

The company also argued that improvements to Robison and Tampico roads will mitigate the closure of Coffin Butte Road, and that it would address wildlife impacts as part of its DEQ permit.

. .... - .....

On Dec. 7, the Benton County Planning Commission **voted 6-0 to reject the application** for a proposed expansion at Coffin Butte. The rejection started the clock on a 14-day period during which appeals could be filed with the Board of Commissioners.

Republic needed the conditional use permit to expand the current disposal cell south beyond the current route of Coffin Butte Road, which would be closed. A new private road would encircle the new disposal area and terminate at a locked gate at Soap Creek Road.

Republic also proposed constructing a new northern route that would link the Soap Creek Road/Tampico Road area to Highway 99W via Robison Road in an effort to replace the highway access lost with the closure of Coffin Butte Road. Residents

would continue to have access to Highway 99W via Tampico Road.

The Phoenix-based company said it needs the expansion because the current landfill site will reach maximum capacity in approximately four years. The adjacent Knife River quarry will not be available to accept waste for perhaps another eight to 10 years.

The quarry, Republic officials said, has a potential disposal lifespan of 15 years. In all, Republic said, approval of the permit would add 30 years of life to the landfill.

Rejection of the application also started a clock on the possible closure of Coffin Butte and the insertion of a massive question mark into the state's landfill equation.

"It is very unlikely that the state would approve a new landfill in the Willamette Valley," Benton County Counsel Vance Croney has said in the past.

That means the closure of Coffin Butte would send all of the regional trash more than 200 miles away to the massive Waste Management facility in Arlington along the Columbia River. The extra distance the trucks would have to travel would likely impact rates.

. ……..

Corvallis resident Amy Luhn, a critic of the expansion plan, was elated to hear the news.

"Oh good, we didn't need anything like that in our county," she said.

Luhn, who has lived in the area for 30 years, said she is not anti-development, but the expansion wasn't planned for the residents of Benton County but to help Republic Service's bottom line in serving a much larger region that goes beyond state lines.

"A quantum expansion of the landfill would not be an improvement to me," she

said.

- **More Corvallis news**

Cody Mann covers Benton County and the cities of Corvallis and Philomath. He can be contacted at 541-812-6113 or . ... Follow him on Twitter via @News_Mann_.

. .. .

. .....-.

As I See It: Assessing our trash future

. . . . . .
. . . . . .

If you're not up on what's been happening with our county trash management lately, that's understandable.

It's kinda icky, for one thing, and for another, you're not alone. Benton County itself is still operating with a trash management plan from circa 1977.

But I urge you to take a moment now to catch up because it turns out this is pretty important for the health of the county. And our commissioners will be mulling over what to do in their meeting on Tuesday, July 19, and looking for public input.

In March, the county commissioned a third-party assessment of its trash situation, and that assessment dropped July 12. The assessment focuses first on the lack of "common understandings" ("facts") that surround our trash management, and in particular, the Coffin Butte Landfill just north of Corvallis. Let me call out a few understandings we should look for in particular:

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

How did the county lose control? I expect Benton County residents regard Coffin Butte (if they think of it at all) as “our landfill” — which it once was. Reviewing landfill history, however, will show that’s certainly not the case today.

It appears the landfill’s now taking in about a million tons of trash a year, and only 66,000 tons (6.6%) of that comes from Benton County, according to the Oregon Department of Environmental Quality. (I think Linn County’s number is similar.) Benton County pays 100% of the landfill’s environmental cost, however, and takes 100% of its risks.

What happened to operating rules? Unbridled trash intake is only one aspect of loss of county control over the landfill. The assessment calls for an accounting of prior “conditions for use” — obligations that the county’s imposed on the landfill that came to nothing.

It seems there are rules in place governing hours of operation, visual screening, litter and so on that are on the books but which a quick trip to the dump will establish are not being heeded.

Chief among these, maybe: landfill leachate. I learned only recently that water that enters the landfill (either in trash or as rainfall on the dump) needs to be pumped out daily lest it threaten groundwater — and it’s toxic with per- and polyfluoroalkyl (“forever”) chemicals and many other pollutants.

Earlier, apparently, the landfill agreed to treat all leachate on site, but now it doesn’t, and so millions of gallons of toxic leachate have to be trucked to the Corvallis treatment plant and passed into the Willamette River.

Greenhouse gases: how much? Perhaps the biggest “understanding” we lack is: How much methane is leaking from the landfill? Strangely, although methane is a highly destructive greenhouse gas and therefore the focus of federal, state and county action against the climate crisis, it seems to fall through the cracks at Coffin Butte. The assessment recommends that Benton County address this by clarifying

which government body has jurisdiction over shared responsibilities such as methane.

Which is important, because, by my math, Coffin Butte's methane already inflicts climate damage equal to a small coal-fired power plant — and these emissions go up with each new ton of garbage.

Once the county documents these understandings, the assessment urges the county to form a work group to advise the commissioners on a new trash management plan. This is where you, dear reader, enter the picture.

That work group is mostly community members, and it operates with public review and input. With your help, we can begin to reestablish control over our trash habit and insist on planning our future with all the facts in place.



Ken Eklund

Ken Eklund is a futurist and artist in game design, and chair of the Benton County Solid Waste Advisory Council. He lives with his family in Corvallis.

https://democratherald.com/tncms/asset/editorial/e81aa154-9c2b-11ed-bfb0-3762ba86d0d8/

ALERT FEATURED TOP STORY

'Complex chemical stew': Leachate concerns in Corvallis

. . . . . .
. . . . . .



A look at the Coffin Butte Landfill near Adair Village.
\Mid-Valley Media (File 2021)

Cody Mann

Corvallis officials are expected this spring to review a city practice of processing polluted liquid from Benton County's regional landfill.

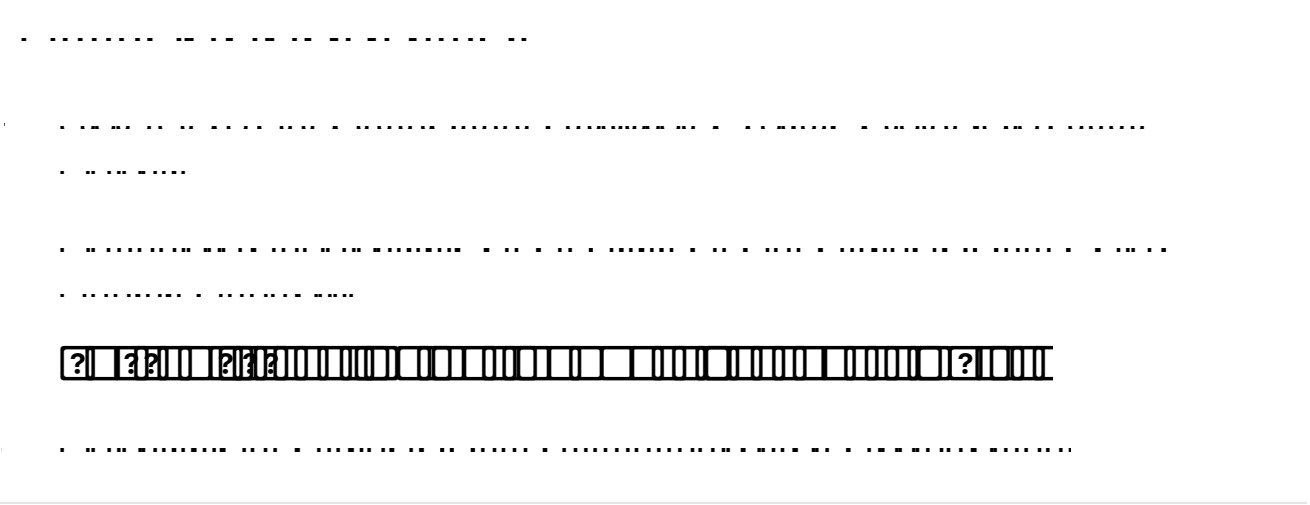
Concerned about the city of Corvallis accepting a liquid pollutant that's hauled in

for disposal at its wastewater plant, Benton County resident Mark Yeager is beseeching the City Council to reconsider the practice.

Yeager is a registered civil and environmental engineer who said he's worked for many years on water quality issues. He spoke to the council during its meeting Jan. 17.

Landfill leachate, derived from liquids in garbage that are dumped in the landfill and from decomposing trash, can be harmful to people and the environment, Yeager said, adding that rainwater flowing through landfills picks up chemicals as it trickles through.

"Leachate is a complex chemical stew containing a high nutrient load, heavy metals like arsenic, lead, mercury, cadmium, etc.," Yeager said, "as well as pesticides, pharmaceuticals, personal care products, and high concentrations of what we're hearing more and more about these days — **the forever chemical, PFAS.**"



PFAS is an abbreviation for perfluoroalkyl and polyfluoroalkyl substances, a group of synthetic, potentially harmful chemicals used in a wide variety of household products and industrial processes, some of which don't degrade naturally and may linger indefinitely in the environment.

Corvallis City Manager Mark Shepard confirmed the issue of accepting leachate

from **Republic Services-owned Coffin Butte Landfill** is slated for a council work session April 20. He told the councilors they will probably get a staff recommendation "very similar" to Yeager's public testimony.

"There are definitely cost ramifications and impacts," Shepard said. "Likely you'll be seeing us recommend we stop that practice moving forward, but it's important you understand the implications because there are significant financial implications."

The city took in $797,000 for processing the leachate in fiscal year 2020-2021 and $596,000 for 2021-2022, according to Shepard.

A spokesperson for Republic Services did not provide details about how much leachate goes to which destinations or what it pays for disposal.

A **2021 Coffin Butte report** does not elaborate on the ultimate fate of leachate hauled from the landfill or costs related to hauling or disposal, but it does note the city of Salem also held a permit to process leachate from Coffin Butte.

The report cites more than a million tons of solid waste received by the landfill in 2021. A breakdown of landfill users by county of origin shows Marion County sent more than 325,000 tons, whereas Linn generated more than 142,000 tons and Benton more than 114,000 tons.

More than 32 million gallons of leachate was produced by the site in the "water year" ending Sept. 30, 2021, according to the report. The past five years of annual reports show a range of 25-31 million gallons of leachate produced yearly at Coffin Butte.

Putting that into perspective, Yeager said, moving that much leachate would take 18 tanker trucks, each hauling 5,500 gallons of leachate, coming from the landfill six days a week.

Yeager is also concerned about whether Corvallis' sewer plant properly treats the

complex suite of chemicals in leachate. He said published research he's read says conventional treatment plants like the city's aren't designed for leachate and let most of the toxic pollutants pass through untreated.

"I am concerned because discharge of these chemicals into the Willamette River has impacts on wildlife through bioaccumulation and recreational uses, such as swimming, boating and fishing," he told Corvallis councilors.

"It also impacts downstream drinking water systems that include Adair Village, Wilsonville, Sherwood, and Tualatin Valley Water that rely on the Willamette River as their source of supply," he said.

Shepard confirmed in an email Corvallis takes leachate from Coffin Butte. He said in calendar year 2022 the wastewater plant processed 12.7 million gallons of leachate, with 18.7 million gallons handled in 2021, and 15.5 million gallons in 2020.

Regarding the wastewater plant's capabilities and downstream impacts, Shepard said the facility is able to accept leachate and still meet regulatory requirements in the city's current Oregon Department of Environmental Quality discharge permit.

The city of Salem also processed some of the leachate from Coffin Butte in past years. Salem did not respond to questions about amounts of leachate accepted or compensation, instead requiring a public records request for that information. It's not clear if Salem will continue the practice of processing leachate.

Continued acceptance of the waste material in Corvallis, in light of evolving regulatory requirements, would put the city in a difficult position in future DEQ discharge permits, Yeager said at the council meeting.

"I urge you to reconsider your practice of accepting this waste into your system, and to evaluate the cost-benefit of accepting this waste, weighed against the liability for any related environmental impacts," he said.

More Corvallis news

Cody Mann covers the cities of Corvallis and Philomath. He can be contacted at 541-812-6113 or . . .

https://democratherald.com/corvallis/opinion/letters/letter-what-is-source-of-the-gaseous-smell/article_009c3902-a723-11ed-baf4-038b8df2d38b.html

Letter: What is source of the gaseous smell?

If methane and natural gas are odorless, what is the source of the very strong gaseous smell I get when driving by Coffin Butte landfill, particularly at night?

Michael Cairns

Independence

From:	Ken Eklund
To:	Benton Public Comment
Subject:	I oppose LU-24-027: reference articles and opinions in the press - 3 of 12
Date:	Thursday, May 8, 2025 2:34:11 PM
Attachments:	writerguy-cube2.png 2 Landfill Failures - PUB 009b.pdf

CAUTION: This email originated from outside of the organization. Do not click links or open attachments unless you recognize the sender and know the content is safe.

This is the second part of a CHEJ pdf on landfills that is too big to email in one piece. – K



Ken Eklund, writerguy

37340 Moss Rock Dr
Corvallis OR 97330
408.623.8372

Creator of
World Without Oil
Ed Zed Omega
FutureCoast
and other storymaking games

Landfill Gas Explosions

Although landfill gas explosions are by no means common occurrences, a number of incidents known or suspected to have been caused by landfill gas explosions have been documented.

1999 An 8-year-old girl was burned on her arms and legs when playing in an Atlanta playground. The area was reportedly used as an illegal dumping ground many years ago. (Atlanta Journal-Constitution 1999)

1994 While playing soccer in a park built over an old landfill in Charlotte, North Carolina, a woman was seriously burned by a methane explosion. (Charlotte Observer 1994)

1987 Off-site gas migration is suspected to have caused a house to explode in Pittsburgh, Pennsylvania. (EPA 1991)

1984 Landfill gas migrated to and destroyed one house near a landfill in Akron, Ohio. Ten houses were temporarily evacuated. (EPA 1991)

1983 An explosion destroyed a residence across the street from a landfill in Cincinnati, Ohio. Minor injuries were reported. (EPA 1991)

1975 In Sheridan, Colorado, landfill gas accumulated in a storm drain pipe that ran through a landfill. An explosion occurred when several children playing in the pipe lit a candle, resulting in serious injury to all the children. (USACE 1984)

1969 Methane gas migrated from an adjacent landfill into the basement of an armory in Winston-Salem, North Carolina. A lit cigarette caused the gas to explode, killing three men and seriously injuring five others. (USACE 1984)

See the box above for a few of many documented situations where all the conditions for explosions were met and explosions actually occurred.

What types of gases can pose an explosion hazard?

- ***Methane.*** Methane is the constituent of landfill gas that is likely to pose the greatest explosion hazard. Methane is explosive between its LEL of 5% by volume and its UEL of 15% by volume. Because methane concentrations within the landfill are typically 50% (much higher than its UEL), methane is unlikely to explode within the landfill boundaries. As methane migrates and is diluted, however, the methane gas mixture may be at explosive levels. Also, oxygen is a key component for creating an explosion, but the biological processes that produce methane require an anaerobic, or oxygen-depleted, environment. At the surface of the landfill, enough oxygen is present to support an explosion, but the methane gas usually diffuses into the ambient air to concentrations below the 5% LEL. In order to pose an explosion hazard, methane must migrate from the landfill and be present between its LEL and UEL.
- ***Other landfill gases.*** Other landfill gas constituents (e.g., ammonia, hydrogen sulfide, and NMOCs) are flammable. However, because they are unlikely to be present at concentrations above their LELs, they rarely pose explosion hazards as individual gases. For example, benzene (an NMOC that may be found in landfill gas) is explosive between its

LEL of 1.2% and its UEL of 7.8%. However, benzene concentrations in landfill gas are very unlikely to reach these levels. If benzene were detected in landfill gas at a concentration of 2 ppb (or 0.0000002% of the air by volume), then benzene would have to collect in a closed space at a concentration 6 million times greater than the concentration found in the landfill gas to cause an explosion hazard.

Table 3-1 summarizes the potential explosion hazards posed by the important constituents of landfill gas. Keep in mind that methane is the most likely landfill gas constituent to pose an explosion hazard. Other flammable landfill gas constituents are unlikely to be present at concentrations high enough to pose an explosion hazard. However, the flammable NMOCs do contribute to total explosive hazard when combined with methane in a confined space.

Table 3-1: Potential Explosion Hazards from Common Landfill Gas Components

Component	Potential to Pose an Explosion Hazard
Methane	Methane is highly explosive when mixed with air at a volume between its LEL of 5% and its UEL of 15%. At concentrations below 5% and above 15%, methane is not explosive. At some landfills, methane can be produced at sufficient quantities to collect in the landfill or nearby structures at explosive levels.
Carbon dioxide	Carbon dioxide is not flammable or explosive.
Nitrogen dioxide	Nitrogen dioxide is not flammable or explosive.
Oxygen	Oxygen is not flammable, but is necessary to support explosions.
Ammonia	Ammonia is flammable. Its LEL is 15% and its UEL is 28%. However, ammonia is unlikely to collect at a concentration high enough to pose an explosion hazard.
NMOCs	Potential explosion hazards vary by chemical. For example, the LEL of benzene is 1.2% and its UEL is 7.8%. However, benzene and other NMOCs alone are unlikely to collect at concentrations high enough to pose explosion hazards.
Hydrogen sulfide	Hydrogen sulfide is flammable. Its LEL is 4% and its UEL is 44%. However, in most landfills, hydrogen sulfide is unlikely to collect at a concentration high enough to pose an explosion hazard.

How can I assess whether a landfill in my community poses an explosion hazard?

The checklist on the following page can help determine if a landfill may pose an explosion hazard. If your evaluation identifies the potential for an explosion, several actions can be taken to prevent harm to the community. Measures and controls to prevent explosion hazards are discussed in Chapter Five. Possible public health actions are described in Appendix B.

Landfill Gas Explosion Hazard Checklist

- ❑ **Is the landfill producing gas and, if so, how much?**
  Because methane and carbon dioxide are the main components of landfill gas and these chemicals are both odorless and colorless, monitoring data are necessary to answer this question. (See Chapter Four for information about how landfill gas is monitored.)
- ❑ **Is a landfill gas collection system in place?**
  Landfill gas collection systems reduce levels of gas migrating from the landfill to surrounding areas. (See Chapter Five for information about collection systems.)
- ❑ **Is gas migrating from the landfill?**
  Off-site monitoring data may be necessary to answer this question. (See Chapter Four.)
- ❑ **If gas is migrating from the landfill and reaching structures, are there places for gas to collect?**
  Uncontrolled gases escaping from a landfill may migrate to structures on the landfill itself or in the surrounding area. However, the further a structure is from the landfill, the less likely it is that gases are migrating to it at concentrations great enough to pose an explosion threat. The most common places for gases to collect are basements, crawl spaces, or buried utility entry ports. Homes with basements, especially those with pipes or cracks in the basement that would allow gas to enter, are more likely to collect gases.
- ❑ **Is gas collecting at concentrations that are high enough to pose an explosion hazard?**
  Monitoring data are needed to answer this question. Caution should be used in selecting sampling equipment to ensure that an ignition source is not introduced into the area. (See Chapter Four for information about monitoring.)
- ❑ **Is there an ignition source?**
  Gases can be ignited by many different sources, such as a furnace in the basement or a pilot light on a gas stove. Other sources may include candles, matches, cigarettes, or a spark. Because there are so many ignition sources, it is safest to assume that the potential for an ignition source is always present.

Asphyxiation Hazards

Landfill gas poses an asphyxiation hazard only if it collects in an enclosed space (e.g., a basement or utility corridor) at concentrations high enough to displace existing air and create an oxygen-deficient environment. The Occupational Safety and Health Administration (OSHA) defines an oxygen-deficient environment as one that has less than 19.5% oxygen by volume (OSHA n.d.a). Ambient air contains approximately 21% oxygen by volume. Health effects associated with oxygen-deficient environments are described in Table 3-2.

Any of the gases that comprise landfill gas can, either individually or in combination, create an asphyxiation hazard if they are present at levels sufficient to create an oxygen-deficient environment.

Carbon dioxide, which comprises 40% to 60% of landfill gas, may pose specific asphyxiation hazard concerns. Because it is denser than air, carbon dioxide that has escaped from a landfill and collected in a confined space, such as a basement or an underground utility corridor, may remain in the area for hours or days after the area has been opened to the air (e.g., after a man-

Science News Online

Landfills Make Mercury More Toxic- by Janet Raloff

Mercury, a nerve poison, is a major ingredient in many products—from thermometers and fluorescent bulbs to batteries and old latex paint. A new study finds that landfill disposal of such products can chemically alter the mercury in them, not only rendering it more toxic but also fostering its release into the air.

While open landfills (above) may expose wildlife directly to poisonous mercury, closed landfills can vent tainted gases through pipes (below).

Although even mercury in its elemental form is toxic, its most poisonous embodiment is methyl mercury, the result of a chemical modification by bacteria (SN: 3/9/91, p. 152). The finding of such a process in landfills underscores the importance of ensuring that mercury doesn't enter the municipal-waste stream, says study leader Steve E. Lindberg of Oak Ridge (Tenn.) National Laboratory.

The decomposition of interred landfill wastes creates methane. Some landfill managers burn the gas in flares as it exits pipes atop the waste field. Most managers, however, merely vent the gas—and any contaminants it may carry—into the air.

Two years ago, Lindberg's team found methyl mercury in the water vapor that condensed out of the gas emanating from a Florida landfill. Concentrations were at least 100 times those typically seen in water. The finding made sense, Lindberg recalls: In wetlands, researchers had previously identified certain bacteria that methylate natural, inorganic mercury derived from minerals. This same family of microbes resides in landfills.

However, methyl mercury comes in two forms—mono- and dimethyl-mercury—with the latter being the more toxic. To probe which form is made in landfills, Lindberg and his coworkers collected gases destined for flaring. In the August Atmospheric Environment, they report finding some 50 nanograms of dimethyl mercury per cubic meter of landfill gas.

That "is higher, by a factor of 30 or 40, than concentrations of total mercury in ambient air," Lindberg notes, and it's at least 1,000 times that of any dimethyl-mercury concentration ever recorded in open air. His team also detected lower concentrations of the less volatile mono-methyl mercury in the landfill gas.

Although chemists had detected methyl mercury in air and rain, "nobody had been able to demonstrate where it comes from," notes John W.M. Rudd of the Winnipeg (Manitoba) Freshwater Institute, part of Canada's Department of Fisheries and Oceans. The new study offers "the first real evidence that landfills might be a major source," he says.

Some 60,000 U.S. children are born each year with developmental impairments triggered by fetal exposure to methyl mercury, usually as a result of their moms having eaten tainted fish (SN: 7/29/00, p. 77). "If it doesn't get methylated, mercury doesn't get into fish," observes Edward Swain of the Minnesota Pollution Control Agency in St. Paul.

To limit the rain of mercury from human activities, regulators have focused on curbing emissions of inorganic mercury from coal burning. However, Lindberg notes, although chemists assumed that mercury could become methylated in the air, they couldn't show it.

Now, Swain posits, a "shift in paradigms" may be in order. He says that sending mercury-containing wastes to landfills may essentially be spoon-feeding copious amounts of the toxicant to methylating bacteria, which then cough the injurious forms into air.

The new findings point to the need to inventory emissions by landfills—especially the older ones, which hold the richest stores of mercury-tainted wastes—says Frank D'Itri of Michigan State University's Institute of Water Research in East Lansing.

Lindberg plans to embark on such an inventory. He says that the new data also suggest a need for technologies to capture methyl mercury from landfills before it can enter the atmosphere.

Vinyl In Landfills Most Likely to Blame For Toxic Gases

- *To*: press-releases@xs2.greenpeace.org
- *Subject*: Vinyl In Landfills Most Likely to Blame For Toxic Gases
- *Date*: Fri, 27 Nov 1998 13:26:19 -0800

VINYL IN LANDFILLS MOST LIKELY TO BLAME FOR TOXIC GASES
Municipalities across Canada urged to investigate

TORONTO - November 27, 1998 - Toxic substances found in the air downwind from Toronto area landfill sites are most likely caused by the dumping of PVC plastic (vinyl), according to Greenpeace, the Toronto Environmental Alliance, and City Councillor Jack Layton, Chair of Toronto's Environmental Task Force. The environmental organizations and Mr.. Layton are urging municipalities across Canada to investigate and take action after worrying levels of cancer-causing vinyl chloride were reported in a Ministry of Environment report obtained by the Globe and Mail.

Studies have shown that PVC provides between one-half and two-thirds of the chlorine present in municipal waste, making it the most probable source of a wide range of chlorine-containing gases emitted by landfills. Vinyl chloride is especially likely to originate from PVC because it is the basic chemical building block of the plastic. According to the U.S. Agency for Toxic Substances and Disease Registry, vinyl chloride is a known human carcinogen which causes liver cancer in people. In animals, it

causes numerous kinds of cancer.

A recent study by the New York State Department of Health reported that women living near municipal landfills where gas is escaping have a four-fold increased chance of bladder cancer or leukemia. A 1995 study of families living near Montreal's Miron Quarry landfill also found an elevated incidence of several cancers and a 20% increased likelihood of low birth weight among those most heavily exposed to gases from the landfill.

"These findings are of great concern and I will be urging the Canadian Federation of Municipalities to investigate and consider restrictions on PVC," said Mr. Layton. The Federation's Environment Committee is meeting next week in Laval, Quebec.

"This news from Toronto is a wake-up call for Canada's mayors to get chlorine - and chlorine-based materials - out of our dumps, " said Lois Corbett, executive director of the Toronto Environmental Alliance.

PVC waste is notorious for its environmental problems. In incinerators, which Environment Canada lists as the largest emitters of deadly dioxin to the atmosphere, PVC is the dominant source of chlorine without which the dioxin cannot be produced, and each kilo of PVC incinerated generates between one and two kilos of secondary hazardous waste. In 1997 when PVC plastic waste burned at the Plastimet recycling plant in Hamilton, the site became contaminated with extraordinarily high concentrations of dioxin. A U.S. study has shown that nearly 200 times more virgin PVC was produced between 1990 and 1996 than was recycled, the worst recycling ratio of any common plastic.

The production of PVC plastic also involves highly toxic precursors and generates hazardous emissions and wastes. And because it often requires hazardous additives such as phthalate esters, lead and cadmium, to make it functional, use of PVC products can also pose risks to human health. This was the case in Health Canada's recent advisory to parents to discard soft PVC teethers and rattles for infants.

"These toxic landfill emissions show there is no acceptable way

to deal with PVC waste - neither incineration, recycling or landfilling," said Greenpeace toxics specialist Dr. Matthew Bramley. "We've had mini-blinds, Plastimet, hazardous PVC children's products, and now landfill emissions. How many scandals does it take to get national action to restrict PVC?"

Greenpeace on the Internet at http://www.greenpeace.org

the Galt Global Review
Career, IT and Business Issues for the 21st Century

Business News

Old PCs toxic in landfill sites

Your computer equipment could contain highly toxic materials.
The European Union is developing a solution.
Composition of a Desktop Personal Computer
Risks related to some e-toxins found in computers

By: Lindsay Wood

Landfill and incinerator facilities are often the final resting-place for electronic waste. Computers, cell phones, electronic games, television sets - are piling up with increasing rapidity, ready to be burned or buried. But are you aware that these leftover gadgets are loaded with toxins that can leak into the groundwater or produce carcinogens and toxins?

Your computer equipment could contain highly toxic materials.

Computer equipment is a complicated assembly of more than 1,000 materials, many of which are highly toxic, such as chlorinated and brominated substances, toxic gases, toxic metals, biologically active materials, acids, plastics and plastic additives.

The average computer has a lifespan of less than two years, and hardware and software companies are constantly generating new programs that fuel the demand for more speed, memory and power. Y2K concerns generated an increase in the number of new systems bought. According to the National Safety Council, as recently as 1994, buyers held on to their computers from four to six years.

The San Francisco Toxic Coalition website states that three quarters of all computers ever bought in the US are sitting in people's attics and basements because they don't know what to do with them.

At the end of last year another 24 million computers in the United States had become "obsolete". Only about 14 percent (or 3.3 million) of these will be recycled or donated. The rest - more than 20 million computers in the U.S. -- will be dumped, incinerated, shipped as waste exports or put into temporary storage in attics, basements, etc.

In contrast, for major appliances such as washing machines, air conditioners, refrigerators, dryers, dishwashers and freezers, the proportion recycled in 1998 was about 70 percent of the number put on the market that year.

The "Electronic Product Recovery and Recycling Baseline Report" --published by the National Safety Council's Environmental Health Center states that by the year 2004, experts estimate that there will be over 315 million obsolete computers in the US.

SVTC say that recycling of hazardous products has little environmental benefit - it simply moves the hazards into secondary products that eventually have to be disposed of. Unless the goal is to redesign the product to use non-hazardous materials, such recycling is a false solution. Carnegie Mellon University estimate that, in four years, there will be 70 million computers in landfills.

To add to the list of injuries, a recent Swedish study found that when computers, fax machines or other electronic equipment are recycled, dust containing toxic flame-retardants is spread in the air.

SVTC also add that the stream of decay involved in electronic scrap significantly contributes to the heavy metals and halogenated substances contained in the municipal waste stream. Because of the variety of different substances found together in "electroscrap", incineration is particularly dangerous. For instance, copper is a catalyst for dioxin formation when flame-retardants are incinerated.

The introduction of waste computers into incinerators results in high concentrations of metals, including heavy metals, in the slag, in the fly ash, the flue gas and in the filter cake. In this context, more than 90 percent of the cadmium put to an incinerator is found in the fly ash and more than 70 percent of the mercury in the filter cake.

Municipal incineration is the largest point source of dioxins into the US and Canadian environments and among the largest point source of heavy metal contamination of the atmosphere.

The European Union is developing a solution.

The European Union is developing a solution that will make producers responsible for taking back their old products. This legislation - which includes "take-back" requirements and toxic materials phase-outs -- also encourages cleaner product design and less waste generation. Under current environmental regulations, a manufacturing facility is responsible for the environmental impacts of its activities; this responsibility does not cover environmental impacts from the products it manufactures.

Extended Producer Responsibility (EPR) encourages producers to prevent pollution and reduce resource and energy use in each stage of the product life cycle through changes in product design and process technology. The term was coined by Thomas Lindhqvist a Swedish professor of environmental economics and was first mandated in Germany on 1991.

Using the principle of EPR, product manufacturers are responsible for the total life-cycle environmental impact of their products, from raw materials extraction and manufacturing to use and disposal (i.e., the product system). The aim of EPR is to encourage producers to prevent pollution and reduce resource and energy consumption at each stage of the product's life cycle.

Examples are partnership agreements with suppliers, consumers, or others; mandatory or voluntary product labeling and disclosure of environmental information; government procurement policies; deposit-refund systems; product take-back programs; product stewardship programs; leasing systems; and life-cycle management programs.

The EC's proposals could cost as much as $18 billion US to $27 billion to implement, estimates the European industry group Orgaville. The electronics industry is lobbying for an extension of the phaseout timetable on the grounds that there are no alternative materials available at the moment.

Many companies have already taken the initiative and are producing cleaner products. Compaq Computer Corp takes back 200,000 computers a year in North America. Hewlett-Packard Company has developed a safe cleaning method for chips using carbon dioxide cleaning as a substitute for hazardous solvents. In 1998 IBM introduced the first computer that uses 100 percent recycled resin (PC/ABS) in all major plastic parts for a total of 3.5 pounds of resin per product.

Researchers at Delft University in Holland are investigating the design of a wind up laptop similar to the wind-up radio that plays one hour for every 20 seconds of hand winding.

Everyone, all those involved along the product chain share responsibility for life-cycle environment impacts of a product, whether buying in parts or complete products or recycling and reusing.

For information on what to do with your old computer see svtc.org for their clean computer campaign and recycling directory.

Composition of a Desktop Personal Computer

Source: Microelectronics and Computer Technology Corporation (MCC).

Plastics Lead Aluminum Germanium Gallium Iron Tin Copper Barium Nickel Zinc Tantalum Indium Vanadium Terbium Beryllium Gold Europium Titanium Ruthenium Cobalt Palladium Manganese Silver Antinomy Bismuth Chromium Cadmium Selenium Niobium Yttrium Rhodium Platinum Mercury Arsenic Silica

Risks related to some e-toxins found in computers

Source: Clean Water Action Alliance, SVTC, Clean Water Fund.

Lead - Found in cathode-ray tubes, solders. Each cathode-ray tube can contain five pounds of lead or more. Can cause damage to the central and peripheral nervous systems, blood system and kidneys in humans. Damage to a child's brain development has also been noted.

Cadmium - Printed circuit boards, semiconductors. By 2005, a total of more than 2 million pounds will exist in discarded computers. Cadmium and cadmium compounds accumulate in the human body, in particular in kidneys it is adsorbed through respiration but is also taken up with food. Cadmium can easily be accumulated in amounts that cause symptoms of poisoning.

Mercury - Batteries, switches. By 2005, 400,000 pounds across the US. Methylated mercury causes chronic damage to the brain.

Chromium - Used as corrosion protection in steel. By 2005, estimated 1.2 million pounds. Chromium VI can easily pass through membranes of cells and is easily absorbed producing various toxic effects within the cells. It causes strong allergic reactions even in small concentrations. Asthmatic bronchitis is another allergic reaction linked to chromium VI. Chromium VI may also cause DNA damage.

PVC Plastics - Cables and housings. Potential waste of 250 million pounds per year. An MCC study estimated that the largest volume of plastics used in electronics manufacturing (at 26%) was polyvinyl chloride (PVC), which creates more environmental and health hazards than most other type of plastic

Brominated Flame Retardants - Used in electronic products as a means for reducing flammability. In computers, they are used mainly in four applications: in printed circuit boards, in components such as connectors, in plastic covers and in cables. Scientific observations indicate that Polybrominated Diphenylethers (PBDE) might act as endocrine disrupters. Research has revealed that levels of PBDEs in human breast milk are doubling every five years and this has prompted concern because of the effect of these chemicals in young animals

These chemicals make computer recycling particularly hazardous to workers

© Copyright 2001. Galt Western Personnel Ltd. Unless otherwise specified, you may reprint this article, quote from it, use it in research or projects, duplicate it or distribute it. Credit of authorship and source MUST be given to galtglobalreview.com. Ownership of Copyright remains with Galt Western Personnel Ltd.

In Our Backyard: Environmental Racism in Dickson

colorlines.com/archives/2009/09/in_our_backyard_environmental_1.html

by Michelle Chen | Print |

You may not have heard of Dickson, Tennessee, but this weekend, the town is center stage in the movement for environmental justice. Civil rights leaders gathered there for a national summit on environmental racism to highlight environmental health issues facing communities of color.

The location was a pointed choice. For about a decade, the town of about 12,000 has been at the center of an environmental lawsuit involving a local family and a contaminated landfill, which is just a stone's throw from dozens of homes in a mostly Black community. The Holts claim that family members have been plagued by health problems due to a toxin from the landfill, trichloroethylene (TCE). Sheila Holt-Orsted and Beatrice Holt, together with the Natural Resources Defense Council, are suing the County alleging that the chemical has poisoned their water system and should be held accountable for the family's struggles with cancer and other ailments.

The federal Environmental Protection Agency has a mandate to support "fair treatment for people of all races, cultures, and incomes, regarding the development of environmental laws, regulations, and policies." But the challenge runs much deeper than regulatory statutes or a contaminated well.

> *The Town of Dickson purchased the land for a "city dump" in 1946. Sometime between 1946 and 1956, the newly acquired land, which was bounded by the old "Negro Coaling School," a one-room county school with grades 1 through 9 that dates back to 1895, became the Dickson "city dump," an open unlined dump….*

According to government records, in 1968, the same year Dr. Martin Luther King was assassinated in Memphis, Scovill-Shrader and several other local industries, buried drums of industrial waste solvents at an "open dump" landfill site…

For years, drums of toxic industrial waste solvents were dumped at the landfill, which later contaminated the groundwater.

Contaminated waste material was cleaned up from other areas in this mostly white county and was trucked to the landfill in the mostly black Eno Road community.

The report also compared the government's testing and monitoring of environmental hazards in Black and white areas and found that "the care and precaution that the government officials initiated to protect the health of the white families was not extended to the black Holt family."

The Holt family's plight is emblematic not just of the depth of environmental racism but of a warped paradigm of upward mobility that mires communities of color in a state of continual disenfranchisement. The report concludes:

> *After slavery, dozens of black families acquired hundreds of acres of land—not part of the empty "40 acres and a mule" government promise—and lived a quiet and peaceful existence in Dickson's historically black Eno Road community. That is, until their wells were poisoned by a county landfill….*
>
> *The Holt family's American Dream of land ownership has become a "toxic nightmare." For more than a decade, this black family has experienced the terror of not knowing what health problems may lay ahead for their children and their children's children.*

Perversely, the modest roots the Holts have struggled to put down now act as another kind of ball and chain.

The Dickson case has garnered national attention because it symbolizes the extremes of environmental racism's reach. But other neighborhoods and homesteads across the country bear the toxic burden more subtly—the kid in West Oakland whose bedroom overlooks a smog-laden highway, or the immigrant farmworker who comes home each night spattered in pesticide. In all these places, and in our backyard, the burden of pollution is heavy with the weight of history.

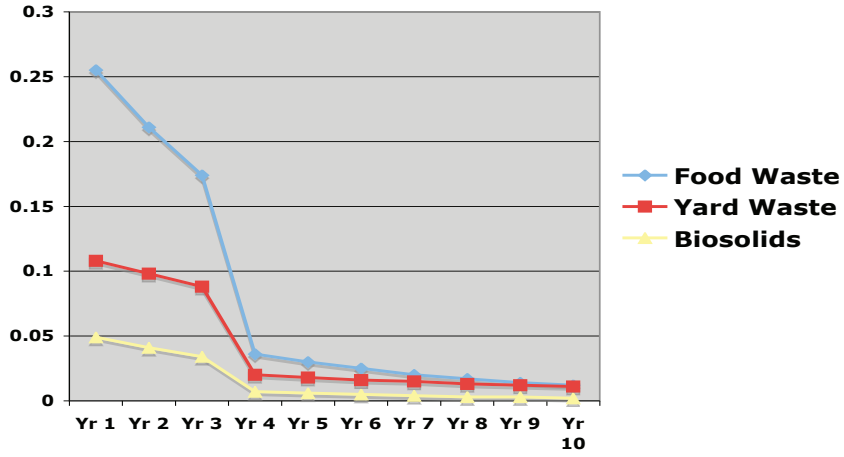
4. **Segregate remaining organics in landfills for the most effective and cost-efficient gas collection** (always maintaining high suction)**.**
5. **Keep out all liquids** from landfills (including not recirculating leachate) to reduce fugitive emissions.
6. **Cap landfills with temporary covers** over the working face to keep out rain and **then install permanent synthetic covers and gas collection systems as soon as possible** (within months is important). (The current 5-year NSPS requirement harms our environment and health.)
7. **All captured methane should be burned in a flare, boiler or a high efficiency turbine**, or used to replace natural gas for heating or fuel cells (after proper filtration to remove harmful gasses); internal combustion (IC) engines should not be used because of unburned methane releases.
8. **Stop new landfill gas to energy projects and don't give "renewable energy" credits to landfill gas** (unless capture rates over the entire landfill and destruction efficiencies are constantly monitored and demonstrated[30] to be equal to those of a flare.) (The argument that credits should be given if gas collection projects are installed earlier than local or NSPS requirements should not apply, since fugitive emissions have been found to be so large. The only way to eliminate these fugitive emissions is to eliminate organics from landfills, which would make landfill gas to energy projects uneconomic. Giving renewable energy credits to landfill gas allows it to undercut clean sources like wind and solar and, most importantly, puts source reduction, reuse, recycling, diversion, composting, and anaerobic digestion at a competitive disadvantage.)

[30] Peter Anderson mentions monitoring costs in "Critique of SCS Engineers' Report Prepared for California's Landfill Companies on Gas Collection Performance," Sept. 5, 2008, p. 12 (anderson@recycleworlds.net). However, a spectroscopy method developed by Picarro proposes efficient monitoring, Rella, Chris, et al., 2009, (http://www.picarro.com/assets/docs/Quantfying_Methane_Fluxes_Simply_and_Accurately_-_Trace_Dilution_Method.pdf).

32% in the first year alone) (see Figure 2.), usually before the gas cap and capture systems are put in place. The normal reason for the delay putting on the cover is the operator is still adding waste to that section of the landfill.

Figure 2. Over 80% of the Methane from Food Waste Escapes in the First 3 Years, Usually Before Capping

[Emissions in tons of methane (CO_{2e}) per wet ton of waste]

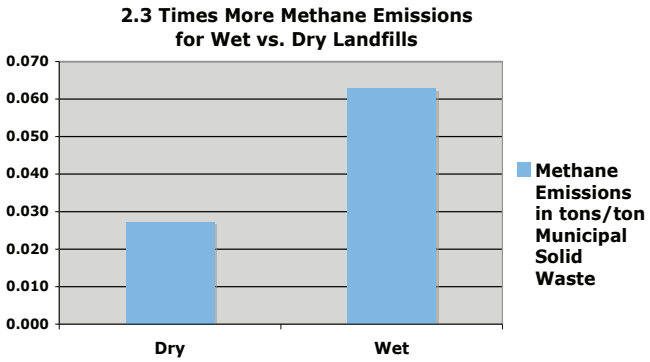


To get the above data, the Chicago Climate Exchange uses a decay model to calculate GHG emissions from a landfill, which is described in detail in their paper.[8] The bottom line is, if there are any organics in the landfill, we need to deal with the ongoing methane emissions from the remaining waste. For many years people installed impermeable caps and gas collection systems to capture the methane and put it into a flare to burn it. Every ton of methane captured and burned avoids the equivalent of adding 104 tons of CO2 to the atmosphere (calculated over a 20-year period).[9]

Wet vs. Dry Landfills

But then people thought, why waste that biomethane burning it in a flare? Why not use it to replace fossil fuels? It sounded like a good idea, except, if you take the methane from a dry landfill and try to burn it in an engine or turbine, it is inefficient. The normal methane flow from a "dry tomb" landfill is so slow and impure, that the operator doesn't make enough money to pay for the additional capital and operating expenses of an engine or turbine. So they need more moisture in the landfill. As the chart below from research done for the U.S. EPA shows, **wet** landfills generate 2.3 times more methane than **dry** ones (based only on measuring the collected gas, not the total emitted, which was not looked at in these studies).[10] If the collection efficiency were the same in both cases, the result is up to **2.3 times more GHG emissions** for energy recovery sites.[11]

Figure 3. Moisture Greatly Increases Methane Emissions



[8] Chicago Climate Exchange, Avoided Emissions from Organic Waste Disposal, Offset Project Protocol, 2009, p. 22. (https://www.theice.com/publicdocs/ccx/protocols/CCX_Protocol_Organic_Waste.pdf)
[9] Calculated from methane global warming factor 105 minus the 1 part CO_2 from the flare burning the methane.
[10] Reinhart, D.R. et al. First-Order Kinetic Gas Generation Model Parameters for Wet Landfills, report prepared for US EPA, 2005, p. 4-5. (nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=P100ADRJ.txt). See also Sally Brown, "Putting the Landfill Energy Myth to Rest," *BioCycle*, May 2010, p. 5.
[11] We note that these data are from experimental sites; some energy recovery sites may not be this wet.

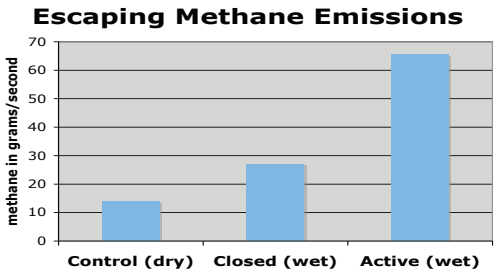
Since it is supposed to be illegal to deliberately add water to a landfill, waste engineers came up with a variety of ideas to increase the gas production in the short term and decrease costs so they could make more money, including such methods as[12]:

- Leaving the cap off as long as possible so more water from rain and snow can enter.
- Regrading the slopes to drain rain into the landfill.
- Recirculating the liquid leachate flowing from the bottom of the landfill back into the top.[13]
- Turning off gas collection wells on a rotating basis in order to give each field time to recharge moisture removed by the gas extraction process itself.
- Reducing the vacuum pump pull on gas collection wells when imperfections in the landfill cover allow air to be drawn into the waste mass. Pulling lower amounts into the collection system allows more methane to escape. (Note: While landfills that just flare gas can accept 3%-5% oxygen infiltration before risking igniting fires, those recovering energy are restricted to as low as 0.1% because a high rate of methane production depends upon having an oxygen-starved environment.)
- Installing more gas collection wells at the center of the landfill, where methane ratios are greatest, and less at the periphery, which could allow more gas to escape with no wells to capture it.

Result of Increasing Moisture is More Uncollected, Fugitive Emissions

The problem is that these aids to more profitable "energy recovery" result in much more uncaptured methane. A report for the US EPA analyzed fugitive emissions for three types of approaches: (1) normal dry tomb landfill, (2) closed landfill, but circulating leachate to provide moisture for energy recovery, and (3) active landfill circulating leachate to provide moisture for energy recovery. The results are shown in Figure 4. The closed, but wet landfill had 1.9 times more escaping emissions, while the active wet landfill designed for maximum energy production had 4.7 times more emissions.[14]

Figure 4. Moisture Increases Fugitive Methane Emissions from a Landfill, by up to 4.7 times



[12] List compiled in March 2010 by Peter Anderson, RecycleWorlds Consulting, based on these publications:
- Augenstein, Don, Landfill Operation for Carbon Sequestration and Maximum Methane, (http://www.osti.gov/bridge/purl.cover.jsp?purl=/795745-EMfXDz/native).
- Institute for Environmental Management (IEM), Emission Control: Controlled Landfilling Demonstration Cell Performance for Carbon Sequestration, Greenhouse Gas Emission Abatement and Landfill Methane Energy, Final Report, February 26, 2000.
- Augenstein, Don, et. al., Improving Landfill Methane Recovery - Recent Evaluations and Large Scale Tests (2007) (http://www.globalmethane.org/expo_china07/docs/postexpo/landfill_augustein_paper.pdf)
- Oonk, Hans, Expert Review of First Order Draft of Waste Chapter to IPCC's 4th Assessment Rpt, 2008 (available from Peter Anderson, anderson@recycleworlds.net)
- SCS Engineers, Technologies and Management Options for Reducing Greenhouse Gas Emissions From Landfills, 2008 (http://www.calrecycle.ca.gov/Climate/CATSubgroups/2008Feb26/Report.pdf).
- U.S. Environmental Protection Agency, 40 CFR Part 60 WWW (proposed and final rule).
- Sierra Club LFGTE Task Force, Sierra Club Report on Landfill-Gas-to-Energy, January 2010 (http://sierraclub.org/policy/conservation/landfill-gas-report.pdf)

[13] "[Director of Butte County's solid waste program] Mannel explained that in this process, liquid is introduced into the sealed "waste cells" in the landfill. The addition of the liquid improves the production of methane up to five times more than the unaugmented process." Chico Enterprise-Record, 6/14/2010 (chicoer.com/news/ci_15292646)

[14] Mark Modrak, et al., Measurement of Fugitive Emissions at a Bioreactor Landfill (2005) (available at http://clubhouse.sierraclub.org/people/committees/lfgte/docs/measurements_fugitivieemissions.pdf)

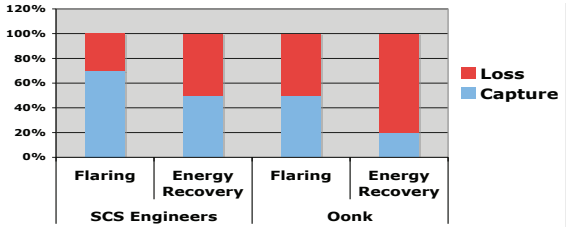
The IPCC estimated that, over the long term, including the extensive times (before and after installation of the gas capture systems) when there is little or no gas collection, the average total fraction captured may be as low as 20%.[15] U.S. EPA's *Compilation of Air Pollutant Emission Factors* (AP-42) assumes a range from 60 to 85 percent, with 75 percent as "typical" for sites having a well-designed active collection control system in place.[16] However, EPA gives no estimates of the amounts lost before the installation of the gas capture system and after landfill maintenance ends, which often are very large.[17]

A report by consultants for the solid waste industry[18] provides their view of the ranges of gas collection values: 50-70% for an active landfill, 54-95% for a inactive landfill or portions of a landfill that contain an intermediate soil cover, or 90-99% for closed landfills that contain a final soil and/or geomembrane cover systems. Their view is stated as, "The **high ends** of the range of these values are proposed for sites with NSPS or similar **quality LFG collection** systems which are designed for and achieve compliance with air quality regulations and surface emissions standards." "The **low end** of the range would be for full LFG systems that are installed and operated for other purposes, such as **energy recovery**, migration control, or odor management; . . ." (emphasis added). Our interpretation of these statements is the high ends of the ranges apply to sites using flaring, while the low ends apply to those doing energy recovery.

However, we note that the Palos Verdes landfill study in the 1990s, which was cited by SCS Engineers for its "capture efficiencies above 95%,"[19] was for a landfill that had been closed for nearly 20 years and had a 5-foot thick clay cap installed. That study was recently reevaluated by the California Air Resources Board, which found a collection rate of only 85%.[20] Thus for closed landfills with a final cover, 85% capture is a more substantiated upper limit, meaning that more than 15% is escaping.

In any event, the SCS report indicates the waste industry recognizes the potential losses in the collection efficiency of energy recovery compared to state of the art flaring. This means that an active landfill (shown in the left two columns in Figure 5 on the next page) using an energy recovery system could have a collection efficiency as low as 50%, compared to about 70% for one using flaring, which implies 1.6 times more methane is likely escaping when a landfill is used for energy recovery. A study of Dutch landfills[21] shown in the two right columns found that, averaged over the life of the landfill, flaring gas extraction systems designed for minimizing emissions could realize collection efficiencies only up to 50%, while energy recovery systems averaged only 20% efficiency. However, the numerical factor is the same, 1.6 times more methane is likely escaping when a landfill is used for energy recovery.

Figure 5. Methane Capture Efficiency at Flaring sites is 1.6 Times greater than at Energy Recovery sites.



[15] Intergovernmental Panel on Climate Change, *Fourth Assessment Report*, Waste Chapter 10, p. 600 (2008). (Note that 54% of all waste x 75% collection efficiency x 50% when collecting = 20%.)
[16] Office of Air Quality Planning and Standards and Office of Air and Radiation, *Emission Factor Documentation for AP-42, Section 2.4, Municipal Solid Waste Landfills* (Revised 1997) (http://www.epa.gov/ttnchie1/ap42/ch02)
[17] "Critique of SCS Engineers' Report Prepared for California's Landfill Companies on Gas Collection Performance," by Peter Anderson, Center for a Competitive Waste Industry, 2008 ().
[18] SCS Engineers, *Current MSW Industry Position and State-of-the-Practice on LFG Collection Efficiency, Methane Oxidation, and Carbon Sequestration in Landfills*, for the Solid Waste Industry for Climate Solutions (June 2008), p. 16-17 (http://www.scsengineers.com/Papers/FINAL_SWICS_GHG_White_Paper_07-11-08.pdf).
[19] California Integrated Waste Management Board, Overview of Climate Change and Analysis of Potential Measures to Implement Greenhouse Gas Emission Reduction Strategies, May 8, 2007.
[20] "Initial Statement of Reasons for the Proposed Regulation to Reduce Methane Emissions from Municipal Solid Waste Landfills," (May 2009) p. IV-5 and Appendix D (http://www.arb.ca.gov/regact/2009/landfills09/isor.pdf).
[21] Oonk and Boom, 1995, *Landfill gas formation, recovery and emissions*, Chapter 7, TNO-report 95-130.

We note that a recent report[22] by Patrick Sullivan, senior vice president of SCS Engineers, consultants for the solid waste industry, states, "Opponents of landfills claim development of LFGTE projects will increase methane emissions at landfills [in comparison with flaring]. . . This is simply not true." Some of the points he makes are quoted in italics below:

1. *"The landfill is required by federal regulations to achieve the same surface emission limits and LFG system operational requirements in either case."* Our response is the landfill operator must demonstrate there is no increase in fugitive emissions from practices that aid LFGTE, such as the six strategies mentioned on page 3 above.
2. *"Landfill opponents suggest that LFG engines, which represent the largest majority of LFGTE devices, do not destroy methane as well as flares. Indeed, the capacity of flares to destroy methane is greater than most LFGTE equipment, but the true difference between the two devices is very small with flares and other control devices achieving more than 99% control and lean-burn LFG engines achieving more than 98% control of methane (Solid Waste Industry for Climate Solutions [SWICS], 2007)."* He is referencing his own company report, but the report cited actually states that methane destruction efficiency of flares is 99.96% compared to internal combustion engines 98.34%. As we will show later, this **1.6% difference is very significant**, even using the outdated GHG multiplier of 21 (and much worse using the 20-year multiplier 105).[23] This means that it is impossible to use engines and have less net impact than flaring, but turbines with high destruction efficiency are acceptable, as are systems that inject the methane directly into natural gas pipelines for normal uses.
3. *"There are some landfills, which are not required by regulation to collect and control LFG, that are developed for LFGTE."* Our response is this is a valid point. Voluntary LFGTE projects undertaken before the NSPS standards require temporary capping and collection could significantly reduce GHG emissions compared to cases where operators wait as long as possible (up to 5 years is allowed for active cells) to cap and install collection systems. A consultant report found the very large collection of methane before the five year limit produced substantial carbon reduction credits.[24] However we feel the EPA needs to drastically tighten the NSPS standards, especially in light of the analyses reported above that the largest emissions from wet organics occur within the first three years.

Combining the Two Effects Produces Much More Net GHG Emissions for Energy Recovery

In addition to the 1.6 times increase in fugitive emissions at energy recovery sites, there is the effect reported above that **wet** landfills produce 2.3 – 4.7 times more methane than dry ones. If we combine these two observed effects, the net result would be **3.8 - 7.8 times more net GHG emissions for energy recovery compared to flaring** (this value is irrespective of the value of the GHG multiplier for methane, but the GHG impact is five times greater when using the 105 multiplier for methane).

The charts in Figure 6 indicate the actual global warming savings using the captured methane from energy recovery to replace the burning of fossil methane are very small (0.0007 tons of carbon dioxide equivalent per typical ton of municipal solid waste (MSW)), much less than the overall impacts of the escaping methane. The left chart shows a net increase of GHG emissions of 0.034 CO_2 equivalent tons/ MSW ton using the old (1995) multiplier of 21 (which is still used by the US EPA for "consistency").

The right chart shows a net increase of GHG emissions of 0.172 CO_2 equivalent tons/MSW ton using the latest (2009) multiplier of 105 over the next critical 20 years. Below the large right red bars for energy recovery in both figures, there is a very tiny blue line (that looks almost like a shadow) that

---

[22] Patrick Sullivan, SCS Engineers, The Importance of Landfill Gas Capture and Utilization in the U.S., April 2010, p. 28-30. (http://www.scsengineers.com/Papers/Sullivan_Importance_of_LFG_Capture_and_Utilization_in_the_US.pdf)

[23] It is very unfortunate that EPA 40 CFR Part 98 allows the use of a default 99% destruction efficiency for methane for all types of LFG combustion devices, including engines, ignoring this large GHG impact.

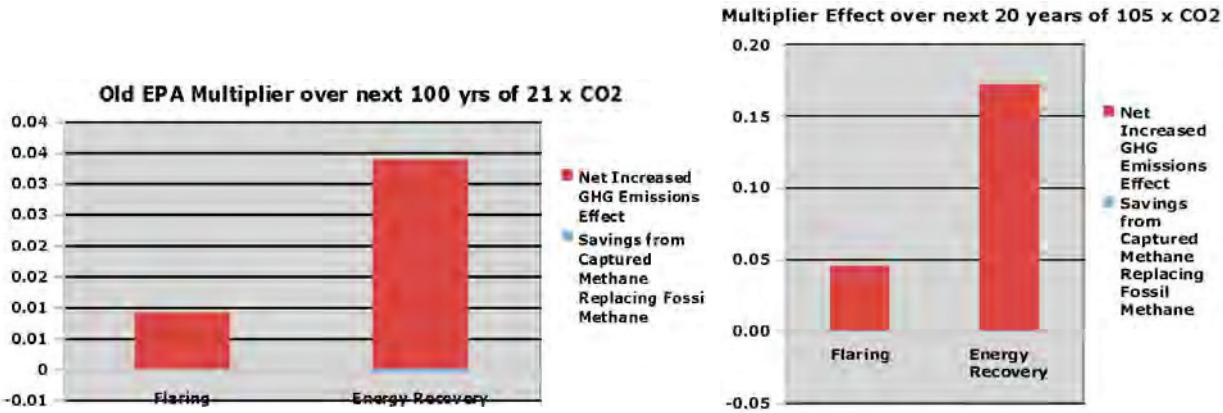
[24] McCommas Bluff LFGTE Project, Voluntary Carbon Standard Assessment, Jan. 2010, by Blue Source LLC, available from the author, Annika Colson, (212) 253-5348, acolston@bluesource.com

represents the amount of benefit from offsetting the use of fossil fuels, which in each case is only 0.0007 tons of carbon dioxide equivalent per typical ton of MSW.

Note that the charts essentially apply to landfills with active gas collection systems, and do not include the methane lost before the landfill is capped, or after the permanent landfill cap is no longer maintained and starts to leak, adding moisture from precipitation, which will increase methane emissions.

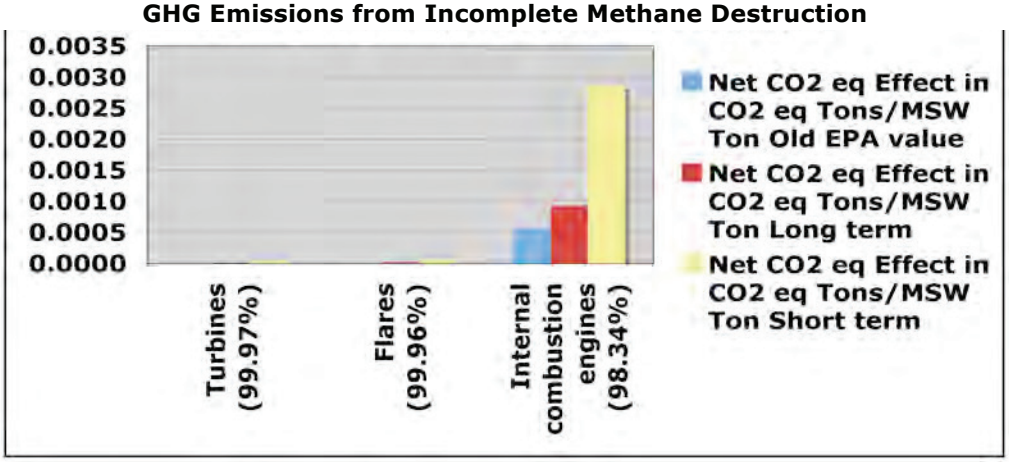
Figure 6. Energy recovery procedures increase global warming impact by at least 3.8 times using either multiplier of 21 or 105, even considering the savings from "energy recovery."

The GHG emissions from escaping methane are expressed in $CO_{2\ equivalent}$ Tons per MSW Ton



Methane Destruction Inefficiency of Internal Combustion Engines Increases GHG Impact

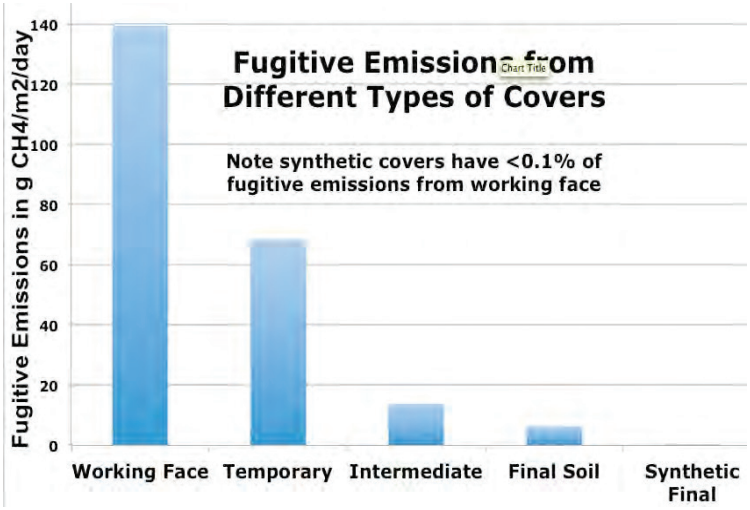
It is important to include recent data from the waste industry of average methane destruction efficiency of flares (99.96%) compared to internal combustion (IC) engines (98.34%) and turbines (99.97%).[25] Their analysis indicates turbine destruction efficiency is essentially equivalent to a flare, but an internal combustion engine adds significant GHG impact from its 1.6% lower destruction efficiency. An EPA report found that a boiler was similar to a flare.[26] But using an engine increases the GHG impact from energy recovery by 0.0006 CO_2 equivalent tons per MSW ton, using the old multiplier of 21, or 0.0028 CO_2 equivalent tons per MSW ton, using the latest 20-year multiplier of 105. The methane destruction **in**efficiency of an internal combustion **engine** (0.0006) essentially **negates its global warming savings** from replacing fossil methane at the old multiplier (0.0007). Using the short-term multiplier of 105 shows the GHG impacts of IC engines are 40 times those of flaring, turbines, or boilers.



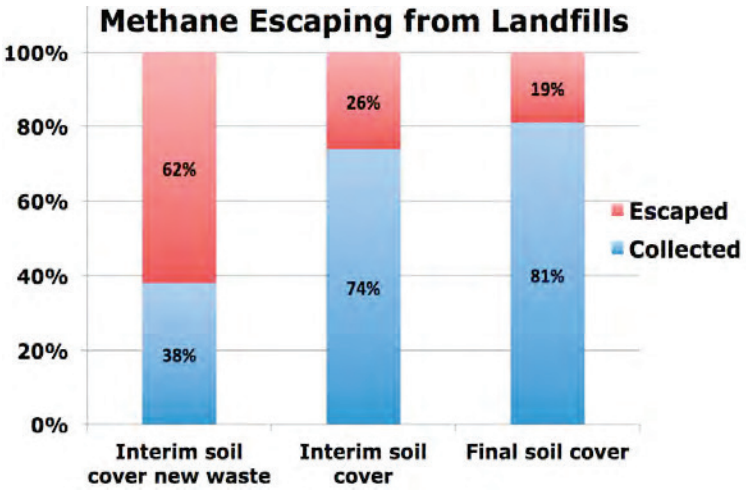
[25] SCS Engineers, *Current MSW Industry Position and State-of-the-Practice on Methane Destruction Efficiency in Flares, Turbines and Engines*, prepared for the Solid Waste Industry for Climate Solutions (July 2007), p. 2.
[26] Roe, S.M., Fields, P.G., and Coad, R. Methodologies for Quantifying Pollution Prevention Benefits from Landfill Gas Control and Utilization. EPA/600/SR-95/089, July 1995. (http://www.p2pays.org/ref/07/06277.pdf)

Effects of Different Types of Covers

A recent paper by Goldsmith et al.[27] compares the efficacies of different types of flat landfill covers in reducing fugitive emissions. Goldsmith et al. discuss the impact of different climates on the fugitive emissions, but since they found such a wide range of emissions for a given cover type within each climate zone, this chart compares the averages of all the results they obtained for the five cover types. Even a temporary cover reduces emissions by over 50%, an intermediate cover by 90%, final soil by 95%, and a synthetic final cover by 99.9%.



A recent EPA report[28] using tracer gas data and optical remote sensing measurements to analyze fugitive emissions from both the tops and side slopes found collected gas for intermediate covers ranged from 70% to 77% for a site with interim soil cover and 73-88% for a site with a final soil cover. Both sites had not accepted waste for years. The one that had just stopped receiving new waste had only 38% capture rate. The gas was being flared with no energy recovery. Note that this EPA report contradicts the report mentioned in footnote 17, by SCS Engineers, consultants for the solid waste industry, which claims collection efficiencies of 90-99% for closed landfills that contain a final soil cover. The results of the Goldsmith and EPA reports make it even more urgent that all landfills install a waterproof, airproof synthetic final cover and efficient gas collection system as soon as each small cell is filled, preferably within a few weeks.



Policy Recommendations

In summary, to reduce global warming requires the following steps to be implemented immediately:

1. Use current GHG impact value of 33 (over 100 years) or 105 (over 20 years) for methane to calculate the **impacts of methane** emissions from landfills.
2. **Divert all organics** (except sewage sludge) from landfills to reduce uncollected emissions.[29]
3. **Either compost all organics or digest them in sealed processors** that capture all methane.

---

[27] Goldsmith, Jr., C.D., Chanton, J., Abichou, T., Swan, N., Green, R., and Hater, G., *Journal of the Air & Waste Management Association*, 62(2):183–197, 2012.

[28] Quantifying Methane Abatement Efficiency at Three Municipal Solid Waste Landfills. EPA/600/R-11/033, report prepared in 2012 by ARCADIS U.S. for Susan A. Thorneloe.

[29] We note that clean organics can be processed by aerobic composting or by anaerobic digesters that can capture all the methane for energy purposes and produce high quality compost, with only small amounts of inert waste remaining for a landfill. However, toxic contaminated organics such as sewage sludge/"biosolids" digestate should be monofilled in separate cells in existing landfills because of the high contamination.

4. **Segregate remaining organics in landfills for the most effective and cost-efficient gas collection** (always maintaining high suction)**.**
5. **Keep out all liquids** from landfills (including not recirculating leachate) to reduce fugitive emissions.
6. **Cap landfills with temporary covers** over the working face to keep out rain and **then install permanent synthetic covers and gas collection systems as soon as possible** (within months is important). (The current 5-year NSPS requirement harms our environment and health.)
7. **All captured methane should be burned in a flare, boiler or a high efficiency turbine**, or used to replace natural gas for heating or fuel cells (after proper filtration to remove harmful gasses); internal combustion (IC) engines should not be used because of unburned methane releases.
8. **Stop new landfill gas to energy projects and don't give "renewable energy" credits to landfill gas** (unless capture rates over the entire landfill and destruction efficiencies are constantly monitored and demonstrated[30] to be equal to those of a flare.) (The argument that credits should be given if gas collection projects are installed earlier than local or NSPS requirements should not apply, since fugitive emissions have been found to be so large. The only way to eliminate these fugitive emissions is to eliminate organics from landfills, which would make landfill gas to energy projects uneconomic. Giving renewable energy credits to landfill gas allows it to undercut clean sources like wind and solar and, most importantly, puts source reduction, reuse, recycling, diversion, composting, and anaerobic digestion at a competitive disadvantage.)

[30] Peter Anderson mentions monitoring costs in "Critique of SCS Engineers' Report Prepared for California's Landfill Companies on Gas Collection Performance," Sept. 5, 2008, p. 12 (anderson@recycleworlds.net). However, a spectroscopy method developed by Picarro proposes efficient monitoring, Rella, Chris, et al., 2009, (http://www.picarro.com/assets/docs/Quantfying_Methane_Fluxes_Simply_and_Accurately_-_Trace_Dilution_Method.pdf).

POLICY. SCIENCE. BUSINESS.

EPA

Court orders agency to address landfill emissions

Ellen M. Gilmer, E&E News reporter

Published: Tuesday, May 7, 2019



Solid waste landfills, like this one in Arizona, are a source of methane emissions. Alan Levine/Flickr

The Trump administration violated the Clean Air Act by not taking action on harmful emissions from landfills, a federal court ruled yesterday.

The U.S. District Court for the Northern District of California **found** EPA failed to meet its statutory obligation to restrict climate-warming methane and various conventional pollutants that spew from municipal solid waste landfills across the country.

The waste sites are the third-largest emitters of human-caused methane in the United States. They also release benzene and other pollutants that can harm human health.

The Obama administration crafted landfill emissions guidelines in 2016 after years of consideration, but Trump officials have not taken the requisite next steps to review state implementation plans or craft a federal program.

"There is no denying EPA's clear failure to meet its nondiscretionary duties," Judge Haywood Gilliam Jr. wrote.

Proponents of tight restrictions on landfill pollutants cheered the ruling as another rebuke to Trump officials' efforts to delay or roll back various environmental standards.

"Courts are showing no patience for EPA's blatant violations of law," David Hayes, executive director of the State Energy & Environmental Impact Center, said in a statement.

"Thankfully, California Attorney General Xavier Becerra and other state attorneys general are holding the Trump Administration accountable for outrageously flouting the rule of law," he added later.

Government lawyers did not dispute allegations that EPA shirked its mandatory duties; instead, they argued that the coalition of states challenging the agency lacked legal standing to bring the case because they failed to show a clear connection between EPA's inaction and specific harm the states would face.

Gilliam, an Obama appointee, rejected the argument, citing the "special solicitude" afforded to sovereign states in litigation, as laid out in the landmark *Massachusetts v. EPA* ruling in which the Supreme Court ruled Massachusetts could challenge EPA's refusal to regulate greenhouse gases.

The state coalition in the landfill case included California, Illinois, Maryland, New Mexico, Oregon, Pennsylvania, Rhode Island and Vermont.

"Noxious landfill emissions affect everyone, but disproportionately hurt our most vulnerable communities, impacting their health, environment, and standard of living," Becerra (D) said in a statement. "Once again, we've held the EPA accountable for its failure to

perform its mandatory duties under the Clean Air Act, and for its unwillingness to protect public health."

The Environmental Defense Fund intervened in the case on the states' side.

"I definitely see this as part of the streak of Trump administration rollbacks that are not holding muster in court," EDF attorney Rachel Fullmer told E&E News.

Under the court's order, EPA must make final decisions approving or disapproving existing state plans by Sept. 6 and finalize a federal plan by Nov. 6 — keeping the court apprised of its progress through status reports every 90 days.

EPA said it is reviewing the decision.

The agency is separately working on a proposal to formally delay implementation deadlines for landfills. The new deadlines would more closely align with those in the Trump administration's proposed replacement for the Obama-era Clean Power Plan, which targeted greenhouse gas emissions from the power sector.

Reporter Jennifer Hijazi contributed.

Twitter: **@ellengilmer** | Email: **egilmer@eenews.net**

The essential news for energy & environment professionals

© 1996-2019 Environment & Energy Publishing, LLC Privacy and Data Practices Policy Site Map Contact Us

An official website of the United States government.

Close

We've made some changes to EPA.gov. If the information you are looking for is not here, you may be able to find it on the EPA Web Archive or the January 19, 2017 Web Snapshot.

United States Environmental Protection Agency

News Releases from Region 09

EPA resolves Clean Water Act violations with Honolulu and Waste Management at Waimanalo Gulch Landfill

04/29/2019

Contact Information:
Margot Perez-Sullivan (perezsullivan.margot@epa.gov)
415-947-4149

For Immediate Release: April 29, 2019

HONOLULU – The U.S. Department of Justice, U.S. Environmental Protection Agency, and Hawaii Department of Health (DOH) have settled with the City and County of Honolulu (CCH) and Waste Management of Hawaii, Inc. (WMH), over Clean Water Act violations at the Waimanalo Gulch Sanitary Landfill in Kapolei, Oahu.

CCH and WMH will pay a combined penalty of $425,000, which will be split evenly between the U.S. and the State of Hawaii. The state will use the funds for coral reef and habitat restoration, monitoring and conservation on the leeward coast of Oahu.

The agreement also calls for a series of facility upgrades to maintain compliance with stormwater regulations. CCH and WMH will retrofit the landfill's existing stormwater drainage pipeline, install a trash screen, revise their stormwater pollution control plan, comply with specific operational and monitoring limits for the stormwater basin, and apply for an individual stormwater permit for the facility. The consent decree is subject to a 30-day public comment period.

"Today's action requires the City and County of Honolulu and Waste Management to improve their stormwater drainage, controls, and monitoring program at Waimanalo Gulch Sanitary Landfill," said EPA Pacific Southwest Regional Administrator Mike Stoker. **"Managing stormwater runoff is critical to protecting residents' health and Oahu's coastal waters."**

"Actions detailed in this consent decree will help prevent future harmful discharges from the landfill and provide resources to restore corals that were impacted by the violations," said Hawaii DOH Deputy Director of Environmental Health Keith Kawaoka. **"The consent decree concludes years of dispute over the horrific discharges of medical waste and sediment that occurred during the winter of 2010."**

Today's settlement marks the end of a long-term effort by EPA and the state of Hawaii to bring the landfill – the largest on Oahu – into compliance with laws designed to protect public health, natural ecosystems, and wildlife.

Waste Management operates the Waimanalo Gulch landfill, which is owned by the City and County of Honolulu. In 2009, WMH and CCH began work on a landfill expansion and new stormwater diversion structure. During construction, Waste Management used temporary stormwater pipes to divert stormwater around the landfill.

Before completion of the permanent stormwater diversion structure, WMH began placing waste in the landfill expansion area. In December 2010 and January 2011, several large storms overwhelmed the temporary pipes and flooded the expanded area of the landfill. The flooding discharged stormwater contaminated with leachate, trash, and medical waste into the Pacific Ocean. Medical waste washed up on area beaches for several weeks, prompting leeward Oahu area beach closures.

EPA issued an order in January 2011 requiring cleanup of leachate, trash, and medical waste discharged during the storms. EPA issued an additional Clean Water Act order in 2012 requiring WMH and CCH to: complete construction of the facility's stormwater diversion system; finish a study of the landfill's detention basin to evaluate its capacity to store and treat stormwater; and develop an interim stormwater monitoring plan. WMH and CCH have completed the requirements in those orders.

In July 2015, WMH pleaded guilty to criminal violations for negligent discharge of pollutants on seven days in violation of the Clean Water Act. The company paid $400,000 in criminal fines, and $200,000 in restitution.

The consent decree for this settlement will be lodged in the federal district court by the U.S. Department of Justice and is subject to a 30-day public comment period and final court approval. A copy of the decree will be available on the Department of Justice website at: https://www.justice.gov/enrd/consent-decrees

For more information on EPA's Stormwater Program please see:
https://www.epa.gov/npdes/stormwater-discharges-industrial-activities

For Hawaii's Stormwater program, please see:
http://health.hawaii.gov/cwb/permitting/industrial-storm-water/

###

WASTEDIVE

BRIEF

Report identifies factors in Advanced Disposal landfill slope failure that left one dead

By Igor Geyn

Published Feb. 7, 2019

Dive Brief:

- The Pennsylvania Department of Environmental Protection (DEP) has approved a third-party root cause analysis (RCA) report identifying the source of a fatal Feb. 2017 slope failure at the Advanced Disposal Services Greentree Landfill in Kersey, PA.
- According to the report, the "placement of non-conventional waste streams … including low shear strength sludges" interacted with an inability to install necessary gas well infrastructure to displace 15.5 acres of waste, resulting in the death of William Pierce.
- The report identified three categories of "factors" as the "primary focus" of the incident investigation team: operational factors, leachate and landfill gas factors (which subsequently contributed to "excessive pore pressure"), and geometric factors “associated with cell configuration and management of waste within [the] configuration.”

Dive Insight:

The 2017 incident led to the DEP requiring Advanced Disposal to pay $695,000 in civil penalties, as well as remediate the slope

failure area and consent to restrictions on sludge acceptance. The company was also responsible for $12,000 in OSHA fines. The company's most recent quarterly filing indicates it had incurred $6.4 million in expenses, net of insurance recoveries, as of June 2018 due to the incident.

Advanced Disposal did not respond to a request for comment on this new report.

In its RCA report, Geosyntec Consultants identified a series of operational conditions that factored into the failure, but said that none "led to (or would have led to)" the collapse in isolation. In combination with pore fluid pressures and geometric factors, Advanced Disposal's use of oil and gas drill cuttings for interim cover, implementation of a "100-ft plus" setback in the affected landfill cell and installation of a segregation layer "led to an unstable waste mass that resulted in the Slope Failure."

Although Greentree staff acted "aggressively" to implement landfill gas well infrastructure, and met both permit conditions and industry standards in individual decisions, the combination of these operational decisions created a section of concentrated, hydrologically nonconductive low shear strength waste (LSSW) that produced bulging, eruption and the eventual collapse.

In a separate lecture on the geotechnical stability of waste fills, Geosyntec Chairman and Senior Principal Dr. Rudolph Bonaparte explained how the lack of timely gas well installation and concentration of more than 40% LSSW in the Greentree Landfill cell exploited the slope's weak zones. Bonaparte also connected the observations from the Greentree failure to a need for greater understanding of "unintended consequences" of waste fill operations, including the management of special waste.

The Advanced Disposal site, which has been in operation since 1986, is permitted for an average of 5,500 daily tons of waste and currently accepts an average of 3,000 tons. It's included in the solid waste plans of several Pennsylvania counties and has contracts with multiple generators in the region.

According to the Bureau of Labor Statistics (BLS), three of the 63 fatalities in the "waste management and remediation services" category occurred at landfills in 2017. While this is a small number relative to the 30 fatalities among collection workers — which often receive more regular attention in safety discussions — it indicates that risks are still present at closed sites. While official 2018 BLS data won't be available until later this year, anecdotal reports indicate that there have already been at least two fatalities at landfills so far in 2019.

WASTEDIVE

BRIEF

Waste Management reaches $4.1M settlement over Ohio landfill

By Rina Li

Published Dec. 5, 2018

Dive Brief:

- Waste Management will pay $4.1 million in a class-action lawsuit over the Stony Hollow Landfill in Dayton, Ohio, reports Dayton Daily News. The settlement was finalized in federal district court on Nov. 26.
- The suit, which was filed in 2016 following numerous odor complaints from neighboring communities, claims Waste Management "failed to sufficiently collect, capture, and destroy landfill gas generated at its landfill to prevent fugitive emissions and to otherwise prevent odors from the landfill from invading the homes and property."
- An estimated 2,000 individuals will share $1.875 million provided by the settlement, according to court documents. In addition to doling out funds to class-action members, Waste Management will also be required to implement $1.45 million worth of improvements to the landfill by the end of 2022 in order to reduce odor emissions.

Dive Insight:

The 169-acre landfill, which takes in an average of 1,100 tons of waste per day, has been an ongoing source of grief for adjacent

communities; odor emissions have prompted hundreds of complaints from area residents since April 2016. While Waste Management has acknowledged the odors — and, according to the landfill's website, taken "significant action" to address underlying structural issues — community members and city officials remain frustrated with the lack of progress.

The suit marks the culmination of a series of odor-related headaches centered around Stony Hollow Landfill. The Ohio EPA issued the site a $16,000 fine for emissions last year, while odor issues have prompted Montgomery County to explore alternative options for solid waste disposal. In addition, Dayton barred the landfill from discharging waste into the city's sanitary sewers after the presence of prohibited chemicals forced cleanup crews to seek medical attention.

Strained relations between landfills and neighboring communities have become increasingly common in recent months: odor emissions from a Waste Connections-owned landfill in Louisiana have prompted multiple pending class-action suits, while another Waste Management landfill in New York was hit with its own class-action suit over odors this past summer.

NEW YORK STATE OF OPPORTUNITY | Department of Environmental Conservation

For Release: Monday, February 5, 2018

DEC Cites High Acres Landfill for Failure to Reduce Odors

Notice of Violation Issued to Waste Management of New York, LLC, for Ongoing Violations of State's Air Pollution Control Requirements and Solid Waste Management Regulations

New York State Department of Environmental Conservation (DEC) Commissioner Basil Seggos today announced that on Friday, Feb. 2, 2018, DEC issued a Notice of Violation (NOV) to Waste Management of New York, LLC, operator of the High Acres Western Expansion Landfill located in the towns of Perinton in Monroe County and Macedon in Wayne County, for ongoing violations of the state's solid waste management regulations, as well as the state's air pollution control requirements related to ongoing odor issues.

DEC Commissioner Basil Seggos said, "The odor condition at High Acres Landfill is unacceptable. New York's stringent rules and regulations governing waste exist to ensure facilities in our state are adhering to the safest practices and highest standards possible to protect public health and the environment. DEC takes any violation of these policies seriously and is taking necessary action to hold these violators accountable. The communities next door to the High Acres Landfill deserve no less."

DEC has received numerous complaints from the neighboring community of persistent unpleasant odors emanating from the landfill that are adversely impacting properties and quality of life. In response to these concerns, DEC immediately bolstered its monitoring of the landfill to determine the nature and extent of the odors, including increased on-site inspections. In addition, DEC has been working in cooperation with the town of Perinton and its Conservation Board to resolve the issue.

Under the terms of the NOV, Waste Management, LLC, must implement operational modifications to ensure best management practices are being applied at High Acres Landfill and undertake several structural improvements to strengthen the integrity of the facility's gas collection and odor mitigation systems to achieve significant odor reductions as expeditiously as possible.

DEC will continue to closely monitor operations and air quality conditions at the landfill and in surrounding communities and will provide strict oversight as the required corrective actions and modifications are implemented by March 16, 2018. Some of the corrective actions are already underway. In addition, DEC is continuing its increased presence at the site to ensure implementation of these measures until the odor issue is resolved.

Waste Management, LLC, may be liable for penalties for past or future violations.

The complete NOV is available (PDF, 212 KB).

BREAKING NEWS

AG Koster releases new expert reports concluding radiation and other pollutants have migrated off-site at Bridgeton Landfill

Sep 3, 2015, 10:06 AM

-- Data also indicates that underground fire has moved beyond the interceptor wells separating the North and South quarries --

Jefferson City, Mo. – Attorney General Chris Koster released today new reports from expert witnesses in the case he is prosecuting against Republic Services, Inc. relating to the subsurface fire at the Bridgeton Landfill. Collectively, the reports paint a troubling picture of the environment surrounding the landfill site. Contamination in groundwater outside the landfill perimeter has been identified, including radiological contamination detected in trees surrounding the site. Further, data indicate that the fire has moved past the two rows of interceptor wells positioned at the neck of the landfill, closer to the North Quarry.

Koster's office gathered the reports to better understand the facts relevant to the lawsuit Koster filed in 2013 against Republic Services for alleged violations of law associated with the still-burning fire. The Attorney General's Office is publicly releasing the reports because they contain information important to the health and safety of the people who live and work near the landfill.

The reports may be viewed below. Their conclusions are briefly summarized as follows:

- Drs. Joel Burken and Shoaib Usman, Environmental Engineering Professor and Nuclear Engineering Associate Professors, respectively, at Missouri University of Science and Technology (S&T), detected radiological and organic contamination in trees on the property of neighboring landowners. According to the report, these findings "indicate the off-site migration of RIM [radiologically impacted material], either in groundwater or aerial transport of particulate matter[,]" and similar off-site migration of organic pollutants, likely through movement of leachate-impacted groundwater.
- Peter Price, a scientist with the Missouri Geological Survey, and Dr. David Wronkiewicz, a Geology Associate Professor at Missouri S&T, discovered volatile organic compounds, including benzene, acetone, and 2-butanone, in high concentrations in the groundwater in wells outside the perimeter of the landfill. They are able to trac the contamination to the landfill by comparing its characteristics to leachate taken from the landfill.
- Drs. Tony Sperling, a landfill-fire expert and professional engineer, and Ali Abedini, a landfill-gas specialist, concluded that the data show the fire has moved beyond both lines of gas interceptor wells at the "neck" of the landfill, in the direction of the OU-1 radiological area. Drs. Sperling and Abedini also concluded that Republic Services "was negligent in aggressively over-extracting the gas system well outside industry best practices." They note that oxygen intrusion caused by over-extraction the leading cause of subsurface fires and smolders in municipal solid waste.
- Todd Thalhamer, a civil engineer from California with extensive experience investigating landfill fires, concluded that what he described as a "catastrophic event" at the landfill "was foreseeable and preventable." He stated that business decisions by the landfill's operators to overdraw gas-collection systems and inadequately maintain th soil cover on the site were factors causing the fire to occur.
- Dr. Timothy Stark, PhD and professional engineer, performed three separate personal inspections of the landfill site. He observed significant slope degradation and area where the waste mass had settled, suggesting the underground waste had been consumed by a smoldering / combustion event.
- Don Wright, a consultant specializing in odor assessment, captured an odor profile from the air surrounding the landfill and was able to identify a dominant odor "emitted by and carried a considerable distance downwind from the Bridgeton Landfill source."
- Kenny Hemmen, a registered geologist at Geotechnology, Inc., conducted a feasibility study to analyze remediation options related to potential groundwater contamination. He examined five alternative approaches with the objective of protecting human health and the environment.

In addition to publicly releasing the reports, the Attorney General's Office forwarded copies to the Environmental Protection Agency, the Missouri Department of Natural Resources, the Missouri Department of Health and Senior Services, and the St. Louis County Public Health Department. Koster encouraged those agencies to carefully review the information in the reports and take further remedial action as appropriate to ensure that the people around the landfill are protected.

"These reports underscore what has been clear from the beginning—Republic Services does not have this site under control," Koster said. "No only does the landfill emit a foul odor, it appears that it has poisoned its neighbors' groundwater and vegetation. The people of Missouri can't afford to wait any longer—Republic needs to get this site cleaned up."

Koster's suit against Republic Services is set for trial in March 2016. He has alleged that Republic's management of the landfill was negligent and that the company has violated the State's environmental laws. The suit seeks penalties, actual damages, and punitive damages as a consequence of Republic's allegedly unlawful conduct.

Full reports:

- **West Lake Landfill Organic Pollutant Phytoforensic Assessment - Burken**
- **Westlake Landfill Phytoforensic Assessment using Gamma Spectroscopy - Usman**
- **Westlake Landfill Tree Core Analysis – Burken/Usman**
- **Bridgeton Sanitary Landfill Groundwater Investigation – Price/Wronkiewicz**
- **Subsurface Self Sustaining Reaction Incident – Sperling/Abedini**
- **Bridgeton Sanitary Landfill Incident – Thalhamer**
- **Field Inspection Reports – Stark**
- **Bridgeton Landfill Downwind Odor Assessment - Wright**
- **Feasibility Study – Groundwater Remediation – Hemmen**

The Rogersville Review
In Historic Rogersville, Tennessee
Your Community Partner Since 1885 - Serving Hawkins County, Rogersville, Mooresburg, Bulls Gap, Surgoinsville, and Church Hill

Carter's Valley landfill listed as possible site for radioactivity

Last updated: 5:05 PM, 08/03/2009

Source: The Rogersville Review



By Jim Beller Staff writer | (jbeller@xtn.net)
KINGSPORT - Just when you thought Hawkins County was a safe place to raise a family, think again. Clean water watchdogs announced Thursday that Carter Valley Landfill is leaking into the groundwater and has been accepting nuclear waste. Officials from The Tennessee Clean Water Network (TCWN) and Nuclear Information and Resource Service (NIRS) addressed the media Thursday at Mead Auditorium in the Kingsport Public Library. "People around regular trash landfills will be shocked to learn that radioactive contamination from nuclear weapons production is ending up there, either directly released by the Department Of Energy or via brokers and processors," stated Diane D'Arrigo, NIRS. TCWN Director of Community Organizing, Rachael Bliss, cited the Hawkins County landfill as a prime example of the Tennessee Department of Environment and Conversation's (TDEC) failure to control leaking landfills contaminating ground and surface water. "Thirty-one percent of our landfills are leaking," said Bliss. "Add to this, the Nuclear Information and Resource Service recent report showing that the state of Tennessee is a leader in licensing processors that can release radioactive materials to a municipal landfill. "There are nine landfills in Northeast Tennessee that are leaking and one is accepting special radioactive waste, Carter Valley Landfill in Hawkins County," she said. "Radioactive waste should not be accepted in our municipal dumps since TDEC has already demonstrated an inability to properly protect our water and communities from toxic landfill leachate. "Last year, statistics from TDEC showed of the 225 permitted landfills across the state, 69 or 31% were leaking," Bliss said. "Landfill leachate, contaminates drinking water sources like groundwater and surface water with toxic pollutants that are known to cause birth defects, cancer, learning disabilities and other health problems. "As recent as May of 2006, the Hawkins County landfill was assessed more than $70,000 in damages and penalties by TDEC for groundwater contamination," Bliss said, adding that "this is after two and a half years of warnings and violations notices that failed to resolve the leak problem. "TDEC claimed that communities surrounding the landfill were in no danger from the leak.

Violations range from lack of litter control to leachate leaks in groundwater, leaks migrating into storm water control structure, problems with collection, inadequate erosion control and leaking pipes. "According to the Johnson City TDEC field office there was no deadline set for BFI, who manages the landfill, to complete its repair of the Carter Valley Landfill leaks in exchange for a negotiated settlement with the Solid Waste Disposal Control Board for its violations." Bliss continued: "As of two days ago, the work was still ongoing. In the absence of a remedy to stop the leaks, Carter Valley Landfill is hauling its leachate by trucks to the Eastman Wastewater Treatment Facility. "According to TDEC records, the landfill is still on a monitoring basis of two times a year," Bliss said. "Evidently, TDEC doesn't think this is serious enough to require quarterly monitoring." Bliss said fewer than five of Tennessee's leaking landfills have "any corrective action being taken to stop the toxic landfill leachate." "TDEC's data from 2006 shows 44% of Class I landfills are leaking," she said. "Class I landfills are sanitary municipal landfills, like Carter's Valley. This means approximately 40 percent of Tennessee's landfills that are held the highest existing design standards that are actively accepting waste are leaking." Bliss said action needed by the Department to control Tennessee's leaking landfills include the regulation of landfills according to TDEC's Division of Solid Waste Management. Among these regulations are remediation of groundwater contamination, monitoring groundwater and methane gas. Another step in this process is requiring the 69 leaking landfills to come into compliance with TDEC's regulations. "TDEC's consistent and efficient enforcement of landfill regulations can prevent an entire community's exposure to toxic leaks from landfills and this can improve our ground and surface water and our right to clean water." D'Arrigo is one author of the recently released report, "Out of Control - On Purpose: DOE's Dispersal of Radioactive Waste into Landfills and Consumer Products." The report was commissioned to track if and how the Department of Energy (DOE) releases some of the low radioactive wastes from nuclear bomb production. The report said Tennessee is a leader in licensing processors that can release radioactive materials into our municipal landfills. "The DOE has on its own, actually in contradiction to the federal and Congressional revocation of these kinds of policies in the early '90s, determined its own levels it decided are acceptable for radiation exposure above the normal background. Several systems within the Department Of Energy allow that radioactive waste to go out to regular garbage or to be recycled into the marketplace or re-used. Equipment can be re-used or concrete and asphalt used again." There are four Class I landfills authorized to receive such wastes: Chestnut Ridge in Anderson County, North Shelby County, Middle Point in Rutherford County, and Carter Valley in Hawkins County. Bliss said local residents who prided themselves on the clean water from private wells before the Carter Valley Landfill began operations, finally took up a petition to receive utility district water when people downstream from the landfill discovered their wells were contaminated. TDEC issued civil fines and penalties at Carter Valley Landfill in October 2006 after 2005 groundwater monitoring found contamination in the groundwater. Additionally, TCWN found that of the 69 landfills across the state known to be leaking, TDEC required corrective action for groundwater contamination at less than 5 of those landfills, including Dickson County, Sevier County, City of McKenzie, and Smelter Services Class 2 landfill in Mt. Pleasant. Dickson County's landfill received national attention for what is believed to be the community's exposure to trichloroethene from leachate in drinking water supplies causing birth defects. The contamination occurred despite the landfill being built under stringent EPA guidelines and the old landfill's closure in 2003. Bliss said Hawkins County has the second highest incidence of birth defects in the state. "We should have a concern about Hawkins County. We need to find a reason and work toward mitigating the impact on the environment. We live in a nuclear neighborhood. Oak Ridge is the home of the atom bomb. Tennessee has a number of nuclear processors, including two in Erwin. There's the Aerojet Ordinance Plant in Jonesborough. Now we know nuclear waste is being accepted at Carter's Valley Landfill." For more information visit http://www.tcwn.org . To read Out of Control - On Purpose: DOE's Dispersal of Radioactive Waste into Landfills and Consumer Products visit: http://www.nirs.org/radwaste/outofcontrol/outofcontrol .htm.

Australia: Methane gas landfill leak forces residents to evacuate suburb

By Peter Byrne

25 September 2008

On September 11, Country Fire Authority chief officer Russell Rees advised owners of about 250 houses in the working class outer-Melbourne suburb of Cranbourne to move out after methane levels of 60 to 65 percent were found in some houses. Concentrations of 5-15 percent are considered an explosion risk.

The gas emanated from a closed landfill bordering the Brookland Greens housing development. Since the evacuation notice was issued, it has been revealed that the state government planning review body approved the housing development after ignoring Environmental Protection Agency safety warnings.

Residents were initially advised they would have to stay away for a year, and that it could be as long as 24 months before measures were put in place to fix the leakage problem. While the Victorian state government offered paltry conditional emergency grants of $8,500, it was left up to households to organise their own accommodation. With few options available, only 33 of the 230 households in the affected zone initially moved out. In the past week, at least 21 of those have returned following zero readings from methane gas monitors.

The immediate danger of home gas explosions seems to have passed, but hundreds of residents are now faced with ongoing safety fears and a continuing methane stench. Many, including those with large mortgages, also face a devastating collapse in the value of their homes, threatening their income security and retirement nest-egg.

The land developer, local council and the Victorian state Labor government and its planning regulatory bodies are now engaged in a mutual blame-shifting exercise. But what emerges is the complicity of all those who had material interests in the development project—yet another expression of the impact of a profit-driven system in which the rights of ordinary people to decent, safe and affordable housing are sacrificed to corporate interests. This fundamental problem has been compounded by a lack of rational urban planning. A chronic housing shortage in Melbourne—which has fuelled rents and property prices particularly in inner-city suburbs—has led to a situation in which many working people can only afford to live in housing developments in outlying areas, often with grossly inadequate public transport, recreational facilities, and other critical social infrastructure.

Brookland Greens, located nearly 50 kilometres south-east of Melbourne, adjoins an exhausted sand quarry in Stevensons Road, which the City of Casey operated as a rubbish tip from 1996 to 2005. About 100,000 tonnes of household waste was dumped each year. Contrary to best practice, the landfill was never lined with clay. Instead, the site was capped with a layer of soil and a gas collection and burning system was installed, designed to collect all the methane produced. This is now failing. According to the EPA, an estimated 1,300 cubic metres of methane per hour are produced with a proportion—several hundred—leaking sideways and percolating up through the ground outside the capped area of the landfill site.

The EPA and council have been monitoring gas problems and fielding complaints about the landfill for at least eight years. Residents have reported skin rashes, eye infections, asthma, burning sensations and headaches.

If there was a substantial buffer-zone between the landfill and residential buildings, then the methane would find its way to the surface and (being lighter than air) simply escape through the ground and into the atmosphere. But when the gas is restricted by an impermeable object like a home's concrete floor slab, it can be channelled through a pipe or cabling penetration and then build up to explosive concentrations in unventilated cupboards or wall cavities. This is what happened two weeks ago in Brookland Greens.

EPA safety warning ignored

Western Australian-based developer Peet Limited bought what was then farmland, adjoining the former Stevensons Road landfill site, in June 1998 for $3.5 million and planned Brookland Greens as a staged subdivision with some 800 lots. Revenue was projected at $100 million over a 10-year period.

In 2000 the council rezoned the land for residential subdivision on condition that a 200-metre buffer between houses and the landfill site would be maintained until declared safe by the EPA and the council. But in 2003 Peet Limited applied to have the buffer effectively junked, based on its assertion that because the tipping of rubbish had ceased in some parts, the 200-metre boundary should move to reflect the point of distance from the active area of the site. Had the company waited for the projected 25 years for the

methane gas leakage to abate, about one third of the 800 lots in Brookland Greens could have been blocked. This would have had a significant impact on the company's bottom line, which last year recorded an annual profit of $48 million.

Casey City Council initially refused the application to remove the buffer zone. In response, Peet Limited successfully appealed to the Victorian Civil and Administrative Tribunal (VCAT), the state government planning review body.

Established in 1998, VCAT has been utilised by successive Liberal and Labor state governments as a means of fast-tracking developers' appeals against unfavourable council planning decisions. The *Age* newspaper reported: "Angry talkback callers have filled the radio airwaves with their own 'tribunal horror stories' since news broke of the gas emergency. Many of the callers have been upset with what they saw as a lack of accountability and transparency."

The Labor government of Premier John Brumby has denied any responsibility for the situation in Brookland Greens. Its position, however, is untenable. The entire land usage regulatory system presided over by the government is geared towards the corporate developers. Underscoring the close relationship between these interests and the state government, it has emerged that Peet donated $10,000 to the Victorian Labor Party between 2003 and 2005.

The council has similarly denied all responsibility and pointed to its denial of Peet's initial application on the buffer zone. But it has been suggested that the local body had an interest in the development and the additional development contribution fees, taxes and rates it would bring. Ben Hardwick, a lawyer acting for Brookland Greens' residents who are considering a class action suit, noted: "[I]t is common practice, for political reasons, for local councils to refuse developers' applications or decline to make a decision, safe in the knowledge that VCAT will make the hard decision for them."

Details of the 2004 VCAT decision, overruling the local council and the EPA on the need for a buffer-zone, provide a damning portrait of the scant regard shown by official state bodies for public safety. The review body simply dismissed out of hand the EPA's recommendation that the buffer should be increased from 200 metres to 500 metres because of the serious problems with the unlined leaking landfill. The environmental agency had fined tip operator Grosvenor Lodge three times and imposed 19 enforcement actions for odour emissions.

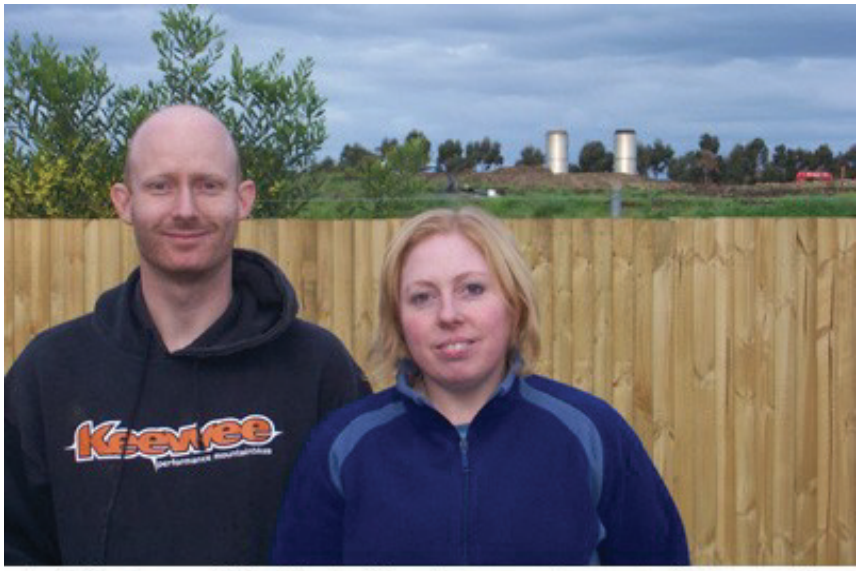
After the successful appeal, Peet Limited quickly built 47 homes in the contested area, garnering revenue of $16.45 million. As the landfill was progressively closed, the buffer was effectively eliminated, with new houses abutting the edge of the capped landfill.

There are indications that Brookland Greens is no isolated incident. The EPA has announced an investigation into dozens of landfill sites in Victoria, while the federal Liberal Party has called on Prime Minister Kevin Rudd to convene a national inquiry and an audit of every landfill site in Australia.

"The land should never have been sold"

The *World Socialist Web Site* spoke to a number of residents whose houses back on to the landfill site. They explained that no government agency warned them of any potential danger before they bought their land.

Andy Rhodes, mechanical engineer, and Nixz Kerr, finance clerk, bought land for $300,000 in March 2007 and moved in later that year.



Andy Rhodes and Nixz Kerr (with methane gas burners in background)

"We liked this particular block because we were told by the developers that the culprit behind us would be a park by about now," Andy explained. "We specifically asked if there would be any problems or had been any problems, and we were told it's all behaving as normal, everything's on schedule. When we bought the land, we were told the tip had been closed for a couple of years. Now the proposed park is years away."

Nixz said: "I think that the land should never have been sold. They didn't know that it was going to be 100 percent OK, so they shouldn't have sold it in the first place. Obviously the developer needs to take some blame because they were already doing monitoring. But we never heard anything until we moved in, although we did ask and were told everything was OK."

Andy added: "I personally think all three are equally to blame—the developer, the council and VCAT. The council hasn't done enough to mitigate the problems and deal with their own landfill. Then VCAT probably jumped the gun. The developer probably pushed pretty hard and they made a lot of money out of the land. We've heard that this is highly unusual; that this is only one of two rubbish dumps that did this. They're supposed to line the bottom and sides. When they cap it they put a layer on top that the methane gas can't come through.

"The smell gets really bad sometimes but we can't move out. We don't have the option and haven't got anywhere to go. We've got a [methane gas measure] monitor but haven't had any positive readings. Technically we're still in the danger zone and we probably shouldn't have a house here. We're worried on a number of counts. What are the health effects? They've said it doesn't harm your health but it can't be good for you either. There's obviously other stuff coming out of the ground when it smells. Is that harmful? We're worried about the potential danger to property if it does explode. And obviously no-one can sell their house. No one's going to buy here, not for decent market value anyway."

Another resident, Antony Krause, moved from Sydney six months ago to be closer to his daughter and look after his grandchild. Now retired, he worked for 21 years at the Reckitt Benckiser factory in Sydney, and paid $295,000 for a house that backs onto the landfill site. "I never heard anything about the gas," he explained. "We do get the smells, the bad egg smells every week or so, only outside. When I bought this house I asked the real estate agent about the tip and he said 'don't worry about that, they're going to build parkland'. And the next day I phoned the council and they sent me a letter that said there's nothing to worry about, we're building a park. I didn't know it was going to be so serious. I can't move out because I planted all my money here and I don't have money to buy another house."



Graeme Hiam

Retired factory manager Graeme Hiam moved into his house 16 months ago. He paid $130,000 for the land and another $190,000 for the house.

"We were never told anything," he told the WSWS. "From the time we purchased the land there was never any mention of the tip. One would assume they didn't know or they weren't telling. Ever since we've been here we've seen people putting rods down the drains. They first put a [methane gas measure] meter in my house a month ago. The house next door had the high reading that has been reported. My opinion is that blame rests between Peet and VCAT. But everyone's blaming someone else."

---

http://www.wsws.org/articles/2008/sep2008/mgas-f25.shtml

insidewasteweekly
A WME publication

Ombudsman's damning report on landfill leak

Tuesday, 20 October 2009
Garth Lamb

Lawyers representing nearly 600 residents of Brookland Greens Estate, who were allegedly effected by landfill gas leaking out of the old Stevensons Road landfill in the Melbourne suburb of Cranbourne last year, have welcomed a damning report by Victoria's independent Ombudsman. Released last week, it found EPA Victoria mainly to blame for the gas migration, which saw hundreds of people evacuated and ongoing claims of depressed property prices.



The Ombudsman traced the problem back to 1992 when the EPA granted works approval for the Shire of Cranbourne (the predecessor of the City of Casey Council). The EPA intended the landfill to be lined with compacted clay if it was to accept putrescible waste – a "favored" but not compulsory practice at the time – but ultimately the regulator bowed to pressure and allowed an unlined facility to be built.

The Ombudsman found the Shire's 1992 contention that a landfill liner would be expensive ($500,000) to install should not have been taken into account by the EPA: "Clearly, environmental standards should not be compromised for the sake of an agency saving money."

While it was the lack of a liner which ultimately saw gas migration become such a high profile issue last September, the Ombudsman was equally scathing about other aspects of site design and operation.

"My investigation identified that the EPA's assessments of the Shire's works approval applications were inadequate," states 289-page, 65-recommendation report, which has been tabled in Parliament.

"The applications contained errors and the EPA failed to properly explore all assertions. The EPA also failed to properly assess the Shire's applications for works approval partly through lack of expertise and partly through allowing the outcome to be the subject of negotiation."

One significant error of the EPA, "was to ignore the condition of the *State Environment Protection Policy (Siting and Management of Landfills Receiving Municipal Waste) 1991* that prohibited landfilling below the level of the water table, 'unless written permission from the Authority has been obtained'".

"Without addressing this condition explicitly in the assessment of the works approvals, the EPA should not have granted permission for the landfill which was not only below the level of the water table, but interrupted a substantial nearby aquifer," states the report.

EPA Victoria CEO Terry A'Hearn rejected claims the EPA did not do its job, telling the *ABC* things hadn't been done perfectly, but "we believe that at all times what we've done is prioritise the safety of the people on the estate".

The Ombudsman was also highly critical of the Shire of Cranbourne and the City of Casey Council, finding "in its narrow focus on the economics of landfilling, the Shire failed to take account of other factors, namely environmental standards".

Perhaps the most acute display of the all round failure of the system is the ongoing series of failures to adequately address the problems, despite multiple opportunities for this to occur.

"I concluded that while there have been significant technological developments in landfill design since the works approval was issued by the EPA in 1992, design standards at the Stevensons Road landfill effectively stood still.

"Essentially, a landfill conceived in the late 1980s, approved in 1992 and licensed in 1996 continued to operate with no landfill liner up until 2005 when it was closed. In the granting of the works approval for an unlined landfill and the subsequent lost opportunities to require a landfill liner, the EPA failed to set conditions for the protection of the environment."

Last November law firm Slater & Gordon launched a class action in the Supreme Court of Victoria seeking unspecified damages from the City of Casey on behalf of residents affected by the gas leak. Lawyer Ben Hardwick said it is now "imperative that the City of Casey and EPA come to the table and try to resolve the matter through mediation".

"Now that the Ombudsman has made his findings, the next step is to fix the problem," he said. "Rather than protracted and expensive legal action through the courts, the City of Casey should sit down and talk with us."

He said the Ombudsman catalogued "a litany of bureaucratic bungling, mismanagement and blame-shifting" and pointed to a particular comment in the report supporting his class action lawsuit.

The Ombudsmand stated, "it is clear to me that the local community has endured considerable anxiety, distress and inconvenience as a result of methane gas leaking from the landfill into the estate and the way that some government agencies handled this issue. On this basis, affected residents should be compensated accordingly".

© Aspermont Limited

Aspermont Limited
Street Address613-619 Wellington Street, Perth WA Australia 6000
Postal Address PO Box 78, Leederville, WA Australia 6902
Head Office Tel +61 8 6263 9100 **Head Office Fax** +61 8 6263 9148
e-mail contact@aspermont.com **website** www.aspermont.com **ABN** 66 000 375 048

Print Page

AllBusiness

Powered by LexisNexis®

Scotland board puts end to landfill project

Jun. 8--LAURINBURG -- The Scotland County Board of Commissioners voted Monday night to end a controversial landfill expansion project.

County officials had considered expanding a closed landfill to create a regional dump as a way to bring in revenue for the struggling county.

But many residents opposed the plan, saying it would turn the county into a dumping ground for trash from all over the state.

Monday's meeting officially killed the project, when commissioners unanimously voted on two items meant to quash the plan for good.

J.D. Willis, chairman of the board and proponent of another regional landfill proposal in 2007, issued a motion to stop plans for the landfill at Patterson Road.

Commissioner John Alford, before voting on the motion, asked that it include language to stop all regional landfill proposals in the county.

Willis agreed.

The motion was passed without dissent.

Immediately afterwards, Bob Davis, a longtime opponent of regional landfills in the county, submitted a detailed resolution banning the Patterson Road landfill expansion.

The resolution stated that "Scotland County discontinue the employment of engineering firms, outside legal counsel and all other firms or companies engaged to assist with the condemnation and/or more expansive plans for disposition of waste."

The resolution asked that the county manager notify all waste management companies that Scotland County was, in effect, out of the landfill business.

It, too, was passed unanimously.

Only Commissioner Guy McCook was absent. Willis said McCook had been hospitalized that morning.

Willis said the landfill had become a divisive issue in the county, and that officials would be better served by channeling resources into other things.

"Having said that, it is my opinion that the climate is not conducive to expanding our existing landfill," he said.

Willis, a longtime board member, was defeated in the May primaries, after refusing to say whether he would vote for or against the landfill expansion project.

Many residents believed Willis was in favor of the project.

In 2007, he was one of five of the board's seven commissioners to vote in favor of a dump that was expected to produce about $4 million a year in revenue for the county.

Eddie Carmichael, a farmer who had spoken out against the Patterson Road landfill, said he was pleased with the board's decision, but remained skeptical.

"It's good they finally listened to the people," Carmichael said.

But, he said, with a wary shrug: "It's politics. They could come in next month with a whole, new

Ads by Google

Salem Weekend Getaway
Red Lion "We Promise or We Pay" Your Comfort is Guaranteed Book Now

Salem
Move Your Career Forward. Get Hired. Apply Today!
FINS.com/Salem

DIRECTV - Official Site
Winston Salem: Save 50% Off DIRECTV 150 Ch Pkg $29.99/mo (1yr)!
www.directv.com

Lose 9lbs in 4 Days
Get Rid of the Pounds By Using This 1 Weird Old Tip
weatherguidetoday.com

Newsrooms are Classrooms
Medill students work as reporters in working newsrooms. Read more.
www.medill.northwestern.edu

State officials file suit over dump site health hazards

March 11, 2010 - By MARY ANN GREIER

Save | Post a comment | SHARE

LISBON - State officials resorted to legal action Wednesday against A & L Salvage in an effort to stop a health threat and environmental hazard caused by the odorous dump outside of Lisbon.

Ohio Attorney General Richard Cordray's office filed the 20-count complaint and preliminary injunction request in Columbiana County Common Pleas Court, asking the court to order A & L Salvage to cover the 42-acre dump site with an additional 12 inches of cohesive earthen material within six weeks of the order.

The preliminary injunction request also asked for immediate access to the site for the Ohio Environmental Protection Agency and its contractors and an immediate elimination of all off-site odors. The case has been assigned to Judge C. Ashley Pike.

The construction and demolition debris landfill stopped operations a year ago, but the odors from hydrogen sulfide remained and became worse in recent months to the point of causing people to become ill with headaches and nausea, a joint press release from the OEPA and OAG said.

The OEPA and OAG offices have been working with the company for a final closure plan to cover the site for over a year with no resolution for a consent decree. OEPA Director Chris Korleski said "enough is enough," according to OEPA spokesman Mike Settles.

"This situation cannot continue as is," Korleski said in a press release. "The odors need to be stopped and the landfill needs to be properly stabilized and closed once and for all."

Residents suffering from the stench have been putting up with the problem for several years, complaining to the Columbiana County Health Board at one point, then going to the OEPA after the state started overseeing C&DD landfills in the county. Settles said Korleski knows how frustrated they've been.

"I am personally grateful for the hard work the OEPA has done. I am also hopeful this court action will finally bring relief for all of us who live around the landfill," state Route 45 resident Don Kibler said in an e-mail.

"We have given A&L Salvage's owners every opportunity to comply with Ohio law and properly close that landfill," Cordray said in the press release. "Instead, they have allowed conditions to deteriorate to a point where we now need the court's help to make things right."

Besides naming A & L Salvage LLC as a defendant, the complaint also named four additional defendants who allegedly own property the OAG has identified as part of the site. Those defendants include Amato Properties LLC, Jack Amato and Jeffrey Aldrich, all of Wellsville, and the Amato Family Trust of East Liverpool.

Dr. Jack Amato serves as chairman of the Columbiana County Health Board, the entity which issued the dump's original permit to operate. A call was made to his home Wednesday evening, but he couldn't be reached for comment.

When asked what those defendants have to do with the dump, OAG spokesman Ali Lehman said they own property that is considered part of the landfill. According to the county Auditor's Web site, A & L Salvage owns about 375 acres along state Route 45 and Black Road. The active part of the dump only covered 42 acres, with the rest being buffer, although the company originally had plans to eventually use the other acreage for dumping.

CLICK TO SUBSCRIBE

Salem, OH
83°F Extended Forecast Find Another Location
Data provided by The Weather Channel ®

News, Blogs & Events

I am looking for:
Search
in:
News, Blogs & Events Web
EZToUse.com

EZToUse.com YOUR YELLOW PAGES CONNECTION Your #1 source for internet yellow pages

Fact Box

The OEPA recently asked for help with the site from the U.S. EPA. Those two agencies, the Ohio Department of Health and the Agency for Toxic Substances and Disease Registry are tracking hydrogen sulfide odors around the site and using gas monitoring wells to see if other gases are leaving the site.

Residents experiencing nuisance odors can call the OEPA odor hotline at 1-800-686-6330 ext. 1212. Information about possible health effects from hydrogen sulfide exposure can be obtained from Greg Stein at the ODH at 614-995-7017 or online at www.odh.ohio.gov

OHIO VALLEY OUTDOORS MAGAZINE

Salem Or Hvac Contractors
Keep Toasty Warm or Cool as a Cucumber. Call for HVAC Services.
Ads by Google

Salem, OR Real Estate
Thousands of properties for sale. Search by ZIP or MLS Number.
Ads by Google

The company and OEPA reached an environmental pact last year, prohibiting the use of any of the property owned by A & L Salvage as any type of dump in the future. The pact also prohibits any future owners from operating a dump on the land.

The county Auditor's Web site lists Amato Properties, Jack Amato and Jeffrey Aldrich as owners of some land on Black Road, but their names weren't listed on the environmental pact filed in the Recorder's Office. Their names also weren't listed on the numerous complaints filed against A & L Salvage for violations of environmental law.

Those violations form the basis for the lawsuit which requests monetary penalties along with the injunctive relief to alleviate the odors. The violations included acceptance of pulverized debris and solid waste, which is prohibited at a C&DD landfill, improper asbestos handling, and creating a nuisance from the hydrogen sulfide, or rotten egg, smell.

The complaint also noted cliffing of debris, which happens when it's not spread out and compacted on the working face of the dump, improper use of unloading zone, failure to manage surface water and allowing a discharge into Patterson Creek, failing to apply weekly cover to debris, failure to comply with Korleski's orders to implement an explosive gas monitoring plan, failure to pay disposal fees, causing a nuisance with dust, failure to properly dispose and bury asbestos or cover asbestos, failure to surround the asbestos disposal site with fencing, failure to display asbestos warning signs, failure to maintain equipment to wet asbestos or prevent dust emissions from asbestos operations, and failure to minimize dust on roads.

The civil penalties being sought exceed $25,000, with no exact estimate available for each violation. Penalties for at least nine violations were listed as $10,000 per day per violation, with the penalties for another 10 violations listed at $25,000 per day per violation. A tax of $300 was requested against each defendant and their property for the statutory nuisance complaint.

The time period for the complaint began in 2005 and continued to the present. The preliminary injunction request said the landfill "is releasing extremely intense odors and has elevated temperatures indicating the possible presence of a subsurface fire."

Jerry Weber, an OEPA environmental specialist responsible for inspections at the site, wrote the OEPA has received at least 350 odor complaints about the site since October 2003, causing him to issue numerous violations. In February, he documented odors which caused him to have a burning throat.

Settles explained that a hydrogen sulfide monitor placed at a nearby residence recorded readings as high as 110 parts per billion. They become concerned about the possible effects to public health when levels exceed 70 parts per billion.

He also said gas monitoring at the site this week showed strong levels of carbon monoxide and a landfill temperature of 191 degrees Fahrenheit, both good indicators that a subsurface fire exists.

By requiring additional soil cover on the site, the odors could be cut down, along with the amount of oxygen fueling a possible subsurface fire, he said.

Mary Ann Greier can be reached at mgreier@salemnews.net

Save | Post a comment |

Recommend Be the first of your friends to recommend this.

Subscribe to Salem News

« Next: Drugs Best First Defense Against Heart Disease for Diabetics | Previous: Grilled Meats Not Tied to Breast Cancer in Older Women »

Bird Flu Virus Can Survive Two Years in Landfill

Posted in: Cold, Flu, and Sinus



Photo: Scott Bauer, US Agricultural Research Service

FRIDAY, June 5 (HealthDay News) — Poultry carcasses infected with the bird flu virus can remain infectious in municipal landfills for as long as two years, say Nebraska researchers.

Hundreds of millions of chickens and ducks infected with bird flu have died or been killed worldwide in an effort to control the spread of the disease, they noted. The remains are disposed of in different ways, including burial in landfills. For example, the carcasses of more than 4 million poultry that were culled or died during a 2002 outbreak in Virginia were placed in municipal landfills, according to a news release from the American Chemical Society.

But the safety of landfill disposal has received little attention, said the researchers who conducted the study. They found that the bird flu virus can survive in landfill leachate — liquid that drains from a landfill — for at least 30 days and up to two years.

Factors that most reduced the virus' survival times were elevated temperatures and acidic or alkaline pH, the news release noted.

"Data obtained from this study indicate that landfilling is an appropriate method of disposal of carcasses infected with avian influenza," concluded Shannon L. Bartelt-Hunt and colleagues, who noted that landfills are designed to hold material for much longer than two years.

The study is to be published in the June 15 issue of the journal *Environmental Science & Technology*.

Department of Justice

FOR IMMEDIATE RELEASE
Thursday, August 7, 2008
WWW.USDOJ.GOV

ENRD
(202) 514-2007
TDD (202) 514-1888

Nevada Landfill Operator Agrees to $36 Million Plan to Close Landfill Site

Republic Services to pay $1 Million Civil Fine

WASHINGTON— Republic Services of Southern Nevada, the current operator of the Sunrise Mountain Landfill located in Clark County, Nev., has agreed to construct and operate a comprehensive remedy for the site and to pay a $1 million civil fine in order to resolve alleged violations of the Clean Water Act, the Justice Department and U.S. Environmental Protection Agency announced today.

The consent decree, filed today in U.S. District Court in Las Vegas, requires Republic Services of Southern Nevada to implement extensive storm water controls, an armored engineered cover, methane gas collection, groundwater monitoring, and long-term operation and maintenance.

"Today's settlement will minimize the risk to Clark County residents from polluted water runoff and hazardous waste discharges from the Sunrise Mountain landfill," said Ronald J. Tenpas, Assistant Attorney General for the Justice Department's Environment and Natural Resources Division. "This settlement reflects the federal government's commitment to protecting valuable natural resources like Lake Mead and its watershed."

The settlement will ensure effective long-term control of the landfill, which contains over 49 million cubic yards of waste. The remedy, which is expected to take roughly two years to build, will be designed to withstand a 200-year storm and is expected to cost over $36 million. Upon completion, the remedy is estimated to prevent the release of over 14 million pounds of contaminants annually, including stormwater pollutants, methane gas and landfill leachate.

"Landfill operators must ensure that effective safeguards are in place to protect the

environment and nearby communities," said Wayne Nastri, administrator of the EPA's Pacific Southwest region. "With today's agreement, Republic is required to properly close the landfill and ensure long-term waste containment."

Sunrise Landfill, a 440-acre closed municipal solid waste landfill, is located three miles outside of Las Vegas city limits. The landfill cover failed during a series of storms in September 1998, sending waste into the Las Vegas Wash. The landfill is located two miles above the Las Vegas Wash, which discharges directly into Lake Mead -- a primary drinking water resource for southern Nevada, including the Las Vegas metro area, as well as the lower Colorado River, the Phoenix metro area and southern California.

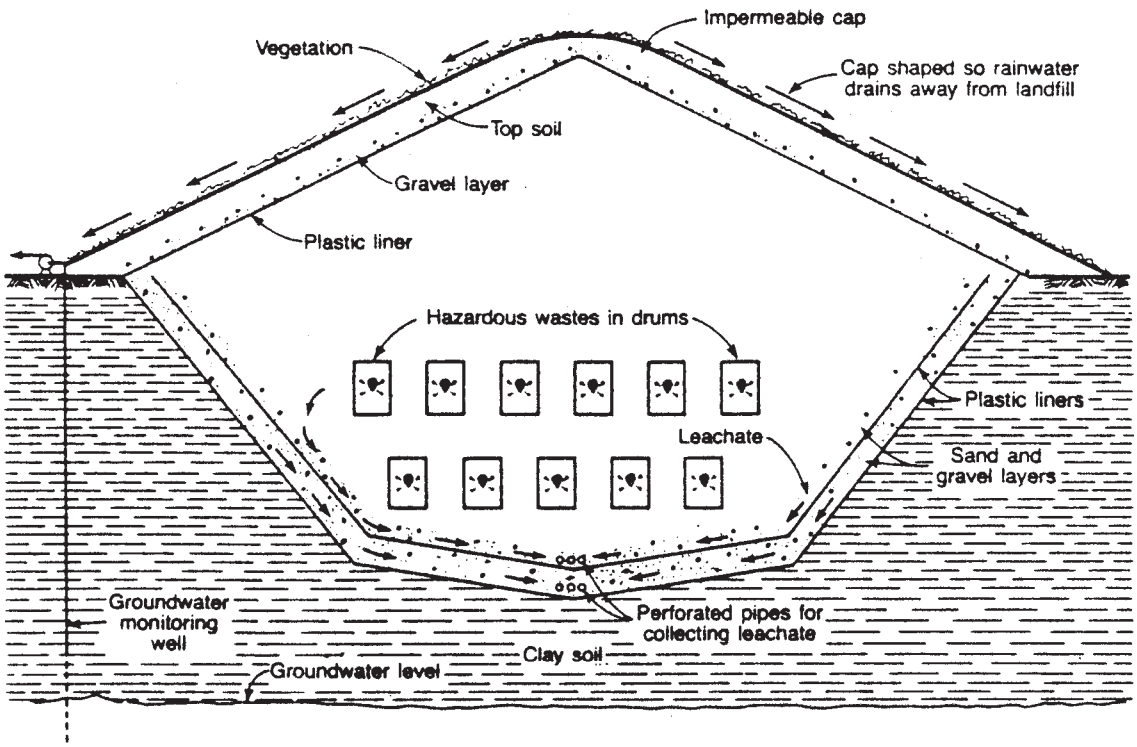
The landfill was operated on behalf of the County by entities related to Republic Services of Southern Nevada from the 1950's through 1993. Following the landfill cover failure in 1998, the EPA ordered Republic Dumpco, a company related to Republic Services of Southern Nevada, and the Clark County Public Works Department to correct violations of the federal clean water laws and to immediately stabilize the site.

Sunrise Mountain Landfill is unlined and contains more than 49-million cubic yards of waste including: municipal solid waste, medical waste, sewage sludge, hydrocarbon-contaminated soils, asbestos, and construction waste.

The proposed consent decree, lodged in the U.S. District Court for the District of Nevada, is subject to a 30-day public comment period and approval by the federal court. A copy of the consent decree is available on the Department of Justice Web site at http://www.usdoj.gov/enrd/open.html.

###

08-698



Hazardous waste landfills: some lessons from New Jersey



New Jersey's experience with operational problems at four hazardous-waste landfills points up ways landfill regulations could be improved.

PETER MONTAGUE
Dept. of Chemical Engineering and
Center for Energy and Environmental Studies
Princeton University
Princeton, N.J.

A SECURE LANDFILL IS a carefully-engineered depression in the ground into which hazardous wastes are put. (3,4) The intention is to avoid any hydraulic connection between the wastes and the surrounding environment, particularly the groundwater. To this end, there are four critical elements in a secure landfill: a bottom liner, a leachate collection system, a cover, and the natural hydrogeologic setting.

The *natural setting* can be selected to minimize the possibility of wastes escaping to groundwater beneath a landfill. The other three elements must be engineered. The *bottom liner* may be one or more layers of clay or a synthetic membrane (or a combination of these); the liner effectively creates a bathtub in the ground. The *leachate collection system* consists of sloping the bottom of the landfill and placing pipes in the low places to pump out contaminated water and other fluids (leachate) that accumulate; the pumped leachate is treated at a wastewater treatment plant. The *cover* will generally consist of several sloped layers—clay or a membrane liner (to prevent rain from intruding), overlain by a very permeable layer of sandy or gravelly soil (to promote rain runoff), overlain by topsoil in which vegetation can root (to stabilize the underlying layers of the cover).

Each of these elements is critical to success. If a liner fails, hazardous wastes may migrate directly into the environment. If leachate is not removed from a landfill, fluids can build up in the bathtub; the resulting hydraulic head is the main force that will drive wastes out into the environment if the liner fails. If the cover is not maintained intact, rain will enter the landfill, solubilizing and mobilizing wastes, resulting in buildup of leachate—even to the point where the bathtub can overflow its sides.

Four secure landfills in New Jersey

New Jersey's industries produce roughly 750,000 tons of hazardous

wastes annually (9,13) but the state's last commercially-operated chemical landfill closed in 1976. By 1977 five major firms were making plans to operate their own secure landfills for on-site disposal of chemical wastes. All five landfills were eventually constructed and are operating today. However, four of the five have experienced operational problems.

E.I. DuPont de Nemours & Co., Inc.

DuPont applied in April, 1978, to the New Jersey Department of Environmental Protection (DEP) for a permit to operate a 10-acre double-lined secure landfill for chemical waste disposal in Carneys Point, N.J. Two five-acre cells were constructed, each with two liners of 0.03 inch (0.76 mm) nylon-reinforced Hypalon®—a tough polymer film—and each with a leak detector, or telltale, between the two liners.

A leak detector consists of pipes that collect any fluids that accumulate between the two liners. Presence of liquids in the leak detector is a signal that something may be going wrong with the upper liner.

The new landfill went into operation in January, 1979. Three months later DuPont management reported the presence of fluids in the leak detector area, accumulating at 124 gallons (469 liters) per day. The company argued that the fluids were rainwater that had been trapped between the liners during construction. The state feared that the primary liner (the upper liner, closest to the wastes) was leaking. The state immediately restricted the kinds of wastes that could be landfilled at the site, but subsequently relented after reaching an agreement with DuPont.

Under the agreement DuPont would analyze samples of the fluids being collected in the leak detector. (By this time the rate of accumulation had decreased to a steady 50 gallons (189 liters) per day.) DuPont suggested, and the state agreed, that an increase in four indicators—total dissolved solids (TDS), chemical oxygen demand (COD), phenol compounds, and color—would signal a leak occurring as distinct from rainwater accumulating. My statistical analysis of these data indicates that a significant increase has occurred in at least half of the indicators. By the criteria established in the agreement, the landfill's primary liner probably should be judged to be leaking.

New Jersey's experience with hazardous-waste landfills shows that synthetic liners are prone to problems—and that clay liners also have their troubles. Also, landfill covers are vulnerable to attack from: erosion; vegetation; soil-dwelling mammals; sunlight; subsidence; and human activities.

Monsanto Industrial Chemical Corp.

Monsanto Industrial Chemical Corp. sought permission from the DEP in 1977 to establish a 6-acre single-lined landfill for chemical waste disposal in Bridgeport, N.J. The DEP persuaded Monsanto that a double-lined landfill with a leak detector made best sense and the company proceeded with construction.

The Monsanto site had previously been used by the U.S. Army Corps of Engineers for disposal of material dredged from the bottom of the nearby Delaware River. DEP engineers therefore feared that soil on the site would be subject to compaction in the future as the waste load increased in the landfill. Monsanto therefore mechanically compacted the soil to 2700 pounds per square foot and installed a 0.9-inch (23 mm) fabric liner of BIDIM®, a proprietary polyester fiber somewhat like the felt pads that people sometimes put beneath rugs—except that BIDIM is lighter, stronger, and more durable than felt, and water passes through it more easily. Monsanto sells BIDIM to provide subsurface support for roadways, railway roadbeds, and construction sites. Above the BIDIM liner, Monsanto placed 12 in. (30.5 cm) of clay with a coefficient of permeability of 5×10^{-8} cm/sec. Such a coefficient of permeability would permit water to flow through 1.6 cm (0.6 in.) of such clay in a year's time. Above that layer of clay came the leak detector; above that came another 18 in. (45.7 cm) of the same clay.

The new landfill went into operation in mid-August, 1978. Within a month Monsanto officials had written to the DEP saying fluids were collecting in the leak detector area. The accumulation rate varied from 26 gallons (98 liters) to 48 gallons (182 liters) per day.

Monsanto hired consulting hydrologists Geraghty and Miller to help find the leak but after four years the effort has not been successful.

J.T. Baker Chemical Co.

J.T. Baker Chemical Co. of Phillipsburg, N.J., applied to the DEP in 1976 for permission to add several new landfills for disposal of chemical wastes. As finally constructed in summer, 1979, the new landfills consist of two liners of 0.03 inch (0.76 mm) polyvinyl chloride (PVC) film, with a leak detector between them. By October, fluids were collecting in the leak detector area between the liners at the rate of about 3 gallons (11 liters) per day; and DEP officials had ordered the firm to analyze samples of the fluids regularly for 13 characteristics.

There are four key elements in a secure landfill: a bottom liner; a leachate collection system; a cover; and the natural hydrogeologic setting. Each of these elements is critical to success.

Using the same procedure agreed to by DuPont and the state (designating an early set of data as baseline and comparing subsequent data to it, to see if concentrations of contaminants are increasing), statistical analysis of the J.T. Baker sites convinces me that the primary liners of two of the landfills are leaking. J.T. Baker officials continue to believe that the fluids, which are now accumulating at the rate of about 1 gallon (4 liters) per day, represent only rainwater trapped during construction.

Toms River Chemical Corp.

Toms River Chemical (TRC), a subsidiary of Ciba-Geigy, sought permission in 1976 to create a secure chemical landfill in Dover, N.J. As constructed, the lower liner is 0.02 inch (0.5 mm) PVC and the upper liner is 0.03 inch (0.76 mm) PVC with a leak detector between them.

The permit to operate the site requires the firm to add a lithium salt to the wastes as a tracer. If lithium appears in the leak detector area, it is a signal that leakage through the upper liner is occurring. The new landfill began operation in January, 1979. And in April DEP officials visiting the site discovered four feet of liquids standing in the leak detector area. Subsequently, company officials determined that the leak rate averages anywhere from 60 gallons (227 liters) to 131 gallons (495 liters) per day. Lithium has consistently been detected at low levels in the leak detector fluids.

I have described my study of these four landfills in greater detail elsewhere.(11) I must stress here that I have no evidence that any of these landfills is contaminating groundwater or significantly impacting the environment. There are groundwater monitoring wells around each of the sites but I have not yet analyzed the monitoring data.

New Jersey's experience with secure landfills should be of use to people in

What constitutes failure of a hazardous-waste landfill?

From New Jersey's experience I can see other potential problems in the federal program. First, EPA's interim regulations (20, p. 33194) call for groundwater monitoring for four parameters to signal landfill leakage (similar to my study of New Jersey's four landfills). However, EPA's regulations omit a key element: they do not say what will constitute the baseline period, to which "new" observations will be compared. This is an important omission that will cause uncertainty and dispute. As I demonstrated in my study, selection of different baseline periods can change the results of the analysis (11).

Second, it is not clear from the regulations how many monitored parameters must increase before a landfill is declared leaking. If one out of four increases, is leakage occurring? Two out of four? In New Jersey, even with many parameters increasing, owners and operators of landfills cannot believe that their landfill liners have failed.

A related problem is construction of landfills on contaminated sites. At two of the four New Jersey sites I studied, contaminated soil was used in construction of the landfill. This makes it very difficult to discern residual contamination from new landfill leakage. There are many reasons to want to build on contaminated sites but this can only increase the difficulty of monitoring new activities.

A way out of these problems would be to require that a *tracer* be added to the wastes. Many tracers have been proposed; unfortunately, all but one have the advantage that they may be degraded or chemically bound up by wastes, particularly as the waste stream changes unpredictably.

Tritium (radioactive hydrogen), however, does not suffer from these disadvantages. If thoroughly mixed with the wastes, it will travel with the leachate. It is easily detected. It has a half-life of 12.3 years so it will disappear in roughly 120 years. For any landfill that doesn't accept tritium-contaminated wastes, and which is built over an aquifer free of tritium contamination, tritium would seem to be a perfect tracer, easy to distinguish from residual non-radioactive contamination.

Lastly, many states (including New Jersey) require construction of landfills out of "impermeable" materials with impermeable defined as a leak rate of 10^{-7} cm/sec. It became clear in New Jersey, when the state tried to enforce this standard at the Toms River Chemical site, that there is no way to reach agreement on the permeability of a leaking membrane liner. The EPA acknowledges that a 10^{-7} cm/sec permeability standard is not appropriate for membrane liners (21, pp. 2837 and 2838). Yet many states have not recognized the problem. Leakage through a membrane liner will occur through a pinhole or through a tear—a concentrated stream of contamination, which is quite different in effect from a slow permeation through the entire bottom and sides of a clay-lined landfill. Permissible leakage through membrane liners should be specified in gallons (or liters) per unit time.

This matter of defining failure goes to the heart of a regulatory philosophy. Although Congress passed the Resource Conservation and Recovery Act (RCRA) six years ago and although roughly 80% of the nation's hazardous wastes go into landfills(8), the EPA has not yet promulgated final criteria for landfills.

On two occasions the Agency has announced elaborate landfill regulations, only to withdraw them later. The first set of regulations(23) established fairly rigid facility design requirements. The Agency said at the time they were using this approach because "the state-of-the-art for predicting discharges or releases from landfills is poor and [the Agency] thus believes that the only option available to ensure protection or human health and the environment is to prescribe design and operating standards which will provide maximum containment in landfills . . . .[T]he Agency is not aware of any method for designing landfills to allow specific constituent release rates, nor is the Agency aware of any method to determine what release rates would be acceptable."(23, p. 58989)

The Agency prescribed facility design requirements such as, the bottom and sides of a landfill had to have a synthetic membrane liner overlain by 6" (30 cm) of sand or soil, overlain by 3 feet (1 meter) of soil with a permeability of 10^{-7} cm/sec, overlain by a leachate collection system, and so on. Subsequently the Agency decided this approach was "not completely adequate to assure ground-water protection"(19, p. 66817) and a new approach was announced.

The new approach(19,24) calls for *risk assessment* of any facility. The Agency now acknowledges that all landfills will eventually leak. The question becomes: how much risk is thereby created? The Agency says, " . . . many organic constituents are stable (degrade very slowly); other hazardous constituents (e.g., toxic metals) never degrade. Yet the existing technology for disposing of hazardous wastes on or in the land cannot confidently isolate these wastes from the environment forever." Such wastes "will remain potentially dangerous for many thousands of years". And "[s]ince disposing of hazardous wastes in or on the land inevitable [sic] results in the release of hazardous constituents to the environment at some time, any land disposal facility creates some risk."(24, p. 28315)

Using the new approach, the permitting authority (whether the federal EPA or a state agency that has assumed RCRA duties) would somehow decide how much risk is acceptable from what rates of release of what kinds of hazardous wastes.

As I see it, the major problem with this approach would be our inability to define failure. We do not have quantitative measures of adverse health or environment effects for the vast majority of hazardous wastes. Under this regulatory approach, we would not know when a facility had "failed" until measurable health or environmental damage had occurred and by then it would probably be too late to do anything about it. In any case, the EPA has withdrawn the proposal.

The EPA is under court order to promulgate yet another plan for regulating landfills. It will be among the most difficult regulatory tasks ever undertaken.

other states and to the federal effort to regulate landfills. The main conclusions from that experience:

• (1) Synthetic liners are prone to problems (5,7,14,22 p. 11128, 23 p. 58989, 25); but clay also has problems (1,6,8,12,17).

• (2) Leachate collection systems only work so long as someone is keeping the pumps going and preventing the pipes from clogging (18,24, p. 28324, 22 p. 11128).

• (3) Covers are vulnerable to attack (10,15,16) from at least six sources:

• (a) *Erosion* by natural weathering (rain, hail, snow, freeze-thaw cycles, and wind).

• (b) *Vegetation*, such as shrubs and trees that continually complete with grasses for available space, sending down roots that will relentlessly seek to penetrate the cover;

• (c) *Burrowing or soil-dwelling mammals*, reptiles, and insects, which will present constant threats to the integrity of the cover;

• (d) *Sunlight* (if any of these other natural agents should succeed in uncovering a portion of the umbrella) will dry out clay (permitting cracks to develop), or destroy membrane liners through the action of ultraviolet radiation;

• (e) *Subsidence*—an uneven slumping of the cap caused by settling of wastes or organic decay of wastes, or by loss of liquids from landfill drums—can result in cracks in clay or tears in membrane liners, or result in ponding on the surface, which can make a clay cap mushy or can subject the cap to freeze-thaw pressures;

• (f) *Human activities* of many kinds.

Contingency plans needed

EPA calls for a contingency plan for all failures, including "non-sudden" occurrences (20, p. 33237). The plan must be kept up to date and must spell out who is to do what in the event of any problems. Two key elements, however, have been omitted from these federal regulations:

• (1) There is no requirement that waste generators must have laternative sites to which they can take their wastes. In New Jersey, the regulatory agency has acknowledged pressures in the past not to close sites that are contaminating the environment because the sites are needed—generators say they have no other place to take their wastes. This compromises the regulatory agency, damaging its credibility.

• (2) Federal regulations require a closure fund and a post-closure maintenance fund—money set aside during the operating life of the facility to assure that the owner/operator can afford proper closure and post-closure maintenance for 30 years. What happens to this fund if a facility fails and has to be closed early? The fund will not build up and will not be available for closure or post-closure maintenance. EPA acknowledges that this is a problem (21 p. 2824) but offers no solution. Clearly this will be an inducement for a regulatory agency to allow inadequate facilities to continue operating so that they can build up the closure and post-closure funds. To solve this problem, the closure and post-closure funds could be required *in toto* before the facility begins operation. ▽



Peter Montague has been studying landfills for radioactive and chemical wastes for the past five years. He is co-author (with his wife) of two books on toxic heavy metals, and is one of the editors of *New Jersey Hazardous Waste News*. With his wife, he has co-founded two non-profit research organizations—Southwest Research and Information Center in Albuquerque, NM, and the Environmental Research Foundation in Lawrenceville, NJ—to bring legal, scientific, and engineering information to bear on public policy problems.

References

• 1. Anderson, David, Brown, K.W., and Green, Jan "Effect of Organic Fluids on the Permeability of Clay Soil Liners," Land Disposal of Hazardous Waste, Proceedings of the Eighth Annual Research Symposium *[EPA-600/9-82-002], U.S. Government Printing Office, Washington, DC, 1982, pp. 179-190*

• 2. Anderson, David, and Brown, K.W., "Organic Leachate Effects on the Permeability of Clay Liners," Land Disposal Hazardous Waste, Proceedings of the Seventh Annual Research Symposium *[EPA-600/9-81-002b], U.S. Government Printing Office, Washington, DC, 1981, pp. 119-130.*

• 3. Farb, Donald G., Upgrading Hazardous Waste Disposal Sites *[SW-677], U.S. Government Printing Office, Washington, DC, 1978*

• 4. Fields, Timothy, Jr., and Lindsey, Alfred W., Landfill Disposal of Hazardous Wastes: A Review of Literature and Known Approaches *[SW-165], U.S. Government Printing Office, Washington, DC, 1975.*

• 5. Geswein, Allen J., Liners For Land Disposal Sites *[EPA/530/SW-137], U.S. Government Printing Office, Washington, DC, 1975.*

• 6. Green, William J., Lee, G. Fred, and Jones, R. Anne, "Clay-Soils Permeability and Hazardous Waste Disposal," Journal of the Water Pollution Control Federation *Vol. 53, No. 8, August, 1981, pp. 1347-1354*

• 7. Haxo, H.E., Jr., "Durability of Liner Materials for Hazardous Waste Disposal Facilities," Land Disposal: Hazardous Waste, Proceedings of the Seventh Annual Research Symposium *[EPA-600/9-81-002b], U.S. Government Printing Office, Washington, DC, 1981, pp. 140-156*

• 8. Josephson, Julian, "Hazardous Waste Landfills," Environmental Science & Technology, *Volume 15, Number 3, March, 1981, pp. 250-253.*

• 9. Kruger, Anne Longsworth, Industrial Wastes Generation and Disposition in New Jersey *[Working Paper No. HW-1], Center for Energy and Environmental Studies, Princeton University, Princeton, NJ, May, 1982.*

• 10. Lutton Richard J., "Selection of Cover For Solid Waste," Land Disposal of Hazardous Wastes, Proceedings of the Fourth Annual Research Symposium *[EPA-600/9-78-016], U.S. Government Printing Office, Washington, DC, 1979, pp. 319-325*

• 11. Montague, Peter, Four Secure Landfills in New Jersey—A Study of the State of the Art in Shallow Burial Waste Disposal Technology *[PU/CEES 135], Center for Energy and Environmental Studies, Princeton University, Princeton, NJ 08544*

• 12. Morrison, Allen, "Can Clay Liners Prevent Migration of Toxic Leachate?" Civil Engineering/ASCE, *July, 1981, pp. 60-63*

• 13. Ricci, Rocco, and others, Report of the Hazardous Waste Advisory Commission to Governor Brendan Byrne, *New Jersey Department of Environmental Protection, Trenton, NJ, Jan., 1980.*

• 14. Shultz, David W., and Miklas, Michael P., Jr., "Procedures for Installing Liner Systems," Land Disposal of Hazardous Waste, Proceedings of the Eighth Annual Research Symposium *[EPA-600/9-82-002], U.S. Government Printing Office, Washington, DC, March, 1981, pp. 224-238.*

• 15. Skinner, Peter N., "Facing The Chemical Waste Disposal Dilemma: The Newco Administrative Proceeding," Capital University Law Review, *Volume 9, Number 3, Spring, 1980, pp. 547-566.*

• 16. Skinner, Peter, "Performance Difficulties of 'Secure' Landfills for Chemical Waste and Available Mitigation Measures," The Hazardous Waste Dilemma: Issues and Solutions, *American Society of Civil Engineers, New York, 1981*

• 17. Stewart, Wilford S., State-of-the-Art Study of Land Impoundment Techniques *[EPA-600/2-78-196], U.S. Government Printing Office, Washington, DC, 1979*

• 18. Tolman, Andrew L., Bellestero, Antonio P., Jr., and others, Guidance Manual for Minimizing Pollution From Waste Disposal Sites *[EPA-600/2-78-142], U.S. Government Printing Office, Washington, DC, 1980.*

• 19. U.S. Environmental Protection Agency, "40 CFR Part 264 [SW FRL 1626-4] Standards Applicable to Owners and Operators of Hazardous Waste Treatment, Storage and Disposal Facilities," Federal Register, *October 8, 1980, p. 66816.*

• 20. U.S. Environmental Protection Agency, "Hazardous Waste and Consolidated Permit Regulations," Federal Register, *Vol. 45, No. 98, May 19, 1980, pp. 33066-33588.*

• 21. U.S. Environmental Protection Agency, "Hazardous Waste Management System, Addition of General Requirements for Treatment, Storage and Disposal Facilities (40 CFR Part 264); Amendment of Interim Status Standards Respecting Closure and Post-Closure Care and Financial Responsibility (40 CFR Part 265); and Conforming Amendments to the Permitting Requirements (40 CFR Part 122), Federal Register, *Vol. 46, No. 7, January 12, 1981, pp. 2802-2897*

• 22. U.S. Environmental Protection Agency, "Hazardous Waste Management System; Standards Applicable to Owners and Operators of Treatment, Storage, and Disposal Facilities; and Permit Program," Federal Register, *Vol. 46, No. 24, Feb. 5, 1981, pp. 11126-11177.*

• 23. U.S. Environmental Protection Agency, "Hazardous Waste—Proposed Guidelines and Regulations and Proposal on Identification and Listing," Federal Register, *Vol. 43, No. 243, December 18, 1978, pp. 58946-59028*

• 24. U.S. Environmental Protection Agency, "Standards Applicable to Owners and Operators of Hazardous Waste Treatment; Storage and Disposal Facilities," Federal Register *May 26, 1981, pp. 28314-28328*

• 25. Ware, Sylvia A., and Jackson, Gilbert S., Liners For Sanitary Landfills and Chemical and Hazardous Waste Disposal Sites *[EPA-600/9-78-005], U.S. Government Printing Office, Washington, DC, 1978*

International Journal of
Environmental Research and Public Health

MDPI

Article

Socio-Environmental and Hematological Profile of Landfill Residents (São Jorge Landfill–Sao Paulo, Brazil)

Vivianni Palmeira Wanderley [1,*], Fernando Luiz Affonso Fonseca [1,2], André Vala Quiaios [3], José Nuno Domingues [3], Susana Paixão [3], João Figueiredo [3], Ana Ferreira [3], Cleonice de Almeida Pinto [1], Odair Ramos da Silva [1], Rogério Alvarenga [1], Amaury Machi Junior [1], Eriane Justo Luiz Savóia [1] and Rodrigo Daminello Raimundo [1]

1 Environmental Health Management Department, ABC MedSchool, Santo André 09060-650, SP, Brazil; profferfonseca@gmail.com (F.L.A.F.); cleo.almeidaabc@hotmail.com (C.d.A.P.); oramos2002@ibest.com.br (O.R.d.S.); alvarengaro@gmail.com (R.A.); machijr@yahoo.com.br (A.M.J.); erianejusto@yahoo.com.br (E.J.L.S.); rodrigodaminelloraimundo@usp.br (R.D.R.)
2 Biological Sciences Department, Institute of Environmental, Chemistry and Pharmaceutical Sciences, Federal University of São Paulo, Diadema 04060-650, SP, Brazil
3 Environmental Health Sciences Department, IPC, EsTesC, Coimbra Health School, Coimbra 3046-854, Portugal; andrequiaios@gmail.com (A.V.Q.); zee_domingues@hotmail.com (J.N.D.); supaixao@estescoimbra.pt (S.P.); laboratoriofmabc@yahoo.com.br (J.F.); anaferreira@estescoimbra.pt (A.F.)
* Correspondence: vivipw28@gmail.com; Tel.: +55-011-4993-5400

Academic Editor: Huixiao Hong
Received: 27 September 2016; Accepted: 31 December 2016; Published: 11 January 2017

Abstract: We are experiencing an unprecedented urbanization process that, alongside physical, social and economic developments, has been having a significant impact on a population's health. Due to the increase in pollution, violence and poverty, our modern cities no longer ensure a good quality of life so they become unhealthy environments. This study aims to assess the effect of social, environmental and economic factors on the hematologic profile of residents of Santo André's landfill. In particular, we will assess the effect of social, economic, and environmental factors on current and potential disease markers obtained from hematological tests. The research method is the observational type, from a retrospective cohort, and by convenience sampling in Santo André in the Greater ABC (municipalities of Santo André, São Bernardo do Campo and São Caetano do Sul, southeast part of the Greater São Paulo Metropolitan Area, Brazil). The study determined a socio-environmental profile and the hematologic diseases screening related to a close location to the landfill. The disease manifests itself within a broad spectrum of symptoms that causes changes in blood count parameters. The objective of this work is to show that there is an association between social, environmental and economic factors and a variety of serious disease outcomes that may be detected from blood screening. A causal study of the effect of living near the landfill on these disease outcomes would be a very expensive and time-consuming study. This work we believe is sufficient for public health officials to consider policy and attempt remediation of the effects of living near a landfill.

Keywords: landfill; waste; socio-environmental impact; hematologic diseases

1. Introduction

Nowadays, due to higher levels of pollution, violence and poverty, cities can no longer ensure a good quality of life for everyone and have become unhealthy environments for a great many local inhabitants [1]. An unprecedented urbanization, along with physical, social and economic developments, is having a significant impact on the health of the population [1,2].

Besides the continuous demographic growth, these factors have an implicit effect on the amount of resources that have to be consumed in order to sustain all citizens of the Earth. This increases waste production, which invariably affects society dynamics in general.

Landfill disposal remains the main destination in waste management, and it is expected to remain so for the next decades [3–5]. It is estimated that at the worldwide scale, over five million people die every year due to waste-related diseases [2]. The adverse effects of municipal solid waste on the environment, not to mention on public and individual health, are widely recognized by several authors [6], who point out a deficiency in the implemented systems and especially the lack of a strong policy emphasizing health safeguards [7].

A few authors state that societies all over the world are focused on consumption, and, therefore, there are significant losses of organic and inorganic materials: waste type [8,9], which would imply an uncertain future for Public Health. The improvement suggestion would be educating the population for a sustainable consumption and a strategic waste management system [9], such as: recycling and treating degraded soils; and to which extent these landfill sites would be usable.

The large amount of waste was not a concern for an extensive period due to the distance between disposal sites and urban areas. Meanwhile, with the population growth, it has been difficult to reduce the distance between them [10]. Another emerging problem linked to population growth is the unsystematic construction of homes in hazardous locations and quite vulnerable environmental areas, which usually lack urban infrastructure (sanitation, electricity), among other things [11,12].

It has been scientifically shown that residences on or near a landfill have impacts on the residents' health and on the environment: air quality, water quality, and soil pollution. The effects of landfills are major public health issues. Consequently, waste, waste treatment and disposal are major sanitary and environmental concerns to cities [3,13,14].

The environmental degradation scenario is unquestionable, and there is a lack of policies to prevent and ameliorate the crisis. The complexity of analyzing all impacts demands studies on the various effects of waste produced daily by the population [15,16]. The first step is to identify any adverse health outcomes using blood tests, which can be an important tool for the evaluation of various situations, such as diagnosis and progression of hematologic diseases, detection of infections and therapeutic monitoring [17].

Therefore, a hemogram can guide the initial suspicions supported by clinical files. The importance of the hematologic analysis is assumed to be an important diagnosis tool, providing useful information for a better handling of these cases.

It is necessary to adopt a set of measures that include politics' globalization, government social efficiency and social participation growth. It is the government's duty to ensure that change is not only possible but always sustained in clear objectives as well in results well defined and with special properly defined interventions [18–20].

Santo André has an area of 174.38 square kilometers and is located in the Greater ABC (municipalities of Santo André, São Bernardo do Campo and São Caetano do Sul, southeast part of the Greater São Paulo Metropolitan Area, Brazil), 18 km from the capital city of São Paulo. The city is strategic for the logistics sector, as it lies in the main economic center of the country. Santo André has 678,486 inhabitants and is the tenth largest city in the state of São Paulo. The landfill of São Jorge (217,000 m^2) is located in Santo André, and is surrounded by the slum São Jorge—about 1400 families. Every month, the landfill receives about 13 thousand tons of household waste and 250 tons of sterilized medical waste [11].

Around the landfill of São Jorge, there are signs that the environment has suffered both physical and social impacts [21,22]. The landfill began to operate in the 1980s and is located in the São Jorge District. Santo André's landfill is a facility that provides treatment and disposal of solid waste produced in the municipality. Therefore, it evolved from a non-official dumping location to a controlled one with good environmental practices. Nowadays, it is an area destined to receive solid waste produced in Santo André and is the most suitable and sustainable destination for the waste.

This study aims to measure the socio-environmental and hematologic profile of residents of Santo André's landfill—the "*Espírito Santo* suburbs"—by using the social and demographic data of the studied area and association between socio-environmental factors and the alterations in hematological parameters as precursors to diseases. This fieldwork will allow better urban planning and Public Health policies for residential areas on and near landfills, as well as a greater degree of social and environmental responsibility for all sectors of society.

2. Method

The research method is observational with a retrospective cohort study where the samples are obtained by convenience in Santo André in the Greater ABC region. The study consists of the elaboration of a demographic and environmental profile and assesses the prevalence of potential diseases identified by hematological screening that may be the result of housing conditions and/or exposure to environmental contaminants from the landfill. The study must be understood as a primary tracking diagnosis, and it will be the kick-off for a transversal study of *Espírito Santo* inhabitants that will be performed in the near future.

The exposed group lives in the vicinity of the landfill. There is a very little knowledge about the reality of this population due to the fact that national entities do not have permission to enter the area to study and help this community. Furthermore, this study got a special permit to develop a campaign for being the spin-off of a more transversal study. The community inhabits a place that was a dumping ground and it is actually contiguous to the landfill; therefore, the study's aim was to establish connections among the location and the community's health.

The study was conducted in two phases. The first phase consisted of a survey and research profile of the residents as the following variables: age, gender, type of house, water treatment, water supply and type of sewage, based on interviews and completing a questionnaire. The second phase consisted of the collection of blood samples into two distinct groups: a group of people living in the community (experimental group) and a group of random people attending a health facility located in the central city (control group).

According to the data obtained, a descriptive and comparative analysis of the differences in hematologic patterns between both groups was made.

The blood samples were collected through peripheral venopunction using the vacuum method. After recovery, the blood was added to the tube with EDTA. The samples were homogenized for 10 min and evaluated through flux cytometry with ABX Pentra 120 equipment (Horiba Medical, Montpellier, France). The serial evaluations were performed in blades using the Leishman method in order to obtain the procedures approached. The analysis was carried out according to good biomedical practices.

Quantitative and qualitative alterations in blood count (viral, bacterial and parasitic) were measured by reading lamina by Fernando Luiz Affonso Fonseca (hematologist)—a blood sample.

A total of 100 blood samples were harvested, but only 62 of them were considered biologically viable. The viability of the blood sample complied with good practices in clinical analyses. Thus, samples hemolyzed with jaundice or still lipemic were not included in the hematological analysis.

Therefore, in a group of inhabitants of the central region, 30 individuals were included (unexposed group). From the group of inhabitants of the vulnerable region (exposed group), 84 were included. However, from these, only 32 consented to having their blood harvested.

The information gathering tool used in this study was a questionnaire taken from the database developed by SEMASA, the Bureau of Environmental Issues of Santo André, São Paulo, Brazil, the institute responsible for the approval of construction, basic sanitation and water supply, as well as for assessing the regularity of housing developments. The applicants were the work's researchers, supervised by the head researcher of the University.

From a total of 100 questionnaires filled out, 84 were considered adequate (valid questionnaires). Thus, 16 were discarded, due to inadequacies in the information provided or a lack of consent from the individuals.

A descriptive analysis of all variables presented was performed in terms of their relative and absolute terms. In order to evaluate the association between the qualitative variables, a chi-square test was used, and/or the exact Fisher test. The level of significance was 5%. The data were processed and treated in the statistics software SPSS 21.0 (Released 2012, IBM SPSS Statistics for Windows, Version 21.0, IBM Corp., Armonk, NY, USA).

At last, an exact Fisher test was applied, in order to evaluate whether there is a connection between the hematological results and the type of exposure, as well as the quantity of hematological changes. The exact Fisher test is used to calculate the association of the analyzed features when the total amount of data is small and when the expected values in one or more of the cells of the 2×2 table is less than or equal to five. Thus, in small samples, this test should be used, since it produces fewer distortions than the chi-square test.

The sample was only gathered after the theme enlightening and authorization of the individuals. Anonymity as well as the confidentiality of the data obtained were guaranteed.

All subjects granted their informed consent for inclusion before participating in the study. The study was conducted in accordance with the Declaration of Helsinki, and the protocol was approved by the Ethics Committee of the Secretária Municipal de Saúde, Santo André (1.587.630).

3. Results

3.1. First Phase

Questionnaires were distributed with the purpose of establishing a social, demographic and biographic profile of the location. Table 1 shows the most significant variables of the community.

Table 1. Socio-biodemographic characteristics of the inhabitants.

Variables	Community Sample	
	n	**%**
Gender		
Female	55	65.5
Male	29	34.5
Age group		
(6–12)	7	8.3
(13–18)	6	7.1
(19–30)	30	35.7
(31–50)	31	36.9
(51–60)	8	9.5
(+60)	2	2.4
House type		
Bricks	53	63.1
Wood	20	23.8
Mix	5	6.0
Another	6	7.1
Income *		
Less than 2	67	79.8
Between 3–5	16	19.0
Between 5–10	1	1.2
Plus 10	0	0.0
Sanitation		
Yes	54	64.3
No	30	35.7
Total	84	100

* Minimum Wage (M.W.) = 724 Reais.

The several variables that were incorporated in the study and tabulated the appropriate statistical program mentioned above are the best ways of reflecting the social and demographic landscape of the target population. It is important to note that the variable "Sanitation" in Table 1 corresponds to the presence of the official public water, sewage and electricity networks.

As can be seen by observing Table 1, there is a predominance of females and the age groups from 19 to 30 and from 31 to 50 are the most prevalent in respondents. It was also verified that the income was below two Brazilian minimum wages (M.W.), which indicates that we face a special group in terms of economic capacity. It is also noted that there is a prevalence of masonry houses (63.1%) and houses with in-door plumbing/sanitation (64.3%).

3.2. Second Phase

In order to obtain plausible conclusions to the case study, it was necessary to compare the effects of the convenience sampling of another group of people that were not exposed to the several harmful environmental factors (Non-Exposed Group) to those who were exposed (Exposed Group).

Of the 84 individuals described in Table 1, 32 were randomly chosen and were designated as the "Exposed Group". The Non-Exposed Group was interviewed at the same time as they did the blood sample. In total, 30 people were interviewed, which corresponds to the amount of blood samples.

As described earlier, in order for the importance of the two groups to share the same characteristics, it appears that the percentages are similar, where the female gender was the most prevalent, with 75% in the "Exposed Group" and 66.7% in "Non-Exposed Group".

Regarding the age, the range between 31–50 years was the most commonly reported, with 11 people (36.7%) in the "Non-Exposed Group" and 19–30 in the "Exposed Group", with 13 persons (40.6%).

It appears that the housing and financial realities are significantly different in each group, where 84.4% of the "Exposed Group" presents an income of less than two minimum wages, while 56.7% of the "Non-Exposed Group" have similar income.

Regarding the "Non-Exposed Group", a greater purchasing power is observable, and, therefore, all of the respondents live in masonry houses and nearly all have sanitation. Table 2 describes the exposure type according to socio-biographic characteristics.

According to the analyzed variables, we observe that both groups have a significant association with the variables' sewage ($p = 0.004$) house type ($p < 0.0001$) and income ($p = 0.025$) with the exception of the variables gender and age group ($p > 0.05$).

It is noted that of the totality of the individuals with sewage (82.3%), 94.4% of them live in the vicinity of the landfill.

According to house type, the totality of the non-exposed live in brick houses, and, from the total of individuals that live in this type ($n = 50$), the majority (62.5%) is exposed to the landfill.

The total of individuals that own an income lower than 2 M.W. is 44 (71%), as 27 of them (84.4%) are exposed to the landfill and (56.7%) correspond to the non-exposed.

In order to verify the association among hematologic changes towards socio-biodemographic characteristics, the next table was prepared (Table 3).

During the analysis of the hematologic changes, no significant association to any variables was observed.

Regarding the age group variable, among the age groups of 6–12 and 51–60, there is a great disparity among changes found. Overall, most (51.6%) do not show hematologic changes.

Regarding the sewage variable, there is a balance in terms of percentages, and we infer that (51.6%) do not have any hematologic changes. As regards the income variable, 44 individuals (71%) have an income lower than two minimum wages.

In order to investigate the existence of an association between exposure type and hematologic changes in individuals, a statistical analysis was carried out. The results of hemogram differences were summarized in Table 4.

Table 2. Association of the socio-biodemographic characteristics with the exposition type.

Socio-Biographic Characteristics		Exposition Type						*p*-Value
		Non-Exposed		Exposed		Total		
		n	%	*n*	%	*n*	%	
Gender	Female	20	66.7	24	75	44	71	0.471
	Male	10	33.3	8	25	18	29	
	Total	30	100	32	100	62	100	
Age Group	(6–12)	2	6.7	6	18.8	8	12.9	0.309
	(13–18)	1	3.3	3	9.4	4	6.5	
	(19–30)	9	30	13	40.6	22	35.5	
	(31–50)	11	36.7	6	18.8	17	27.4	
	(51–60)	5	16.7	3	9.4	8	12.9	
	≥60	2	6.7	1	3.1	3	4.8	
	Total	30	100	32	100	62	100	
Sanitation	Yes	29	96.7	22	84.4	51	82.3	0.004 *
	No	1	3.3	10	15.6	11	17.7	
	Total	30	100	32	100	62	100	
Type of House	Brick	30	100	20	62.5	50	80.6	<0.001 *
	Wood	0	0	12	37.5	12	19.4	
	Total	30	100	32	100	62	100	
Income	Less 2 M.W.	17	56.7	27	84.4	44	71	0.025 *
	Among 3–5 M.W.	9	30	5	15.6	14	22.6	
	Among 5–10 M.W.	4	13.3	0	0	4	6.5	
	Total	30	100	32	100	62	100	

* Statistical significance (chi-square test; exact Fisher).

Table 3. Hematologic changes discovered in individuals' hemograms.

Variable	Description	Hematologic Changes						*p*-Value
		Yes		No		Total		
		n	%	*n*	%	*N*	%	
Gender	Female	20	45.5	24	54.5	44	29.0	0.470
	Male	10	55.6	8	44.4	18	71.0	
	Total	30	45.5	32	54.5	62	100	
Age Group	(6–12)	5	62.5	3	37.5	8	12.9	no assumptions
	(13–18)	2	50.0	2	50.0	4	6.5	
	(19–30)	11	50.0	11	50.0	22	35.5	
	(31–50)	9	52.9	8	47.1	17	27.4	
	(51–60)	2	25.0	6	75.0	8	12.9	
	≥60	1	33.3	2	66.7	3	4.8	
	Total	30	48.4	32	51.6	62	100	
Sanitation	Yes	25	49.0	26	51.0	51	82.3	no assumptions
	No	5	45.5	6	54.5	11	17.7	
	Total	30	48.4	32	51.6	62	100	
House Type	Masonry	25	50.0	25	50.0	50	80.6	0.604
	Timber	5	41.7	7	58.3	12	19.4	
	Total	30	48.4	32	51.6	62	100	
Income	Less 2 M.W.	17	56.7	27	84.4	44	71	no assumptions
	Between 3–5 M.W.	9	30	5	15.6	14	22.6	
	Between 5–10 M.W.	4	13.3	0	0	4	6.5	
	Total	30	100	32	100	62	100	

Table 4. Association among exposure type with hematologic change.

Groups			Hematologic Change		
			Change	**No Change**	**Total**
Exposure Type	Non-Exposed	*n*	10	20	30
		% Line	33.3%	66.7%	100.0%
		% Column	33.3%	62.5%	48.4%
		% Total	16.1%	32.3%	48.4%
	Exposed	Count	20	12	32
		% Line	62.5%	37.5%	100.0%
		% Column	66.7%	37.5%	51.6%
		% of Total	32.3%	19.4%	51.6%

$p = 0.022$.

In Table 4, we can observe an association among the variables of Exposure Type and Hematologic Change as being significant from a statistical perspective ($p < 0.05$). We verified a pattern of association between exposure and the presence/absence of hematologic changes ($p = 0.022$).

From the sum of people exposed to landfills (32 cases), the majority had hematological disorders (62.5%). It was found that, from 30 cases where the presence of hematological abnormalities was found, most are exposed to the landfill (66.7%).

As noted in Table 4, there was a 50% increase in changes in the screening performed in the "Exposed Group" compared to the "Non-Exposed Group", which indicates that the population is not in its best health.

The chance of occurrence of hematological disorders is 3.33 times higher in subjects exposed to the landfill compared to those who presented hematological changes in the "Non-Exposed Group". It is recognized, by the observation data, that 10 individuals from the "Non-Exposed Group" showed alterations in parameters, whereas the incidence in the "Exposed Group" was significantly higher, with 20 individuals undergoing changes.

Diseases such as leukocytosis, anemia, lymphocytosis and neutropenia were the major findings, and changes are evident in the "Exposed Group" compared to the "Non-Exposed Group".

4. Discussion

Analyzing the changes in vital functions of living beings, it is possible to know the effects of exposure to pollutants before their occurrence and the existence of any other significant damages [18,23–26].

It is considered that proving the cause–effect connection with environmental exposures that may trigger chronic manifestations in humans requires specific studies that prove to be costly and time-consuming [27–30]. It is necessary for the data to be collected in the field so as to be compared with experimental observations, in order to demonstrate the process and how the interactions occur regarding study dynamics [16].

The effects of human exposure to environmental pollutants are manifested typically in the long term and are masked by other causes. Adding to this, the fact that the probability of harmful elements' synergy and exponentiation of the risk is generally unknown, and it is thus extremely difficult to corroborate it with science based on laboratory tests, without incorporating other relevant factors, such as corporate interests, and industrial or professional regulators who hinder the analysis and detection of any effects on human health [20,24,26,30].

Given these considerations, as well as relying on the limitations of the health system itself in identifying peculiarities in the epidemiological profile of the population, a methodology was defined that aims to fully understand the exposure process. There are five parameters that are difficult to materialize including individual characteristics, duration of exposure, frequency of exposure, average time and "contact rate", always bearing in mind that the characteristics of the individual vary by age, gender, occupation, and body weight [31].

The focus of the study is the exposure of individuals to organisms, as well as to social, economic and environmental processes in anticipation of models that historically focus on the monitoring and maintenance of health [21,22]. Several papers have been published that address the role that the landfill can play in people's health [30–32]. There is no doubt that a landfill should be viewed from a holistic point of view, in that it must manage the direct and indirect effects that it may have [3,18,32].

Despite the existence of federal government programs for vulnerable populations, there do not seem to have been any improvements in the living conditions of this community [13,14]. The hemogram exam (counting blood cells—CBC) is used as a tool to promote the indicative tracking and respective improvements to minimize ongoing risks in analyses of a certain population. Given its great potential as a monitoring method, CBC integrates a set of parameters that describe the number and characteristics of some elements in the blood. The CBC consists of three basic features, namely erythrocyte evaluation (or red series), leukocytes evaluation (white or series), review of erythrocytes and platelets (platelet or series) [33].

Lymphocytosis is characterized by an increase in the number of lymphocytes (sub-group of white blood cells). The disease neutropenia indicates a low number of neutrophils that are a subset of leukocytes originating in the bone marrow, thus revealing an immune susceptibility. The increase of leukocytes is a sign of a viral infection, i.e., people near the landfill tend not to have viral and bacterial infections [33]. The disease leukocytosis reveals an increased number of leukocytes that reveals the existence of an infection, since they are the elements that are linked to immune system defenses against foreign bodies. The greater the leukocytosis is, the more contaminated the landfill will probably be, which can be interpreted as a parameter that reveals and establishes causal links. The disease of anemia is more complex, so the causes are more comprehensive and diversified. This immediately implies a more detailed investigation into these cases [33–35].

The lymphocytosis, neutropenia and leukocytosis diseases can be understood as correlated, although they have opposite directions of growth, as previously conveyed [35].

The results express the presence of discrepancies in the health of the São Jorge population, compared with the other subjects in the study, which requires the completion of further studies to detect the most common causes and the consequences for the residents in order to enable the development of a continuous and systematic supervision program for the residents. The suggestion is to carry out a more in-depth study in order to make improvements in this type of group exposed to potential health hazards, such as those identified in this study, in comparison with the Non-Exposed Group.

The problems derived from municipal solid waste are still present and without a proper solution [36]. There is no alternative but a behavioral change in relation to waste, given the reduction in its production, and in order to gradually implement technologies that are within our technical capabilities and to leverage resources to gradually develop a greater level of control over the environmental and health effects caused by waste [37].

The prevention measures and control of public health consequences of urban solid waste lack information and epidemiological data in which causal relationships can be established. There is a colossal deficiency in studies on the recovery of areas degraded by disposal of urban solid waste. In this context, this article seeks to contribute to a consolidation of the state-of-the-art related to the theme, in order to raise awareness of the elements that improve the quality of urban areas and hence the quality of life of their citizens [31,36].

Supporting research of this kind is a priority. The development of greater technical training, in view of the environmental and health issues, as well as the involvement of professionals in integrated waste management systems, in the medium and long term, may introduce these variables in projects and plans [15,37,38].

Data from this study should be compared to other data, which may involve a characterization of the epigenetic profile of the population [39] and even a characterization of the study areas for the presence of particulate material [40]. The challenge is to continue collecting more valid and reliable data in order to achieve an extrapolation between environmental and respective consequences for the

health of population's risk factors to make a comparison on a national and global scale [18]. The study described is the first step in a study involving the whole *Espírito Santo* community.

The data obtained in this tracking study indicate that strategies for prevention and health promotion should include joint actions established between citizens and the management of services and should always be aimed at improving living conditions, particularly urban planning, implementation educational programs, as well as raising awareness about behavioral changes, once isolated actions are considered ineffective in reducing any problems [38,41].

It can be inferred that this study has a purpose of consolidating knowledge, which contributes to the prevention and detection of either known or unknown adverse health effects [40,41] to the public that are related to environmental exposure. The study should be understood as a primary screening indicating some pathologies, which, in addition to enabling us to assess the state of health of the inhabitant, may be indicative of the level of pollution of landfill, insofar as the conditions are reflected on the inhabitants of the landfill.

We must identify priorities at the community level, which is why the understanding of environmental health problems is essential. Sustainable planning may be a possible tool to implement a research-oriented future intervention, and thus to address the issues of greatest importance. However, this process is not simple in communities featuring persistent health disparities and a historical lack of confidence in health professionals [40,41].

The main alterations found in the completed study were anemia, leukocytosis, lymphocytosis and neutropenia. These data show that this is a group with greater immune susceptibility, adding that some elements of the exposed group already have infections, which are consistent with exposure to contaminants, supporting the existence of a pattern. Aiming at the promotion of health, it is suggested that the project should continue to be monitored in order to gather a greater quantity of evidence in support of the result of the tracking work carried out and described [42,43].

Based on the study, the exposed group is 3.33 times more likely to develop hematological abnormalities, taking as reference its exposure to the landfill, as opposed to the group that was not exposed. There is much [8,44] research on urban landfills, but none involving the social and hematological profile have been found in the literature.

Although the results only show the events occurred at the São Jorge landfill, in the Greater ABC region. They also provide important information on the expansion of knowledge concerning the assessment of this risk in residential areas around the planet. The demand for a thorough investigation is urgent in order to spread information related to the potential effects of human exposure to contaminants from multiple sources that affect public health.

A recent bibliographical survey study about the difficulty of assessing the impacts on the health of populations exposed to waste [45] shows that the biggest difficulty is the access to immediate and recent results of studies about biomonitoring of the effects of waste exposure on human health [45]. It is noted that this occurs due to several factors: identifying the profile of the exposed population, characterization and diversity of the analyzed area, socio-economic factors (education, unemployment, home ownership, family structure and access to health services), as well as government interests.

The analysis provides evaluation of quantitative data on the environment. However, the complexity and specificity related to historical and cultural features of this population caused some limitations in this study, such as: it was a convenience sampling, the way people moved to the landfill area, and, mainly, whether these blood changes in people living near the waste were due to their displacement alone. Besides those, there are limited potential confounders, such as population diet, family history and other risk factors that were not controlled in the analyses.

Future investigations may include concepts like nanoparticles and epigenetics, in order to promote a holistic view of the causes, mechanisms and consequences caused by the exposure of humans to a multitude of organisms, thereby complementing the present study and scientific knowledge, eliminating existing cross-limitations.

5. Conclusions

The full blood element count analysis was performed and it found that the blood counts of residents living near the landfill had positive results for hematological changes, and diseases such as leukopenia, anemia, neutropenia and lymphocytosis were the most frequently encountered changes. However, proving the cause-effect relation with environmental exposure factors that may trigger chronic manifestations in humans requires specific studies, which often are very costly and time-consuming.

Acknowledgments: The authors would like to express their gratitude to the ABC Medical School and to the School of Health Technology Coimbra-IPC-Polytechnic Institute of Coimbra-Portugal and the Department of Environmental Health and Public Health, as well as company SEMASA-Sanitation and Insurance Central, for their support and cooperation with this study.

Author Contributions: All authors contributed significantly to the successful completion of this work both intellectually and financially. Fernando Luiz Affonso Fonseca, Rodrigo Daminello Raimundo, Eriane Justo Luiz Savóia, José Nuno Domingues and Ana Ferreira conducted sampling and interviews and analyzed the data; Cleonice De Almeida Pinto, Hating Odair Ramos Da Silva and Rodrigo Daminello Raimundo did the statistical analysis of data; Vivianni Palmeira Wanderley conducted the study and manuscript revisions, André Vala Quiaios, Susana Paixão, João Figueiredo, Rogério Alvarenga and Amaury Machi Junior made relevant comments on the manuscript. Finally, all authors read and approved the final manuscript.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. De Souza Porto, M.F.; de Moura Juncá, D.C.; de Souza Gonçalves, R.; de Freitas Filhote, M.I. Lixo, trabalho e saúde: Um estudo de caso com catadores em um aterro metropolitano no Rio de Janeiro, Brasil. *Cad. Saúde Públ.* **2004**, *20*, 1503–1514.
2. Confalonier, U.E.C.; Marinho, D.P. Mudança Climática Global e Saúde: Perspectivas para o Brasil. Available online: http://www.multiciencia.unicamp.br/artigos_08/a_03_8.pdf (accessed on 4 January 2017).
3. Beaven, R.P.; Knox, K.; Gronow, J.R.; Hjelmar, O.; Greedy, D.; Scharff, H. A new economic instrument for financing accelerated landfill aftercare. *Waste Manag.* **2014**, *34*, 1191–1198. [CrossRef] [PubMed]
4. Seco, J.I.; Fernández-Pereira, C.; Vale, J. A study of the leachate toxicity of metal containing solid wastes using Daphnia magna. *Ecotoxicol. Environ. Saf.* **2003**, *56*, 339–350. [CrossRef]
5. Nagendran, R.; Selvam, A.; Joseph, K.; Chiemchaisri, C. Phytoremediation and rehabilitation of municipal solid waste landfills and dumpsites: A brief review. *Waste Manag.* **2006**, *26*, 1357–1369. [CrossRef]
6. Heller, L.; Catapreta, C.A. Solid waste disposal in urban areas and health—The case of Belo Horizonte, Brazil. *Waste Manag. Res.* **2003**, *21*, 549–556. [CrossRef] [PubMed]
7. Santos, I.D.C. A participação do Brasil nos programas de paz da ONU. *Interfaces Cient.-Direito* **2013**, *1*, 67–74. [CrossRef]
8. Václavík, V.; Ondrašiková, I.; Dvorský, T.; Černochová, K. Leachate from municipal waste landfill and its natural degradation—A case study of Zubří. Zlín region. *Int. J. Environ. Res. Public Health* **2016**, *13*, 873. [CrossRef]
9. Zaman, A.U.; Lehmann, S. Challenges and opportunities in transforming a city into a "Zero Waste City". *Challenges* **2011**, *2*, 73–93.
10. Jacobi, P.R.; Besen, G.R. Gestão de resíduos sólidos em São Paulo: Desafios da sustentabilidade. *Estudos Avançados* **2011**, *25*, 135–158. [CrossRef]
11. RIMA Ampliação da Área de Disposição de Resíduos da CTR de Santo André. Available online: http://www.semasa.sp.gov.br/admin/biblioteca/docs/pdf/rima.pdf (accessed on 12 September 2016).
12. Kostopoulou, P.; Karagiannidis, A.; Rakimbei, P.; Tsiouvaras, K. Simulating the water balance in an old non-engineered landfill for optimizing plant cover establishment in an arid environment. *Desalination* **2010**, *250*, 373–377.
13. Beltrão, A.F.G. *Aspectos Jurídicos do Estudo de Impacto Ambiental*; MP Editora: São Paulo, Brazil, 2008.
14. Oliveira, M. *Caracterização dos Impactos Sócio—Ambientais no Entorno do Aterro Controlado de JARDIM Gramacho*; Município de Duque de: Caxias, Brazil, 2007.

15. Ferreira, J.A.; Dos Anjos, L.A. Aspectos de saúde coletiva e ocupacional associados à gestão dos resíduos sólidos municipais. *Cad. Saúde Públ.* **2011**, *17*, 689–696. [CrossRef]
16. López, A.; Lobo, A. Emissions of C&D refuse in landfills: A European case. *Waste Manag.* **2014**, *24*, 1446–1454.
17. Pfeffer, N.; Laws, S. "It's only a blood test": What people know and think about venipuncture and blood. *Soc. Sci. Med.* **2006**, *62*, 3011–3023. [CrossRef] [PubMed]
18. Payne-Sturges, D.; Gee, G. National environmental health measures for minority and low-income populations: Tracking social disparities in environmental health. *Environ. Res.* **2006**, *10*, 154–171. [CrossRef] [PubMed]
19. Huang, X.Y.; Lessner, L.; Carpenter, D.O. Exposure to persistent organic pollutants and hypertensive disease. *Environ. Res.* **2006**, *102*, 101–106. [CrossRef] [PubMed]
20. Sachs, I. *Estratégias de Transição Para o Século XXI: Desenvolvimento e Meio Ambiente; Tradução de Magda Lopes*; Studio Nobel: São Paulo, Brazil, 1993; p. 39.
21. Kirkeby, J.T.; Birgisdottir, H.; Bhander, G.S.; Hauschild, M.; Christensen, T.H. Modelling of environmental impacts of solid waste landfilling within the lifecycle analysis program EASEWASTE. *Waste Manag.* **2007**, *27*, 961–970. [CrossRef] [PubMed]
22. Arias, A.R.L.; Inacio, A.F.; Novo, L.A.; Viana, T.A.P.; Albuquerque, C. Utilização de bio marcadores como ferramenta de monitoramento e avaliação ambiental: O caso de recursos hídricos. *Mundo Vida* **2005**, *6*, 34–41.
23. Poulsen, O.M.; Breum, N.O.; Ebbehøj, N.; Hansen, Å.M.; Ivens, U.I.; van Lelieveld, D.; Malmros, P.; Matthiasen, L.; Nielsen, B.H.; Nielsen, E.M.; et al. Sorting and recycling of domestic waste. Review of Occupational health problems and their possible causes. *Sci. Total Environ.* **1995**, *168*, 33–56. [CrossRef]
24. Blumenthal, K. *Generation and Treatment of Municipal Waste*; Eurostat, European Commission: Luxembourg City, Luxembourg, 2011.
25. DEFRA (Department for Environment, Food and Rural Affairs). *The Economics of Waste and Waste Policy: Waste Economics Team—Environment and Growth Economics*; DEFRA: London, UK, 2011.
26. Hogg, D.; Sherrington, C.; Vergunst, T. *A Comparative Study on Economic Instruments Promoting Waste Prevention*; Final Report to Bruxelles Environment; Eunomia: Bristol, UK, 2011.
27. Kirkeby, J.T.; Birgisdottir, H.; Hansen, T.L.; Christensen, T.H.; Bhander, G.S.; Hauschild, M. Environmental assessment of solid waste systems and technologies: EASEWASTE. *Waste Manag. Res.* **2006**, *24*, 3–15. [CrossRef] [PubMed]
28. El-Fadel, M.; Findikakis, A.N.; Leckie, J.O. Environmental impacts of solid waste landfilling. *J. Environ. Manag.* **1997**, *50*, 1–25. [CrossRef]
29. Deng, W.J.; Louie, P.K.K.; Liu, W.K.; Bid, X.H.; Fu, J.M.; Wong, M.H. Atmospheric levels and cytotoxicity of PAHs and heavy metals in TSP and $PM_{2.5}$ at an electronic waste recycling site in southeast China. *Atmos. Environ.* **2006**, *40*, 6945–6955. [CrossRef]
30. ILO. *Encyclopaedia on Occupational Health and Safety*, 4th ed.; International Labour Organization: Geneva, Switzerland, 2011; Available online: http://www.ilocis.org/en/contilo.html (accessed on 15 September 2016).
31. Li, Y.; Li, J.H.; Chen, S.S.; Diao, W.H. Establishing indices for groundwater contamination risk assessment in the vicinity of hazardous waste landfills in China. *Environ. Pollut.* **2012**, *165*, 77–90. [CrossRef] [PubMed]
32. Ribeiro, T.; Guimarães, M.; Carvalho, D.; Campina, N.; Lobarinhas, M.; Lopes, A.; Cunha, M.; Wanderley, V.; Invenção, A.; Braga, T.; et al. Prevalence of blood diseases in the Estuary of Santos, Brazil. In Proceedings of the 21st Annual Conference of the International Society for Environmental Epidemiology, Dublin, Ireland, 25–29 August 2009; pp. S206–S207.
33. Naoum, P.C.; Naoum, F.A. *Interpretação Laboratorial do Hemograma*; Disponível EM: São José do Rio Preto, Brazil, 2008; Available online: http://www.ciencianews.com.br/arquivos/ACET/IMAGENS/Artigos_cientificos/Interphemo.pdf (accessed on 23 July 2014).
34. Lorenzi, T.F. *Manual de Hematologia. Propedêutica e Clínica*, 3nd ed.; Editora Médica Científica: São Paulo, Brazil, 2003.
35. Hoffbrand, A.V.; Petit, J.E. *Moss PAH—Essential Haematology*, 4th ed.; Blackwell Science: Oxford, UK, 2002.
36. Laner, D.; Fellner, J.; Brunner, P.H. Flooding of municipal solid waste landfills—An environmental hazard? *Sci. Total Environ.* **2009**, *40*, 73674–73680. [CrossRef] [PubMed]

37. Senese, V.; Boriani, E.; Baderna, D.; Mariani, A.; Lodi, M.; Finizio, A.; Testa, S.; Benfenati, E. Assessing the environmental risks associated with contaminated sites: Definition of an ecotoxicological classification index for landfill areas (ECRIS). *Chemosphere* **2010**, *80*, 60–66. [CrossRef] [PubMed]
38. De Liliane Costa, B.; Gabriela, D.; José Antônio, L.; Carmen Rejane Flores, W. *Análise dos Impactos Sócio-Ambientais Provocados Pelo Aterro Sanitário no Município de São Gabriel, 2011*; Educação e Ciência na Era Digital in XV Simpósio de Ensino; Pesquisa e Educação da Universidade Federal de Santa Maria: Santa Maria, Brazil, 2010.
39. Gelberg, K.H. Health study of New York City Department of Sanitation landfill employees. *J. Occup. Environ. Med.* **1997**, *39*, 1103–1110. [CrossRef] [PubMed]
40. Deloraine, A.; Zmirou, D.; Tillier, C.; Boucharlat, A.; Bouti, H. Case-control assessment of the short-term health effects of an industrial toxic waste landfill. *Environ. Res.* **1995**, *68*, 124–132. [CrossRef] [PubMed]
41. Butt, T.E.; Gouda, H.M.; Baloch, M.I.; Paul, P.; Javadi, A.A.; Alam, A. Literature review of baseline study for risk analysis—The landfill leachate case. *Environ. Int.* **2014**, *63*, 149–162. [CrossRef] [PubMed]
42. Corrêa, C.R.S.; Abrahão, C.E.C.; Carpintero, M.D.C.C.; Anaruma Filho, F. O aterro sanitário como fator de risco para doenças respiratórias em crianças. *J. Pediatr.* **2011**, *87*, 319–324.
43. Palmiotto, M.; Fattore, E.; Paiano, V.; Celeste, G.; Colombo, A.; Davoli, E. Influence of a municipal solid waste landfill in the surrounding environment: Toxicological risk and odor nuisance effects. *Environ. Int.* **2014**, *68*, 16–24. [CrossRef] [PubMed]
44. Petrescu-Mag, R.M.; Petrescu, D.C.; Oroian, I.G.; Safirescu, O.C.; Bican-Brișan, N. Environmental equity through negotiation: A case study on urban landfills and the Roma community. *Int. J. Environ. Res. Public Health* **2016**, *13*, 591. [CrossRef] [PubMed]
45. Triassi, M.; Alfano, R.; Illario, M.; Nardone, A.; Caporale, O.; Montuori, P. Environmental pollution from illegal waste disposal and health effects: A review on the "Triangle of Death". *Int. J. Environ. Res. Public Health* **2015**, *12*, 1216–1236. [CrossRef] [PubMed]



© 2017 by the authors; licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC-BY) license (http://creativecommons.org/licenses/by/4.0/).

International Journal of Epidemiology, 2016, 806–815
doi: 10.1093/ije/dyw052
Advance Access Publication Date: 24 May 2016
Original article

Environmental Exposures and Cancer

Morbidity and mortality of people who live close to municipal waste landfills: a multisite cohort study

Francesca Mataloni,[1]* Chiara Badaloni,[1] Martina Nicole Golini,[1] Andrea Bolignano,[2] Simone Bucci,[1] Roberto Sozzi,[2] Francesco Forastiere,[1] Marina Davoli[1] and Carla Ancona[1]

[1]Department of Epidemiology, Lazio Regional Health Service, Rome, Italy and [2]Lazio Environmental Protection Agency, Rome, Italy

*Corresponding author. Department of Epidemiology, Lazio Regional Health Service, Via Cristoforo Colombo, 112. 00147 Rome, Italy. E-mail: f.mataloni@deplazio.it

Accepted 27 January 2016

Abstract

Background: The evidence on the health effects related to residing close to landfills is controversial. Nine landfills for municipal waste have been operating in the Lazio region (Central Italy) for several decades. We evaluated the potential health effects associated with contamination from landfills using the estimated concentration of hydrogen sulphide (H_2S) as exposure.

Methods: A cohort of residents within 5 km of landfills was enrolled (subjects resident on 1 January 1996 and those who subsequently moved into the areas until 2008) and followed for mortality and hospitalizations until 31 December 2012. Assessment of exposure to the landfill (H_2S as a tracer) was performed for each subject at enrolment, using a Lagrangian dispersion model. Information on several confounders was available (gender, age, socioeconomic position, outdoor PM_{10} concentration, and distance from busy roads and industries). Cox regression analysis was performed [Hazard Ratios (HRs), 95% confidence intervals (CIs)].

Results: The cohort included 242 409 individuals. H_2S exposure was associated with mortality from lung cancer and respiratory diseases (e.g. HR for increment of 1 ng/m^3 H_2S: 1.10, 95% CI 1.02–1.19; HR 1.09, 95% CI 1.00–1.19, respectively). There were also associations between H_2S and hospitalization for respiratory diseases (HR = 1.02, 95% CI 1.00–1.03), especially acute respiratory infections among children (0–14 years) (HR = 1.06, 95% CI 1.02–1.11).

Conclusions: Exposure to H_2S, a tracer of airborne contamination from landfills, was associated with lung cancer mortality as well as with mortality and morbidity for respiratory diseases. The link with respiratory disease is plausible and coherent with previous studies, whereas the association with lung cancer deserves confirmation.

Key words: waste, landfills, residential cohort study

© The Author 2016. Published by Oxford University Press on behalf of the International Epidemiological Association.

This is an Open Access article distributed under the terms of the Creative Commons Attribution-NonCommercial-NoDerivs licence (http://creativecommons.org/licenses/by-nc-nd/4.0/), which permits non-commercial reproduction and distribution of the work, in any medium, provided the original work is not altered or transformed in any way, and that the work properly cited. For commercial re-use, please contact journals.permissions@oup.com

From:	Ken Eklund
To:	Benton Public Comment
Subject:	I oppose LU-24-027: reference articles and opinions in the press - 4 of 12
Date:	Thursday, May 8, 2025 2:35:23 PM
Attachments:	writerguy-cube2.png 2 Landfill_Failures_-_PUB_009c 2.pdf

CAUTION: This email originated from outside of the organization. Do not click links or open attachments unless you recognize the sender and know the content is safe.

This is the third and final part of a CHEJ pdf on landfills that is too big to email in one piece. – K



Ken Eklund, writerguy

37340 Moss Rock Dr
Corvallis OR 97330
408.623.8372

Creator of
World Without Oil
Ed Zed Omega
FutureCoast
and other storymaking games

International Journal of Epidemiology, 2016, Vol. 45, No. 3

Key Messages

- The evidence on the health of people living close to landfills is still controversial; most of the published studies are characterized by poor exposure assessment, use of health data at the aggregate level and limited possibility of adjusting for socioeconomic status.
- We evaluated the potential health effect of living near nine landfills (Lazio region, Italy), using a residential cohort approach and a dispersion model for exposure assessment.
- Exposure to landfills was associated with mortality from lung cancer and respiratory diseases and with hospitalizations for respiratory diseases, both in adults and in children.

Introduction

People who live close to municipal solid waste (MSW) landfills could be exposed to air pollutants emitted by the plants (landfill gas containing methane, carbon dioxide, hydrogen sulphide and other contaminants including volatile organic compounds, particulate matter and bioaresols) or to contaminated soil and water. The possible health effects related to residence close to these sites have been assessed in several original papers[1–9] and evaluated in systematic reviews.[10,11] Excess of mortality for some cancer sites (e.g. liver, pancreas, kidney, larynx) and non-Hodgkin lymphoma has been noted in some studies,[1–3] but the results have not been confirmed in other investigations.[4–6] In addition, some studies have indicated an increase of respiratory symptoms among residents close to biodegradable waste facilities.[12] In 2009, Porta *et al.*[10] concluded that evidence of an association between living close to a landfill and adverse health effects is inconclusive. Most of the published studies have methodological problems, including poor exposure assessment based only on distance from the source, use of health data at the aggregate level and limited possibility of adjusting for socioeconomic status. The quality of the epidemiological studies and scientific knowledge about the issue would be improved by using a residential cohort approach[13] and applying dispersion models to provide a better exposure assessment.[14]

This study aimed at evaluating the association between estimated exposure to hydrogen sulphide (H_2S, produced by anaerobic decomposition of sulphur-containing organic matter in landfills) and mortality and morbidity of a cohort of residents living within 5 km of the nine MSW landfills of the Lazio region (Central Italy, about 5 million inhabitants including the city of Rome). The study was part of a larger project on the characteristics of municipal solid waste treatment plants, their emissions and potential health effects in Lazio (www.eraslazio.it).

Methods

Study areas

Nine municipal solid waste landfills have been operating in Lazio for several decades. Only in the past two decades they were equipped with containments (including leachate collection and treatment, landfill cap construction and landfill gas collection and treatment). The main characteristics of the landfills (together with other potentially relevant environmental factors in the areas, e.g. arsenic contamination)[14] are described in Supplementary Table 1, Landfill characteristics, and in Supplementary Figure 2, Study areas, (available as Supplementary data at *IJE* online). The study area was defined for each landfill as a 5-km radius from the boundary of the landfills assessed using GIS software and regional technical maps with a scale of 1:5000. The World Geodetic System of 1984, with the Universal Transverse Mercator zone 33Nord projection (WGS84_UTM33N) was the reference for the geographical coordinates.

Exposure assessment

H_2S has been considered a surrogate measure of all contaminants emitted by landfills, and the airborne concentrations were predicted using a dispersion model. Dispersion models, such as the one we have been using here, have been recently used to assess the health effects of waste management processes.[15–17] We followed a process in three steps. First, yearly H_2S emissions from each sector of the landfills were estimated using a Landfill Gas Emissions Model.[18] Using several variables (the start and end dates of operations for each sector of the landfills, the waste capacity and waste acceptance rate), the annual emission rates for H_2S were calculated by means of a first-order decomposition rate equation:

$$Q_{H_2S} = \sum_{t=1}^{n} \sum_{j=0.1}^{1} KL_0 \left(\frac{M_t}{10}\right) e^{-kt_{ij}}$$

where:

QH_2S = annual emission rate (m^3/year)

t = age of the jth section of the landfill

i = 1 year time increment

n = (year of the calculation) – (initial year of waste acceptance)

j = 0.1 year time increment

K = hydrogen sulphide generation rate (year-1)

L_o = potential hydrogen sulphide generation capacity (m^3/Mg)

M_t = mass of waste accepted until t (in Mg)

tij = age of the waste mass accepted until the ith year (M_t) at the jth section

Mg = Megagram.

We used inventory defaults parameters derived from the US Environmental Protection Agency (EPA) Compilation of Air Pollutant Emission Factors[19] to define hydrogen sulphide generation rate (K) and potential hydrogen sulphide generation capacity (L_o), and Mt and tij were defined by the Lazio Environmental Protection Agency (EPA) using local data. Second, the EMMA software was used for the temporal and spatial modulation of the estimated emissions. EMMA approximates landfills shape as a regular grid with a resolution of 125 m x 125 m.[20] Finally, we used a Lagrangian particle model (SPRAY ver.5, ARIANET Srl, Italy) to simulate H_2S concentrations around the landfills and to produce maps of annual average concentrations around the sites; 2008 was chosen as the reference year for all the sites. The meteorological data were derived from regional measurements made by Lazio EPA in 2005 (that year is considered representative of the meteorological conditions in the area), and used in connection with RAMS data.[21] The Lagrangian model simulates the transport, dispersion and deposition of pollutants emitted using the orography, the meteorological data, the turbulence and the hourly spatial distribution (horizontal and vertical) of the emissions, based on the characteristics of the single source and on the mass fluxes. The model follows the path of fictitious particles in the atmospheric turbulent flow, and it is able to take into account complex situations, such as the presence of obstacles, breeze cycles, strong meteorological non-homogeneities and non-stationary, calm wind conditions.

Each subject in the cohort (see below) was assigned an H_2S exposure value corresponding to the estimated annual average value from the dispersion model at the baseline address. In other words, no exposure variation over time was considered and each person remained at the same exposure level during the all study period.

Enrolment of the cohort and follow-up procedures

All residents living within 5 km of the borders of the landfill on 1 January 1996, or those who later moved to the areas until 31 December 2008, were enrolled; datasets from 16 municipalities were used. Vital status was assessed using local registries until 31 December 2012. We considered subjects at risk until they died or moved out of the municipality.

Health outcomes

We analysed natural and cause-specific mortality and hospital admissions for cardiorespiratory diseases. The underlying cause of death for deceased subjects was retrieved from the Regional Registry of Causes of Death, and hospital admissions were obtained from the Regional Hospital Information System which collects information related to all hospital admissions that occur each year in public and private hospitals. Causes of death and diagnoses of hospitalization were coded according to the ICD 9 revision. For each subject, only the principal diagnosis that was the reason for the hospitalization was used and the event (i.e. failure in the Cox model) was defined at the time of the first hospitalization for a specific cause that occurred in the study period. Respiratory hospital admissions for children (residents under 14 years) were also analysed.

Covariates

We considered for each subject an area-based socioeconomic position (SEP) index, based on several characteristics at the census tract level (around 400 inhabitants) such as education level, occupation, housing conditions, family size and country of origin, classified into five levels (high, middle-high, medium, middle-low, low).[22] Modelled outdoor PM_{10} concentrations ($\mu g/m^3$) from primary emissions were assigned to the residential addresses of the cohort participants as a measure of background air quality.[23] The dispersion model was based on the integration between the meteorological Regional Atmospheric Modelling System [21] and the Eulerian Flexible Air Quality Regional Model (FARM, ARIANET Srl, Italy). As an additional indicator of long-term exposure to traffic-related air pollution at the baseline address, we used the Functional Road Class (FRC) (included in the TeleAtlasMultiNet road network) to classify the type of street: motorway (FRC = 0) and major traffic roads (FRC = 1–5). Presence of an industrial plant in the 2-km buffer from the residence was also considered. Information on individual lifestyle factors was not available.

Statistical analysis

The association between landfill H_2S exposure and mortality and hospital admissions was evaluated using Cox proportional hazard regression models [hazard ratios (HRs), 95% confidence intervals (CIs)], with age as the underlying time variable.

For mortality we defined a latency period of 5 years; therefore we considered all cohort participants who were residents of the area on 1 January 1996 (and started the follow-up on 1 January 2001) and those who subsequently moved to the areaup until 31 December 2003 (starting the follow-up 5 years after enrolment). No latency was allowed for the analyses of cardiorespiratory hospitalizations. We first compared the mortality and hospitalization risk of residents according to quartiles of the H_2S distribution. We then considered H_2S as a continuous variable, using the value of the annual mean exposure at residence. A linear association was estimated for increments equal to 1 ng/m^3 of H_2S. We considered as potential confounders socioeconomic position (SEP), PM_{10} background concentrations, residence within 150 m of main roads, 500 m from highways and within 1 or 2 km of industrial plants. With the exception of PM_{10}, which was a continuous variable, all other covariates were considered in the model as categorical variables. In addition, the analyses were performed stratifying in the Cox analysis by landfill sites, to take into account the possible different background rates in the various local areas, by gender and by calendar period (1996–2000, 2001–04, 2005–08, 2009–12), to take into account possible time-related changes in background rates of mortality and hospitalization. Diagnostic tools were used to check the proportional-hazard assumption for all categorical covariates. If any variable in the individual cohort models violated this assumption, effect estimates were compared with a stratified Cox analysis for that covariate. SAS (SAS Institute, NC) and STATA ver. 12 (StataCorp, TX) software programs were used for the statistical analyses.

Results

A total of 242 409 individuals were enrolled in the cohort from 1996 to 2008 (50.4% females), and H_2S concentrations were estimated for each of them at the address of recruitment. The annual average H_2S exposure levels of the population was rather low, 6.3 ng/m^3 [standard deviation (SD) 22.5]; as expected, people living close to the larger landfills (Latina and Rome) had higher H_2S exposure levels [mean = 32.7 ng/m^3 (SD 76.3) and mean = 45.8 ng/m^3 (SD 59), respectively].

The main characteristics of the study cohort according to H_2S concentrations (divided by quartiles of exposure) are described in Table 1. The distribution of gender, age and vital status was rather similar across exposure categories. However, people living in areas with higher concentrations of H_2S were more likely to be of lower SEP compared with people living in areas with lower exposure. PM_{10} background concentrations were higher in the most exposed group compared with those in the low exposure category. People in the higher exposure category tended to live farther from high traffic roads (500 m) but closer to highways and industrial plants (0–1 km). There was a good correlation between distance from landfill and H_2S exposure.

At the end of the follow-up there were 18 609 deaths (7.7%), and for 40 740 subjects (16.8%) the follow-up ended at the time of move away from the municipality of residence.

Table 2 shows the association between H_2S concentrations and cause-specific mortality; effect estimates are given for the quartile distribution of H_2S (25–50, 50 75 and > 75 percentile of the distribution vs < 25 percentile) and for a linear increase of H_2S equal to 1 ng/m^3. There were associations between H_2S exposure and lung cancer (HR 1.34, 95% CI 1.06–1.71), and respiratory diseases (HR 1.30, 95% CI 0.99–1.70) when comparing residents in areas with H_2S concentrations greater than 75 percentiles to the reference group. These findings were confirmed when we consider H_2S exposure as linear (HR 1.10, 95% CI 1.02–1.19 for lung cancer and HR 1.09, 95% CI 1.00–1.19 for respiratory diseases). No other associations were noted.

Table 3 shows the results for cardiorespiratory hospital admissions. No association was detected for cardiovascular diseases. There was an association between the highest quartile of exposure to H_2S and hospitalizations for respiratory diseases (H 1.05, 95% CI 0.99–1.11) also when considering H_2S exposure as linear (HR 1.02, 95% CI 1.00–1.03). H_2S exposure was linked with respiratory diseases and acute respiratory infection hospital admissions among children (for the highest quartile, HR 1.11, 95% CI 1.01–1.22; HR 1.20, 95% CI 1.04–1.38, respectively) also when we considered H_2S exposure as a linear term in the model. We found an association with paediatric admissions for asthma but with wider confidence intervals.In both mortality and hospitalization analyses, we did not find effect modification by gender (data not shown).

Because of the peculiarity of the urban site in Rome ('Malagrotta') (where a large landfill, an incinerator of medical wastes, and a petrochemical refinery are located within just a few kilometres of each other[3]), we repeated the analyses excluding the subjects who live close to the Malagrotta landfill. There were no important changes in the results (See Supplementary Tables 3 'Mortality excluding Malagrotta landfill' and 4 'Morbidity excluding Malagrotta landfill', available as Supplementary data at *IJE* online). We did perform the same sensitivity analysis excluding each landfill at the time, and again the results were similar (see Supplementary Figures 7 'Lung cancer mortality', 8 'Respiratory mortality', 9 'Respiratory morbidity' and 10 'Respiratory morbidity in children', available as Supplementary data at *IJE* online).

Table 1. Descriptive individual and environmental characteristics of the cohort members by hydrogen sulphide (H_2S) exposure

	Total		H_2S exposure levels (ng/m^3)							
			<25° perc (<0.77)		25°–50° perc (0.77–2.1)		50°–75° perc (2.1–4.2)		>75° perc (>4.2)	
	No.	%	No.	%	No.	%	No.	%	No.	%
Total	242 409	100	60 927	100.0	60 775	100	63 962	100	56 745	100
Gender										
Males	120 232	49.6	29 781	49.0	30 137	49.6	31 979	50.0	28 335	49.9
Females	122 177	50.4	31 146	51.0	30 638	50.4	31 983	50.0	28 410	50.1
Vital status										
Alive	183 060	75.5	48 306	79.3	45 948	75.6	44 673	69.8	44 133	77.8
Migrant	40 740	16.8	8 169	13.4	10 228	16.8	14 446	22.6	7 897	13.9
Dead	18 609	7.7	4 452	7.3	4 599	7.6	4 843	7.6	4 715	8.3
Age at recruitment (years)										
0–14	53 082	21.9	12 246	20.0	13 011	21.4	16 266	25.4	11 559	20.4
15–44	112 754	46.5	27 380	45.0	28 383	46.7	30 661	47.9	26 330	46.4
45–64	50 146	20.7	13 296	22.0	12 584	20.7	11 727	18.3	12 539	22.1
>65	26 427	10.9	8 005	13.0	6 797	11.2	5 308	8.3	6 317	11.1
Area-based socioeconomic position										
High	23 589	9.7	10 012	16.0	6 033	9.9	4 779	7.5	2 765	4.9
Middle-high	41 955	17.3	7 843	13.0	8 834	14.5	9 548	14.9	15 730	27.7
Medium	42 286	17.4	7 447	12.0	8 588	14.1	13 958	21.8	12 293	21.7
Middle-low	50 394	20.8	5 364	9.0	16 816	27.7	17 563	27.5	10 651	18.8
Low	62 157	25.6	22 806	37.0	15 206	25.0	11 906	18.6	12 239	21.6
Missing	22 028	9.1	7 455	12.0	5 298	8.7	6 208	9.7	3 067	5.4
PM_{10} (μg/m^3)										
< 11.99 (<50° perc)	121 222	50.0	44 371	73.0	29 696	48.9	23 986	37.5	23 169	40.8
11.99–17.69 (50°–90° perc)	96 369	39.8	16 556	27.0	28 967	47.7	31 661	49.5	19 185	33.8
> 17.69 (>90° perc)	24 818	10.2	0	0.0	2 112	3.5	8 315	13.0	14 391	25.4
Distance from major roads (metres)										
<= 150 m	114 698	47.3	31 842	52.0	25 876	42.6	34 506	53.9	22 474	39.6
> 150 m	127 711	52.7	29 085	48.0	34 899	57.4	29 456	46.1	34 271	60.4
Distance from highways (metres)										
<= 500 m	9 428	3.9	2 908	5.0	1 087	1.8	744	1.2	4 689	8.3
> 500 m	232 981	96.1	58 019	95.0	59 688	98.2	63 218	98.8	52 056	91.7
Distance from industrial plants (km)										
0–1 km	12 863	5.3	376	1.0	2 676	4.4	1 130	1.8	8 681	15.3
1–2 km	50 503	20.8	1 138	2.0	9 589	15.8	28 809	45.0	10 967	19.3
> 2 km	179 043	73.9	59 413	98.0	48 510	79.8	34 023	53.2	37 097	65.4
Distance from landfill (km)										
0–1 km	5 187	2.1	0	0.0	3	0.0	19	0.0	5 165	9.1
1–2 km	21 475	8.9	2	0.0	4 225	7.0	5 835	9.1	11 413	20.1
2–3 km	65 386	27.0	8 372	13.7	20 588	33.9	23 627	36.9	12 799	22.6
3–4 km	77 722	32.1	19 739	32.4	18 787	30.9	20 217	31.6	18 979	33.4
4–5 km	72 639	30.0	32 814	53.9	17 172	28.3	14 264	22.3	8 389	14.8

An additional analysis was performed using distance from the landfills (0–2 km, 2–3 km vs 3–5 km), instead of estimated H_2S concentration, as the exposure variable. Although the results for mortality using distance were not similar to what has been observed using H_2S concentrations (see Supplementary Table 5 'Mortality by distance', available as Supplementary data at *IJE* online) the results for hospitalizations were similar to those obtained using H_2S concentrations (see Supplementary Table 6 'Morbidity by distance', available as Supplementary data at *IJE* online).

Our final concern was that migration outside the areas could bias the results in the case of migration being associated with the exposure and if residents with pre-existing diseases were more likely to migrate. We compared the characteristics of people who migrated outside the study

Table 2. Associations between hydrogen sulphide (H_2S in quartiles and continuous) and cause specific mortality: number of deaths (No.) hazard ratios (HR) and 95% confidence intervals (95% CI)

Cause of death (ICD-9-CM)	H_2S concentrations														
	<25° percentile[a]	25°–50° percentile				50°–75° percentile				>75° percentile				Linear trend	
	No.	No.	Crude HR	HR	95% CI	No.	Crude HR	HR	95% CI	No.	Crude HR	HR	95% CI	HR	95% CI
Natural causes (001–799)	3 701	3 946	0.98	1.01	(0.96–1.06)	4 254	1.00	1.02	(0.97–1.08)	4 104	0.96	0.98	(0.91–1.05)	1.00	(0.98–1.02)
All cancers (140–239)	1 282	1 307	0.97	0.99	(0.91–1.08)	1 493	1.03	1.05	(0.95–1.16)	1 452	1.00	1.03	(0.91–1.16)	1.01	(0.98–1.05)
Stomach (151)	75	88	1.03	0.98	(0.70–1.37)	108	1.27	1.23	(0.84–1.79)	105	1.00	0.88	(0.54–1.42)	1.00	(0.87–1.16)
Colorectal (153–154,159)	154	170	0.99	1.00	(0.79–1.27)	176	0.96	0.97	(0.74–1.28)	159	0.93	0.91	(0.64–1.28)	0.97	(0.87–1.08)
Liver (155–156)	102	89	0.86	0.83	(0.61–1.13)	106	0.89	0.77	(0.53–1.11)	89	0.74	0.76	(0.48–1.2)	0.90	(0.78–1.05)
Pancreas (157)	68	64	0.92	0.93	(0.64–1.35)	69	0.92	0.95	(0.61–1.49)	72	0.69	0.73	(0.41–1.32)	0.93	(0.77–1.11)
Larynx (161)	17	15	0.81	0.72	(0.33–1.56)	11	0.38	0.40	(0.14–1.14)	23	0.43	0.26	(0.07–0.95)	0.64	(0.43–0.97)
Lung (162)	276	281	0.98	1.06	(0.89–1.27)	360	1.09	1.18	(0.97–1.45)	361	1.19	1.34	(1.06–1.71)	1.10	(1.02–1.19)
Bladder (188)	54	48	0.88	0.89	(0.59–1.36)	56	1.22	1.33	(0.81–2.16)	50	1.01	0.94	(0.5–1.80)	1.03	(0.85–1.26)
Kidney (189)	36	30	0.76	0.85	(0.51–1.43)	36	0.87	0.94	(0.52–1.70)	31	0.70	0.86	(0.41–1.83)	0.96	(0.75–1.22)
Brain (191)	23	29	1.26	1.25	(0.70–2.26)	38	1.63	1.63	(0.84–3.17)	41	1.70	1.76	(0.81–3.81)	1.22	(0.95–1.56)
Lymphatic and haematopoietic tissue (200–208)	108	115	1.03	1.16	(0.87–1.54)	106	0.94	0.96	(0.68–1.35)	102	1.06	1.12	(0.74–1.17)	1.02	(0.89–1.16)
Cardiovascular diseases (390–459)	1 457	1 681	1.02	1.05	(0.97–1.13)	1 676	0.96	1.00	(0.91–1.09)	1 641	0.90	0.91	(0.81–1.02)	0.98	(0.94–1.01)
Ischaemic heart diseases (410–414)	512	570	0.99	1.00	(0.88–1.14)	574	0.86	0.91	(0.78–1.06)	530	0.77	0.78	(0.64–0.95)	0.93	(0.87–0.99)
Respiratory diseases (460–519)	256	244	0.88	0.92	(0.76–1.11)	279	1.15	1.13	(0.90–1.40)	264	1.30	1.30	(0.99–1.70)	1.09	(1.00–1.19)
Digestive diseases (520–579)	158	163	0.93	0.97	(0.77–1.24)	218	1.06	1.09	(0.83–1.41)	186	0.94	0.97	(0.69–1.35)	1.01	(0.91–1.12)
Urinary system diseases (580–599)	58	92	1.49	1.54	(1.08–2.21)	74	1.25	1.28	(0.83–1.97)	67	1.26	1.42	(0.84–2.40)	1.11	(0.94–1.30)

[a]Reference category

Table 3. Associations between hydrogen sulphide (H_2S, in quartiles and continuous) and cardiorespiratory morbidity: number of people hospitalized (No.), hazard ratios (HR) and 95% confidence intervals (95% CI)

Diagnosis (ICD-9-CM)	H_2S concentrations													
	<25° percentile[a]		25°–50° percentile			50°–75° percentile			>75° percentile			Linear trend		
	No.		No.	Crude HR	HR	95% CI	No.	Crude HR	HR	95% CI	No.	Crude HR	HR	95% CI	HR	95% CI
Total cohort																
Cardiovascular diseases (390–459)	6 666		6 090	0.99	0.99	(0.95–1.03)	6 291	0.99	1.00	(0.96–1.04)	6 677	1.03	1.02	(0.97–1.07)	1.00	(0.99–1.02)
Cardiac diseases (390–429)	3 991		3 585	0.99	0.98	(0.93–1.03)	3 580	0.97	0.98	(0.92–1.04)	4 022	1.05	1.04	(0.97–1.11)	1.01	(0.98–1.03)
Ischaemic heart diseases (410–414)	1 393		1 347	1.03	1.02	(0.94–1.10)	1 288	0.94	0.94	(0.85–1.03)	1 426	1.01	0.99	(0.88–1.10)	0.99	(0.95–1.02)
Cerebrovascular diseases (430–438)	1 635		1 482	0.98	0.98	(0.91–1.06)	1 466	0.97	0.97	(0.89–1.06)	1 543	0.97	0.98	(0.88–1.10)	0.99	(0.96–1.03)
Respiratory diseases (460–519)	4 372		4 249	0.98	0.97	(0.92–1.01)	5 628	1.02	1.01	(0.96–1.06)	4 837	1.06	1.05	(0.99–1.11)	1.02	(1.00–1.03)
Acute respiratory infections (460–466,480–487)	1 447		1 441	1.00	0.96	(0.89–1.04)	1 721	1.00	0.97	(0.89–1.05)	1 509	1.09	1.07	(0.97–1.18)	1.02	(0.98–1.05)
COPD (490–492,494,496)	654		592	0.96	0.94	(0.84–1.06)	535	0.92	0.90	(0.78–1.04)	577	1.09	1.06	(0.90–1.25)	1.00	(0.95–1.05)
Asthma (493)	332		355	1.01	1.00	(0.86–1.17)	594	1.16	1.17	(0.99–1.38)	365	1.11	1.09	(0.90–1.33)	1.04	(0.98–1.11)
Children 0–14 years old																
Respiratory diseases (460–519)	1 457		1 522	1.00	0.99	(0.92–1.07)	2 420	1.07	1.08	(0.99–1.17)	1 499	1.10	1.11	(1.01–1.22)	1.04	(1.01–1.07)
Acute respiratory infections (460–466,480–487)	573		669	1.10	1.02	(0.91–1.15)	925	1.15	1.10	(0.97–1.25)	617	1.25	1.20	(1.04–1.38)	1.06	(1.02–1.11)
Asthma (493)	257		267	0.98	0.99	(0.83–1.19)	506	1.23	1.29	(1.06–1.55)	276	1.11	1.13	(0.91–1.41)	1.07	(0.99–1.14)

[a]Reference category

areas (40 740 subjects) with those who remained in the areas until the end of the follow-up (201 669 subjects) See Supplementary Table 11 'Comparison between migrant and not migrant', available as Supplementary data at *IJE* online). We considered gender, age, socioeconomic status and H_2S exposure as fixed variables. Since occurrence of hospitalizations before migration is a time-dependent variable, we compared subjects migrating in the period 2004–12 (19 695 subjects) with all subjects who did not migrate before that period (189 560 subjects), evaluating the occurrence of cardiorespiratory hospitalizations during1998–2003. Migration was associated with male gender, younger age and lower exposure to H_2S; no clear differences of migrants compared with non-migrants were found for socioeconomic status. In a multinomial logistic regression(data not shown), we found no major differences between the two groups for respiratory diseases, whereas migrants were less likely than non-migrants to suffer from two or more hospitalizations for cardiovascular disease (OR, 0.74, 95% CI 0.57–0.95) before migrating. All these results indicate that bias due to increased susceptibility of migrants is unlikely given that migrants are less exposed and tend to be healthier than non-migrants.

Discussion

We found a positive association between exposure to hydrogen sulphide (H_2S), that we used as a surrogate for all the pollutants co-emitted from the landfills, and mortality for lung cancer and respiratory diseases as well as hospital admissions for respiratory diseases, especially in children.

Previous studies have investigated the association between residence close to landfills and cancer incidence or cause-specific mortality, with conflicting results. A Canadian cohort study compared cancer incidence in males living close to a landfill with that of residents of farther away areas.[1] The distance from the landfill was assigned to each person based on the residential address at diagnosis. Excess risks for non-Hodgkin lymphoma and liver, pancreas and kidney cancers were found in male residents close to the site. Malagrotta (Rome) residents who lived near (in an area about 2 km^2) a large landfill of municipal solid waste, an incinerator and a petrochemical refinery showed an association between proximity to landfill and laryngeal cancer.[2] A more recent residential cohort study of the same area found that H_2S exposure from the landfill was related to higher risk of mortality from laryngeal cancer and bladder cancer in women, as well as hospitalizations for cardiorespiratory diseases.[3] Jarup *et al.* compared cancer incidence (bladder, brain and hepatobiliary cancers and leukaemias) in the population resident within 2 km of 9565 landfills in UK with cancer rates of

those who lived more than 2 km away.[4] Despite the large statistical power, the study did not show excess cancer risk associated with proximity to landfill sites. An ecological study compared mortality, hospital admissions and reproductive health of a population living near a landfill site in Wales with another population matched for socioeconomic status.[5] No differences between the two populations were found. A study in Brazil evaluated the association between residence close to solid waste landfill sites and cancer mortality.[6] The exposed areas were defined using a 2-km buffer radius around 15 sites. Standardized mortality ratios were analysed in Bayesian spatial models. The results did not indicate any excess risk for people close to landfills. Some elevated risks of bladder and liver cancer, and death due to congenital malformation were found, although they did not have statistical significance.

The results we found regarding respiratory diseases are consistent with others suggesting a relationship between living close to landfill areas and damage to the respiratory system,[24,25] as highlighted in a recent systematic review.[26] Occurrence of respiratory symptoms was documented among residents living close to waste sites[12] and was linked to inhalation exposure to endotoxin, microorganisms, and aerosols from waste collection and land filling.[27]

Occupational exposure to organic dust, particulate matters from microbial, plant or animal origin, has been associated with an increased risk of lung cancer in a pooled analysis of case-control studies.[25] High lung cancer mortality was found among male residents of Italian National Priority Contaminated Sites with industrial waste landfills or illegal dumps[29] and among residents living near incinerators and landfills of hazardous waste in Spain,[30] but the overall evidence that residing near landfills is associated with increased risk of lung cancer is still inadequate.[10]

This study attempted to overcome some of the limitations of the previously conducted studies, which included issues of study design, exposure assessment and confounding.[11] We used a residential cohort approach to provide a more detailed estimation of the population at risk. To each subject in the cohort we assigned an H_2S exposure value(corresponding to the estimated H_2S concentration at the baseline address). It was not possible to consider indexes of average or cumulative exposure based on the different residences, because only a few municipality databases provided information about changes of residence during the follow-up. For this reason, individual exposure reflects residence at the beginning of the follow-up.

Previous studies have considered distance from landfills as a proxy of exposure.[4,7,9] Distance-to source is easy to understand because it assumes that people living near the landfill are more exposed than people living further away. We used modelled H_2S concentrations as an exposure measure of the landfill gases, on the assumption that the pollution from landfills does not spread uniformly around the site but depends on the quantity of incoming waste, the prevailing winds and the orography of the area.[3] Our results for hospitalizations were confirmed when we used distance from the source as the exposure variable instead of modelled H_2S concentrations. There are, however, several aspects in the exposure assessment process we used that should be considered. H_2S generation rates were taken from EPA published material, and waste acceptance capacity and waste acceptance rates were from derived from legal authorized values. It is likely, then, that the derived absolute emissions data were more accurate for the recent period and less certain for the past. On the other hand, we used the shape of the H_2S concentrations on the ground to rank subjects as more exposed or less exposed, and this shape is of greater importance than the exact absolute values. Of course, the major limitation of our exposure assessment is related to the lack of a validation study with *in situ* measurements. Nonetheless, SPRAY is a consolidated model that has been validated using a 'conventional' validation framework,[31] and its performances and efficiency have been evaluated and validated in multiple real conditions with different orography, size of domain, number of grid cells in the domain, meteorological conditions and emission types.[32–34] The model has been already used in other locations to study health effects of waste management.[3,17] Another aspect of concern is the use of meteorological parameters that greatly influence the dispersion of the pollutants. We considered the year 2005 as representative of the study area meteorological conditions because there were no particular meteorological anomalies in that year. Running the dispersion model with meteorological data for different years could change the landfills footprint only in presence of extreme weather conditions that strongly affect the annual average. In our opinion, the difference among years is generally minimal and the uncertainty associated with the use of specific meteorological data is negligible.

Our results were adjusted for several confounders: age, socioeconomic position and variables related to the environmental context (proximity to roads with heavy traffic, proximity to industrial sites, air quality) that might otherwise distort the study association. In particular, high level of PM_{10} ($>$ 90 percentile of the distribution vs $<$ 50 percentile) was associated in our model with cardiovascular and respiratory hospitalizations (HR 1.08, 95% CI 1.01–1.16 and HR 1.03, 95% CI 0.96–1.12, respectively). However, no data were available on the personal habits of the subjects, which could have had a role in the diseases investigated, especially cigarette smoking but also alcohol use, physical activity and obesity. The collection of this

information, through telephone interviews or home visits, would have been prohibitive for such a large cohort, and the lack of this information may have biased the results because of confounding not controlled in the analysis. It should be noted, however, that many personal habits are associated with socioeconomic position. It is therefore reasonable to assume that the analysis that adjusted for socioeconomic index also took into account others individual variables, including smoking. Moreover, excess of hospitalizations for respiratory diseases were found also in children, and no excess mortality/morbidity for cardiovascular diseases (indicative of most of the unmeasured lifestyle factors including smoking) was found, despite the larger statistical power than for respiratory diseases. Therefore, although residual confounding cannot be excluded, it is unlikely that the observed relationship between H_2S exposure and respiratory disturbances could be entirely due to unmeasured smoking habits and other factors.

In conclusion, we found associations between H_2S exposure from landfills and mortality from lung cancer as well as mortality and morbidity for respiratory diseases. The link with respiratory diseases has been observed in other studies and it is potentially related to irritant gases and other organic contaminants. The excess of lung cancer is a relatively new finding.

Supplementary Data

Supplementary data are available at *IJE* online.

Funding

This study was supported by the Lazio Waste General Directorate (DGR n929/08) as a part of a larger project on the health effects of waste treatment plants in the Lazio region (ERAS Lazio: Epidemiology, Waste, Environment and Health —www.eraslazio.it). The funder had no scientific role.

Acknowledgements

We wish to thank Margaret Becker for her help in editing the manuscript and Carlo A. Perucci, former director of our department, for initiating the ERAS Lazio project and for his long-standing support of environmental epidemiology.

Conflict of interest: None declared.

References

1. Goldberg MS, Siemiatyck J, DeWar R, Dèsy M, Riberdy H. Risk of developing cancer relative to living near a municipal solid waste landfill site in Montreal, Quebec, Canada. *Arch Environ Health* 1999;**54**:291–96.
2. Michelozzi P, Fusco D, Forastiere F *et al*. Small area study of mortality among people living near multiple sources of air pollution. *Occup Environ Med* 1998;**55**:611–15.
3. Ancona C, Badaloni C, Mataloni F *et al*. Mortality and morbidity in a population exposed to multiple sources of air pollution: a retrospective cohort study using air dispersion models. *Environ Res* 2015;**137**:467–74.
4. Jarup L, Briggs D, de Hoogh C *et al*. Cancer risks in populations living near landfill sites in Great Britain. *Br J Cancer* 2002;**86**:1732–36.
5. Fielder HMP, Poon-King CM, Palmer S R *et al*. Assessment of impact on health of residents living near the Nant-y-Gwyddon landfill site: retrospective analysis. *BMJ* 2000;**320**:19–22.
6. Gouveia N, Prado RR. Health risks in areas close to urban solid waste landfill sites. *Rev Saude Publica* 2010;**44**:859–66.
7. Pukkala E, Pönkä A. Increased incidence of cancer and asthma in houses built on a former dump area. *Environ Health Perspect* 2001;**109**:1121–25
8. Forastiere F, Badaloni C, de Hoogh K *et al*. Health impact assessment of waste management facilities in three European countries. *Environ Health* 2011;**10**:53.
9. WHO. Population health and waste management: scientific data and available options. http://www.euro.who.int/document/E91021.pdf (24 March 2015, date last accessed).
10. Porta D, Milani S, Lazzarino AI *et al*. Systematic review of epidemiological studies on health effects associated with management of solid waste. *Environ Health* 2009;**23**:8–60.
11. Giusti L. A review of waste management practices and their impact on human health. *Waste Manag* 2009;**29**:2227–39.
12. Blanes-Vidal V, Bælum J, Schwartz J *et al*. Respiratory and sensory irritation symptoms among residents exposed to low-to-moderate air pollution from biodegradable wastes. *J Expo Sci EnvironEpidemiol* 2014;**24**:388–97.
13. Ancona C, Mataloni F, Badaloni C *et al*. Residential cohort approach in industrial contaminated sites: the ERAS Lazio project. *Epidemiol Prev* 2014;**38**(**Suppl 1**):158–61.
14. D'Ippoliti D, Santelli E, De Sario M *et al*. Arsenic in drinking water and mortality for cancer and chronic diseases in Central Italy, 1990-2010. *PloS One* 2015;**10**:e0138182.
15. Ranzi A, Fano V, Erspamer L *et al*. Mortality and morbidity among people living close to incinerators: a cohort study based on dispersion modeling for exposure assessment. *Environ Health* 2011;**10**:22.
16. Candela S, Ranzi A, Bonvicini L *et al*. Air pollution from incinerators and reproductive outcomes: a multisite study. *Epidemiology* 2013;**24**:863–70.
17. Golini MN, Ancona C, Badaloni CA *et al*. Morbidity in a population living close to urban waste incinerator plants in Lazio Region (Central Italy): a retrospective cohort study using a before-after design. *Epidemiol Prev* 2014;**38**:323–34.
18. Alexander A, Burklin C, Singleton A *et al*. *Landfill Gas Emissions Model (LandGEM) Version 3.02 User's Guide*, May 2005.
19. US Environmental Protection Agency. *Compilation of Air Pollutant Emission Factors; AP-42*. http://www3.epa.gov/ttnchie1/ap42/ (24 March 2015, date last accessed).
20. Calori G, Radice P. *Emission Manager – Reference Guide*. Milan, Italy: ARIANET R2004.29, 2004.
21. Pielke RA, Cotton WR, Walko RL *et al*. A comprehensive Meteorological Modeling System RAMS. *Meteorol. Atmos. Phys*. 1992;**49**:69–91.

22. Cesaroni G, Agabiti N, Rosati R, Forastiere F, Perucci CA. An index of socioeconomic position based on 2001 Census, Rome. *Epidemiol Prev* 2006;**30**:352–57.
23. Sozzi R, Bolignano A, Barberini S, Di Giosa AD. apporto sullo stato della qualitÁ dell aria nella Regione Lazio 2011. ARPA Lazio. 2012.
24. Heaney CD, Wing S, Campbell RL *et al*. Relation between malodor, ambient hydrogen sulfide, and health in a community bordering a landfill. *Environ Res* 2011;**111**:847–52.
25. Corrêa CR, Abrahão CE, CarpinteroMdo C, AnarumaFilho F. Landfills as risk factors for respiratory disease in children. *J Pediatr (Rio J)* 2011;**87**:319–24.
26. Mattiello A, Chiodini P, Bianco E *et al*. Health effects associated with the disposal of solid waste in landfills and incinerators in populations living in surrounding areas: a systematic review. *Int J Public Health* 2013;**58**:725–35.
27. Park DU, Ryu SH, Kim SB, Yoon CS. An assessment of dust, endotoxin, and microorganism exposure during waste collection and sorting. *J Air Waste Manag Assoc* 2011;**61**:461–68.
28. Peters S, Kromhout H, Olsson AC *et al*. Occupational exposure to organic dust increases lung cancer risk in the general population.*Thorax* 2012;**67**:111–16.
29. Fazzo L, Minichilli F, Pirastu R *et al*. A meta-analysis of mortality data in Italian contaminated sites with industrial waste landfills or illegal dumps. *Ann Ist Super Sanità* 2014;**50**:278–85.
30. García-Pérez J, Fernández-Navarro P, Castelló A *et al*. Cancer mortality in towns in the vicinity of incinerators and installations for the recovery or disposal of hazardous waste. *Environ Int* 2013;**51**:31–44.
31. Olesen HR. Toward the establishment of a common framework for model evaluation. In: Gryning SE, Schiermeier F (eds). *Air Pollution Modeling and Its Application XI*. New York, NY:Plenum Press, 1996.
32. Brusasca G, Tinarelli G, Anfossi D. Particle model simulation of diffusion in low windspeed stable conditions, *Atmos Environ* 1989; **26**, 707–723.
33. Brusasca G, Tinarelli G, Anfossi D. Comparison between the results of a Monte Carlo atmospheric diffusion model and tracer experiments, *Atmosp Environ* 1992;**23**: 1263–80.
34. Anfossi D, Tinarelli G, TriniCastelli S *et al*. A new Lagrangian particle model for the simulation of dense gas dispersion. *Atmos Environ* 2010;**44:** 753–62.

Environmental Health

BioMed Central

Review

Open Access

Systematic review of epidemiological studies on health effects associated with management of solid waste

Daniela Porta[1], Simona Milani[1], Antonio I Lazzarino[1,2], Carlo A Perucci[1] and Francesco Forastiere*[1]

Address: [1]Department of Epidemiology, Regional Health Service Lazio Region, Rome, Italy and [2]Division of Epidemiology, Public Health and Primary Care, Imperial College, London, UK

Email: Daniela Porta - porta@asplazio.it; Simona Milani - milani@asplazio.it; Antonio I Lazzarino - a.lazzarino@imperial.ac.uk; Carlo A Perucci - perucci@asplazio.it; Francesco Forastiere* - forastiere@asplazio.it

* Corresponding author

Published: 23 December 2009

Environmental Health 2009, **8**:60 doi:10.1186/1476-069X-8-60

Received: 4 May 2009
Accepted: 23 December 2009

This article is available from: http://www.ehjournal.net/content/8/1/60

© 2009 Porta et al; licensee BioMed Central Ltd.
This is an Open Access article distributed under the terms of the Creative Commons Attribution License (http://creativecommons.org/licenses/by/2.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Abstract

Background: Management of solid waste (mainly landfills and incineration) releases a number of toxic substances, most in small quantities and at extremely low levels. Because of the wide range of pollutants, the different pathways of exposure, long-term low-level exposure, and the potential for synergism among the pollutants, concerns remain about potential health effects but there are many uncertainties involved in the assessment. Our aim was to systematically review the available epidemiological literature on the health effects in the vicinity of landfills and incinerators and among workers at waste processing plants to derive usable excess risk estimates for health impact assessment.

Methods: We examined the published, peer-reviewed literature addressing health effects of waste management between 1983 and 2008. For each paper, we examined the study design and assessed potential biases in the effect estimates. We evaluated the overall evidence and graded the associated uncertainties.

Results: In most cases the overall evidence was inadequate to establish a relationship between a specific waste process and health effects; the evidence from occupational studies was not sufficient to make an overall assessment. For community studies, at least for some processes, there was limited evidence of a causal relationship and a few studies were selected for a quantitative evaluation. In particular, for populations living within two kilometres of landfills there was limited evidence of congenital anomalies and low birth weight with excess risk of 2 percent and 6 percent, respectively. The excess risk tended to be higher when sites dealing with toxic wastes were considered. For populations living within three kilometres of old incinerators, there was limited evidence of an increased risk of cancer, with an estimated excess risk of 3.5 percent. The confidence in the evaluation and in the estimated excess risk tended to be higher for specific cancer forms such as non-Hodgkin's lymphoma and soft tissue sarcoma than for other cancers.

Conclusions: The studies we have reviewed suffer from many limitations due to poor exposure assessment, ecological level of analysis, and lack of information on relevant confounders. With a moderate level confidence, however, we have derived some effect estimates that could be used for health impact assessment of old landfill and incineration plants. The uncertainties surrounding these numbers should be considered carefully when health effects are estimated. It is clear that future research into the health risks of waste management needs to overcome current limitations.

Introduction

"Waste management", that is the generation, collection, processing, transport, and disposal of solid waste is important for both environmental reasons and public health. There are a number of different options available for the management and treatment of waste including minimisation, recycling, composting, energy recovery and disposal. At present, an increasing amount of the resources contained in waste is recycled, but a large portion is incinerated or permanently lost in landfills. The various methods of waste management release a number of substances, most in small quantities and at extremely low levels. However, concerns remain about potential health effects associated with the main waste management technologies and there are many uncertainties involved in the assessment of health effects.

Several studies of the possible health effects on populations living in proximity of landfills and incinerators have been published and well-conducted reviews are available [1-4]. Both landfills and incinerators have been associated with some reproductive and cancer outcomes. However, the reviews indicate the weakness of the results of the available studies due to design issues, mainly related to a lack of exposure information, use of indirect surrogate measures, such as the distance from the source, and lack of control for potential confounders. As a result, there is great controversy over the possible health effects of waste management on the public due to differences in risk communication, risk perception and the conflicting interests of various stakeholders. Therefore, there is the need for an appropriate risk assessment that informs both policy makers and the public with the information currently available on the health risks associated with different waste management technologies. Of course, the current uncertainties should be taken into account.

Within the EU-funded INTARESE project [5], we aimed to assess potential exposures and health effects arising from solid wastes, from generation to disposal, or treatment. A key part in the health impact assessment was selecting or developing a suitable set of relative risks that link individual exposures with specific health endpoints. In this paper, we systematically reviewed the available epidemiological literature on health effects in the vicinity of landfills and incinerators and among workers at waste processing plants to derive usable excess risk estimates for health impact assessment. The degree of uncertainty associated with these estimates was considered.

Methods

We considered epidemiological studies conducted on the general population with potential exposures from collecting, recycling, composting, incinerating, and landfilling solid waste. We also considered studies of employees of waste management plants as they may be exposed to the same potential hazards as the community residents, even if the intensity and duration of the exposure may differ. However, to limit our scope, we did not consider studies on biomarkers of exposure and health effects.

Relevant papers were found through computerized literature searches of MEDLINE and PubMed Databases from 1/1/1983 through 31/12/2008, using the MeSH terms "waste management" and "waste products" and the subheading "adverse effects". We identified 144 papers with this method. We also conducted a free search with several combinations of relevant key words (waste incinerator or landfill or composting or recycling) and (cancer or birth outcome or health effects), and 285 papers were identified. In addition, articles were traced through references listed in previous reviews [1-3,6-9], and in publications of the UK Department for Environment, Food and Rural Affairs [10]. Finally, we used information from two recent reviews of epidemiological studies on populations with potential exposures from toxic and hazardous wastes for reproductive [4], and cancer [11] outcomes, respectively.

The eligibility of all papers was evaluated independently by three observers, and disagreements were resolved by discussion. As indicated, studies on sewage treatment and on biological monitoring were not included. We also excluded articles in languages other than English, not journal articles, and six studies [12-17] conducted at the municipal level (usually small towns) where it was not possible to evaluate the extent of the population potentially involved and the possibility of exposure misclassification was high.

Papers were grouped according to the following criteria:

• waste management technologies: recycling, composting, incinerating, landfilling (considering controlled disposal of waste land and toxic or hazardous sites);

• health outcomes: cancers (stomach, colorectal, liver, larynx and lung cancer, soft tissue sarcoma, kidney and bladder cancer, non-Hodgkin's lymphoma, childhood cancer), birth outcomes (congenital malformations, low birth weight, multiple births, abnormal sex ratio of newborns), respiratory, skin and gastrointestinal symptoms or diseases.

We have reported in the appropriate tables (in the online additional files) for each paper: study design (e.g. geographical, cohort, cross-sectional, case-control study, etc.), population characteristics (subjects, country, age, sex), exposure measures (e.g. occupational exposure to waste incinerator by-products, residence near a landfill, etc.), and the main results (including control for major

confounders) with respect to the quantification of the health effects studied. For each study we have evaluated the potential sources of uncertainty in the results due to design issues. In particular, the possibility that selection bias, information bias, or confounding could artificially increase or decrease the relative risk estimate has been noted in the tables using the plus/minus scale to indicate that effect estimates are likely to be overestimated (or underestimated) up to 20% (+/-), from 20 to 50% (++/--) and more than 50% (+++/---). Uncertainties were graded by two observers (SM and FF), who discussed the inconsistencies.

After a description of the available studies, the overall evaluation of the epidemiological evidence regarding the process/disease association was made based on the IARC (1999) criteria, and two categories were chosen, namely: "*Inadequate*" when the available studies were of insufficient quality, consistency, or statistical power to determine the presence or absence of a causal association; "*Limited*" when a positive association was observed between exposure and disease for which a causal interpretation is considered to be credible, but chance, bias, or confounding could not be ruled out with reasonable confidence. There were no instances where the category "sufficient" evidence could be used. Only when the specific process/disease association was judged as limited (suggestive evidence but not sufficient to infer causality) we decided to evaluate the strength of the association and to measure appropriate relative risks. For this purpose, we considered the set of studies providing the best evidence and assigned an overall level of scientific confidence of the specific effect estimate based on an arbitrary scale: very high, high, moderate, low, very low. This evaluation was made by three assessors (SM, DP, and FF).

Results

A total of 49 papers were reviewed: 32 concerning health effects in communities in proximity to waste sites, and 17 on employees of waste management sites. The majority of community studies evaluated possible adverse health effects in relation to incinerators and landfills. We found little evidence on potential health problems resulting from environmental or occupational exposures from composting or recycling, and very little on storage/collection of solid waste. A description of the main findings follows.

Studies of communities near landfills

One of the main problems in dealing with studies on landfill sites (an to some extent also for incinerators) is the distinction between sites for municipal solid wastes and sites for other wastes. The definition of different types of waste is far from being standardised across the world. The terms hazardous, special, toxic, industrial, commercial, etc, are variously applied in different countries and time periods to designate non-household wastes. In earlier time periods definitions were even less clear and some disposal sites may have switched categories (e.g. if they used to take industrial waste they may now only take municipal waste). Since two systematic reviews were already available for toxic wastes [4,11], we did not replicate the literature search, but summarized the evidence reported in the available reviews and tried to compare and discuss the results with studies where mainly municipal solid wastes were landfilled. The additional file 1 contain several details of the studies reviewed.

Cancer

Russi et al. [11] carried out Medline searches of the peer-reviewed English language medical literature covering the period from January 1980 to June 2006 using the keywords "toxic sites" and "cancer", and identified articles from published reviews. They included 19 articles which fit the following selection criteria: 1) the study addressed either cancer incidence or cancer mortality as an endpoint, 2) the study was carried out in a community or a set of communities containing a known hazardous waste site; 3) the study had to address exposure from a specific waste site, rather than from a contaminated water supply resulted from multiple point sources. As the authors recognized, some of the location investigated included both toxic wastes and municipal solid wastes as in the study from Goldberg et al. [18] or Pukkala et al. [19]. There are two investigations considered in this review that are important to evaluate because of the originality of the approach (cohort study, [19] and due to the large size [20].

In Finland, Pukkala et al. [19] studied whether the exposure to landfills caused cancer or other chronic diseases in inhabitants of houses built on a former dumping area containing industrial and household wastes. After adjusting for age and sex, an excess number of male cancer cases were seen, especially for cancers of the pancreas and of the skin. The relative risk slightly increased with the number of years lived in the area. However, some uncertainties were likely to affect the results of the study with regards to the exposure assessment (-), outcome assessment (+) and presence of residual confounding (-).

Jarup et al. [20] examined cancer risks in populations living within 2 km of 9,565 (from a total of 19,196) landfill sites that were operational at some time from 1982 to 1997 in Great Britain. No excess risks of cancers of the bladder and brain, hepato-biliary cancer or leukaemia were found, after adjusting for age, sex, calendar year and deprivation. The study was very large and had high power, however misclassification of exposure could have decreased the possibility of detecting an effect (--).

Based on the findings and on the evaluation of the quality of the studies, Russi et al. [11] concluded that epidemiological studies of populations living in the vicinity of a toxic waste site have not produced evidence of adequate quality to establish a casual link between toxic waste exposures and cancer risk. In our terms, the evidence may be considered as "inadequate".

In addition to the articles reviewed by Russi et al. [11], we reviewed the article by Michelozzi et al. [21], which investigated the mortality risk in a small area of Italy (Malagrotta, Rome) with multiple sources of air contamination (a very large waste disposal site serving the entire city of Rome, a waste incinerator plant, and an oil refinery plant). Standardised Mortality Ratios (SMRs) were computed in bands of increasing distance from the plants, up to a radius of 10 km. No association was found between proximity to the sites and cancer of various organs, in particular liver, lung, and lymph haematopoietic cancer, however, mortality from laryngeal cancer declined with distance from the pollution sources, and a statistically significant trend remained after adjusting for a four-level index of socio-economic status. The main uncertainty of the study is related to the exposure assessment (--) since only distance was considered thus decreasing the possibility of detecting an effect. There are also uncertainties in using mortality to estimate cancer incidence in proximity to a suspected source of pollution (+). On the other hand, even though the authors did adjust for an area-based index of deprivation, residual confounding (+) from socioeconomic status was likely.

In summary, there is inadequate evidence of an increased risk of cancer for communities in proximity of landfills. The three slightly positive studies from Goldberg et al. [18], Pukkala et al. [19] and Michelozzi et al. [21] are not consistent.

Birth defects and reproductive disorders

Saunders [4] reviewed 29 papers examining the relationship between residential proximity to landfill sites and the risk of an adverse birth outcome. The review included either studies on municipal waste or on hazardous waste. Eighteen papers reported some significant association between adverse reproductive outcome and residence near a landfill site. Two of the strongest papers conducted on hazardous waste landfill sites in Europe (EUROHAZCON) found similarly moderate but significant associations between residential proximity (within 3 km) to hazardous waste sites and both chromosomal [22] (Odds Ratio, OR: 1.41, 95%CI: 1.00-1.99) and non-chromosomal [23] (OR: 1.33, 95%CI: 1.11-1.59) congenital anomalies.

Included in the Saunders's review [4] is the national geographical comparison study on landfills in the UK by Elliott et al. [24]. This study investigated the risk of adverse birth outcomes in populations living within two km of 9,565 landfill sites in Great Britain, operational at some time between 1982 and 1997, compared with those living further away (reference population). The sites included 774 sites for special (hazardous) waste, 7803 for non-special waste and 988 handling unknown waste; a two km zone was defined around each site to detect the likely limit of dispersion for landfill emissions, including 55% of the national population. Among the 8.2 million live births and 43,471 stillbirths, 124,597 congenital anomalies (including miscarriage) that were examined, there were: neural tube defects, cardiovascular defects, abdominal wall defects, hypospadias and epispadias, surgical correction of gastroschisis and exomphalos; low and very low birth weights were also found , defined as less than 2500 g and less than 1500 g, respectively. The main analysis, conducted for all landfill sites during their operation and after closure, found a small, but still statistically significant, increased risk of total and specific anomalies (OR: 1.01, 95%CI: 1.005-1.023) in populations living within 2 Km, and also an increased risk of low (OR: 1.05, 95%CI: 1.047-1.055) and very low birth weight (OR: 1.04, 95%CI: 1.03-1.05). Additional analyses were carried out separately for sites handling special waste and non-special waste, and in the period before and after opening, for the 5,260 landfills with available data. After adjusting for deprivation and other potential confounding variables (sex, year of birth, administrative region), there was a small increase in the relative risks for low and very low birth weight and for all congenital anomalies, except for cardiovascular defects. The risks of all congenital anomalies were higher for people living near special waste disposals (OR: 1.07 CI95%:1.04-1.09) compared to non-special waste disposals (OR: 1.02, CI95%:1.01-1.03). There was no excess risk of stillbirth. On these bases, the author [4] concluded that while most studies reporting a positive association are of good quality, over half report no association with any adverse birth outcome and most of the latter are also well conducted. The review considered that the evidence of an association of residence near a landfill with adverse birth outcomes as unconvincing.

After the review by Saunders [4], we considered four additional studies examining reproductive effects of landfill emissions.

Elliot et al. recently updated the previous study [25] in order to evaluate whether geographical density of landfill sites was related to congenital anomalies. The analysis was restricted to 8804 sites operational at some time between 1982 and 1997. There were 607 sites handling special (hazardous) waste and 8197 handling non-special or

unknown waste type. The exposure assessment took into account the overlap of the two km buffers around each site, to define an index of exposure with four levels of increasing landfill density. Several anomalies (hypospadias and epispadias, cardiovascular defects, neural tube defects and abdominal wall defects) were evaluated. The analysis was carried out separately for special and non-special waste sites and was adjusted for deprivation, presence or absence of a local congenital anomalies register and maternal age. The study found a weak association between intensity of hazardous sites and some congenital anomalies (all, cardiovascular, hypospadia and epispadias).

The studies conducted in the United Kingdom suffer from the same limitations, namely the possibility that misclassification of exposure could have decreased the relative risk estimates to some extent (--); on the other hand, there are several uncertainties related to the quality of reporting and registration of congenital malformations. In the latter case, a positive bias is more likely (++). For the recent report by Elliott et al. [25], location uncertainties and differential data reliability regarding the sites, together with the use of distance as the basis for exposure classification, limit the interpretation of the findings (--).

In Denmark, Kloppenborg et al. [26] marked the geographical location of 48 landfills and used maternal residence as the exposure indicator in a study of congenital malformations. The authors found no association between landfill location and all congenital anomalies or of the nervous system, and a small excess risk for congenital anomalies of the cardiovascular system. Potential confounding from socioeconomic status is the major limitation of this study (+++).

Jarup et al. [27] studied the risk of Down's syndrome in the population living near 6829 landfills in England and Wales. People were considered exposed if they lived in a two-km zone around each site, people beyond this zone were the reference group. A two-year lag period between potential exposure of the mother and her giving birth to a Down's syndrome child was allowed. The analysis was adjusted for maternal age, urban-rural status and deprivation index. No statistically significant excess risk was found in the exposed populations, regardless of waste type.

Finally, Gilbreath et al. [28] studied births in 197 Native Alaskan villages containing open dumpsites with hazardous waste, scoring the exposure into high, intermediate and low hazard level on the basis of maternal residence. The authors found an association between higher levels of hazard and low birth weight and intrauterine growth retardation. The major limit of the study is the low specificity of the exposure definition.

In summary, an increased risk of congenital malformations and of low birth weight has been reported from studies conducted in the UK. When compared with the results from studies conducted in proximity of hazardous waste sites, studies in proximity of non-toxic waste landfills provide lower effect estimates. The main uncertainty of these studies is the completeness of data on birth defects, the use of distance from the sites for exposure classification, and the classification as toxic and non-toxic waste sites.

Respiratory diseases

A study conducted by Pukkala et al. [19] in Finland evaluated prevalence of asthma in relation to residence in houses built on a former dumping area containing industrial and household wastes. Prevalence of asthma was significantly higher in the dump cohort than in the reference cohort (living nearby but outside the landfill site). Unfortunately, this study has not been replicated and the overall evidence may be considered inadequate.

Studies of landfills workers

Only one study on landfill workers was reviewed. Gelberg et al. [29] conducted a cross-sectional study to examine acute health effects among employees working for the New York City Department of Sanitation, focusing on Fresh Kills landfill employees. Telephone interviews conducted with 238 on-site and 262 off-site male employees asked about potential exposures both at home and work, health symptoms for the previous six months, and other information (social and recreational habits, socio-economic status). Landfill workers reported a significantly higher prevalence of work-related respiratory, dermatological, neurologic and hearing problems than controls. Respiratory and dermatologic symptoms were not associated with any specific occupational title or task, other than working at the landfill, and the association remained, even after controlling for smoking status.

Studies of communities living near incinerators

Twenty-one epidemiologic studies conducted on residents of communities with solid waste incinerators have been reviewed and their characteristics are listed in the additional file 2.

Cancer

Eleven studies have been reviewed on cancer risk in relation with incinerators, usually old plants with high polluting characteristics. The studies are reported below by country.

In the United Kingdom, Elliott et al. [30] investigated cancer incidence between 1974 and 1987 among over 14 million people living near 72 solid waste incinerator plants. Data on cancer incidence among the residents, obtained from the national cancer registration programme, were compared with national cancer rates, and numbers of observed and expected cases were calculated after stratifying for deprivation, based on the 1981 census. Observed-expected ratios were tested for decline in risk up to 7.5 km away. The study was conducted in two stages: the first involved a stratified random sample of 20 incinerators and, based on the findings, a number of cancers were then further studied around the remaining 52 incinerators (second stage). Over the two stages of the study there was a statistically significant ($p < 0.05$) decline in risk with distance from incinerators for all cancers, stomach, colorectal, liver and lung cancer. The use of distance as the exposure variable in this study could have led to some degree of misclassification (--). On the other hand, the same authors observed that residual confounding (+) as well as misdiagnosis (+) might have increased the risk estimates. When further analyses were made, including a histological review of liver cancer cases [31], the risk estimates were lower (0.53-0.78 excess cases per 10^5 per year within 1 km, instead of 0.95 excess cases per 10^5 as previously estimated).

Using data on municipal solid waste incinerators from the initial study by Elliott et al. [30], Knox [32] examined a possible association between childhood cancers and industrial emissions, including those from incinerators. From a database of 22,458 cancer deaths that occurred in children before their 16th birthday between 1953 and 1980, he extracted 9,224 cases known to have moved at least 0.1 km in their life time, and using a newly developed technique of analysis, he compared distances from the suspected sources to the birth addresses and to the death addresses. The childhood-cancer/leukaemia data showed highly significant excesses of moves away from birthplaces close to municipal incinerators, but the specific effects of the municipal incinerators could not be separated clearly from those of nearby industrial sources of combustion. Misclassification of exposure is the main limit of this paper (--).

In France, Viel et al. [33] detected a cluster of patients with non-Hodgkin's lymphoma (NHL) and soft tissue sarcoma around a French municipal solid waste incinerator with high dioxin emissions. To better explore the environmental origin of the cluster suggested by these findings, Floret et al. [34] carried out a population-based case-control study in the same area, comparing 222 incident cases of NHL diagnosed between 1980 and 1995 and controls randomly selected from the 1990 census. The risk of developing lymphomas was 2.3 times higher among individuals living in the area with the highest dioxin concentration than among those in the area with the lowest concentration. Given that a model was used to attribute exposure to cases and controls, a random misclassification could have reduced the effect estimates (--). Based of these results, a nationwide study on NHL was conducted [35]. A total of 13 incinerators in France were investigated and dispersion modelling was used to estimate ground-level dioxin concentration. Information about the exposure levels and potential confounders was available at the census block level. A positive association between dioxin level and NHL was found with a stronger effect among females. Although the study represents an improvement regarding exposure assessment compared to investigations based on distance from the source, it should be noted that the analysis was conducted at the census block level and the possibility of misclassification of the exposure (-) as well as of residual confounding from socioeconomic status (+) remains.

Viel et al. [36] have recently reported the findings from a case-control study on breast cancer. There was no association or even a negative association between exposure to dioxin and breast cancer in women younger or older than 60 years, respectively, living near a French municipal solid waste incinerator with high exposure to dioxin. Design issues and residual confounding from age and other factors (---) limit the interpretations of the study.

In Italy, Biggeri et al. [37] conducted a case-control study in Trieste to investigate the relationship between multiple sources of environmental pollution and lung cancer. Based on distance from the sources, spatial models were used to evaluate the risk gradients and the directional effects separately for each source, after adjusting for age, smoking habits, likelihood of exposure to occupational carcinogens, and levels of air particulate. The results showed that the risk of lung cancer was inversely related to the distance from the incinerator, with a high excess relative risk very near the source and a very steep decrease moving away from it. The main problem of the study is the difficulty to separate the effects of other sources of pollution based on distance, and the possibility of potential confounding from other sources remains (++). An excess risk of lung cancer was also found in females living in two areas of the province of La Spezia (Italy) exposed to environmental pollution emitted by multiple sources, including an industrial waste incinerator [38]. Again in this study the limited exposure assessment could have decreased the risk estimates (--), but positive confounding from other sources is very likely.

A case-control study by Comba et al. [39] showed a significant increase in risk of soft tissue sarcomas associated with residence within two km of an industrial waste incin-

erator in the city of Mantua, with a rapid decrease in risk at greater distances. There is a slight likelihood that increased attention to the diagnosis for this form of cancer in the vicinity of the plant could have introduced a small bias (+) in the risk estimate. Another case-control study, carried out in the province of Venice by Zambon et al. [40] analyzed the association between soft-tissue sarcoma and exposure to dioxin in a large area with 10 municipal solid waste incinerators. The authors found a statistically significant increase in the risk of sarcoma in relation to both the level and the length of environmental modelled exposure to dioxin-like substances. The results were more significant for women than for men.

In summary, although several uncertainties limit the overall interpretation of the findings, there is limited evidence that people living in proximity of an incinerator have increased risk of all cancers, stomach, colon, liver, lung cancers based on the studies of Elliott et al. [30]. Specific studies on incinerators in France and in Italy suggest an increased risk for non-Hodgkin's lymphoma, and soft-tissue sarcoma.

Birth defects and reproductive disorders

Six studies examined reproductive effects of incinerator emissions (see additional file 2).

Jansson et al. [41] analysed whether the incidence of cleft lip and palate in Sweden increased since operation of a refuse incineration plant began. The results of this register study, based on information from the central register of malformations and the medical birth register, did not demonstrate an increased risk.

A study by Lloyd et al. [42] examined the incidence of twin births between 1975 and 1983 in two areas near a chemical and a municipal waste incinerator in Scotland: after adjusting for maternal age, an increased frequency of twinning in areas exposed to air pollution from incinerators was seen. In the same study areas, Williams et al. [43] investigated gender ratios, at various levels of geographical detail and using three-dimensional mapping techniques: analyses in the residential areas at risk from airborne pollution from incinerators showed locations with statistically significant excesses of female births.

To investigate the risk of stillbirth, neonatal death, and lethal congenital anomaly among infants of mothers living close to incinerators (and crematoriums), Dummer et al. [44] conducted a geographical study in Cumbria (Great Britain). After adjusting for social class, year of birth, birth order, and multiple births, there was an increased risk of lethal congenital anomaly, in particular spina bifida and heart defects.

Subsequently, Cordier et al. [45] studied communities with fewer than 50,000 inhabitants surrounding the 70 incinerators that operated for at least one year from 1988 to 1997 in France. Each exposed community was assigned an exposure index based on a Gaussian plume model, estimating concentrations of pollutants per number of years the plant had operated. The results were adjusted for year of birth, maternal age, department of birth, population density, average family income, and when available, local road traffic. The rate of congenital anomalies was not significantly higher in exposed compared with unexposed communities; only some subgroups of congenital anomalies, specifically facial cleft and renal dysplasia, were more frequent in the exposed communities.

Tango et al. [46] investigated the association of adverse reproductive outcomes with mothers living within 10 km of 63 municipal solid waste incinerators with high dioxin emission levels (above 80 ng international toxic equivalents TEQ/m^3) in Japan. To calculate the expected number of cases, national rates based on all live births, fetal deaths and infant deaths occurred in the study area during 1997-1998 were used and stratified by potential confounding factors available from the corresponding vital statistics records: maternal age, gestational age, birth weight, total previous deliveries, past experience of fetal deaths, and type of paternal occupation. None of the reproductive outcomes studied showed statistically significant excess within two km of the incinerators, but a statistically significant decline in risk with distance from the incinerators was found for infant deaths and for infant deaths with congenital anomalies, probably due to dioxin emissions from the plants.

In sum, there are multiple reports of increased risk of congenital malformations among people living close to incinerators but there are no consistencies between the investigated outcomes. The overall evidence may be considered as limited. The study by Cordier et al. [45] provides the basis for risk quantifications at least for facial cleft and renal dysplasia. Quantification for other reproductive disorders is more difficult.

Respiratory and skin diseases or symptoms

Four studies examined respiratory and/or dermatologic effects of incinerator emissions (see additional file 2).

Hsiue et al. [47] evaluated the effect of long-term air pollution resulting from wire reclamation incineration on respiratory health in children. 382 primary school children who resided in one control and three polluted areas in Taiwan were chosen for this study. The results revealed a decrement in pulmonary function (including forced vital capacity and forced expiratory volume in one second) of those residents in the vicinity of incineration sites.

Shy et al. [48] studied the residents of three communities having, respectively, a biomedical and a municipal incinerator, and a liquid hazardous waste-burning industrial furnace, and then compared results with three matched-comparison communities. After adjustment for several confounders (age, sex, race, education, respiratory disease risk factors), no consistent differences in the prevalence of chronic or acute respiratory symptoms resulted between incinerator and comparison communities. Additionally, no changes in pulmonary function between subjects of an incinerator community and those of its comparison community resulted from the study by Lee et al. [49], based on a longitudinal component from the Health and Clean Air study by Shy et al. [48].

Miyake et al. [50] examined the relationship between the prevalence of allergic disorders and general symptoms in Japanese children and the distance of schools from incineration plants, measured using geographical information systems. After adjusting for grade, socio-economic status and access to health care per municipality, schools closer to the nearest municipal waste incineration plant were associated with an increased prevalence of wheeze and headache; there was no evident relationship between the distance of schools from such plants and the prevalence of atopic dermatitis. The main factors that may have affected the relative risk estimates in this study could be reporting bias (++) and residual confounding from socioeconomic status (++).

In sum, although the intensive study conducted by Shy et al. [48] did not show respiratory effects, there are some indications of an increased risk of respiratory diseases, especially in children. However, the uncertainty related to outcome assessment and residual confounding is very high and the overall evidence may be considered inadequate.

Occupational studies on incinerator employees

Four studies conducted on incinerator employees were reviewed (see additional file 3).

In 1997, Rapiti et al. [51] conducted a retrospective mortality study on 532 male workers employed at two municipal waste incinerators in Rome (Italy) between 1962 and 1992. Standardized mortality ratios (SMRs) were computed using regional population mortality rates. Mortality from all causes resulted significantly lower than expected, and all cancer mortality was comparable with that of the general population. Mortality from lung cancer was lower than expected, but an increased risk was found for stomach cancer: analysis by latency since first exposure indicated that this excess risk was confined to the category of workers with more than 10 years since first exposure.

Bresnitz et al. [52] studied 89 of 105 male incinerator workers in Philadelphia, employed at the time of the study in late June 1988. Based on a work site analysis, workers were divided into potentially high and low exposure groups, and no statistically significant differences in pulmonary function were found between the two groups, after adjusting for smoking status.

A similar study was conducted by Hours et al. [53]: they analysed 102 male workers employed by three French urban incinerators during 1996, matched for age with 94 male workers from other industrial activities. The exposed workers were distributed into 3 exposure categories based on air sampling at the workplace: crane and equipment operators, furnace workers, and maintenance and effluent-treatment workers. An excess of respiratory problems, mainly daily cough, was more often found in the exposed groups, and a significant relationship between exposure and decreases in several pulmonary parameters was also observed, after adjusting for tobacco consumption and centre. The maintenance and effluent group, and the furnace group had elevated relative risks for skin symptoms.

In the same year, Takata et al. [54] conducted a cross-sectional study in Japan on 92 workers from a municipal solid waste incinerator to investigate the health effects of chronic exposure to dioxins. The concentrations of these chemicals among the blood of the workers who had engaged in maintenance of the furnace, electric dust collection, and the wet scrubber of the incinerator were higher compared with those of residents in surrounding areas, but there were no clinical signs or findings correlated to blood levels of dioxins.

In sum, there are some studies that suggest increased gastric cancer and respiratory problems among incinerators workers. However, there are a great number of uncertainties, which make it difficult to derive conclusions.

Epidemiological studies of health effects of other waste management processes

Twelve epidemiologic studies on the potential adverse health effects of other waste management practices are reviewed and listed in additional file 4.

Waste collection

Ivens et al. [55] investigated the adverse health effects among waste collectors in Denmark. In a questionnaire-based survey among 2303 waste collectors and a comparison group of 1430 male municipal workers, information on self-reported health status and working conditions was collected and related to estimated bioaerosol exposure. After adjusting for several confounders (average alcohol consumption per day, smoking status, and the psychosocial exposure measures support/demand), a dose-

response relationship between level of exposure to fungal spores and self-reported diarrhoea was indicated, meaning that the higher the weekly dose, the more reports of gastrointestinal symptoms.

In contrast with these results, a study of 853 workers employed by 27 municipal household waste collection departments in Taiwan did not find an excess of gastrointestinal symptoms [56]. The workers answered a questionnaire and were classified into two occupational groups by specific exposures based on the reported designation of their specific task. The exposed group included those working in the collection of mixed domestic waste, front runner or loader, collection of separated waste and special kinds of domestic waste (paper, glass, etc.), garden waste, bulky waste for incineration, and the vehicle driver; the control group included accountants, timekeepers, canteen staff, personnel, and other office workers. No significant differences were found in the prevalence of gastrointestinal symptoms, but results indicated that all respiratory symptom prevalence, except dyspnoea, were significantly higher in the exposed group, after adjusting for age, gender, education, smoking status, and duration of employment.

Composting facilities

In a German cross sectional study by Bünger et al. [57], work related health complaints and diseases of 58 compost workers and 53 bio-waste collectors were investigated and compared with 40 control subjects. Compost workers had significantly more symptoms and diseases of the skin and the airways than the control subjects. No correction was performed for the confounding effect of smoking, as there were no significant differences in the smoking habits of the three groups.

A subsequent study in Germany by Herr et al. [58] examined the health effects on community residents of bio-aerosol, emitted by a composting plant. A total of 356 questionnaires from residents living at different distances from the composting site, and from unexposed controls were collected: self-reported prevalence of health complaints over past years, doctors' diagnoses, as was residential odor annoyance; microbiological pollution was measured simultaneously in residential outdoor air. Reports of airway irritation were associated with residency in the highest bio-aerosol exposure category, 150-200 m (versus residency >400-500 m) from the site, and periods of residency more than five years.

Bünger et al. [59] conducted a prospective cohort study to investigate, in 41 plants in Germany, the health risks of compost workers due to long term exposure to organic dust that specifically focused on respiratory disorders. Employees, exposed and not exposed to organic dust, were interviewed about respiratory symptoms and diseases in the last 12 months and had a spirometry after a 5-year follow-up. Exposure assessment was conducted at 6 out of 41 composting plants and at the individual level. Eyes, airways and skin symptoms were higher in compost workers than in the control group. There was also a steeper decline of Forced Vital Capacity among compost workers compared to control subjects, also when smoking was considered.

Materials recycling facilities

There are no epidemiological studies of populations living near materials recycling facilities; only studies on employees are available.

In the already-quoted study by Rapiti et al. [51] on workers at two municipal plants for incinerating and garbage recycling, increased risk was found for stomach cancer in employees who had worked there for at least 10 years, while lung cancer mortality risk was lower than expected.

In the study by Rix et al. [60], 5377 employees of five paper recycling plants in Denmark between 1965 and 1990 were included in a historical cohort, and the expected number of cancer cases was calculated from national rates. The incidence of lung cancer was slightly higher among men in production and moderately higher in short term workers with less than 1 year of employment; there was significantly more pharyngeal cancer among males, but this may have been influenced by confounders such as smoking and alcohol intake.

Sigsgaard et al. [61] conducted a cross-sectional study to examine the effect of shift changes on lung function among 99 recycling workers (resource recovery and paper mill workers), and correlated these findings with measurements of total dust and endotoxins. Exposure to organic dust caused a fall in FEV_1 over the work shift, and this was significantly associated with exposure to organic dust; no significant association was found between endotoxin exposure and lung function decreases.

The same authors [62] also analysed skin and gastrointestinal symptoms among 40 garbage handlers, 8 composters and 20 paper sorters from all over Denmark, and found that garbage handlers had an increased risk of skin itching, and vomiting or diarrhoea.

In a nationwide study, Ivens et al. [63] reported findings of self-reported gastrointestinal symptoms by self-reported type of plant. A questionnaire based survey among Danish waste recycling workers at all composting, biogas-producing, and sorting plants collected data on occupational exposures (including questions on type of plant, type of waste), present and past work environment,

the psychosocial work environment, and health status. Prevalence rate ratios adjusted for other possible types of job and relevant confounders were estimated with a comparison group of non-exposed workers, and an association was found between sorting paper and diarrhoea, between nausea and work at plastic sorting plants, and non-significantly between diarrhoea and work at composting plants.

The health status of workers employed in the paper recycling industry was also studied by Zuskin et al. [64]. A group of 101 male paper-recycling workers employed by one paper processing plant in Croatia, and a group of 87 non-exposed workers employed in the food packing industry was studied for the prevalence of chronic respiratory symptoms, and results indicated significantly higher prevalence of all chronic respiratory symptoms were found in paper workers compared with controls.

Gladding et al. [65] studied 159 workers from nine materials recovery facilities (MRFs) in the United Kingdom. Total airborne dust, endotoxins, (1-3)-beta-D-glucan were measured, and a questionnaire-survey was completed. The results suggest that materials recovery facilities workers exposed to higher levels of endotoxins and (1-3)-beta-D-glucan at their work sites experience various work-related symptoms, and that the longer a worker is in the MRF environment, the more likely he is to become affected by various respiratory and gastrointestinal symptoms.

Choosing relative risk estimates for health impact assessment of residence near landfills and incinerators

The reviewed studies have been used to summarize the evidence available, as indicated in table 1. When the overall degree of evidence was considered "inadequate" we decided not to propose a quantitative evaluation of the relative risk; when we arrived to a conclusion that "limited" evidence was available, relative risk estimates were extracted for use in the health impact assessment process. Table 2 summarizes the relevant and reliable figures for health effects related to landfills and incinerators. For each relative risk the distance from the source has been reported as well as the overall level of confidence of the effect estimates based on an arbitrary scale: very high, high, moderate, low, very low.

Landfills

From the review presented above and following the work already made by Russi et al. [11], it is clear that the studies on cancer are not sufficient to draw conclusions regarding health effects near landfills, both with toxic and non-toxic wastes. The largest study conducted in England by Jarup et al. [21] does not suggest an increase in the cancer types that were investigated. Investigations of other chronic dis-

Table 1: Summary of the overall epidemiologic evidence on municipal solid waste disposal: landfills and incinerators.

HEALTH EFFECT	LEVEL OF EVIDENCE	
	LANDFILLS	**INCINERATORS**
All cancer	Inadequate	Limited
Stomach cancer	Inadequate	Limited
Colorectal cancer	Inadequate	Limited
Liver cancer	Inadequate	Limited
Larynx cancer	Inadequate	Inadequate
Lung cancer	Inadequate	Limited
Soft tissue sarcoma	Inadequate	Limited
Kidney cancer	Inadequate	Inadequate
Bladder cancer	Inadequate	Inadequate
Non Hodgkin's lymphoma	Inadequate	Limited
Childhood cancer	Inadequate	Inadequate
Total birth defects	Limited	Inadequate
Neural tube defects	Limited	Inadequate
Orofacial birth defects	Inadequate	Limited
Genitourinary birth defects	Limited*	Limited**
Abdominal wall defects	Inadequate	Inadequate
Gastrointestinal birth defects§	Inadequate	Inadequate
Low birth weight	Limited	Inadequate
Respiratory diseases or symptoms	Inadequate	Inadequate

"*Inadequate*": available studies are of insufficient quality, consistency, or statistical power to decide the presence or absence of a causal association.
"*Limited*": a positive association has been observed between exposure and disease for which a causal interpretation is considered to be credible, but chance, bias, or confounding could not be ruled out with reasonable confidence.
* Hypospadias and epispadias
** Renal dysplasia
§ The original estimates were given for "surgical corrections of gastroschisis and exomphalos"

Table 2: Relative risk estimates for community exposure to landfills and incinerators

Health effect	Distance from the source	Relative Risk (Confidence Interval)	Level of confidence**
Landfills			
Congenital malformations [24]			
All congenital malformations	Within 2 km	1.02 (99% CI = 1.01-1.03)	Moderate
Neural tube defects	Within 2 km	1.06 (99% CI = 1.01-1.12)	Moderate
Hypospadias and epispadias	Within 2 km	1.07 (99% CI = 1.04-1.11)	Moderate
Abdominal wall defects	Within 2 km	1.05 (99% CI = 0.94-1.16)	Moderate
Gastroschisis and exomphalos*	Within 2 km	1.18 (99% CI = 1.03-1.34)	Moderate
Low birth weight [24]	Within 2 km	1.06 (99% CI = 1.052-1.062)	High
Very low birth weight	Within 2 km	1.04 (99% CI = 1.03-1.06)	High
Incinerators			
Congenital malformations [45]			
Facial cleft	Within 10 km	1.30 (95% CI = 1.06-1.59)	Moderate
Renal dysplasia	Within 10 km	1.55 (95% CI = 1.10-2.20)	Moderate
Cancer [30]			
All cancer	Within 3 km	1.035 (95% CI = 1.03-1.04)	Moderate
Stomach cancer	Within 3 km	1.07 (95% CI = 1.02-1.13)	Moderate
Colorectal cancer	Within 3 km	1.11 (95% CI = 1.07-1.15)	Moderate
Liver cancer	Within 3 km	1.29 (95% CI = 1.10-1.51)	High
Lung cancer	Within 3 km	1.14 (95% CI = 1.11-1.17)	Moderate
Soft-tissue sarcoma	Within 3 km	1.16 (95% CI = 0.96-1.41)	High
Non-Hodgkin's lymphoma	Within 3 km	1.11 (95% CI = 1.04-1.19)	High

*The original estimates were given for "surgical corrections of..". **The following scale for the level of confidence has been adopted: very high, high, moderate, low, very low.

eases are lacking, especially of respiratory diseases, yet there is one indication of an increased risk of asthma in adults [19], but with no replication of the findings. Overall, the evidence that living near landfills may be associated with health effects in adults is inadequate.

A slightly different picture appears for congenital malformations and low birth weight, where limited evidence exists of an increased risk for infants born to mothers living near landfill sites. The relevant results come from the European EUROHAZCON Study [23] and the national investigation from Elliott et al. [24]. In the UK report, statistically significant higher risk were found for all congenital malformations, neural tube defects, abdominal wall defects, surgical correction of gastroschisis and exomphalos, and low and very low birth weight for births to people living within two km of the sites, both of hazardous and non-hazardous waste. Although several alternative explanations, including ascertainment bias, and residual confounding cannot be excluded in the study, Elliott et al. [24] provide quantitative effect estimates whose level of confidence can be considered as moderate.

Incinerators

Quantitative estimates of excess risk of specific cancers in populations living near solid waste incinerator plants were provided by Elliott et al. [30]. We have reported in table 2 the effect estimates for all cancers, stomach, colon, liver, and lung cancer based on their "second stage" analysis. There was an indication of residual confounding from socioeconomic status near the incinerators and a concern of misdiagnosis among registrations and death certificates for liver cancer. The histology of the liver cancer cases was reviewed, re-estimating the previously calculated excess risk (from 0.95 excess cases 10^{-5}/year to between 0.53 and 0.78 excess cases 10^{-5}/year). We then graded the confidence of the assessment for these tumours as "moderate" with the exception of liver cancer (high) since the misdiagnosis was reassessed and the extent of residual confounding was lower. In the study by Elliott et al. [30] no significant decline in risk with distance for non-Hodgkin's lymphoma and soft tissue sarcoma was found. However, the studies of Viel et al. [33] and Floret et al. [34] conducted in France and the studies from Comba et al. [39] and Zambon et al. [40] in Italy provide some indications that an excess of these forms of cancers may be related to emissions of dioxins from incinerators. As a result, we provided effect estimates in table 2 also for non-Hodgkin's lymphoma and soft tissue sarcoma as derived from the conservative "first stage" analysis conducted by Elliott et al. [30]. We graded the level of confidence of these relative risk estimates as "high".

With regards to congenital malformations near incinerators, Cordier et al. [45] provided effect estimates for facial cleft and renal dysplasia, as they were more frequent in the "exposed" communities living within 10 km of the sites. Other reproductive effects, such as an effect on twinning rates or gender determination, have been described; however the results are inadequate.

Conclusions

We have conducted a systematic review of the literature regarding the health effects of waste management. After the extensive review, in many cases the overall evidence was inadequate to establish a relationship between a specific waste process and health effects. However, at least for some associations, a limited amount of evidence has been found and a few studies were selected for a quantitative evaluation of the health effects. These relative risks could be used to assess health impact, considering that the level of confidence in these effect estimates is at least moderate for most of them.

Most of the reviewed studies suffer from limitations related to poor exposure assessment, aggregate level of analysis, and lack of information on relevant confounders. It is clear that future research into the health risks of waste management requires a more accurate characterization of individual exposure, improved knowledge of chemical and toxicological data on specific compounds, multi-site studies on large populations to increase statistical power, approaches based on individuals rather than communities and better control of confounding factors.

List of abbreviations used

EU: European Union; INTARESE: Integrated Assessment of Health Risks of Environmental Stressors in Europe; NHL: non-Hodgkin's Lymphoma; OR: Odds ratio; TEQ: Toxic Equivalent.

Competing interests

The authors declare that they have no competing interests.

Authors' contributions

DP participated in the design of the study, conducted the systematic review and drafted the manuscript. SM conducted the systematic review and contributed to draft the manuscript. AIL participated in the systematic review and contributed to draft the manuscript. CAP helped to conceive of the study and to write and revise the manuscript. FF conceived and coordinated the study and helped to write and revise the manuscript. All authors have read and approved the final manuscript.

Additional material

Additional file 1

***Studies on landfills**. The data provided represent a brief description of the studies on populations living near landfills.*
Click here for file
[http://www.biomedcentral.com/content/supplementary/1476-069X-8-60-S1.XLS]

Additional file 2

***Studies on incinerators**. The data provided represent a brief description of the studies on populations living near incinerators.*
Click here for file
[http://www.biomedcentral.com/content/supplementary/1476-069X-8-60-S2.XLS]

Additional file 3

***Studies on occupational exposures among incinerators and landfills workers**. The data provided represent a brief description of the studies on workers of waste management plants.*
Click here for file
[http://www.biomedcentral.com/content/supplementary/1476-069X-8-60-S3.XLS]

Additional file 4

***Studies on other waste management processes**. The data provided represent a brief description of the studies on population living near plants using waste management technologies different from landfills and incinerators.*
Click here for file
[http://www.biomedcentral.com/content/supplementary/1476-069X-8-60-S4.XLS]

Acknowledgements

This study was funded by the INTARESE project. INTARESE is a 5-year Integrated Project funded under the EU 6th Framework Programme - Priority 6.3 Global Change and Ecosystems. We thank Margaret Becker for a linguistic revision the text. We are in debt to Martine Vrijheid for her comments on an earlier version of the manuscript.

References

1. Vrijheid M: **Health effects of residence near hazardous waste landfill sites: a review of epidemiologic literature.** *Environ Health Perspect* 2000, **108(suppl 1):**101-112.
2. Rushton L: **Health hazards and waste management.** *Br Med Bull* 2003, **68:**183-197.
3. Franchini M, Rial M, Buiatti E, Bianchi F: **Health effects of exposure to waste incinerator emissions: a review of epidemiological studies.** *Ann Ist Super Sanita* 2004, **40:**101-115.
4. Saunders P: **A systematic review of the evidence of an increased risk of adverse birth outcomes in populations living in the vicinity of landfill waste disposal sites.** In *Population health and waste management: scientific data and policy options. Report of a WHO workshop Rome, Italy, 29-30 March 2007* Edited by: Mitis F, Martuzzi M. WHO, Regional Office for Europe, Copenhagen; 2007:25-27.
5. Briggs DJ: **A framework for integrated environmental health impact assessment of systemic risks.** *Environ Health* 2008, **7:**61.
6. Poulsen OM, Breum NO, Ebbehoj N, Hansen AM, Ivens UI, van Lelieveld D, Malmros P, Matthiasen L, Nielsen BH, Nielsen EM, Schibye B, Skov T, Stenbaek EI, Wilkins CK: **Sorting and recycling of domestic waste. Review of occupational health problems and their possible causes.** *Sc Total Environ* 1995, **168:**33-56.
7. Poulsen OM, Breum NO, Ebbehoj N, Hansen AM, Ivens UI, van Lelieveld D, Malmros P, Matthiasen L, Nielsen BH, Nielsen EM, Schibye B, Skov T, Stenbaek EI, Wilkins CK: **Collection of domestic waste. Review of occupational health problems and their possible causes.** *Sc Total Environ* 1995, **170:**1-19.
8. Hu SW, Shy CM: **Health effects of waste incineration: a review of epidemiologic studies.** *J Air Waste Manag Assoc* 2001, **51:**1100-1109.
9. Dolk H, Vrijheid M: **The impact of environmental pollution on congenital anomalies.** *Br Med Bull* 2003, **68:**25-45.

10. Department for Environment, Food and Rural Affairs (DEFRA): *Review of Environmental and Health Effects of waste management: municipal solid waste and similar wastes. UK* 2004.
11. Russi MB, Borak JB, Cullen MR: **An examination of cancer epidemiology studies among populations living close to toxic waste sites.** *Environ Health* 2008, **26:**7-32.
12. Rydhstroem H: **No obvious spatial clustering of twin births in Sweden between 1973 and 1990.** *Environ Res* 1998, **76:**27-31.
13. Fukuda Y, Nakamura K, Takano T: **Dioxins released from incineration plants and mortality from major diseases: an analysis of statistical data by municipalities.** *J Med Dent Sci* 2003, **50:**249-255.
14. Altavista P, Belli S, Bianchi F, Binazzi A, Comba P, Del Giudice R, Fazzo L, Felli A, Mastrantonio M, Menegozzo M, Musmeci L, Pizzuti R, Savarese A, Trinca S, Uccelli R: **Cause-specific mortality in an area of Campania with numerous waste disposal sites.** *Epidemiol Prev* 2004, **28:**311-321. Italian
15. Biggeri A, Catelan D: **Mortality for non-Hodgkin lymphoma and soft-tissue sarcoma in the surrounding area of an urban waste incinerator. Campi Bisenzio (Tuscany, Italy) 1981-2001.** *Epidemiol Prev* 2005, **29:**156-159.
16. Minichilli F, Bartolacci S, Buiatti E, Pallante V, Scala D, Bianchi F: **A study on mortality around six municipal solid waste landfills in Tuscany Region.** *Epidemiologia' Prevenzione* 2005, **29(suppl 5-6):**53-56.
17. Bianchi F, Minichilli F: **Mortality for non-Hodgkin lymphoma in the period 1981-2000 in 25 Italian municipalities with urban solid waste incinerators.** *Epidemiol Prev* 2006, **30:**80-81.
18. Goldberg MS, Siemiatyck J, DeWar R, Dèsy M, Riberdy H: **Risk of developing cancer relative to living near a municipal solid waste landfill site in Montreal, Quebec, Canada.** *Arch Environ Health* 1999, **54:**291-296.
19. Pukkala E, Pönkä A: **Increased incidence of cancer and asthma in houses buuilt on a former dump area.** *Environ Health Perspect* 2001, **109:**1121-1125.
20. Jarup L, Briggs D, de Hoogh C, Morris S, Hurt C, Lewin A, Maitland I, Richardson S, Wakefield J, Elliott P: **Cancer risks in populations living near landfill sites in Great Britain.** *Br J Cancer* 2002, **86:**1732-1736.
21. Michelozzi P, Fusco D, Forastiere F, Ancona C, Dell'Orco V, Perucci CA: **Small area study of mortality among people living near multiple sources of air pollution.** *Occup Environ Med* 1998, **55:**611-615.
22. Vrijheid M, Dolk H, Armstrong B, Abramsky L, Bianchi F, Fazarinc I, Garne E, Ide R, Nelen V, Robert E, Scott JE, Stone D, Tenconi R: **Chromosomal congenital anomaliesand residence near hazardous waste landfill sites.** *Lancet* 2002, **359:**320-322.
23. Dolk H, Vrijheid M, Armstrong B, Abramsky L, Bianchi F, Garne E, Nelen V, Robert E, Scott JE, Stone D, Tenconi R: **Risk of congenital anomalies near hazardous-waste landfill sites in Europe: the EUROHAZCON study.** *Lancet* 1998, **352:**423-427.
24. Elliott P, Briggs D, Morris S, de Hoogh C, Hurt C, Jensen TK, Maitland I, Richardson S, Wakefield J, Jarup L: **Risk of adverse birth outcomes in populations living near landfill sites.** *Br Med J* 2001, **323:**363-368.
25. Elliot P, Richardson S, Abellan JJ, Thomson A, de Hoog C, Jaruo L, Briggs DJ: **Geographic density of landfill sites and risk of congenital anomalies in England.** *Occup Environ Med* 2009, **66:**81-89.
26. Kloppenborg SCh, Brandt UK, Gulis G, Ejstrud B: **Risk of congenital anomalies in the vicinity of waste landfills in Denmark; an epidemiological study using GIS.** *Cent Eur J Public Health* 2005, **13:**137-143.
27. Jarup L, Morris S, Richardson S, Briggs D, Cobley N, de Hoog C, Gorog K, Elliot P: **Down syndrome in births near landfill sites.** *Prenat Diagn* 2007, **27:**1191-1196.
28. Gilbreath S, Kaas PH: **Adverse birth outcomes associated with open dumpsites in Alaska native villages.** *Am J Epidemiol* 2006, **164:**518-528.
29. Gelberg KH: **Health study of New York City Department of Sanitation landfill employees.** *Journal of Occup Environ Med* 1997, **39:**1103-1110.
30. Elliott P, Shaddick G, Kleinschmidt I, Jolley D, Walls P, Beresford J, Grundy C: **Cancer incidence near municipal solid waste incinerators in Great Britain.** *Br J Cancer* 1996, **73:**702-710.
31. Elliott P, Eaton N, Shaddick G, Carter R: **Cancer incidence near municipal solid waste incinerators in Great Britain. Part 2: histopathological and case-note review of primary liver cancer cases.** *Br J Cancer* 2000, **82:**1103-1106.
32. Knox E: **Childhood cancers, birthplaces, incinerators and landfill sites.** *Int J Epidemiol* 2000, **29:**391-397.
33. Viel JF, Arveux P, Baverel J, Cahn JY: **Soft-tissue sarcoma and non-Hodgkin's lymphoma clusters around a municipal solid waste incinerator with high dioxin emission levels.** *Am J Epidemiol* 2000, **152:**13-19.
34. Floret N, Mauny F, Challier B, Arveux P, Cahn JY, Viel JF: **Dioxin emissions from a solid waste incinerator and risk of non-Hodgkin lymphoma.** *Epidemiology* 2003, **14:**392-398.
35. Viel JF, Daniau C, Goria S, Fabre P, de Crouy-Chanel P, Sauleau EA, Empereur-Bissonnet P: **Risk for non Hodgkin's lymphoma in the vicinity of French municipal solid waste incinerators.** *Environ Health* 2008, **7:**51.
36. Viel JF, Clement MC, Hägi M, Grandjean S, Challier B, Danzon A: **Dioxin emissions from a municipal solid waste incinerator and risk of invasive breast cancer: a population-based case-sontrol study with GIS-derived exposure.** *Environ Health* 2008, **7:**4.
37. Biggeri A, Barbone F, Lagazio C, Bovenzi M, Stanta G: **Air pollution and lung cancer in Trieste, Italy: spatial analysis of risk as a function of distance from sources.** *Environ Health Perspect* 1996, **104:**750-754.
38. Parodi S, Baldi R, Benco C, Franchini M, Garrone E, Vercelli M, Pensa F, Puntoni R, Fontana V: **Lung cancer mortality in a district of La Spezia (Italy) exposed to air pollution from industrial plants.** *Tumori* 2004, **90:**181-185.
39. Comba P, Ascoli V, belli S, Benedetti M, Gatti L, Ricci P, Tieghi A: **Risk of soft tissue sarcomas and residence in the neighborhood of an incinerator of industrial wastes.** *Occup Environ Med* 2003, **60:**650-683.
40. Zambon P, Ricci P, Bovo E, Casula A, Gattolin M, Fiore AR, Chuiosi F, Guzzinati S: **Sarcoma risk and dioxin emissions from incinerators and industrial plants: a population-based case-control study (Italy).** *Environ Health* 2007, **6:**19.
41. Jansson B, Voog L: **Dioxin from Swedish municipal incinerators and the occurrence of cleft lip and palate malformations.** *Int J Environ Stud* 1989, **34:**99-104.
42. Lloyd OL, Lloyd MM, Williams FL, Lawson A: **Twinning in human populations and in cattle exposed to air pollution from incinerators.** *Br J Ind Med* 1988, **45:**556-560.
43. Williams FL, Lawson AB, Lloyd OL: **Low sex ratios of births in areas at risk from air pollution from incinerators, as shown by geographical analyis and 3-dimensional mapping.** *Int J Epidemiol* 1992, **21:**311-319.
44. Dummer TJ, Dickinson HO, Parker L: **Adverse pregnancy outcomes around incinerators and crematoriums in Cumbria, north west England, 1956-93.** *J Epidemiol Community Health* 2003, **57:**456-461.
45. Cordier S, Chevrier C, Robert-Gnansia E, Lorente C, Brula P, Hours M: **Risk of congenital anomalies in the vicinity of municipal solid waste incinerators.** *Occup Environ Med* 2004, **61:**8-15.
46. Tango T, Fujita T, Tanihata T, Minowa M, Doi Y, Kato N, Kunikane S, Uchiyama I, Tanaka M, Uehata T: **Risk of adverse reproductive outcomes associated with proximity to municipal solid waste incinerators with high dioxin emission levels in Japan.** *J Epidemiol* 2004, **14:**83-93.
47. Hsiue TR, Lee SS, Chen HI: **Effects of air pollution resulting from wire reclamation incineration on pulmonary function in children.** *Chest* 1991, **100:**698-702.
48. Shy CM, Degnan D, Fox DL, Mukerjee S, Hazucha MJ, Boehlecke BA, Rothenbacher D, Briggs PM, Devlin RB, Wallace DD, Stevens RK, Bromberg PA: **Do waste incinerators induce adverse respiratory effects? An air quality and epidemiological study of six communities.** *Environ Health Perspect* 1995, **103:**714-724.
49. Lee JT, Shy CM: **Respiratory function as measured by peak expiratory flow rate and PM10: six communities study.** *J Expo Anal Environ Epidemiol* 1999, **9:**293-299.
50. Miyake Y, Yura A, Misaki H, Ikeda Y, Usui T, Iki M, Shimizu T: **Relationship between distance of schools from the nearest municipal waste incineration plant and child health in Japan.** *Eur J Epidemiol* 2005, **20:**1023-1029.
51. Rapiti E, Sperati A, Fano V, Dell'Orco V, Forastiere F: **Mortality among workers at municipal waste incinerators in Rome: a retrospective cohort study.** *Am J Ind Med* 1997, **31:**659-661.

52. Bresnitz EA, Roseman J, Becker D, Gracely E: **Morbidity among municipal waste incinerator workers.** *Am J Ind Med* 1992, **22:**363-378.
53. Hours M, Anzivino-Viricel L, Maitre A, Perdrix A, Perrodin Y, Charbotel B, Bergeret A: **Morbidity among municipal waste incinerator workers: a cross-sectional study.** *Int Arch Occup Environ Health* 2003, **76:**467-472.
54. Takata T: **Survey on the health effects of chronic exposure to dioxins and its accumulation on workers of a municipal solid waste incinerator, rural part of Osaka Prefecture, and the results of extended survey afterwards.** *Ind Health* 2003, **41:**189-196.
55. Ivens UI, Hansen J, Breum NO, Ebbehoj N, Nielsen BH, Poulsen OM, Wurtz H, Skov T: **Diarrhoea among waste collectors associated with bioaerosol exposure.** *Ann Agric Environ Med* 1997, **4:**63-68.
56. Yang CY, Chang WT, Chuang HY, Tsai SS, Wu TN, Sung FC: **Adverse health effects among household waste collectors in Taiwan.** *Environ Res* 2001, **85:**195-199.
57. Bunger J, Antlauf-Lammers M, Schulz TG, Westphal GA, Muller MM, Ruhnau P, Hallier E: **Health complaints and immunological markers of exposure to bioaerosols among biowaste collectors and compost workers.** *Occup Environ Med* 2000, **57:**458-464.
58. Herr CE, Zur Nieden A, Jankofsky M, Stilianakis NI, Boedeker RH, Eikmann TF: **Effects of bioaerosol polluted outdoor air on airways of residents: a cross sectional study.** *Occup Environ Med* 2003, **60:**336-342.
59. Bünger J, Schappler-Sheele B, Hilgers R, Hallier E: **A 5-year follow-up study on respiratory disorders and lung function in workers exposed to organic dust from composting plants.** *Int Arch Occup Environ Health* 2007, **80:**306-312.
60. Rix BA, Villadsen E, Engholm G, Lynge E: **Risk of cancer among paper recycling workers.** *Occup Environ Med* 1997, **54:**729-733.
61. Sigsgaard T, Abel A, Donbaek L, Malmros P: **Lung function changes among recycling workers exposed to organic dust.** *Am J Ind Med* 1994, **25:**69-72.
62. Sigsgaard T, Hansen J, Malmros P: **Biomonitoring and work related symptoms among garbage handling workers.** *Ann Agric Environ Med* 1997, **4:**107-112.
63. Ivens UI, Ebbehoj N, Poulsen OM, Skov T: **Gastrointestinal symptoms among waste recycling workers.** *Ann Agric Environ Med* 1997, **4:**153-157.
64. Zuskin E, Mustajbegovic J, Schachter EN, Kanceljak B, Kern J, Macan J, Ebling Z: **Respiratory function and immunological status in paper-recycling workers.** *J Occup Environ Med* 1998, **40:**986-993.
65. Gladding T, Thorn J, Stott D: **Organic dust exposure and work-related effects among recycling workers.** *Am J Ind Med* 2003, **43:**584-591.

Publish with **BioMed Central** and every scientist can read your work free of charge

"BioMed Central will be the most significant development for disseminating the results of biomedical research in our lifetime."

Sir Paul Nurse, Cancer Research UK

Your research papers will be:

- available free of charge to the entire biomedical community
- peer reviewed and published immediately upon acceptance
- cited in PubMed and archived on PubMed Central
- yours — you keep the copyright

Submit your manuscript here:
http://www.biomedcentral.com/info/publishing_adv.asp

BioMedcentral

Health Effects of Residence Near Hazardous Waste Landfill Sites: A Review of Epidemiologic Literature

Martine Vrijheid

Environmental Epidemiology Unit, Department of Public Health and Policy, London School of Hygiene and Tropical Medicine, London, United Kingdom

This review evaluates current epidemiologic literature on health effects in relation to residence near landfill sites. Increases in risk of adverse health effects (low birth weight, birth defects, certain types of cancers) have been reported near individual landfill sites and in some multisite studies, and although biases and confounding factors cannot be excluded as explanations for these findings, they may indicate real risks associated with residence near certain landfill sites. A general weakness in the reviewed studies is the lack of direct exposure measurement. An increased prevalence of self-reported health symptoms such as fatigue, sleepiness, and headaches among residents near waste sites has consistently been reported in more than 10 of the reviewed papers. It is difficult to conclude whether these symptoms are an effect of direct toxicologic action of chemicals present in waste sites, an effect of stress and fears related to the waste site, or an effect of reporting bias. Although a substantial number of studies have been conducted, risks to health from landfill sites are hard to quantify. There is insufficient exposure information and effects of low-level environmental exposure in the general population are by their nature difficult to establish. More interdisciplinary research can improve levels of knowledge on risks to human health of waste disposal in landfill sites. Research needs include epidemiologic and toxicologic studies on individual chemicals and chemical mixtures, well-designed single- and multisite landfill studies, development of biomarkers, and research on risk perception and sociologic determinants of ill health. *Key words*: epidemiology, hazardous waste, health effects, landfill, residence, review. — *Environ Health Perspect* 108(suppl 1):101–112 (2000).
http://ehpnet1.niehs.nih.gov/docs/2000/suppl-1/101-112vrijheid/abstract.html

The disposal of wastes in landfill sites has increasingly caused concern about possible adverse health effects for populations living nearby, particularly in relation to those sites where hazardous waste is dumped. Studies on the health effects of landfill sites have been carried out mainly in North America and existing reviews focus entirely on this literature (*1,2*). Recent publications of large studies both in and outside North America warrant an update of evidence presented in previous reviews. Up-to-date knowledge about epidemiologic evidence for potential human health effects of landfill sites is important for those deciding on regulation of sites, their siting and remediation, and for those whose task it is to respond to concerns from the public in a satisfactory way.

We intend to present a critical discussion of all major epidemiologic studies published since 1980 on health effects related to residence near landfill sites in North America, Europe, and elsewhere. Special attention is paid to recent studies and studies outside the United States that have not been included in previous reviews.

Methods

Throughout this review the term landfill is used for any controlled or uncontrolled disposal of waste to land. Relevant papers were found through computerized literature searches on MEDLINE (MEDLINE Database, National Library of Medicine, Bethesda, MD) (*www.biomednet.com*) and BIDS Databases, Joint Information Systems Committee, University of Bath, Bath, UK (*www.bids.ac.uk*) from 1980 through to 1998 using keywords "landfill" and "hazardous waste site." In addition, articles were traced through references listed in previous reviews. All papers found in this manner that studied health effects in residents near waste landfill sites and that were published in journals available through the British Library and libraries of the University of London were included in this review. A few papers referred to in previous reviews could not be traced because they were published in local journals in the United States. Published reports of recent studies that have not yet appeared in peer-reviewed journals have been included in the review. A few abstracts of European studies have been included, although full research papers of these studies have not been published because they reflect growing concerns about landfill in Europe. A total of 50 papers, reports, and abstracts are reviewed in this article. Investigations of the health risks to those employed in the handling, transport, clean-up, or maintenance of substances at landfill sites are very scarce and have not been included in this review. Many chemicals or groups of chemicals potentially present in landfill sites, including organic solvents, polychlorinated biphenyls (PCBs), and heavy metals, have shown adverse effects on human health or in animal experiments. A discussion of findings from either epidemiologic or toxicologic research on health effects related to specific chemicals is beyond the scope of this review.

Epidemiologic Studies on Health Effects of Landfill Sites

The majority of studies evaluating possible health effects in human populations living near landfill sites investigate communities near one specific waste disposal site (single-site studies), frequently in response to concerns from the public about reported contamination from the site or reported clusters of disease. A small number of studies have addressed the risks of living near waste sites, independent of whether the sites caused concern, by a priori specifying a number of sites for study. These will be referred to as multisite studies. Single- and multisite studies have different methodologic problems and are therefore discussed separately in this paper. Most individual studies are discussed in detail in this article. Where appropriate due to common methodologic issues (e.g., in studies of self-reported health outcomes and clusters of disease) or due to a common landfill site of concern (e.g., in the Love Canal studies and Santa Clara County studies), less emphasis was put on individual studies and more on common issues. Studies included in the review are summarized in Table 1 (single-site studies) and Table 2 (multisite studies). Discussion of individual single- and multisite studies is preceded by a discussion of issues common to the interpretation of all landfill studies.

Address correspondence to M. Vrijheid, Environmental Epidemiology Unit, London School of Hygiene and Tropical Medicine, Keppel Street, WC1E 7HT London, UK. Telephone: 44 171 927 2415. Fax: 44 171 580 4524. E-mail: m.vrijheid@lshtm.ac.uk

This work was conducted under a research fellowship from The Colt Foundation. The project was funded specifically by the U.K. Environment Agency. The views expressed are those of the author and the Environment Agency accepts no liability for any loss or damage arising from the interpretation or use of the information or reliance on views contained herein. The author is grateful to H. Dolk and B. Armstrong for their comments on several drafts of this review.

Received 24 November 1998; accepted 7 June 1999.

Table 1. Single-site studies.

Ref.	Study design	Study subjects	Exposure measure	Health outcomes studied	Reported findings
(7)	Geographical comparison	Love Canal census tract; comparison: New York State	Residence in Love Canal census tract	Cancer: liver, lymphomas, leukemia, other organ sites	No increased incidence
(8)	Cross-sectional	46 exposed residents; comparison: residents in adjacent census tract	Residence in houses where chemicals were detected	SCEs and CAs	No difference in frequency of chromosome changes
(9)	Cross-sectional	523 Love Canal children; 440 control children	Proximity to site; at least 5 months' residence in Love Canal area	Self-reported health problems: seizures, learning problems, hyperactivity, eye irritation, skin rashes, abdominal pain, and incontinence	Increased prevalence of all symptoms
(10)	Cross-sectional	428 Love Canal children; 493 control children	Born in Love Canal and more than 75% of life in Love Canal	Children's stature, weight, weight for stature	Shorter stature for Love Canal children. No difference in weight
(11)	Retrospective follow-up	174 births near site; 443 live births in rest of Love Canal area; all births in New York State	Residence in Love Canal area	LBW	Higher percentage of LBW in exposed area; excess in period of active dumping
(12)	Retrospective follow-up	239 exposed children; 707 unexposed	Residence in Love Canal area during pregnancy	LBW, birth defects	3-fold risk of LBW (homeowners only); increased risk for birth defects (homeowners and renters)
(26)	Retrospective follow-up	2,092 births in proximate area; 6,840 births in control area	Residence at birth in area closest to landfill	Average birth weight, LBW, preterm birth	Significantly lower average birth weight, higher proportion of LBW and prematurity during the time of heaviest pollution
(14)	Retrospective follow-up	25,216 births	Residence in census tract, proximate zone, and frequency of odor complaints	LBW, fetal mortality, infant mortality, prematurity	No difference over entire study period; moderate decrease in birth weight in high odor complaint zone in period of highest exposure
(27)	Case–control	7,977 LBW cases; 7,856 control births	Residence in areas adjacent to landfill and level of estimated exposure to landfill gas	LBW, very LBW, preterm birth, small for gestational age	Excess in LBW and small for gestational age births; no excess in very LBW or preterm birth
(21)	Geographical comparison	Residents of Montreal Island	Residence in areas adjacent to landfill and level of estimated exposure to landfill gas	Cancers of 17 organ sites for men; 20 organ sites for women.	Increase in incidence of stomach, liver, lung and prostate cancer for men, stomach and cervix–uteri cancer for women.
(15)	Cross-sectional	51 residents of exposed village incl. 11 children and 52 control persons	Residence in exposed village	SCEs	Higher frequency of SCEs in exposed population, particularly in children
(28)	Cross-sectional	47 children from exposed village; 45 unexposed children	Residence in exposed village and time of exposure	Chromosomal changes	Chromosome damage frequency returned to background levels after site remediation
(29)	Geographical comparison	Cancer deaths and birth defects compared to Pennsylvania and U.S.	Residence in counties surrounding waste site, incl. Clinton county, PA	Bladder cancer and cancers of other organ sites; birth defects	Increase in bladder cancer deaths in Clinton; increase in number of other cancers in Clinton and 3 surrounding counties; no excess in birth defects.
(16)	Cross-sectional	179 long-term exposed residents; 151 residents in comparison areas	Residence in area near waste site	14 self-reported diseases; 15 self-reported symptoms	Increased prevalence of skin problems and sleepiness
(17)	Cross-sectional	1,049 exposed; 948 unexposed residents	Residence in household close to site	36 self-reported health problems	Increased prevalence of minor respiratory symptoms (wheezing, cough, persistent cold), irregular heart beat, fatigue, bowel complaints
(30)	Retrospective follow-up	614 exposed households; 636 comparison households	Residence within 750 m of edge of site: long-/short-term residence	Self-reported health problems	Increased prevalence of mood disorders, narcotic symptoms, skin and respiratory disorders, eye problems, muscle weakness
(31)	Cross-sectional	403 exposed households; 203 comparison households	Residence in proximate area	19 self-reported diseases, 23 symptoms; mortality, cancer incidence, LBW, birth defects, spontaneous abortions	Increase in majority of self-reported diseases and symptoms. No significant association for mortality, cancer morbidity, reproductive effects
(32)	Cross-sectional	257 residents in exposed zones; 105 in comparison area	Distance based zones: zone 1: < 300 m zone 2: 300–1,000 m	Self-reported diseases and symptoms, miscarriages, stress levels	Increased reporting of majority of symptoms, miscarriages, stress
(18)	Follow-up survey	57 high-, 66 low-, 70 unexposed residents	Exposure zones based on odor zones	22 self-reported health problems	2-fold increase in 64% of reported symptoms
(33)	Cross-sectional	321 high-exposed persons; 351 persons with low/minimal exposure	Cumulative exposure index based on distance from sites and amount of chemicals present at sites	29 self-reported health problems	Excess in reporting of 11 of 29 symptoms: mainly neurologic symptoms

(*Continued*)

Table 1. *Continued.*

Ref.	Study design	Study subjects	Exposure measure	Health outcomes studied	Reported findings
(*34*)	Cross-sectional	456 exposed residents; 481 comparison persons	Residence near site	14 self-reported health problems	Increased reporting of 11 of 14 symptoms.
(*19*)	Retrospective follow-up	694 residents	Individual exposure index based on concentration of pollutants and daily activity of study subjects	Amount of prescribed medication for selected diseases (respiratory, ophthalmologic, dermatologic, gastrointestinal, neurologic)	No relationship between individual exposure index and drug consumption
(*20*)	Case–control	432 cases; 384 controls	Individual exposure index based on concentration of pollutants and daily activity of study subjects	Dermatologic, respiratory, eye, gastrointestinal diseases, psychologic disorders and other conditions	Relationship between exposure level and existing cases of respiratory and psychologic conditions
(*38*)	Geographical comparison	Three counties adjacent to waste dump compared to whole region	Communities near dump; distance of community to dump	Leukemia, multiple myeloma, malignant lymphoma	Excess in leukemia incidence
(*39*)	Geographical comparison	Ward surrounding landfill compared to whole region	Residence in landfill ward, surrounding wards, area downwind from landfill	All childhood cancers	No excess of childhood cancer
(*40*)	Geographical comparison	5 wards near landfill compared to 22 wards elsewhere	Wards near landfill	Mortality rates, hospital admissions for asthma, cancer, and other conditions, spontaneous abortions, birth defects, drug prescriptions	No consistent differences in mortality rates, hospital admissions, spontaneous abortions. Excess in birth defects before and after start of the landfill. Increase in prescriptions for certain medications
(*41*)	Geographical comparison	Cancer rates in 8 counties in Illinois compared to national rates	Residence in town with contaminated wells	Bladder cancer	Excess in bladder cancer in town with contaminated wells
(*44*)	Geographical comparison	Woburn cancer rates compared to national rates	Residence in Woburn	Childhood leukemia	More than 2-fold excess in childhood leukemia
(*45*)	Case–control	20 leukemia cases; 164 control children	Exposure index based on fraction of water supply in household from contaminated wells	Childhood leukemia	Significant association with exposure index
(*45*)	Retrospective follow-up	4,396 pregnancies; 5,018 children under 18	Exposure index based on fraction of water supply in household from contaminated wells	Childhood disorders; adverse pregnancy outcomes: spontaneous abortions, perinatal death, LBW, birth defects	Increase in eye/ear anomalies, CNS/chromosomal/cleft anomalies; perinatal deaths; kidney/urinary tract disorders, lung/respiratory disorders
(*46*)	Cross-sectional	28 family members of leukemia cases; 30 healthy controls	Being a family member of a Woburn leukemia case	Immunologic abnormalities, medical examination	Immunologic abnormalities in family members
(*47*)	Retrospective follow-up	Births in exposed census tracts compared to births in the entire county	Residence in census tract served by contaminated water supply	Congenital heart defects	2-fold excess in cardiac anomalies
(*48*)	Retrospective follow-up	Pregnancies in exposed census tract; pregnancies in unexposed census tract	Residence in census tract served by contaminated water supply	Spontaneous abortions, birth defects, LBW	Increase in spontaneous abortions and birth defects; no excess in LBW
(*49*)	Retrospective follow-up	Pregnancies in 2 exposed census tracts; pregnancies in 2 unexposed census tracts	Residence in 2 census tracts served by contaminated water supply	Spontaneous abortions, birth defects, LBW	No excess in spontaneous abortions or malformations in new exposed study area
(*50*)	Retrospective follow-up	Pregnancies in 2 exposed census tracts	% water in census tract from contaminated well; estimated concentration of solvents	Spontaneous abortions, birth defects	No relation between abortion or malformation rate and estimated exposure
(*51*)	Case–control	145 cases with cardiac malformations; 176 nonmalformed control births	Mother's consumption of home tap water	Congenital heart defects	Elevated risk for consumption of more than 4 glasses of tap water compared to none
(*52*)	Retrospective follow-up	349 pregnancies in 1 exposed and 1 unexposed census tract	Mother's consumption of home tap water	Spontaneous abortions, birth defects	Spontaneous abortions: significant trend with number of glasses tap water per day. Birth defects: no trend
(*53*)	Retrospective follow-up	1,016 pregnancies in exposed and unexposed areas	Mother's consumption of home tap water	Spontaneous abortions, birth defects, LBW	Spontaneous abortions: 7-fold risk for any versus no tap water. Birth defects: nonsignificant increase. No association with LBW
(*13*)	Cross-sectional and follow-up	49 exposed residents; 57 unexposed residents	Use of contaminated well water	Liver function	Abnormalities in liver function in exposed residents. Returned to normal 2 months later.
(*54*)	Cross-sectional	676 exposed residents; 778 unexposed residents	Residence in high-exposure area based on groundwater flow	Self-reported disease: cancer, liver disease, respiratory illness, skin disease, seizures	Statistically significant increase in respiratory disease and seizures, not significant after accounting for smoking
(*55*)	Cross-sectional	65 exposed residents; 66 residents from control households	Residence in households with contaminated well water	15 self-reported health symptoms; 14 self-reported diseases	Increased reporting of eye irritation, diarrhea, sleepiness.

Abbreviations: CAs, chromosomal aberrations; CNS, central nervous system; LBW, low birth weight; SCEs, sister chromatid exchanges.

Table 2. Multisite studies.

Ref	Study design	Study sties	Study subjects	Exposure measure	Health outcomes studied	Reported findings
(56)	Geographical comparison	593 NPL waste sites in U.S.	339 counties with waste site, more than 3,000 without	County with site	Cancer mortality	Increased rates of cancer of the lung, bladder, stomach, and rectum
(57)	Case–control	12 sites in New York State	339 deceased lung-cancer cases; 676 deceased controls	Residence in census tract with site; duration of residence	Lung cancer	No association
(58)	Case–control	38 sites with likely landfill gas migration in New York State	9,020 cancer cases; 9,169 deceased controls	Residence within 250 ft	Cancer of liver, lung, bladder, kidney and brain; non-Hodgkin lymphoma, leukemia	Excess of female bladder cancer and female leukemia
(59)	Case–control	300 sites in 1,072 census tracts in California	5,046 birth defects cases and 28,085 control births. 1,904,000 births for birth weight analysis	Residence in census tract with site and potential for human exposure	Birth defects, LBW	1.5-fold increase in risk of heart defects. Other malformations and birth weight not associated
(60)	Case–control	1,281 NPL sites in U.S.	17,407 births	Residence within 1 mile	Birth weight, birth defects, fetal deaths, infant deaths	No association between adverse pregnancy outcomes and living near a NPL site
(61)	Case–control	590 waste sites in New York State	9,313 live births with birth defects; 17,802 normal control births	Residence within 1 mile and hazard score of site	Birth defects	Increased risk for all malformations (12%), integument system, nervous system, musculoskeletal. Indications for dose–response relation with exposure risk
(62)	Case–control	643 waste sites in New York State	473 cases with central nervous system defects; 3,305 musculoskeletal cases; 12,436 control births	Ratings of exposure probability within 1 mile of each site	Central nervous system defects and musculo-skeletal defects	No association between two types of and proximity to waste sites
(64)	Case–control	317 waste sites in New York State	259 cases of end-stage renal disease and 259 controls	Residence within 1 mile, exposure probability; years of residence within 1 mile	End-stage renal disease	Nonstatistically significant increase in risk of renal disease for ever living within 1 mile, having lived within 1 mile for more than 12 years, and a medium/high probability of exposure
(65)	Case–control	105 NPL and 659 non-NPL sites in California	507 neural tube defects, 517 controls; 210 heart defects, 439 oral clefts, and 455 controls	Census tracts: no site, non-NPL site, NPL site; residence within 1 mile and residence within 1/4 mile	Birth defects: neural tube defects, heart defects, and oral clefts	No increased risks relating to residence in census tract with site. Small, nonsignificant increase in risk of NTD and heart defects for living within 1/4 mile
(66)	Case–control	21 sites in 5 European countries	1,089 cases with non-chromosomal birth defects; 2,366 control births	Residence within 3 km	Birth defects	Increased risk for all malformations (33%), NTD, cardiac defects

NTD, neural tube defect.

Issues Common to the Interpretation of Landfill Studies

A general problem in epidemiologic studies of landfill sites, whether studying single or multiple sites, is that there is insufficient information regarding potential human exposures from landfill sites. Although landfill sites are numerous and widespread, very few have been evaluated with respect to both the types of chemicals they contain and the extent to which they may be releasing chemicals. Most such work has been conducted in the United States under the Superfund program (*3*). In other countries, information is largely lacking. Moreover, although chemicals have been found to migrate off site at a number of sites that have been thoroughly investigated (*2*), we know very little about the extent to which residents living near a site are exposed to these chemicals. A few studies that have attempted to measure certain chemicals in blood and urine of populations near waste sites have generally not found increased levels of volatile organic compounds (VOCs) (*4*), mercury (*5*), or PCBs (*6*). Because knowledge of whether and to what extent substances from waste sites reach the human population is still largely lacking, and because resources are rarely available to carry out extensive exposure measurements or modeling, epidemiologic studies have based the assessment of exposure to landfills mainly on surrogate measures such as residence in an area close to a waste site or distance of residence from a waste site. The use of such surrogate, indirect exposure measurements can lead to misclassification of exposure which, if not different for diseased and nondiseased persons, will decrease the sensitivity of the study to find a true effect.

In addition to being hampered by insufficient exposure data, the study of landfill exposures is complicated by the fact that if residential populations are exposed to chemicals from landfill sites, it will generally be to low doses of mixtures of chemicals over long periods of time. Associations with such low-level environmental exposures in the general population are by their nature hard to establish. Low-dose exposures are generally expected to generate small increases in relative risk that will be difficult to distinguish from noise effects introduced by confounding factors and biases.

In most of the landfill studies reviewed in this article, residents near waste sites are studied without knowledge of the exact route(s) of exposure to chemicals from the site. Migration of hazardous substances into groundwater is often an important environmental concern in relation to landfill sites, which may represent a public health problem, especially when a site is located near aquifers supplying public drinking water. However, in many situations the drinking water supply of residents near waste sites does not originate

from the local area. For people living in the vicinity of these sites, other routes of exposure may be of more concern. Landfill sites may be a source of airborne chemical contamination via the off-site migration of gases and via particles and chemicals adhered to dust, especially during the period of active operation of the site. Very little is known about the likelihood of air exposure from landfill sites through landfill gases or dust. At some of the sites described below, low levels of volatile organic chemicals have been detected in indoor air of homes near landfill sites (*7–13*), in outdoor air in areas surrounding sites (*14–20*) or in on-site landfill gas (*21*). Other possible routes of exposure include contamination of soil, ground, and surface water, which may lead to direct contact or pollution of indoor air in the case of evaporation of VOCs into basements of nearby houses. Contamination via the food chain may sometimes be of concern for nearby residents in the case of consumption of home-grown vegetables. Drinking water is a possible route of exposure only if water for domestic use is locally extracted. If this is the case, other domestic water uses (bathing, washing) may also lead to exposure via inhalation of evaporated VOCs and/or direct contact (*13*).

Some issues related to specific health outcomes should be noted in both single- and multisite studies. A general problem in studies of cancer incidence is the long latency period between exposure and clinical manifestation of the cancer. Studies may not always allow for a long enough latency period, which reduces their power to pick up long-term effects. Moreover, because of the long latency period, a considerable number of people may have migrated into or out of the exposed areas between time of exposure and time of diagnosis, which will lead to misclassification of exposures. Studies of chromosome changes (chromosome aberrations and sister chromatid exchanges) are undertaken with the assumption that such changes are related to the mechanisms underlying cancer and possibly birth defects. Chromosomal changes are studied as biomarkers of early response or effect of exposure to mutagenic and carcinogenic chemicals. Sorsa et al. (*22*) point out that theoretically it is reasonable to assume that chromosome damage is directly related to cancer etiology, but the number of agents clearly shown to induce such damage in humans is still limited. Increased frequencies of chromosome changes may indicate exposure to mutagens and carcinogens, but it is not clear at present how well they predict cancer risk. Low birth weight is thought to be relatively sensitive to effects of chemical exposures (*23*). It is also relatively easy to collect accurate information on birth weight from birth certificates. However, a large number of risk factors are associated with low birth weight (including smoking, socioeconomic status, nutritional factors, parental height) (*24*), and these may act as confounding factors, giving biased estimates of association with residence close to a site. Birth defects have fewer established risk factors than other reproductive outcomes such as low birth weight, and studies of birth defects may therefore be less affected by confounding factors, although unknown risk factors could still play a confounding role. Also, birth defects represent an etiologically very heterogeneous set of conditions; analyses of the total malformation rate (all defects combined) have the advantage of larger numbers but may not be sensitive enough to pick up increases in risk of specific defects. The grouping of malformations into groups that are etiologically similar is difficult because of lack of knowledge on causes of specific defects. Grouping therefore always entails a compromise between large enough numbers and etiologic specificiry.

Single-Site Studies

The investigation of single landfill sites has been important as a response to community concerns; many of the single-site studies discussed below are prompted by public concerns, often under considerable political pressure. This means that they are prone to recall and reporting biases that may weaken the investigations and partly explain increases in reported health outcomes. Single-site studies have examined a vast range of possible health outcomes, often without a specific disease hypothesis being proposed a priori. Such "fishing expeditions" are thought to be of less scientific value than studies that start with a clear hypothesis (*1*). Including these fishing expeditions in evaluating the consistency of findings across multiple studies is important nevertheless when assessing evidence for health risks.

A less avoidable problem in single-site studies is that the size of populations living near waste sites generally is small and, especially when the outcome is a rare disease, this can seriously limit the statistical power of an investigation.

Single-site studies discussed in this section are grouped into those examining hard end points such as cancer and reproductive outcomes, those studying self-reported health outcomes and symptoms, those following up reported clusters of disease near landfill sites with geographic comparisons of disease rates, and those specifically investigating the contamination of well water used for drinking or other domestic uses in relation to health effects. These last studies were discussed separately to determine whether conclusions can be drawn about specific pathways of exposure.

Studies of cancers, reproductive outcomes, and chromosomal damage. Large quantities of toxic materials (residues from pesticide production) were dumped at the landfill of Love Canal, New York State, during the 1930s and 1940s, followed by the building of houses and a school on and around the landfill in the 1950s. By 1977 the site was leaking and chemicals were detected in neighborhood creeks, sewers, soil, and indoor air of houses. This led to one of the most widely known and publicized incidents of environmental pollution from landfill. Exposure of Love Canal residents, although not well understood, may have occurred via inhalation of volatile chemicals in home air or via direct contact with soil or surface water (*10*). The drinking water supply was not contaminated. Chemicals detected at Love Canal were primarily organic solvents, chlorinated hydrocarbons and acids, including benzene, vinyl chloride, PCBs, dioxin, toluene, trichloroethylene, and tetrachloroethylene. Several studies were conducted to detect whether Love Canal residents suffered adverse health effects.

Janerich et al. (*7*) compared cancer incidence for the Love Canal area with data for the entire state from 1955 to 1977 and found no increase in cancer rates at Love Canal for any organ site. This included leukemia, lymphoma, and liver cancer, which were thought to be the cancers most likely to result from exposures to the chemicals found at the site. The study is limited in that no information was available on confounding factors such as socioeconomic status and smoking. Subsequently, Heath et al. (*8*) compared the frequencies of chromosome changes (sister chromatid exchanges and chromosomal aberrations) in residents who lived in the first ring of houses adjacent to Love Canal in 1978 with those of control persons from socioeconomically similar census tracts. No differences in frequencies of chromosome damage were found. Chromosome changes were measured in 1981 and 1982, a few years after people were evacuated from the first ring of houses and therefore were no longer exposed. The authors point out that chromosome damage may be a reversible effect, which may explain the negative findings.

Infants and children have been the subject of other Love Canal studies. A cross-sectional study (*9*) reported an increased prevalence of seizures, learning problems, hyperactivity, eye irritation, skin rashes, abdominal pain, and incontinence in children living close to the Love Canal site compared to controls from other areas, as reported by the parents of the children. It has been noted in previous reviews (*1,25*) that this study was conducted in 1980, 2 years after the residents of Love Canal had become aware of the hazardous

waste problem, when media and public interest were high, and people were being evacuated. This makes it likely that the results were biased by differential reporting of health problems. However, a similar population of children (spending 75% or more of their childhood in the Love Canal area) had significantly shorter stature for their age than control children after allowing for factors such as birth weight, socioeconomic status, and parental height (*10*). Vianna and Polan (*11*) found an excess of low birth weights (less than 2500 g) during the period of active dumping (1940–1953) in areas of Love Canal where exposure had been highest. Rates of low birth weight between 1960 and 1978 after the site had been closed were comparable to those in upstate New York as a whole. It is not clear whether exposure from Love Canal was highest during the active dumping period or during the period after the site was closed, when the building of houses near the site increased and the landfill was leaking. A study by Goldman et al. (*12*) reported a 3-fold risk of low birth weight for children exposed during gestational life to the Love Canal area compared to that for control children born elsewhere from 1965 to 1978. Data were analyzed separately for homeowners and renters so that groups of similar socioeconomic status were compared, and after allowing for confounding factors, the risk of low birth weight was significantly increased for homeowners only. This finding is difficult to interpret because there are no strong reasons to believe that homeowners would be more susceptible than renters to the effects of toxic chemicals. In the same study an increased risk of birth defects was observed for both homeowners and renters. Information on birth defects relied mainly on reports from parents. Some recall bias can therefore be suspected, in particular for defects of lesser severity, but this is unlikely to account for the entire association found for major birth defects.

Berry and Bove (*26*) studied birth weight at the Lipari Landfill in New Jersey, a site for municipal and industrial waste. Leachate from the site migrated into nearby streams and a lake adjacent to a residential area. Inhalation of volatile chemicals emitted from the landfill and contaminated waters was thought to be the most important exposure pathway. The site closed in 1971 after complaints of residents, but the heaviest pollution was estimated to have occurred during the late 1960s to the mid-1970s. The study found a convincing increase in proportion of low birth weight babies (< 2500 g) and a lower average birth weight in the population living closest (within a radius of 1 km) to the landfill in the time period when potential for exposure was thought to be greatest (1971–1975) compared to these factors in a control population. Although information on some confounding variables such as smoking, alcohol consumption, and socioeconomic status was not available, mothers in the exposed area were more highly educated and therefore appeared to be of higher socioeconomic status. One would expect higher birth weights in areas of higher socioeconomic status, so as the authors point out, confounding by socioeconomic status does not explain the lower birth weights found. In time periods before and after heavy dumping and off-site pollution, birth weights were higher in the area closer to the site than in the control area, which supports the hypothesis that pollution from the waste site may have been related to low birth weights in the community close to the site.

A range of reproductive effects including low birth weight was studied around the large BKK hazardous waste disposal site in Los Angeles County, California (*14*), after previous investigations of vital records found that trends in low birth weight and neonatal deaths corresponded closely with times and quantities of dumping at the landfill. Results for the whole study period showed no increase in adverse reproductive effects, but during the period of heaviest dumping, birth weights were significantly lower in exposed areas than in control areas using odor complaint frequency zones to classify exposure. All results were adjusted for education, income, and race. The decrease in mean birth weight found in the high-odor complaint zone was small (59 g) compared to that in the Lipari Landfill study (192 g) and was less than a third of birth-weight reductions caused by smoking during pregnancy (*26*). Odor complaint frequency zones corresponded better with vinyl chloride monitoring data and meteorology around the site than did census tract areas or distance-based (< 0.7 miles) exposure zones, and this was therefore thought to be the most accurate method for classifying exposure. Using census tract or distance-based exposure zones, smaller decreases in mean birth weight were found (35.2 g, $p = 0.02$ and 20.4 g, $p = 0.25$, respectively).

Miron Quarry, a large (the third largest in North America) municipal solid waste site in Montreal, Quebec has prompted studies on both reproductive outcomes (low birth weight and preterm births) (*27*) and cancers (*21*). Gas from the site was the main environmental and health concern and a range of VOCs, including a number of recognized or suspected human carcinogens, had been detected in the gas. An excess of 20% in low birth weight was found among babies of mothers who were living in the high-exposure area adjacent to the landfill at the time of delivery, taking account of confounding factors such as education and age of the mother. No excess was found in the low-exposure zone compared to a control area. Exposure zones were based on proximity to the site and accounted for the direction of dominant winds. Control areas were selected that were similar to exposure areas on a number of sociodemographic variables so as to limit the potential for confounding. The cancer study used the same exposure zones and control areas and increases were found in incidences of cancers of the stomach, liver, prostate, and lung for men, and stomach and cervix/uterus for women. Incidences of cancers of other organ sites were not increased in the exposed areas. Age and sex were the only confounders that could be controlled for directly and the authors admit that area matching for sociodemographic factors was based on fairly broad zones. The landfill started operation in 1968 and cancer incidence was studied between 1981 and 1988, which allowed a maximum latency of only 20 years among those residents in the area throughout the period.

In Mellery, Belgium, gases containing a complex mixture of VOCs escaped when the clay seal of a landfill site cracked. Because some of the detected chemicals were known mutagens and/or carcinogens, damage to chromosomes was studied and an increase in chromosome damage (sister chromatid exchanges) was found among Mellery residents but not in unexposed subjects in subgroups of both smokers and nonsmokers (*15*). In children 8–15 years of age, a more marked difference was found between exposed and unexposed groups than among adults. The findings indicated exposures similar to those of occupationally exposed populations. The adult unexposed comparison subjects were recruited from a volunteer blood donor list and may therefore have comprised a group with risk behavior and exposure to possible risk factors for chromosome damage different from those of the general population. They also reported less occupational exposure than the Mellery inhabitants. It is unclear how occupational exposure was defined and results have not been adjusted for it. A follow-up study after site remediation reduced the concentration of the atmospheric pollutants to background levels reported that chromosomal damages in Mellery children had returned to background levels and were no longer different from those for unexposed populations (*28*).

At the Drake Superfund Site, an industrial chemical dump in Pennsylvania, widespread on- and off-site contamination of groundwater, soil, and surface water with organic (benzene, chlorinated benzene, phthalates) and inorganic (arsenic, mercury) compounds prompted a

cancer mortality and birth defects study (*29*) and a community health survey (*16*). Air monitoring near the site identified a small number of organic compounds, but the main exposure route was thought to be direct contact with surface waters and soil in recreational areas near the site. Budnick et al. (*29*) found an increase in mortality from bladder cancer (cancer of primary a priori concern because of aromatic amines detected on and off site) in the male population of one of the counties surrounding the waste site compared to average mortality rates in the entire state and the United States. Bladder cancer in females did not show such an effect. The authors point out that an occupational effect for males working in the Drake chemical plant may explain the fact that the association was found in men only. No excess in risk of birth defects was found. The subsequent health survey (*16*) found increased reporting of sleepiness and skin problems in the exposed community and concluded that it was difficult to say whether toxic chemicals from the site, overreporting of symptoms by the exposed community (reporting bias), or other factors such as stress and occupational exposure caused these symptoms.

Studies of self-reported health symptoms. A number of other community health surveys have investigated a wide range of health problems, including respiratory symptoms; irritation of skin, nose, and eyes; gastrointestinal problems; fatigue; headaches; psychological disorders; and allergies. These studies have been conducted in response to concerns from the public, often triggered by smells and odors from the sites. In a number of studies, self-reported health problems were increased in exposed populations (people living close to the waste sites) compared to control populations [Drake Superfund Site (*16*); Lowell, Massachusetts (*17*); Hamilton, Ontario (*30*); Stringfellow, California (*31*); Queensland, Australia (*32*); McColl waste site, California (*18*); Houston, Texas (*33*); Harris County, Texas (*34*)] (see Table 1 for details). The majority of these health surveys rely on residents reporting symptoms and diseases through questionnaires or interviews. The possibility exists that higher reporting rates of symptoms in exposed areas are at least partly explained by reporting and/or recall biases. From a public health point of view, the findings of high symptom reporting, whether or not due to differential self-reporting, may indicate the impact that stress and concerns related to landfill can have on ill health and/or perceived ill health. In the survey by Ozonoff et al. (*17*), residents who indicated they were worried about neighborhood pollution reported more symptoms than those who were not worried, both in the exposed and the control area. Although this does not eliminate the possibility of an effect of toxic chemicals from the site, it suggests that stress and/or recall bias may have been responsible for the findings. Miller and McGeehin (*34*) and Dunne et al. (*32*) found increased symptom prevalence only in residents who indicated they were worried about, or aware of, an environmental problem in their neighborhood. The study by Lipscomb et al. (*18*) showed a 2-fold risk in most symptoms for residents who were worried compared to those who were not worried among the exposed population. The authors concluded that being worried, rather than a toxicologic effect from the site, explained the symptoms. Hertzman et al. (*30*) used medical records to confirm certain symptoms and found no over- or underreporting. They concluded that this finding indicated limited reporting bias; however, only a small proportion of the respondents' records were reviewed. Moreover, seeing a physician (and therefore having a medical record) may itself be related to concerns about the site. Baker et al. (*31*) studied self-reported health problems as well as mortality, cancer incidence, and pregnancy outcomes from medical registers at the Stringfellow waste dump in California. Self-reported diseases and symptoms were the only outcomes that differed between exposed and unexposed areas. Again, a higher perception of threat was related to a higher risk of nearly all self-reported symptoms.

The complicated relation between worry, odor perception, and symptom reporting related to hazardous waste landfill sites is further discussed by several authors (*35–37*).

Two recent studies around the French landfill of Montchanin used records of prescribed medication (*19*) and cases from general practitioners (GPs) (*20*) to define health outcome, in order to avoid biases related to self-reporting of symptoms. Exposure classification in both studies was based on an individual index, taking into account the concentration of airborne pollutants and daily activities of study subjects. High concentrations of VOCs were detected in areas near the site and both leachates and air from the site were reported to be highly toxic in 1988 and 1989, shortly after site closure. Consumption of drugs prescribed for most conditions from 1987 to 1989 did not show a trend with exposure level, although a slight trend was found for drugs taken for ear, nose, and throat, and pulmonary conditions. In the second study, patients with conditions thought to be associated with dump emissions were compared to other GP patients and an association was found for respiratory symptoms and psychological disorders. Again, consulting a doctor for such conditions and subsequent diagnosis of the conditions by the physician may be related to fears of adverse effects from the landfill rather than to toxic chemical effects.

Cluster Investigations. In addition to the above papers, a number of reports are available of geographical comparison studies initiated after high rates (clusters) of specific diseases were reported in the vicinity of landfill sites. For example, increased rates of leukemia found in communities nearest a toxic waste dump in North-Rhine Westfalia, Germany, supported a GP report of a cluster near the site (*38*). A cluster of childhood cancer reported by residents near a landfill site in Walsall, England, was not confirmed in a geographical comparison of rates in the ward containing the site to expected rates based on the regional average (*39*). Only short reports of these two investigations have been published.Concerns from residents and a GP about increased rates of congenital abnormalities (specifically gastroschisis, a defect in the abdominal body wall) among the population living near the Welsh landfill of Nant-y-Gwyddon were supported by the finding that rates of congenital abnormalities in exposed wards were almost 1.9-fold those in unexposed wards over the period from 1990 to 1996 (*40*). However, rates in the exposed wards were already high (1.9-fold those of unexposed wards) between 1983 and 1987 before the site opened, and it is unlikely, therefore, that these increased rates were due to the landfill. Four cases of confirmed gastroschisis indicated a significant 9-fold excess in rates of gastroschisis among exposed wards between 1989 and 1996. A cluster of bladder cancer cases in one town in Illinois in the United States, was observed by researchers and subsequently linked to the presence of two contaminated wells close to a landfill site (*41*).

A general problem in the interpretation of all cluster investigations is that localized areas of high disease density may occur even as part of a random pattern of disease. It is difficult to distinguish clusters derived from this random pattern from those where there is a common underlying local cause (*42,43*). Also, areas with higher disease densities, although part of the random pattern of disease, may be selectively picked for study.

Studies of drinking water contamination incidents. The presence of chemicals in groundwater and drinking water is an important factor in determining the risk posed by landfill sites. However, it does not tell us what effect, if any, the consumption of contaminated water has on human health. Studies of adverse health effects prompted by the contamination of well water used for drinking water and other domestic uses by hazardous substances from waste disposal sites (mainly sites where chemical waste drums were buried) are discussed below. Literature on contaminated water and potential health effects is more extensive than that presented

in this section, which focuses only on water contamination directly related to the disposal of waste. The 1991 review by the National Research Council (*2*) gives a more comprehensive review of studies on contamination of domestic water supplies and health effects and concludes that although the available literature is scanty and not conclusive, drinking water contamination could lead to adverse health effects. Most of the studies summarized below have been discussed extensively in previous reviews (*1,2*).

In Woburn, Massachusetts, toxic chemicals (industrial solvents, mainly trichloroethylene) from a waste disposal site were detected in municipal drinking water wells. Residents of Woburn reported a cluster of 12 leukemia cases in children, and a first study confirmed that this number was significantly higher than expected on the basis of national rates (*44*). The problems with cluster analyses are discussed above. Because of lack of information on exposure to the contaminated wells, it was not possible in this first report to link the leukemia cases with exposure to the well water. Lagakos et al. (*45*) followed up these findings by compiling an exposure score for residential zones in Woburn using information on what fraction of the water supply in each zone had come from the contaminated wells annually since the start of the wells. Childhood leukemia incidence, perinatal deaths, congenital anomalies, and childhood disorders were studied in relation to the exposure scores. A significant excess was found again comparing leukemia rates for Woburn with national rates, and an association was found between leukemia incidence and exposure scores. The pregnancy outcome survey found associations with eye/ear congenital anomalies and central nervous system/oral cleft/chromosomal anomalies (mostly Down syndrome) but not with low birth weight or most childhood disorders. Pregnancy outcomes were self-reported in this study, but because residents were not aware of their exact exposure scores, the authors conclude that it is unlikely that this led to substantial differential overreporting. Byers et al. (*46*) undertook a study of 28 family members of patients with leukemia in Woburn. Damage to the immune and nervous systems was found in exposed relatives but not in unexposed controls. Exposure in this study was not measured by exposure to contaminated well water but by being related to a leukemia patient in Woburn, which makes it difficult to interpret the findings. The authors point out that it is impossible to say whether the association is due to an inherited predisposition or to a common environmental exposure of family members to agents that damage the immune system.

A number of studies followed the contamination of two drinking-water wells in Santa Clara County, California, with chlorinated solvents that had leaked from an underground waste storage tank. Residents living near one of the contaminated wells reported a cluster of adverse pregnancy outcomes, mainly spontaneous abortions and congenital heart defects. A first investigation (*47*) confirmed a significant excess of cardiac anomalies in the service area of the water company that operated the contaminated well compared to those among residents of an unexposed area. The excess was found within the potentially exposed time period and not in an unexposed time period after the well was closed. The authors conclude that the solvent leak was an unlikely explanation for the excess of cardiac anomalies found because the excess occurred mainly in the first 12 months of the exposed time period, and there was a significant (p = 0.03) deficit of cases during the second 8 months corresponding to the time when exposure was thought to be more certain. However, it is unclear when the leak started and the potentially exposed period was defined beforehand as the full 20-month period. A second study in the same area reported an increased risk of all congenital malformations combined and spontaneous abortions (*48*). A follow-up study including a second exposed area did not observe an increase in either outcome in this second area, even though it was thought to have the same water exposure as the original area (*49*). An exposure study estimating monthly concentrations of solvents in each census tract found no difference in probability of exposure between women with adverse pregnancy outcomes and women with normal births (*50*). Subsequent studies investigating water consumption in Santa Clara County report significant associations between reported tap water consumption and risk of cardiac defects (*51*) and spontaneous abortions (*52,53*), regardless of whether women lived in areas that received contaminated water. As the authors of these studies point out, recall biases cannot be excluded.

In Hardeman County, Tennessee, well water used as drinking water by residents was found to be contaminated with high concentrations of carbon tetrachloride and other chlorinated compounds after complaints were received about the taste of the water. A nearby landfill where 300,000 barrels of pesticide waste had been buried was responsible for the contamination. Analysis of indoor air and bathroom air while showers were running both indicated detectable levels of carbon tetrachloride and other organic compounds in houses that received water from the contaminated wells. Carbon tetrachloride has been identified in toxicologic studies as a strong liver toxin. The investigation, conducted several months after the population had stopped using the water for drinking, showed abnormally high levels of liver enzymes (indicating liver damage) in residents who had used contaminated water compared to controls, who had not (*13*). The authors concluded that these high liver enzyme levels probably resulted mainly from exposure due to washing and toilet water uses, and possibly from previous exposure through drinking and cooking. Two months later, when use of the well had completely stopped, liver function in the exposed population had returned to normal. This study benefited from relatively well-documented exposure information and a clear hypothesis about the possible health effects (i.e., liver disease) related to exposure to carbon tetrachloride.

Leakage from an industrial dump of chemical waste drums in New Jersey caused contamination of groundwater and well water with organic chemicals (including benzene, toluene, trichloroethylene, and lead). Najem et al. (*54*) found higher self-reported prevalence of respiratory disease and seizures but not cancer, liver illness, and skin disease in people living in a high-exposure area estimated on the basis of groundwater flow patterns. Residents in the high-exposure area used private drinking-water wells, ate homegrown food, and smoked more often than populations living in unexposed areas, and when these factors were adjusted for, differences in health outcomes disappeared. Adjusting for possible exposure routes such as local food consumption and use of private wells may have led to overadjustment, however, which would explain why no differences in health outcome were found.

An ex-military base in Dauphin County, Pennsylvania contained drums of toxic chemicals, fly ash, and other waste; well water for homes located on the perimeter of the site was contaminated with trichloroethylene, PCBs, pesticides, and other chemicals (*55*). Residents were instructed to stop using the water. Higher rates of eye irritation, diarrhea, and sleepiness were reported by residents of households with contaminated well water than by residents of households not having contaminated water.

Multisite Studies

The problems with single-site studies prompted by community pressures have increasingly been recognized, and recently several large studies have investigated adverse health effects near sets of hundreds of sites selected independently of community concerns or reported disease clusters (Table 2). These studies have the additional advantage of large numbers of subjects, which would give them enough statistical power to detect

small increases in risk of rare diseases such as birth defects and specific cancers. On the other hand, their large scale makes exposure assessment even more complicated than in single-site studies, as adequate information must be collected for each of many sites. A number of the studies discussed below have used the U.S. National Priority Listing (NPL) of hazardous waste sites developed by the U.S. Environmental Protection Agency (U.S. EPA) to select their sites. The NPL ranks all hazardous waste sites in the United States deemed to be of considerable threat to the environment or public health. NPL sites have been relatively well assessed with respect to the potential or actual migration of hazardous chemical substances from the sites through groundwater, surface water, and air (*2*). Most multisite studies, however, were not able to distinguish between different types and pathways of contamination and, in absence of better exposure data, based their assessments of exposure on distance of residence from the sites or residence in an area with a site. Exposure misclassification, if nondifferential, may be expected to dilute true effects in these investigations. Multisite studies mainly investigated cancers and reproductive outcomes.

Cancer studies. Griffith et al. (*56*) identified 593 NPL sites over the entire United States where contamination of groundwater used for drinking water had been detected by laboratory analyses. Cancer mortality rates for counties containing one or more of these NPL sites were compared to those for counties not containing sites and raised levels of lung, bladder, stomach, and rectum cancer were found. These results were not adjusted for confounding factors such as socioeconomic status and smoking and are therefore difficult to interpret.

A case–control study in New York State (*57*) examined lung-cancer in relation to residence in a census tract with a waste site. Twelve waste sites known to contain suspected lung carcinogens were studied. A questionnaire survey among next of kin of the deceased cases and controls attempted to collect information on factors such as smoking, diet, education, and residential history. Smoking was significantly more frequent among cases, but there was no association between having lived in or duration of living in an exposed census tract and risk of lung cancer. Low response rates (around 60%) and possible recall bias limit this study.

A recent study in New York State (*58*) investigated cancer risks near 38 landfills where migration of landfill gas through soil was likely. Migration of soil gas could result in indoor exposure in nearby houses to hazardous VOCs carried with the landfill gas. Potential exposure areas were defined around each site, and extended 250 ft from the landfill at 36 sites and 500 ft at 2 sites. Incident cases of cancer collected from the New York State Cancer Registry were compared with a random selection of deaths from causes other than cancer, matched by age and sex. Only cancers of the liver, lung, bladder, kidney, and brain, and non-Hodgkin lymphoma and leukemia were studied, as they were regarded potentially sensitive to chemical exposures. Statistically significant excesses in the defined exposure areas were reported only for bladder cancer in women and leukemia in women. The results were adjusted for sociodemographic characteristics of the areas of residence. No information was available on individual factors such as smoking or on how long cases and controls had been living at certain addresses. The use of deceased controls makes interpretation of this study extremely complicated. The deceased population from which controls were selected may differ from the population from which the cases were drawn on a number of variables, including their residence locations.

Studies of reproductive outcomes. Shaw et al. (*59*) conducted a study on the risk of congenital malformations and low birth weight in areas with landfills, chemical dump sites, industrial sites, and hazardous treatment and storage facilities in the San Francisco Bay, California area. Census tracts were classified as *a*) no hazardous site in area, *b*) hazardous site in area but no evidence of human exposure, and *c*) hazardous site and plume in the area with evidence of potential human exposure. A small increase (1.5-fold) in risk was found for heart and circulatory malformations in the areas with potential human exposure. This increased risk was present across chemical classes and exposure routes. Risk of other malformations or low birth weight was not significantly increased. Results were adjusted for some potential risk factors (maternal age, race, sex of child, birth order) but not for socioeconomic status.

Reproductive outcomes have been studied in a number of other multisite studies. Sosniak et al. (*60*) investigated the risk of adverse pregnancy outcomes for people living within 1 mile of a total of 1,281 NPL sites over the entire United States. The risk for low birth weight and other pregnancy outcomes (infant and fetal death, prematurity, and congenital anomaly) was not associated with living near a site after taking into account a large number of potential confounding factors, including socioeconomic variables collected through questionnaires. However, only around 63% of women originally sampled for the study returned the questionnaire and were included in the study. Also, it is unclear how congenital anomalies were defined, and no subgroups of malformations were studied.

Geschwind et al. (*61*) investigated the risk of congenital malformations in the vicinity of 590 hazardous waste sites in New York State. A 12% increase in congenital malformations was found for people living within 1 mile of a site. For malformations of the nervous system, musculoskeletal system, and integument (skin, hair, and nails), higher risks were found. Some associations between specific malformation types and types of waste were evaluated and found to be significant. A dose–response relationship (higher risks with higher exposure) was reported between estimated hazard potential of the site and risk of malformation, adding support to a possible causal relationship. However, a follow-up study of Geschwind's findings (*62*) found no relation between two selected types of malformations (central nervous system and musculoskeletal) and living near a hazardous waste disposal site. The study did report an increased risk of central nervous system defects for those living near solvent- or metal-emitting industrial facilities. Subjects for the first 2 years of this study were also included in Geschwind's study, and 2 more years were studied. Marshall et al. (*62*) attempted to improve the exposure measurement in the first study by assessing the probability of specific contaminant–pathway combinations in 25 sectors of the 1-mile exposure zones (*63*). The risk of particular pathways or contaminant groups could not be investigated, however, because of limited numbers of cases in each subgroup. Hall et al. (*64*) used the same method of exposure assessment to study renal disease near 317 waste sites in 20 counties in New York State. Increased risks were found for associations between renal disease and residential proximity to a site (within 1 mile), the number of years lived near a site, and a medium or high probability of exposure, although the associations did not reach statistical significance.

A study by Croen et al. (*65*) based exposure measurement on both residence in a census tract containing a waste site and distance of residence from a site. Three specific types of birth defects (neural tube defects [NTDs], heart defects, and oral clefts) were studied; little or no increase in the risk was found using either measure of exposure. Risks of neural tube (2-fold) and heart defects (4-fold) were increased for maternal residence within 1/4 mile of a site, although numbers of cases and controls were too small (between 2 and 8) for these risk estimates to reach statistical significance. Births were ascertained from nonmilitary-base hospitals only, and the authors point out that the increased risk of NTDs may have resulted from lower ascertainment of exposed controls than exposed cases where exposure zones included military bases. Military base residents with pregnancies

affected by NTDs may have been more likely to deliver in nonmilitary hospitals than residents with unaffected pregnancies.

A first European multisite study recently reported a 33% increase in all nonchromosomal birth defects combined for residents living within 3 km of 21 hazardous waste sites in 10 European regions (*66*). Neural tube defects and specific heart defects showed statistically significant increases in risk. Confounding factors such as maternal age and socioeconomic status did not readily explain the results. The study included both open and closed sites that ranged from uncontrolled dumps to relatively modern controlled operations. This disparity makes it difficult at this stage to conclude, if indeed the association is causal, whether risks are related to landfill sites in general or whether specific types of sites may be posing the risks.

Conclusions

The presence of large quantities of mixtures of potentially hazardous chemicals in landfill sites close to residential populations has increasingly caused concern. Concerns have led to a substantial number of studies on the health effects associated with landfill sites. From this review we can conclude that increases in risk of adverse health effects have been reported near individual landfill sites and in some multisite studies. Although biases and confounding factors cannot be excluded as explanations for these findings, the findings may indicate real risks associated with residence near certain landfill sites.

For several reasons, evidence is limited for a causal role of landfill exposures in the health outcomes examined despite the large number of studies. Effects of low-level environmental exposure in the general population are by their nature difficult to establish. Also, existing epidemiologic studies are affected by a range of methodologic problems, potential biases, and confounding factors, making the interpretation of both positive (statistically significant increase in risk) and negative (no increase in risk) findings difficult (*67*). Lack of direct exposure measurement and resulting misclassification of exposure affects most studies and can limit their powers to detect health risks.

It is possible that studies not showing associations have been less likely to be included in this review because they may have been less likely to be submitted or selected for publication, thereby causing the review to be biased toward studies that did report positive associations. However, a number of so-called negative studies have been published and included in this review. We feel that most large, good-quality, epidemiologic investigations, particularly those starting with an a priori hypothesis rather than a specific cluster, would have resulted in publication, whether or not the findings were positive.

An increase in self-reported health outcomes and symptoms such as headaches, sleepiness, respiratory symptoms, psychological conditions, and gastrointestinal problems has been found consistently in health surveys around sites where local concerns were evident (*9,16–18,30–34,54,55*). In these health surveys symptoms were usually reported by the exposed population without further confirmation of the diagnoses by medical examination. It is not possible at this stage to conclude whether the symptoms are an effect of direct toxicologic action of chemicals present in waste sites, an effect of stress and fears related to the waste site, or an effect of reporting bias (the tendency of exposed people to remember and report more symptoms than unexposed people). Several authors have discussed the possibility that odor complaints and related worry about a site may trigger symptoms of stress-related disease or lead to an increased awareness of existing symptoms (*36,37*). Further research in this area is urgently needed to improve our understanding of the impact of social factors and risk perceptions on both actual and perceived ill health in waste site communities. Issues of environmental equity and environmental justice must form an integral part of such research.

Evidence for a causal relationship between landfill exposures and cancers is still weak. Cancers are difficult to study because of long latency periods, as discussed in previous sections. Also, cancer studies have mainly compared incidence or mortality rates between geographic areas without collecting adequate information on confounding factors. Excesses in bladder, lung, and stomach cancer and leukemia were reported in more than one study (*21,29,41,45,56,58*). Well-designed studies with long follow-up and good quality information about confounding factors such as smoking are needed to confirm these findings.

A number of studies have suggested a relationship between residential proximity to landfill sites and adverse pregnancy outcomes. An increase in infants with low birth weights has been the most consistent finding in single-site studies (*11,12,14,26,27*). These were generally well-designed studies and low birth weight is thought to be a sensitive marker of effects of chemical exposures. Small increases in the risk of birth defects and certain specific birth defects (cardiac defects, central nervous system defects, musculoskeletal defects) have been reported, mainly in multisite studies (*12,59,61,65,66*). Studies are still too few, however, to draw conclusions regarding causality. Fetuses, infants, and children are generally thought to be more vulnerable and therefore experience toxic effects at lower doses than the adult population (*25*). The finding of shorter stature in Love Canal children (*10*) may also be an example of this.

An increased presence of chromosomal changes was reported in the vicinity of a landfill site in Mellery, Belgium (*15,28*), but not in Love Canal (*8*). Findings in Mellery were related to children in particular, which may again be an indication that children are more susceptible to low-level exposures from waste sites. It is not clear at present how well chromosomal changes predict cancer risk in humans.

Other adverse health outcomes such as abnormalities in liver function (*13*) and in renal disease (*64*) have also been reported in relation to hazardous waste exposure, although in single studies only.

For the future planning and regulation of landfill sites it is important to know which types of sites are most likely to entail risks. Landfill sites may differ enormously in the conditions that render them hazardous, and conditions that determine the exposure to and resulting health risks posed by any waste site are likely to be unique to that particular site. Such conditions may include the types, quantities, and age of the waste present; hydrogeologic and metereologic factors; and site management and engineering practices. We have not in this review attempted to relate technical aspects of waste disposal to health effects. Much of the existing epidemiologic work investigates large, old sites, uncontrolled dumps, and sites where heavy off-site migration of chemicals was detected. On the basis of current evidence, we cannot extrapolate findings for these individual sites to landfill sites in general or conclude which landfill sites are more likely than others to affect the health of nearby human populations.

It is also not possible to determine whether sites with airborne or waterborne exposures are more likely to pose a risk to human health. Although drinking water contamination is usually the primary concern related to landfill sites, in most cases local water supplies do not originate from the local area. Most studies, therefore, concern landfill sites where no local drinking-water wells were present and potential exposure was either airborne or through other routes such as direct contact and consumption of homegrown vegetables.

At present information regarding adverse health effects of exposure to landfill sites in European countries is largely lacking.

Further Research Needs

Research into the health effects of landfill sites is relatively immature, and further research could improve our current understanding (*1,2,25,68*). Future studies of landfill sites would greatly benefit from a more

interdisciplinary approach, drawing from the fields of landfill engineering, environmental sciences, toxicology, and epidemiology.

Improvements in the base of toxicologic and epidemiologic data on effects of specific chemical exposures would improve our understanding of possible risks of the migration of these chemicals from landfill sites into the environment. Johnson and DeRosa (*69*), in a recent review of toxicologic hazards of Superfund waste sites, conclude that although a large body of toxicologic research is under way to assess the toxicity of chemicals commonly contaminating the environment surrounding waste sites, equally significant work is still to be done before these chemicals have adequate toxicity profiles that can be used by health and risk assessors. Johnson and DeRosa discuss data needs established by the Agency for Toxic Substances and Disease Registry and the U.S. EPA for research of individual chemicals and find these needs mainly in dose–response studies, reproductive studies, and immunotoxicology studies. Improved data on effects of individual chemical exposures would improve the quality of quantitative risk assessments that can be made for landfill exposures. However, quantitative risk assessments are based to a large extent on unverifiable assumptions, and therefore cannot negate the necessity for direct epidemiologic studies of people living near landfill sites.

More research into effects of chemical mixtures and possible interactions between single chemicals is needed to improve understanding of effects of multiple chemical exposures. Such research is complex, but new research initiatives are under way, mainly in the United States. For example, the U.S. EPA MIXTOX database, which contains toxicologic data on interactions of hundreds of pairs of chemicals, is a promising new development (*70*). Research developments and future directions in this field are discussed in detail by a number of authors (*70–72*).

The investigation of single landfill sites is important as a response to community concerns. More multisite studies with large study populations should also be conducted to draw conclusions about more general risks. Ideally, such multisite studies should attempt to classify sites in such a way that risks related to specific site characteristics can be investigated. However, systematic site assessments needed to underpin such classifications are at present totally lacking in Europe. There is little detailed information on waste inputs, especially for old landfills, and monitoring practices vary hugely for factors such as frequency of monitoring, the environmental media monitored, and types of chemicals monitored. Standardized waste-input recording systems and monitoring practices across European countries and the availability of summary reports of waste inputs and monitoring results would aid site classifications for epidemiologic studies as well as risk assessments. A recent report evaluating the use of a risk assessment tool on two U.S. and three U.K. landfill sites concluded that in the United Kingdom it is not possible to characterize the majority of landfills, even to the level at which a simple risk assessment framework can be employed on a site-specific basis. This particularly applies to the characterization of emplaced waste (*73*).

Epidemiology has increasingly made use of so-called biomarkers—biological monitors of either the internal dose of a chemical (biomarkers of exposure) or the biologic response to exposure (biomarkers of early effect). Biomarkers of the first type measure levels of chemicals in human tissue and fluids (e.g., blood, urine). These techniques can generally measure only a small number of chemicals, and their use is limited to situations in which environmental monitoring data indicate specific landfill chemicals that are of particular concern. The presence of chemicals in the body is currently difficult and costly to measure, but this may change. Biomarkers of the second type measure biological responses such as chromosomal changes (sister chromatid exchanges) and molecular changes (DNA adducts), and could be seen as early effect manifestations. Interpretation of these effect biomarkers is difficult; their link with clinically overt disease remains unclear, but their use could give studies much greater statistical power than studies of rare disease outcomes. Biomarker techniques have been used mainly in occupational settings and there has been less discussion of their use in environmental studies (*74,75*). Collaboration is required between epidemiologists and basic scientists to further develop biomarker techniques for use in studies of environmental exposures.

Specific areas of further research likely to prove most useful are

- The study of vulnerable groups—groups of the population likely to develop adverse health effects at levels of exposure lower than those of the general population. Such groups include: fetuses, infants, and children; elderly people; and people with impaired health.
- The study of people with higher exposures, for example, children (because they come into higher contact with potentially contaminated soil); people who eat local food products; workers at waste sites; people with life-styles (possibly socioeconomically determined) that lead to higher exposures.
- The study of worst-case landfills. In the absence of adequate exposure data, it is difficult to define worst-case sites. Ranking systems are in use, e.g., in the Superfund program (*76*), to rank waste sites according to their hazard potential, but their application generally requires extensive site investigations. Few epidemiologic studies would have the resources to carry out such investigations. It could be argued that identification of worst-case landfills should form part of regulatory practice in Europe. However, in the absence of systematic investigation of this kind, the study of sites where high off-site contamination has been detected and sites that have been subject to less regulation (possibly sites in developing countries or Eastern Europe) could be suitable for the study of worst-case scenarios provided appropriate health data can be collected.

It is possible with suitable investment to improve levels of understanding about risks of hazardous wastes to human health. However, because of the complicated nature of the exposure, it is likely that there will always remain a degree of uncertainty regarding health effects of landfill sites.

References and Notes

1. Upton AC. Public health aspects of toxic chemical disposal sites. Annu Rev Public Health 10:1–25 (1989).
2. National Research Council. Environmental Epidemiology. Vol 1: Public Health and Hazardous Wastes. Washington, DC:National Academy Press, 1991.
3. Hill RD. Superfund. In: Hazardous Wastes and Toxic Materials: Safe Handling and Disposal (Fawcett HH, ed). New York:John Wiley, 1988;281–307.
4. Hamar GB, McGeehin MA, Phifer BL, Ashley DL. Volatile organic compound testing of a population living near a hazardous waste site. J Expo Anal Env Epidemiol 6:247–255 (1996).
5. Reif JS, Tsongas TA, Anger WK, Mitchell J, Metzger L, Keefe TJ, Tessari JD, Amler R. Two-stage evaluation of exposure to mercury and biomarkers of neurotoxicity at a hazardous waste site. J Toxicol Environ Health 40:413–422 (1993).
6. Stehr-Green PA, Burse VW, Welty E. Human exposure to polychlorinated biphenyls at toxic waste sites: investigations in the United States. Arch Environ Health 43:420–424 (1988).
7. Janerich DT, Burnett WS, Feck G, Hoff M, Nasca P, Polednak AP, Greenwald P, Vianna N. Cancer incidence in the Love Canal area. Science 212:1404–1407 (1981).
8. Heath CW, Nadel MR, Zack MM, Chen ATL, Bender MA, Preston J. Cytogenetic findings in persons living near the Love Canal. JAMA 251:1437–1440 (1984).
9. Paigen B, Goldman LR, Highland JH, Magnant MM, Steegman AT. Prevalence of health problems in children living near Love Canal. Haz Waste Haz Mat 2:23–43 (1985).
10. Paigen B, Goldman LR, Magmant MM, Highland JH, Steegman AT. Growth of children living near the hazardous waste site, Love Canal. Hum Biol 59:489–508 (1987).
11. Vianna NJ, Polan AK. Incidence of low birth weight among Love Canal residents. Science 226:1217–1219 (1984).
12. Goldman LR, Paigen B, Magnant MM, Highland JH. Low birth weight, prematurity and birth defects in children living near the hazardous waste site, Love Canal. Haz Waste Haz Mat 2:209-223 (1985).
13. Clark CS, Meyer CR, Gartside PS, Majeti VA, Specker B, Balistreri WF, Elia VJ. An environmental health survey of drinking water contamination by leachate from a pesticide waste dump in Hardeman County, Tennessee. Arch Environ Health 37:9–18 (1982).
14. Kharrazi M, VonBehren J, Smith M, Lomas T, Armstrong M, Broadwin R, Blake E, McLaughlin B, Worstell G, Goldman L. A community-based study of adverse pregnancy outcomes near a large hazardous waste landfill in California. Toxicol Ind Health 13:299–310 (1997).
15. Lakhanisky T, Bazzoni D, Jadot P, Joris I, Laurent C, Ottogali M,

Pays A, Planard C, Ros Y, Vleminckx C. Cytogenetic monitoring of a village population potentially exposed to a low level of environmental pollutants. Phase 1: SCE analysis. Mutat Res 319:317–323 (1993).
16. Logue JN, Fox JM. Residential health study of families living near the Drake Chemical Superfund site in Lock Haven, Pennsylvania. Arch Env Health 41:222–228 (1986).
17. Ozonoff D, Colten ME, Cupples A, Heeren T, Schatzin A, Mangione T, Dresner M, Colton T. Health problems reported by residents of a neighborhood contaminated by a hazardous waste facility. Am J Ind Med 11:581–597 (1987).
18. Lipscomb JA, Goldman LR, Satin KP, Smith DF, Vance WA, Neutra RR. A follow-up study of the community near the McColl waste disposal site. Environ Health Perspect 94:15–24 (1991).
19. Zmirou D, Deloraine A, Saviuc P, Tillier C, Boucharlat A, Maury N. Short-term health effects of an industrial toxic waste landfill: a retrospective follow-up study in Montchanin, France. Arch Environ Health 49:228–238 (1994).
20. Deloraine A, Zmirou D, Tillier C, Boucharlat A, Bouti H. Case–control assessment of the short-term health effects of an industrial toxic waste landfill. Environ Res 68:124–132 (1995).
21. Goldberg MS, Al-Homsi N, Goulet L, Riberdy H. Incidence of cancer among persons living near a municipal solid waste landfill site in Montreal, Quebec. Arch Environ Health 50:416–424 (1995).
22. Sorsa M, Wilbourn J, Vainio H. Human cytogenetic damage as a predictor of cancer risk. In: Mechanisms of Carcinogenesis in Risk Identification (Vainio H, Magee PN, McGregor DB, McMichael AJ, eds). IARC Sci Publ 116:543–554 (1992).
23. Sullivan FM. Impact of the environment on reproduction from conception to parturition. Environ Health Perspect 101(suppl 2):13–18 (1993).
24. Kramer MS. Determinants of low birth weight: methodologic assessment and meta-analysis. Bull World Health Org 65:663–737 (1987).
25. British Medical Association. Hazardous Waste and Human Health. Oxford:Oxford University Press, 1991.
26. Berry M, Bove F. Birth weight reduction associated with residence near a hazardous waste landfill. Environ Health Perspect 105:856–861 (1997).
27. Goldberg MS, Goulet L, Riberdy H, Bonvalot Y. Low birth weight and preterm births among infants born to women living near a municipal solid waste landfill site in Montreal, Quebec. Environ Res 69:37–50 (1995).
28. Klemans W, Vleminckx C, Schriewer L, Joris I, Lijsen N, Maes A, Ottogali M, Pays A, Planard C, Gigaux G, et al. Cytogenetic biomonitoring of a population of children allegedly exposed to environmental pollutants. Phase 2: Results of a three- year longitudinal study. Mutat Res 342:147–156 (1995).
29. Budnick LD, Sokal DC, Falk H, Logue JN, Fox JM. Cancer and birth defects near the Drake Superfund site, Pennsylvania. Arch Environ Health 39:409–413 (1984).
30. Hertzman C, Hayes M, Singer J, Highland J. Upper Ottawa street landfill site health study. Environ Health Perspect 75:173–195 (1987).
31. Baker D, Greenland S, Mendlein J, Harmon P. A Health study of two communities near the Stringfellow waste disposal site. Arch Environ Health 43:325–334 (1988).
32. Dunne MP, Burnett P, Lawton J, Raphael B. The health effects of chemical waste in an urban community. Med J Austr 152:592–597 (1990).
33. Dayal H, Gupta S, Trieff N, Maierson D, Reich D. Symptom clusters in a community with chronic exposure to chemicals in two Superfund sites. Arch Environ Health 50:108–111 (1995).
34. Miller MS, McGeehin MA. Reported health outcomes among residents living adjacent to a hazardous waste site, Harris County, Texas, 1992. Toxicol Ind Health 13:311–319 (1997).
35. Roht LH, Vernon SW, Weir FW, Pier SM, Sullivan P, Reed LJ. Community exposure to hazardous waste disposal sites: assessing reporting bias. Am J Epidemiol 122:418–433 (1985).
36. Neutra R, Lipscomb J, Satin K, Shusterman D. Hypotheses to explain the higher symptom rates observed around hazardous waste sites. Environ Health Perspect 94:31–38 (1991).
37. Shusterman D, Lipscomb J, Neutra R, Satin K. Symptom prevalence and odor-worry interaction near hazardous waste sites. Environ Health Perspect 94:25–30 (1991).
38. Greiser E, Lotz I, Brand H, Weber H. Increased incidence of leukemias in the vicinity of a previous industrial waste dump in North Rhine-Westfalia, West Germany [Abstract]. Am J Epidemiol 134:755 (1991).
39. Muir KR, Hill JP, Parkes SE, Cameron AH, Mann JR. Landfill waste disposal: an environmental cause of childhood cancer? Paed Perinat Epidemiol 4:484–485 (1990).
40. Fielder HMP, Monaghan S, Poon-King C, Palmer SR. Report on the health of residents living near the Nant-Y-Gwyddon landfill site using routinely available data. Cardiff:Welsh Combined Centres for Public Health, 1997.
41. Mallin K. Investigation of a bladder cancer cluster in northwestern Illinois. Am J Epidemiol 132:S96–S106 (1990).
42. Alexander FE, Cuzick J. Methods for the assessment of clusters. In: Geographical and Environmental Epidemiology: Methods for Small-Area Studies (Elliott P, Cuzick J, English D, Stern R, eds). Oxford:Oxford University Press, 1992;238–250.
43. Rothman KJ. A sobering start for the cluster busters' conference. Am J Epidemiol 132(suppl 3):S6–S13 (1990).
44. Cutler JJ, Parker GS, Rosen S, Prenney B, Healey R, Caldwell GG. Childhood leukemia in Woburn, Massachusetts. Public Health Rep 101:201–205 (1986).
45. Lagakos SW, Wessen BJ, Zelen M. An analysis of contaminated well water and health effects in Woburn, Massachusetts. J Am Stat Assoc 81:583–596 (1986).
46. Byers VS, Levin AS, Ozonoff DM, Baldwin RW. Association between clinical symptoms and lymphocyte abnormalities in a population with chronic domestic exposure to industrial solvent-contaminated domestic water supply and a high incidence of leukemia. Cancer Immunol Immunother 27:77–81 (1988).
47. Swan SH, Shaw G, Harris JA, Neutra RR. Congenital cardiac anomalies in relation to water contamination, Santa Clara County, California, 1981–1983. Am J Epidemiol 129:885–893 (1989).
48. Deane M, Swan SH, Harris JA, Epstein DM, Neutra RRI. Adverse pregnancy outcomes in relation to water contamination, Santa Clara County, California,1980–1981. Am J Epidemiol 129:894–904 (1989).
49. Wrensch M, Swan S, Lipscomb J, Epstein D, Fenster L, Claxton K, Murphy PJ, Shusterman D, Neutra R. Pregnancy outcomes in women potentially exposed to solvent-contaminated drinking water in San Jose, California. Am J Epidemiol 131:283–300 (1990).
50. Wrensch M, Swan S, Murphy PJ, Lipscomb J, Claxton K, Epstein D, Neutra R. Hydrogeologic assessment of exposure to solvent-contaminated drinking water: pregnancy outcomes in relation to exposure. Arch Environ Health 45:210–216 (1990).
51. Shaw GM, Swan SH, Harris JA, Malcoe LH. Maternal water consumption during pregnancy and congenital cardiac anomalies. Epidemiology 1:206–211 (1990).
52. Deane M, Swan SH, Harris JA, Epstein DM, Neutra RR. Adverse pregnancy outcomes in relation to water consumption: a re-analysis of data from the original Santa Clara study, California, 1980–1981. Epidemiology 3:94–97 (1992).
53. Wrensch M, Swan SH, Lipscomb J, Epstein DM, Neutra RR, Fenster L. Spontaneous abortions and birth defects related to tap and bottled water use, San Jose, California, 1980–1985. Epidemiology 3:98–103 (1992).
54. Najem GR, Strunck T, Feuerman M. Health effects of a Superfund hazardous chemical waste disposal site. Am J Prev Med 10:151–155 (1994).
55. Logue JN, Stroman RM, Reid D, Hayes CW, Sivarajah K. Investigation of potential health effects associated with well water chemical contamination in Londonderry Township, Pennsylvania, U.S.A. Arch Environ Health 40:155–160 (1985).
56. Griffith J, Duncan RC, Riggan WB, Pellom AC. Cancer mortality in U.S. counties with hazardous waste sites and ground water pollution. Arch Environ Health 44:69–74 (1989).
57. Polednak AP, Janerich DT. Lung cancer in relation to residence in census tracts with toxic-waste disposal sites: a case-control study in Niagara County, New York. Environ Res 48:29–41 (1989).
58. Lewis-Michl EL, Kallenbach LR, Geary NS, Melius JM, Ju CL, Orr MF, Forand SP. Investigation of cancer incidence and residence near 38 landfills with soil gas migration conditions: New York State, 1980–1989. ATSDR/HS-98-93. Atlanta:Agency for Toxic Substances and Disease Registry, 1998.
59. Shaw GM, Schulman J, Frisch JD, Cummins SK, Harris JA. Congenital malformations and birthweight in areas with potential environmental contamination. Arch Environ Health 47:147–154 (1992).
60. Sosniak WA, Kaye WE, Gomez TM. Data linkage to explore the risk of low birthweight associated with maternal proximity to hazardous waste sites from the National Priorities List. Arch Environ Health 49:251–255 (1994).
61. Geschwind SA, Stolwijk JAJ, Bracken M, Fitzgerald E, Stark A, Olsen C, Melius J. Risk of congenital malformations associated with proximity to hazardous waste sites. Am J Epidemiol 135:1197–1207 (1992).
62. Marshall EG, Gensburg LJ, Deres DA, Geary NS, Cayo MR. Maternal residential exposure to hazardous wastes and risk of central nervous system and musculoskeletal birth defects. Arch Environ Health 52:416–425 (1997).
63. Marshall EG, Geary NS, Cayo MR, Lauridsen PA. Residential exposure summary methodology for a reproductive health study of multiple hazardous waste sites. J Exp Anal Environ Epidemiol 3 (suppl 1):87–98 (1993).
64. Hall HI, Kaye WE, Gensburg LS, Marshall EG. Residential proximity to hazardous waste sites and risk of end-stage renal disease. J Environ Health 59:17–21 (1996).
65. Croen LA, Shaw GM, Sanbonmatsu L, Selvin S, Buffler PA. Maternal residential proximity to hazardous waste sites and risk of selected congenital malformations. Epidemiology 8:347–354 (1997).
66. Dolk H, Vrijheid M, Armstrong B, Abramsky L, Bianchi F, Garne E, Nelen V, Robert E, Scott JES, Stone D, Tenconi R. Risk of congenital anomalies near hazardous-waste landfill sites in Europe: the EUROHAZCON study. Lancet 352:423–427 (1998).
67. Johnson BL. Hazardous waste: human health effects. Toxicol Ind Health 13:21–43 (1997).
68. National Institute of Environmental Health Sciences (NIEHS). NIEHS/EPA Superfund Basic Research Program. Available: *http://www.niehs.nih.gov/sbrp/home.htm* [cited 1998].
69. Johnson BL, DeRosa CT. The toxicologic hazard of Superfund hazardous waste sites. Rev Environ Health 12:35–251 (1997).
70. Teuschler L, Hertzberg R. Current and fututre risk assessment guidelines, policy, and methods development for chemical mixtures. Toxicology 105:137–144 (1995).
71. DeRosa CT, Johnson BL, Fay M, Hansen H, Mumtaz MM. Public health implications of hazardous waste sites: findings, assessment and research. Food Chem Toxicol 34:1131–1138 (1996).
72. Johnson B, DeRosa C. Chemical mixtures released from hazardous waste sites: implications for health risk assessment. Toxicology 105:145–156 (1995).
73. Department of the Environment. Health Effects from Hazardous Waste Landfill Sites. The Technical Aspects of Controlled Waste Management. Rpt no CWM/057/92. London:Department of the Environment, 1994.
74. Vine MF. Biologic markers of exposure: current status and future research needs. Toxicol Ind Health 12:189–200 (1996).
75. National Research Council. Use of biological markers in assessing human exposure to airborne contaminants. In: Human Exposure Assessment for Airborne Pollutants (National Research Council, ed). Washington, DC:National Academy of Sciences, 1991.
76. U.S. Environmental Protection Agency. Hazard Ranking System—Final Rule. 40 CFR Pt 300. Fed Reg 55(241):51532–51667 (1999).

Risk of adverse birth outcomes in populations living near landfill sites

Paul Elliott, David Briggs, Sara Morris, Cornelis de Hoogh, Christopher Hurt, Tina Kold Jensen, Ian Maitland, Sylvia Richardson, Jon Wakefield, Lars Jarup

Abstract

Objective To investigate the risk of adverse birth outcomes associated with residence near landfill sites in Great Britain.

Design Geographical study of risks of adverse birth outcomes in populations living within 2 km of 9565 landfill sites operational at some time between 1982 and 1997 (from a total of 19 196 sites) compared with those living further away.

Setting Great Britain.

Subjects Over 8.2 million live births, 43 471 stillbirths, and 124 597 congenital anomalies (including terminations).

Main outcome measures All congenital anomalies combined, some specific anomalies, and prevalence of low and very low birth weight (<2500 g and <1500 g).

Results For all anomalies combined, relative risk of residence near landfill sites (all waste types) was 0.92 (99% confidence interval 0.907 to 0.923) unadjusted, and 1.01 (1.005 to 1.023) adjusted for confounders. Adjusted risks were 1.05 (1.01 to 1.10) for neural tube defects, 0.96 (0.93 to 0.99) for cardiovascular defects, 1.07 (1.04 to 1.10) for hypospadias and epispadias (with no excess of surgical correction), 1.08 (1.01 to 1.15) for abdominal wall defects, 1.19 (1.05 to 1.34) for surgical correction of gastroschisis and exomphalos, and 1.05 (1.047 to 1.055) and 1.04 (1.03 to 1.05) for low and very low birth weight respectively. There was no excess risk of stillbirth. Findings for special (hazardous) waste sites did not differ systematically from those for non-special sites. For some specific anomalies, higher risks were found in the period before opening compared with after opening of a landfill site, especially hospital admissions for abdominal wall defects.

Conclusions We found small excess risks of congenital anomalies and low and very low birth weight in populations living near landfill sites. No causal mechanisms are available to explain these findings, and alternative explanations include data artefacts and residual confounding. Further studies are needed to help differentiate between the various possibilities.

Introduction

Waste disposal by landfill accounts for over 80% of municipal waste in Britain.[1] Human exposure to toxic chemicals in landfill (which include volatile organic compounds, pesticides, solvents, and heavy metals[2–4]) may occur by dispersion of contaminated air or soil,[2] leaching or runoff,[5] or by animals and birds, although evidence for any substantial exposures is largely lacking.[6] Excess risks of congenital anomalies and low birth weight near landfill have been reported,[6–9] including from recent European and UK studies,[10 11] although some have reported less significant[12] or negative findings.[13] The aim of our present study was to examine risk of adverse birth outcomes associated with residence near landfill using data on all known sites in Great Britain.

Methods

Classification of populations near landfill sites

Data provided by the national regulatory agencies were merged in a geographical information system to give a database containing 19 196 sites. Data on boundaries were unavailable for most sites, so point locations had to be used. These comprised the site centroids for 70% of sites and, for the remainder, the location of the site gateway at the time of reporting. Data for site locations were of low accuracy (often rounded to 1000 metres), and data on area were inadequate to allow estimation of the extent of most sites. Landfill sites also change considerably over time as old areas are closed and new areas develop, while postcodes (used to define the location of cases and births) give only an approximation of place of residence, accurate to 10-100 metres in urban areas but >1 km in some rural areas; also, landfill sites are highly clustered, so that individual postcodes may lie close to 30 or more sites. Therefore, distance from nearest landfill site was not regarded as a meaningful proxy for exposure. As a compromise between the need for spatial precision and the limited accuracy of the data, we constructed a 2 km zone around each site (figure), giving resolution similar to or higher than that of previous studies,[10 11] and at the likely limit of dispersion for landfill emissions.[14] Postcodes within the 2 km buffer zone were classified hierarchically by operational status, year on year, such that sites still operating took precedence over those closed earlier in the study period, which took precedence over sites opening later in the study period.[15] People living more than 2 km from all known landfill sites during the study period comprised the reference population.

Because of concerns about the quality of landfill data for earlier years, and because health data were available only to 1998, we excluded 9631 sites (25% of the population) that closed before 1982 or opened after 1997 (to allow a one year lag period for the birth outcomes) or for which there were inadequate data. The remaining 9565 sites comprised 774 sites for special (hazardous) waste, 7803 for non-special waste, and 988 handling unknown wastes. The 2 km surrounding these sites included 55% of the national population; 20% were included in the reference area.

Health and denominator data

We used national postcoded registers held by the Small Area Health Statistics Unit. These comprised the National Congenital Anomaly System in England and

Editorial by McNamee and Dolk

Small Area Health Statistics Unit (SAHSU), Department of Epidemiology and Public Health, Imperial College, St Mary's Campus, London W2 1PG

Paul Elliott *director*

David Briggs *professor of environment and health*

Sara Morris *research associate*

Cornelis de Hoogh *research associate*

Christopher Hurt *research associate*

Tina Kold Jensen *lecturer*

Ian Maitland *database manager*

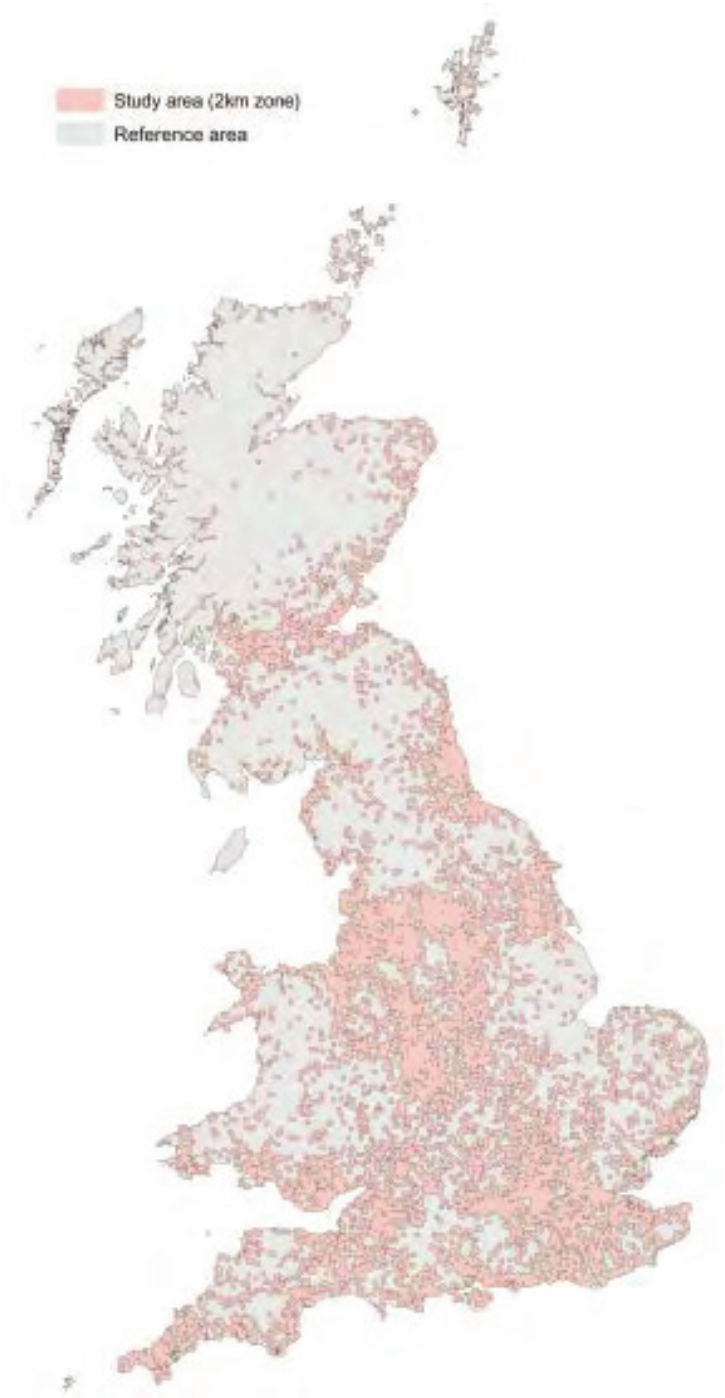
Sylvia Richardson *professor of statistics*

Jon Wakefield *reader in statistics*

Lars Jarup *assistant director*

Correspondence and reprint requests to: P Elliott p.elliott@ic.ac.uk

BMJ 2001;323:363–8



Map of Great Britain showing 2 km zones around landfill sites and reference area

Wales, 1983-98, and data on terminations, 1992-8, performed for "grounds E" of the 1967 Abortions Act ("where there is a substantial risk that if the child were born it would suffer from such physical or mental abnormality as to be seriously handicapped"); congenital anomaly and terminations data for Scotland, 1988-94; hospital admissions data for England and Scotland, 1993-8 (Welsh data were considered unreliable); and national births and stillbirths data, 1983-98.

Cases were coded to ICD-9 (international classification of diseases, ninth revision) from 1983 to 1994, and to ICD-10 thereafter. Outcomes were all congenital anomalies combined (ICD-9 740-59; ICD-10 Q00-Q99); neural tube defects (ICD-9 740.0-740.2, 741.0-741.9, 742.0; ICD-10 Q00.0-Q00.2, Q05.0-Q05.9, Q01.0-Q01.9); cardiovascular defects (ICD-9 745.0-747.9; ICD-10 Q20.0-Q28.9); abdominal wall defects (ICD-9 756.7; ICD-10 Q79.2-Q79.4); hypospadias and epispadias (ICD-9 752.6; ICD-10 Q54.0-Q54.9, Q64.0); surgical correction of hypospadias and epispadias (M731, M732); and surgical correction of gastroschisis and exomphalos (T281). Multiple anomalies were counted under each outcome (once only for all anomalies combined).

Surgical corrections (England and Scotland only) were analysed by date of birth, not date of surgical procedure. For hypospadias and epispadias, we included only procedures carried out before the age of 3 years, and, for gastroschisis and exomphalos, in the first year of life only. Low and very low birth weights were defined as <2500 g and <1500 g respectively. The relevant denominators and years of analysis are shown in table 1.

Statistical methods

We calculated risks for the population within 2 km of landfill relative to the reference population by indirect standardisation, assuming a common relative risk for all landfill sites. We used model predictions from Poisson regression of data from the reference area to provide standard rates. The regression function included year of birth, administrative region ($n=10$), sex (for birth weight and stillbirths), and deprivation. We obtained deprivation by assigning postcodes to tertiles of the national distribution of the Carstairs' deprivation index[16] based on 1991 census statistics at enumeration district level (we used tertiles rather than quintiles of the Carstairs index because of the small number of events for the rarer outcomes in the most deprived part of the reference area). We used a descending stepwise selection procedure starting from the fullest model including all possible interactions. This was repeated without deprivation, and then the two models were constrained (where necessary) to differ only in terms of deprivation (table 2). For the hospital admissions data (where there were fewer years), unadjusted and deprivation-adjusted results only were obtained, and no modelling was done.

Some degree of overdispersion and a widening of the confidence intervals is to be expected if our model assumptions fail to hold (for example, because of data anomalies, unmeasured confounding, or sampling variability of the rates). We therefore calculated Poisson 99% (rather than 95%) confidence intervals, but this does not necessarily ensure that all additional variability has been captured—we emphasise estimation of relative risks and their stability (or otherwise) to choice of model confounders rather than significance testing.

We assessed the sensitivity of our results to model choice by using an alternative model for each birth outcome (table 2). We also included urban or rural status and examined risks for rural areas only, and for birth weight (where data were sufficient) we examined sensitivity to the use of quintiles (rather than tertiles) of the Carstairs index. For abdominal wall defects, we also examined maternal age (<20 and ≥ 20 years, available 1986-98 for England and Wales only).[17]

The main analysis identified at outset was for all landfill sites for the combined period during their

Table 1 Denominators and years for analyses of birth outcomes near landfill sites (within 2 km) and in reference area (≥2 km from any site), and before opening and during operation and after closure for sites that opened during the study period

			All operating and closed sites by waste type				Sites that opened during study period (all waste types) by operating status	
Analysis	Denominator	Years	All	Special waste	Non-special waste	Reference area	Before opening	During operation and after closure
Congenital anomalies*	Live births, stillbirths, and terminations	E, W 1983-98; S 1988-94	5 825 575	803 833	4 517 196	2 026 074	429 160	4 150 320
Surgical corrections (hypospadias and epispadias)†	Live male births	E, S 1993-5	585 414	67 281	469 149	199 974	9 982	424 271
Hospital admissions (abdominal wall defects) or surgical corrections (gastroschisis and exomphalos)†	Live births	E, S 1993-7	1 903 892	222 179	1 522 851	646 415	21 282	1 384 135
Stillbirths	Live births and stillbirths	E, S, W 1983-98	6 062 700	825 456	4 725 120	2 177 796	461 776	4 295 686
Low and very low birth weight	Live births	E, S, W 1983-98	6 030 429	821 124	4 699 860	2 166 596	459 358	4 272 510

E=England, W=Wales, S=Scotland.
*Includes terminations for England and Wales 1992-8, for Scotland 1988-94. For hypospadias and epispadias, denominator data are male live births and stillbirths only: numbers are 2 983 963 (all landfill sites), 412 201 (special waste sites), 2 313 135 (non-special waste sites), 1 037 320 (reference area), 220 227 (before opening of sites), 2 125 477 (after opening of sites).
†England and Scotland only.

operation and after closure. Subsidiary analyses examined risks separately for special and non-special waste sites, and in the period before and after opening for the 5260 landfill sites with available data.[17]

Results

Urban or rural status and Carstairs index were strongly correlated. Within the reference area, 49% of the most affluent tertile of areas was classified as rural (7% for the most deprived tertile), while for all outcomes rates were higher in the most deprived areas compared with the most affluent areas: the ratio ranged from 1.02 (surgical correction of hypospadias and epispadias) to 1.52 (very low birth weight).[17] The area within 2 km of the 9565 landfill sites tended to be more deprived than the reference area: 34% (v 23%) of the population were in the most deprived tertile of Carstairs score (36% for special waste sites). The area near landfill also had a higher proportion of births to mothers under 20 years of age (7.7% v 6.1%) and, among women aged 15-44, included (1991 census) a higher proportion of women of Indian, Pakistani, or Bangladeshi origin (4.8% v 3.2%) and a lower proportion of black women (2.0% v 3.4%).

Table 3 shows the numbers of cases for each birth outcome and relative risks for the area near landfill compared with the reference area. The relative risk for all congenital anomalies combined was 0.92 (99% confidence interval 0.907 to 0.923) unadjusted, and 1.01 (1.005 to 1.023) adjusted for deprivation and other confounders. After adjustment for deprivation (which reduced excess risks) relative risk was 1.05 (1.01 to 1.10) for neural tube defects, 1.08 (1.01 to 1.15) for abdominal wall defects (and 1.07 (0.98 to 1.18) for hospital admissions), 1.19 (1.05 to 1.34) for surgical correction of gastroschisis and exomphalos, and 1.05 (1.047 to 1.055) and 1.04 (1.03 to 1.05) for low and very low birth weight respectively. The risk was 0.96 (0.93 to 0.99) for cardiovascular defects and 1.07(1.04 to 1.10)

Table 2 Models chosen by the stepwise selection procedure in the reference area for each outcome*

Outcome	Model	No of parameters in chosen model	Terms added in alternative model†
Deprivation unadjusted			
All anomalies	Year+region+region:year	151	—
Neural tube defects	Year+region	25	Region:year
Cardiovascular defects	Year+region	25	Region:year
Hypospadias and epispadias	Year+region	25	Region:year
Abdominal wall defects	Year+region	25	Region:year
Stillbirth	Year+region+sex+region:sex	35	Region:year
Low birth weight	Year+region+sex	26	Region:year
Very low birth weight	Year+region	25	Region:year
Deprivation adjusted			
All anomalies	Deprivation+year+region+region:deprivation+region:year	171	Year:deprivation
Neural tube defects	Deprivation+year+region	27	Region:year
Cardiovascular defects	Deprivation+year+region+region:deprivation	45	Region:year
Hypospadias and epispadias	Deprivation‡+year+region	27	Region:year
Abdominal wall defects	Deprivation+year+region	27	Region:year
Stillbirth	Deprivation+year+region+sex+region:sex	37	Deprivation:year
Low birth weight	Deprivation+year+region+sex+region:deprivation+deprivation:sex	48	Region:year
Very low birth weight	Deprivation+year+region+region:deprivation	45	Deprivation:year

Interactions are denoted by ":"
*No modelling was done for the hospital admissions data.
†Terms added in alternative model used in sensitivity analysis, defined as the most important term excluded at the last step (no alternative is shown for all anomalies combined, deprivation unadjusted, because the model is already saturated).
‡Deprivation not selected by stepwise selection process but was added as a main effect.

Table 3 Risks of congenital anomalies, stillbirths, and low and very low birth weight in populations living within 2 km of a landfill site (all waste types) during operation or after closure compared with those in the reference area (≥2 km from any site)

	Near landfill (<2 km)		Reference area		Relative risk (99% CI)		
Birth outcome	No of cases	Rate (per 100 000 births)	No of cases	Rate (per 100 000 births)	Unadjusted	Adjusted (but not for deprivation)	Adjusted (and for deprivation)
Congenital anomalies (register and terminations data*)							
All congenital anomalies	90 272	1550	34 325	1694	0.92 (0.907 to 0.923)	1.01 (1.00 to 1.02)	1.01 (1.005 to 1.023)
Neural tube defects	3 508	60	1 140	56	1.07 (1.02 to 1.12)	1.08 (1.03 to 1.12)	1.05 (1.01 to 1.10)
Cardiovascular defects	6 723	115	2 716	134	0.86 (0.83 to 0.89)	0.95 (0.92 to 0.98)	0.96 (0.93 to 0.99)
Hypospadias and epispadias†	7 363	247	2 485	240	1.03 (1.00 to 1.06)	1.07 (1.04 to 1.10)	1.07 (1.04 to 1.10)
Abdominal wall defects	1 488	26	448	22	1.16 (1.08 to 1.23)	1.14 (1.06 to 1.22)	1.08 (1.01 to 1.15)
Congenital anomalies (hospital admissions)							
Hypospadias and epispadias‡	1 503	257	536	268	0.96 (0.90 to 1.02)	—	0.96 (0.90 to 1.02)
Abdominal wall defects	755	40	227	35	1.13 (1.03 to 1.24)	—	1.07 (0.98 to 1.18)
Gastroschisis and exomphalos‡	467	25	126	19	1.26 (1.12 to 1.42)	—	1.19 (1.05 to 1.34)
Stillbirths and birth weight							
Stillbirths	32 271	532	11 200	514	1.04 (1.02 to 1.05)	1.05 (1.03 to 1.06)	1.00 (0.99 to 1.02)
Low birth weight	422 149	7000	137 958	6367	1.10 (1.095 to 1.104)	1.11 (1.102 to 1.111)	1.05 (1.047 to 1.055)
Very low birth weight	62 191	1031	20 858	963	1.07 (1.06 to 1.08)	1.08 (1.07 to 1.09)	1.04 (1.03 to 1.05)

See table 1 for denominators and years of analysis and table 2 for adjustments.
*Terminations included for England and Wales 1992-8, Scotland 1988-94.
†Excludes terminations (3 cases).
‡Surgical corrections.

and 0.96 (0.90 to 1.02), respectively, for hypospadias and epispadias and their surgical correction (for which deprivation adjustment had little or no effect).

Table 4 summarises findings (adjusted for deprivation) for the special and non-special waste sites, and for the sites that opened during the study period. For special waste sites, risks above one were found for all but two outcomes, ranging up to 1.11 (1.03 to 1.21) for cardiovascular defects and for hypospadias and epispadias. For the specific anomalies, except neural tube and cardiovascular defects, risks were higher in the period before opening of a landfill site compared with after opening, especially for hospital admissions for abdominal wall defects. For birth weight and stillbirth, risks were higher after opening.

Sensitivity analysis showed that the risk estimates were robust to the different models used.[17] Urban or rural status did not materially alter results with deprivation included, though modelling of data for rural areas only (where numbers of cases were much lower than in the main analysis) did reduce risk estimates for neural tube defects and hypospadias and epispadias—relative risks (for all waste types, deprivation adjusted) were 0.99 (0.89 to 1.10) and 1.01 (0.94 to 1.09) respectively. Inclusion of maternal age as a confounder had only a small effect on risk of abdominal wall defects.[17]

Discussion

This is by far the largest study of associations between residence near landfill and adverse birth outcomes. We found a small excess risk of neural tube defects, abdominal wall defects, surgical correction of gastro-

Table 4 Estimated relative risks (99% confidence intervals) of birth outcomes for populations living within 2 km of a landfill site, adjusted for deprivation and other variables* according to waste type and to operating status for those sites that opened during the study period

	All operating and closed sites, by waste type			Sites that opened during study period (all waste types), by operating status†	
Birth outcome	All wastes	Special waste	Non-special waste	Before opening	During operation or after closure
Congenital anomalies (register and terminations data‡)					
All congenital anomalies	1.01 (1.005 to 1.023)	1.07 (1.04 to 1.09)	1.02 (1.01 to 1.03)	1.02 (0.99 to 1.05)	1.00 (0.99 to 1.01)
Neural tube defects	1.05 (1.01 to 1.10)	1.07 (0.95 to 1.20)	1.06 (1.01 to 1.12)	0.98 (0.82 to 1.16)	1.05 (0.99 to 1.10)
Cardiovascular defects	0.96 (0.93 to 0.99)	1.11 (1.03 to 1.21)	0.95 (0.91 to 0.98)	0.92 (0.81 to 1.04)	0.92 (0.88 to 0.95)
Hypospadias and epispadias§	1.07 (1.04 to 1.10)	1.11 (1.03 to 1.21)	1.07 (1.04 to 1.11)	1.08 (0.98 to 1.19)	1.05 (1.02 to 1.09)
Abdominal wall defects	1.08 (1.01 to 1.15)	1.03 (0.86 to 1.25)	1.07 (0.99 to 1.16)	1.24 (0.97 to 1.60)	1.06 (0.98 to 1.14)
Congenital anomalies (hospital admissions)					
Hypospadias and epispadias¶	0.96 (0.90 to 1.02)	0.98 (0.81 to 1.19)	0.96 (0.90 to 1.04)	1.42 (0.94 to 2.16)	0.93 (0.86 to 1.00)
Abdominal wall defects	1.07 (0.98 to 1.18)	1.08 (0.82 to 1.42)	1.05 (0.94 to 1.16)	2.26 (1.23 to 4.15)	1.12 (1.01 to 1.25)
Gastroschisis and exomphalos¶	1.19 (1.05 to 1.34)	1.10 (0.77 to 1.58)	1.18 (1.03 to 1.34)	1.33 (0.46 to 3.81)	1.24 (1.09 to 1.42)
Stillbirths and birth weight					
Stillbirths	1.00 (0.99 to 1.02)	0.99 (0.95 to 1.03)	1.00 (0.99 to 1.02)	1.01 (0.96 to 1.06)	1.02 (1.00 to 1.03)
Low birth weight	1.05 (1.047 to 1.055)	1.05 (1.04 to 1.06)	1.06 (1.052 to 1.062)	1.01 (0.99 to 1.02)	1.07 (1.062 to 1.072)
Very low birth weight	1.04 (1.03 to 1.05)	1.03 (1.00 to 1.06)	1.04 (1.03 to 1.06)	0.98 (0.94 to 1.02)	1.04 (1.03 to 1.05)

See table 1 for denominators and years of analysis.
*See table 2 for other variables adjusted for.
†522 landfill sites with available data for hospital admissions.
‡Terminations included for England and Wales 1992-8, Scotland 1988-94.
§Excludes terminations (3 cases).
¶ Surgical corrections.

schisis and exomphalos, low and very low birth weight. Findings for cardiovascular defects and hypospadias and epispadias were inconsistent, and there was no association with stillbirth. By including all landfill sites in Great Britain and using routine data sources, we avoided the possibility of bias from selective reporting[18 19] and maximised statistical power, but problems with data quality and confounding could have led to spurious associations.[20] These merit further discussion.

Exposure classification and data quality issues

In the absence of information on site or geological factors affecting emissions from landfill, we examined data for special waste sites as a proxy for potential hazard. The UK practice of co-disposal of special and non-special wastes (in contrast, for example, with US "superfund" sites[3]) means that most special waste sites handle small volumes of hazardous wastes. They are subject to stricter management and design standards than other UK sites, while hazardous wastes may have been disposed of, unreported, in non-special sites. Thus exposure risks from special waste sites may be no greater than from other sites. Exposures to environmental contamination from sources other than landfill may also be relevant because sites tend to be located in old mineral or other excavations, often on old industrial or contaminated land or close to current industrial activities.

A key issue was the possibility of misclassification from use of a 2 km zone to define proximity to landfill sites. However, in view of the low spatial resolution of the landfill data (hundreds of metres) and complex nature of landfill sites, using finer subdivisions of the 2 km zone or distance as a continuous measure to examine proxy dose-response relationships would not yield meaningful results. Misclassification of potential exposure to landfill may also have occurred if mothers moved home during the relevant period after conception.[21]

While the data for births and stillbirths are well recorded, the national congenital anomaly system in England and Wales is known to be incomplete[22] (though we found relative over-reporting in Scotland), and there were marked fluctuations in rates of anomalies over the study period, partly because of coding changes[23] and the dates that the terminations data became available. We adjusted for calendar year to deal with fluctuating rates, but ascertainment artefacts could have biased our results (in either direction) if they were differential with respect to landfill locations. Though we had no reason to suspect that this had occurred, such inconsistencies could explain differences of the order detected in this study. On the other hand, we included data on terminations to improve ascertainment, especially for neural tube defects, and included data on hospital admissions and surgical corrections to give an independent source of data for those specific anomalies.

Confounding

We addressed confounding in two ways. Firstly, analysis included potential confounders, with and without adjustment for deprivation. Residual confounding may persist if the adjustment did not account completely for relevant individual characteristics such as smoking,[24] drug use,[25] and infections during pregnancy.[26] As in the Eurohazcon study,[10] maternal age (for risk of abdominal wall defects[27]) did not seem to be a strong confounder, and, unlike in the United States,[28] location of waste sites near ethnic minority communities was not a key feature. Increased risks (about 1.5 to 2) of low and very low birth weight,[29 30] and (more weakly) of certain congenital anomalies (especially neural tube defects[31]) have been reported among offspring of women of South Asian origin,[32] but the higher proportions of women of Indian, Pakistani, or Bangladeshi origin living near landfill sites compared with the reference area would explain only around 1% excess in our study.

Secondly, we examined rates both before and after the opening of landfill sites that opened during the study period. Because this analysis is restricted to one set of areas, it is less subject to confounding by socio-demographic factors than comparisons between different areas—although confounding by temporal trends (which are strong for some of the health outcomes studied here[17]) is possible. Consequently, we did not compare the risks before and after opening directly but estimated each with respect to the reference region. We found excess risks for some specific anomalies in the period before opening (and which were higher than in the period during operation or after closure, especially for hospital admission for abdominal wall defects). This implies that factors other than landfill might be responsible. The Nant-y-Gwyddon study also noted an excess risk of all congenital anomalies combined before the site was opened.[11]

A possible causal association with landfill should also be considered. Given the large heterogeneity between landfill sites and the likelihood that the effect of any emissions would be greatest close to the sites,[33] causal effects related to particular landfill sites might have been greatly diluted. None the less, we know of no causal mechanism that might explain our findings, and there is considerable uncertainty as to the extent of any possible exposure to chemicals found in landfills.[6] Further understanding of the potential toxicity of landfill emissions and possible exposure pathways is needed in order to help interpret the epidemiological findings.

What is already known on this topic

Various studies have found excess risks of certain congenital anomalies and low birth weight near landfill sites

Risks up to two to three times higher have been reported

These studies have been difficult to interpret because of problems of exposure classification, small sample size, confounding, and reporting bias

What this study adds

Some 80% of the British population lives within 2 km of known landfill sites in Great Britain

By including all landfill sites in the country, we avoided the problem of selective reporting, and maximised statistical power

Although we found excess risks of congenital anomalies and low birth weight near landfill sites in Great Britain, they were smaller than in some other studies

Further work is needed to differentiate potential data artefacts and confounding effects from possible causal associations with landfill

We thank the Office for National Statistics, the Department of Health, and the Information and Statistics Division of the Scottish Health Service for providing data on congenital anomalies, births, stillbirths, and hospital admissions. We thank the Environment Agency in England and Wales and the Scottish Environment Protection Agency for providing data on landfill and for their help in resolving discrepancies. The views expressed in this publication are those of the authors and not necessarily those of the funding departments, data providers, or of Office for National Statistics. We thank Sean Reed and Richard Arnold for their help in preliminary analyses and Alex Lewin for help in the statistical analysis.

Contributors: PE and LJ initiated the project and, with DB and SM, drafted the paper. DB, CdH, CH, and IM performed the analysis of landfill sites. SM, CH, and IM performed the statistical analysis, overseen by JW and SR. TKJ contributed to the epidemiological analysis and interpretation. All authors contributed to and approved the final paper. PE is guarantor for the paper.

Funding: The Small Area Health Statistics Unit is funded by a grant from the Department of Health; Department of the Environment, Food, and Rural Affairs; Environment Agency; Health and Safety Executive; Scottish Executive; National Assembly for Wales; and Northern Ireland Assembly.

Competing interests: None declared.

1 *Digest of environmental statistics*. London: Department of the Environment, Transport and the Regions, 2001.
2 Ward RS, Williams GM, Hills CC. Changes in major and trace components of landfill gas during subsurface migration. *Waste Manage Res* 1996;14:243-61.
3 Johnson BL, DeRosa C. The toxicologic hazard of superfund hazardous-waste sites. *Rev Environ Health* 1997;12:235-51.
4 Hamar GB, McGeehin MA, Phifer BL, Ashley DL. Volatile organic compound testing of a population living near a hazardous waste site. *J Expo Anal Environ Epidemiol* 1996;6:247-55.
5 El-Fadel M, Findikakis AN, Leckie JO. Environmental impacts of solid waste landfilling. *J Environ Manage* 1997;50:1-25.
6 Vrijheid M. Health effects of residence near hazardous waste landfill sites: a review of epidemiologic literature. *Environ Health Perspect* 2000;108:101-12.
7 Geschwind SA, Stolwijk JA, Bracken M, Fitzgerald E, Stark A, Olsen C, et al. Risk of congenital malformations associated with proximity to hazardous waste sites. *Am J Epidemiol* 1992;135:1197-207.
8 Shaw GM, Schulman J, Frisch JD, Cummins SK, Harris JA. Congenital malformations and birthweight in areas with potential environmental contamination. *Arch Environ Health* 1992;47:147-54.
9 Vianna NJ, Polan AK. Incidence of low birth weight among Love Canal residents. *Science* 1984;226:1217-9.
10 Dolk H, Vrijheid M, Armstrong B, Abramsky L, Bianchi F, Garne E, et al. Risk of congenital anomalies near hazardous-waste landfill sites in Europe: the EUROHAZCON study. *Lancet* 1998;352:423-7.
11 Fielder HM, Poon-King CM, Palmer SR, Moss N, Coleman G. Assessment of impact on health of residents living near the Nant-y-Gwyddon landfill site: retrospective analysis. *BMJ* 2000;320:19-22.
12 Croen LA, Shaw GM, Sanbonmatsu L, Selvin S, Buffler PA. Maternal residential proximity to hazardous waste sites and risk for selected congenital malformations. *Epidemiology* 1997;8:347-54.
13 Marshall EG, Gensburg LJ, Deres DA, Geary NS, Cayo MR. Maternal residential exposure to hazardous wastes and risk of central nervous system and musculoskeletal birth defects. *Arch Environ Health* 1997;52:416-25.
14 World Health Organization. *Methods of assessing risk to health from exposure to hazards released from waste landfills. Report from a WHO meeting Lodz, Poland, 10-12 April 2000*. Bilthoven, Netherlands: WHO Regional Office For Europe, European Centre for Environment and Health, 2001.
15 Briggs D, de Hoogh K, Hurt C, Maitland I. *A geographical analysis of populations living around landfill sites*. London: Small Area Health Statistics Unit, Imperial College, 2001. (SAHSU Technical Report 2001.1.)
16 Carstairs V, Morris R. Deprivation: explaining differences between mortality between Scotland and England. *BMJ* 1989;299:886-9.
17 Elliott P, Morris S, Briggs D, Hurt C, de Hoogh C, Maitland I, et al. *Birth outcomes and selected cancers in populations living near landfill sites. Report to the Department of Health*. London: Small Area Health Statistics Unit, Imperial College, 2001.
18 Roht LH, Vernon SW, Weir FW, Pier SM, Sullivan P, Reed LJ. Community exposure to hazardous waste disposal sites: assessing reporting bias. *Am J Epidemiol* 1985;122:418-33.
19 Neutra R, Lipscomb J, Satin K, Shusterman D. Hypotheses to explain the higher symptom rates observed around hazardous waste sites. *Environ Health Perspect* 1991;94: 31-8.
20 Elliott P, Wakefield JC. Bias and confounding in spatial epidemiology. In: Elliott P, Wakefield JC, Best NG, Briggs D, eds. *Spatial epidemiology: methods and applications*. Oxford: Oxford University Press, 2000:68-84.
21 Schulman J, Selvin S, Shaw GM, Malcoe LH. Exposure misclassification due to residential mobility during pregnancy in epidemiologic investigations of congenital malformations. *Arch Environ Health* 1993;48:114-9.
22 Working Group of the Registrar General's Medical Advisory Committee. *The OPCS monitoring scheme for congenital malformations*. London: Office of Population Censuses and Surveys, 1995. (Occasional paper 43.)
23 Office of Population Censuses and Surveys. *A statistical review of notifications of congenital malformations received as part of the England and Wales monitoring system, 1992. Congenital malformations statistics notifications*. London: HMSO, 1992.
24 Wasserman CR, Shaw GM, O'Malley CD, Tolarova MM, Lammer EJ. Parental cigarette smoking and risk for congenital anomalies of the heart, neural tube, or limb. *Teratology* 1996;53:261-7.
25 Torfs CP, Velie EM, Oechsli FW, Bateson TF, Curry CJ. A population-based study of gastroschisis: demographic, pregnancy, and lifestyle risk factors. *Teratology* 1994;50:44-53.
26 Lynberg MC, Khoury MJ, Lu X, Cocian T. Maternal flu, fever, and the risk of neural tube defects: a population-based case-control study. *Am J Epidemiol* 1994;140:244-55.
27 Tan KH, Kilby MD, Whittle MJ, Beattie BR, Booth IW, Botting BJ. Congenital anterior abdominal wall defects in England and Wales 1987-93: retrospective analysis of OPCS data. *BMJ* 1996;313:903-6.
28 Soliman MR, Derosa CT, Mielke HW, Bota K. Hazardous wastes, hazardous materials and environmental health inequity. *Toxicol Ind Health* 1993;9:901-12.
29 Afflick EF, Hessol NA. Impact of Asian ethnicity and national origin on infant birth weight. *Am J Epidemiol* 1997;145:148-55.
30 Parsons L, Duley L, Alberman E. Socio-economic and ethnic factors in stillbirth and neonatal mortality in the NE Thames Regional Health Authority (NETRHA) 1983. *Br J Obstet Gynaecol* 1990;97:237-44.
31 Balarajan R, Raleigh VS, Botting B. Mortality from congenital malformations in England and Wales: variations by mother's country of birth. *Arch Dis Child* 1989;64:1457-62.
32 Leck I, Lancashire RJ. Birth prevalence of malformations in members of different ethnic groups and in the offspring of matings between them, in Birmingham England. *J Epidemiol Community Health* 1995;49:171-9.
33 US Environmental Protection Agency. *Revised risk assessment for the air characteristic study. Volume 1, overview*. Washington: US EPA, Office of Solid Waste, 1999. (530-R-99-19a.)

(Accepted 3 August 2001)

Department of Health

News releases

Largest ever study into health of populations around landfill sites published

Published date: 16 August 2001

A major study into the possible health risks for populations living around landfill sites is published today. The Small Area Health Statistics Unit (SAHSU) studied the rates of birth defects, low birthweight, stillbirths, and of certain cancers in populations living within 2km of landfill sites. The group examined 9,565 landfill sites that were in operation between 1982 and 1997. It is the most extensive study into landfill sites anywhere in the world.

The study was commissioned in response to public concerns about the possible health effects of living close to landfill sites. SAHSU, an independent unit funded by government departments, found that 80 per cent of the population lives within 2 kilometres of a landfill site.

Results on birth outcomes of the SAHSU study will be published in the British Medical Journal on 17 August. The key findings are:

- the study found no increase in rates of cancer in populations living close to landfill sites
- the rate of congenital anomalies in populations living within 2km of all landfills is one per cent more than expected
- the rate of congenital anomalies in populations living within 2km of landfill sites containing hazardous waste is seven per cent more than expected
- rates of low birth weight babies are around five per cent higher near to landfill sites, but there is no difference in the rate of stillbirths
- rates of birth defects did not increase, and in some cases reduced, after landfill sites were opened in certain areas

The SAHSU study says that it is not clear at present that landfills are causing these effects and that other explanations are possible. These could include limits in the information available for the study, or the possibility that the study did not completely take into account other factors which increase the risk of birth defects or low birth weight. They recommend that further work is done to distinguish between these possibilities.

The Government's expert advisory Committee on the Toxicity of Chemicals in Food, Consumer Products and the Environment (COT) noted that the findings for the birth outcomes were not consistent and that the study provided no evidence that rates of anomalies increased after landfill sites opened. They commented that this made it difficult to draw conclusions about the possible health effects of landfill sites on the basis of this study. The COT recommended that the finding of a 7 per cent higher rate of congenital anomalies around special waste sites merited further investigation, whether or not it was related to the presence of the landfill sites.

Dr Pat Troop, Deputy Chief Medical Officer, said:

“"This is an important study and the Government is taking it seriously. The results are difficult to interpret and we need to put them into context. We cannot say that there is no risk from landfill sites, but given the small numbers of congenital anomalies and the uncertainties in the findings, we are not changing our advice to pregnant women and they should continue with the recommended ante-natal programme.""

This study is part of an ongoing Government-funded research programme to investigate the possible impact of landfill sites on human health. In response to the recommendation of the COT, SAHSU will be asked to look further at the data to see if it is possible to identify any areas with particularly high rates of birth defects and to further investigate what these might be associated with.

Notes to editor

1. The Small Area Health Statistics Unit (SAHSU) was established in 1987, to investigate the incidence of disease around sources of environmental pollution and to advise government. It is wholly funded by government departments of Health; Environment, Food and Rural Affairs; Health and Safety Executive, Scottish Executive; National Assembly of Wales; Environment Agency; and Northern Ireland Department of Health, Social Security and Public Safety.
2. A full report of the study will be published on the DH website at: www.doh.gov.uk/landh.htm A paper publishing the results of the birth

outcomes analyses is published in the British Medical Journal on 17 August 2001.

3. In summer 1998, a report of the EUROHAZCON study was published in the Lancet. This investigated the incidence of congenital anomaly around 21 hazardous waste landfill sites in 5 European countries. It found an increased risk of congenital anomaly in babies whose mothers live close to the landfill sites. The study did not establish cause and effect, but concluded that there was a need for further work.
4. The SAHSU study was part of ongoing work to look at potential health impacts from landfill sites. Other research underway includes a review of the known causes of birth defects, a review of the potential for substances emanating from landfill sites to cause birth defects, a study of the geographical variation in overall rates of birth defects and the rates of specific anomalies, and a detailed study of emissions from landfill sites.
5. It is Government policy to reduce reliance on landfill. The Government's Waste Strategy 2000 set out a comprehensive strategy to reduce reliance on landfill, to reduce waste, to recycle it and to gain value from waste. The EU Landfill Directive which came into force on 16 July 2001 imposes stringent targets on the UK to reduce the amount of biodegradable municipal waste which it landfills to 35% of that produced in 1995 by 2020. The WS 2000 also sets challenging targets for increasing household recycling and composting and a target to reduce the amount of industrial and commercial waste landfilled. We produce over 100 million tonnes of waste a year from households, commerce and industry alone. Most waste produced in England and Wales goes to landfill. About 83% of municipal waste and 54% of commercial and industrial waste are managed in this way.
6. Landfills are subject to strict controls. The purpose of the licensing system is to ensure that waste is recovered or disposed of in ways which protect the environment and human health. Landfill sites are subject to strict licensing and regulatory controls by the Environment Agency in England and Wales and the Scottish Environment Protection Agency (SEPA) in Scotland. The purpose of the licensing system is to ensure that waste is recovered or disposed of in ways which protect the environment and human health. Details of landfill sites can be found on the public registers of the EA and SEPA, and information about landfill sites in England and Wales can be found at www.environment-agency.gov.uk/yourenv/
7. The EU Landfill Directive will impose additional requirements on landfill including banning some wastes from landfill altogether and requiring that waste is pre-treated before it is landfilled. Regulations to implement the Directive were issued for consultation on 8 August.
8. For further information contact Department of Health media centre on 0207 210570752334860 or DEFRA press office 0207 238 5391

Contact: Press officer

Address: Media Centre, Department of Health
Richmond House, 79 Whitehall
London
SW1A 2NL

Phone: **Media Centre**
020 7210 5221

PubMed www.pubmed.gov

U.S. National Library of Medicine
and the National Institutes of Health

1: J Occup Environ Med. 1997 Nov;39(11):1103-10.

Health study of New York City Department of Sanitation landfill employees.

Gelberg KH.

New York State Department of Health, Bureau of Occupational Health, Albany 12203, USA.

Employees currently working at a large municipal landfill expressed concern that they experience higher rates of illness than other municipal sanitation workers. Therefore, this study was designed to examine acute health effects among employees working at the New York City Department of Sanitation, with special emphasis upon the landfill workers. Interviews conducted with 238 landfill and 262 off-site male employees asked questions about health symptoms experienced in the six months prior to the interview and about workplace exposures. This study found a higher prevalence among landfill employees of work-related dermatologic, neurologic, hearing, and respiratory symptoms, and sore and itching throats than among off-site employees. The respiratory and dermatologic symptoms were not associated with any specific occupational title or work task, other than working at the landfill. Off-site laborers experienced more neuromuscular symptoms and injuries.

PMID: 9383721 [PubMed - indexed for MEDLINE]

Environmental Research 111 (2011) 847–852

Contents lists available at ScienceDirect

Environmental Research

journal homepage: www.elsevier.com/locate/envres

Relation between malodor, ambient hydrogen sulfide, and health in a community bordering a landfill ☆

Christopher D. Heaney [a,*], Steve Wing [a], Robert L. Campbell [b], David Caldwell [b], Barbara Hopkins [b], David Richardson [c], Karin Yeatts [a]

[a] Department of Epidemiology, Gillings School of Global Public Health, University of North Carolina at Chapel Hill, CB# 7435, Chapel Hill, NC 27599-7435, USA
[b] Rogers-Eubanks Neighborhood Association, P.O. Box 16903, Chapel Hill, NC 27516-6903, USA
[c] Institute for the Environment, University of North Carolina at Chapel Hill, CB#1105 Chapel Hill, NC 27599-1105, USA

ARTICLE INFO

Article history:
Received 31 August 2010
Received in revised form
17 May 2011
Accepted 29 May 2011
Available online 15 June 2011

Keywords:
Community-driven research
Solid waste landfills
Air pollution
Hydrogen sulfide
Malodor
Health

ABSTRACT

Background: Municipal solid waste landfills are sources of air pollution that may affect the health and quality of life of neighboring communities.
Objectives: To investigate health and quality of life concerns of neighbors related to landfill air pollution.
Methods: Landfill neighbors were enrolled and kept twice-daily diaries for 14 d about odor intensity, alteration of daily activities, mood states, and irritant and other physical symptoms between January and November 2009. Concurrently, hydrogen sulfide (H_2S) air measurements were recorded every 15-min. Relationships between H_2S, odor, and health outcomes were evaluated using conditional fixed effects regression models.
Results: Twenty-three participants enrolled and completed 878 twice-daily diary entries. H_2S measurements were recorded over a period of 80 d and 1-h average H_2S=0.22 ppb (SD=0.27; range: 0–2.30 ppb). Landfill odor increased 0.63 points (on 5-point Likert-type scale) for every 1 ppb increase in hourly average H_2S when the wind was blowing from the landfill towards the community (95% confidence interval (CI): 0.29, 0.91). Odor was strongly associated with reports of alteration of daily activities (odds ratio (OR)=9.0; 95% CI: 3.5, 23.5), negative mood states (OR=5.2; 95% CI: 2.8, 9.6), mucosal irritation (OR=3.7; 95% CI=2.0, 7.1) and upper respiratory symptoms (OR=3.9; 95% CI: 2.2, 7.0), but not positive mood states (OR=0.6; 95% CI: 0.2, 1.5) and gastrointestinal (GI) symptoms (OR=1.0; 95% CI: 0.4, 2.6).
Conclusions: Results suggest air pollutants from a regional landfill negatively impact the health and quality of life of neighbors.
© 2011 Elsevier Inc. All rights reserved.

Annotated Resources on Landfills and Health Effects

1. **Porta, D. et al. Systemic Review of Epidemiological Studies on Health Effects Associated with Management of Solid Waste.** ***Environmental Health*** **(2009) 8:60-73.**

   This paper provides an overview of the studies in the published literature that evaluated the adverse health effects associated with different waste management methods including landfills. The authors also scored the reported effects in order to derive useable excess risk estimates for health impact assessment. The study design and potential biases in effect estimates were evaluated for each study included in the review. The authors found that for populations living with 2 kilometers of landfills, there was limited evidence of congenital anomalies and low birth weight with an excess risk of 2 percent and 6 percent, respectively. The excess risk tended to be higher when sites handled toxic waste. Many of the studies suffered from various limitations that are described in the review. Despite this, the authors concluded with a moderate degree of confidence that "we have derived some effect estimates that could be used for health impact assessment."

2. **Kouznetsova, M., et al. Increased Rate of Hospitalization for Diabetes and Residential Proximity of Hazardous Waste Sites.** ***Environmental Health Perspectives*** **(2007) 115(1): 75-79.**

   This study investigated whether residence near persistent organic pollutants (POPs)-contaminated hazardous waste sites increased rates of hospitalization for diabetes. The authors examined adult diabetes patients 25-74 years of age in New York State from 1993-2000. After controlling for major potential confounders, the study found a statistically significant increase in the rate of hospitalization for diabetes among patients residing in ZIP codes containing POPs-contaminated waste sites versus patients in "clean" sites. These results do not prove a cause and effect relationship; however, this study provides further support for the association between diabetes and exposure to environmental contaminants.

3. **Kuehn, C.M., et al. Risk of Malformations Associated with Residential Proximity to Hazardous Waste Sites in Washington State.** ***Environmental Research*** **(2007) 103: 405-412.**

   This study examines the relationship between malformations occurring in infants and maternal residential proximity to hazardous waste sites in Washington State. Maternal residence of infants born with malformations from 1987-2001 was compared to maternal residence of infants who were randomly selected and who were born without malformations during this same time period. The authors found that infants born within 5 miles of a hazardous waste site had an increased risk of malformations compared to infants born more than 5 miles away from a hazardous waste site.

4. **Gilbreath, S and Philip Kass. Adverse Birth Outcomes associated with open dumpsites in Alaska Native Villages.** ***American Journal of Epidemiology*** **(2006) 164(4): 518-528.**

   This study evaluates adverse birth outcomes in infants whose birth records indicate that the mothers lived in villages with dumpsites that were potentially hazardous to public health. The authors found that mothers who lived in villages with intermediate and high hazard dumpsite has a higher proportion of low birth weight infants than did mothers in the control group. More infants born to mothers who lived in the intermediate and high hazard villages suffered from intrauterine growth retardation.

5. **Palmer, S. et al. Risk of congenital anomalies after the opening of landfill sites. *Environmental Health Perspectives* (2005) 113(10): 1362-1365.**

   This study was conducted to investigate whether there was an increased risk of births with congenital malformations for mothers living near 24 landfill sites in Wales that opened between 1983 and 1997. Expected rates of congenital anomalies were compared to those of mothers living within 2 km of the sites, before and after opening of the landfills. Results showed risk of congenital anomalies for mothers living near the landfills increased when the sites were opened. However, the data could not establish a causal link between the landfills and the malformations because of a variety of biases that may have confounded the relationship. Nonetheless, the increase in risk associated with the opening of sites requires continued surveillance.

6. **Morgan, O., Vrijheid, M., Dolk, H. Risk of low birth weight near EUROHAZCON hazardous waste landfill sites in England. *Archives of Environmental Health* (2004) 59(3): 149-151.**

   This study evaluated risk of low birth weight near 10 English hazardous waste sites used in a previous study of congenital anomalies (see below). The authors found a small but not statistically significant increase in risk of low birth weight within 3 km of sites. The findings of this study suggests that previously reported results for congenital anomalies should not be extrapolated to a wider range of reproductive effects but instead evaluated separately for each outcome.

7. **Dummer, T., Dickinson, H., Parker, L. Adverse pregnancy outcomes near landfill sites in Cumbria, northwest England, 1950-1993. *Archives of Environmental Health* (2003) 58(11): 692-697.**

   This study evaluated the risks of stillbirth or neonatal death for mothers living near landfills. All stillbirths, neonatal deaths, and lethal congenital anomalies occurring among 287,993 births to mothers in Cumbria, northwest England during the period 1950-1993 were studied. For the period 1970-1993, a small but significant increase in risk of "other congenital anomalies of the nervous system" was found in mothers living near domestic waste landfill sites. This finding was consistent with other researchers, but a casual effect could not be inferred and the possibility that the results occurred by chance could not be ruled out.

8. **Vrijheid et al. Chromosomal congenial anomalies and residence near hazardous waste landfill sites. *Lancet* (2002) 359: 320-322.**

   This study revealed that there is an increased risk of chromosomal anomalies in people who live close to hazardous waste landfills. Adjustments were made for maternal age and socioeconomic status. The results of this study suggest that an increase in the risk of chromosomal anomalies is similar to that found for non-chromosomal anomalies.

9. **Elliot, P. et al. Risk of adverse birth outcomes in populations living near landfill sites. *British Medical Journal* (2001) 323: 363-368.**

   Between 1982 and 1997, a study was conducted to investigate the risk of adverse birth outcomes associated with residence near landfill sites. Individuals living 2 km from one of 9565 landfill sites throughout Great Britain were sampled. This has been the largest study of associations between residence near landfill and adverse birth outcomes thus far. It was concluded that residents near landfill sites are at risk of having children with congenital anomalies and low birth weight, however, further studies are needed to explain these findings.

10. McNamee, R., Dolk, H. Editorial: Does exposure to landfill waste harm the fetus? *British Medical Journal* (2001) 323: 351-352.

This editorial addresses issues concerning the article entitled "Risk of adverse birth outcomes in populations living near landfill sites" by Elliot et al. in the August 2001 edition of the British Medical Journal.

11. Pukkala, E and Antti Ponka. Increased incidence of cancer and asthma in houses built on a former dump area. Environmental Health Perspectives (2001) 109(11): 1121-1125.

This study evaluated the health of people who moved into twelve blockhouses in Helsinki, Finland that were built on a former dumpsite. Cancer and other chronic diseases were evaluated. The authors found a statistically significant increase in cancer for both sexes. The relative risk increased slightly with the number of years lived in the area. They also found increases in asthma and chronic pancreatitis. The authors concluded that the "possibility of a causal association between the dump exposure and incidence of cancer and asthma cannot be fully excluded." Nonetheless, the city council decided to demolish all houses in the dump area.

12. Berger, S., Jones P., White, M. Exploratory analysis of respiratory illness among persons living near a landfill. *Journal of Environmental Health* (2000) 62.6: 19.

Due to concern expressed by residents in two Staten Island, NY communities, the authors of this study evaluated the severity and frequency of respiratory symptoms occurring over a 12-month period among self-identified residents with asthma, severe breathing, or other respiratory conditions. Responses indicated that residents who lived adjacent to the landfill and those from the north-shore (seven miles from the landfill) had differing health problems, with landfill residents reporting higher rates of certain odors and eye, nose and throat irritation. The authors concluded that further investigation of respiratory illnesses should be conducted, as the study showed high rates of respiratory-related symptoms and conditions.

13. Vrijheid et al. Health effects of residence near hazardous waste landfill sites: a review of epidemiologic literature. *Environmental Health Perspectives* (2000) 108: (Suppl. 1) 101-112.

This review is an evaluation of current literature on the adverse health effects due to residence near landfill sites. It is difficult to make a conclusion about direct causes for adverse health effects and risks of landfills in general are hard to quantify. Of the studies reviewed, all proved to have insufficient exposure information. This article suggests that research of exposure to landfill sites needs to take a more interdisciplinary approach. Furthermore, epidemiologic and toxicologic studies need to be conducted for individual chemicals and chemical mixtures in order to understand what their effects may be on a population living near a landfill.

14. Knox, EG. Childhood cancers, birthplaces, incinerators and landfill sites. *International Journal of Epidemiology* (2000) 29: 391-397.

A study conducted in Great Britain between 1974 and 1987 found that children living near incinerators, both municipal and medical, were at more risk of getting cancer than those children living near landfill sites. This study targeted the sensitivity of children to carcinogenic emissions, but it failed to take into account the association of additional toxic sources in the vicinity. This study also did not account for the migration of families from areas of high toxicity to areas of low toxicity before, during, or after a child's birth.

15. State of New York Department of Health, Center for Environmental Health. Investigation of cancer incidence near 38 landfills with soil gas migration conditions: New York state, 1980-1989, 1998. Available from: New York State DOH, 2 University Place, Albany, NY 12203-3399. Phone: 1-800-458-1158.

Thirty-eight landfills throughout the state of New York were selected for a study to find out if people living near certain landfills had an increased risk of cancer compared to people living elsewhere. This study evaluated cancer incidence among people living around these 38 landfills between 1980 and 1989. All cases of leukemia, non-Hodgkin's lymphoma, liver, lung, kidney, bladder and brain cancer were identified and located on a map. Although this study had many limitations, it still found that women living near the landfills had a higher incidence of bladder cancer and leukemia. In comparison, men did not show an increased risk of any type of cancer despite their proximity to a landfill.

16. Dolk, H. et al. Risk of congenital anomalies near hazardous-waste landfill sites in Europe: the EUROHAZCON study. *Lancet* (1998) 352: 423-427.

This study examined seven regional registers of congenital anomalies in five different countries in Europe to determine if exposure from hazardous chemicals at landfills increased the risk of birth defects. Twenty-one sites were examined overall and among those sites mothers within a 3 km radius showed a significantly raised risk of having children with congenital anomalies. The results of this study were adjusted for maternal age and socioeconomic status. However, this study's findings are limited by a lack of information on exposures.

17. Berry, M., and Bove, F. Birth weight reduction associated with residence near a hazardous waste landfill. *Environmental Heath Perspectives* (1997) 105(8): 856-861.

Twenty-five years of birth certificate information (1961-1985) was collected in order to examine the relationship between birth weight and mother's residence near the Lipari Landfill located in New Jersey. The results indicated that there was a significant impact to infants born to residents who lived near the landfill during the time they would have been at greatest risk of exposure to hazardous chemicals. Many factors, including maternal health, cigarette and alcohol consumption during pregnancy, and socioeconomic status were not available for this study.

18. Goldberg, M. et al. Incidence of cancer among persons living near a municipal solid waste landfill site in Montreal, Quebec. *Archives of Environmental Health* (1995) 50(6): 416-424.

In a Canadian study, researchers from the Public Health Department in Montreal evaluated cancer incidence rates in people living around the Miron Quarry municipal landfill. Thirty-five volatile organic chemicals were identified in the landfill gases sampled, including known human carcinogens. When evaluating cancer incidence rates among persons living near the landfill, it was concluded that there might have been increased risks for certain cancers, such as stomach, liver, lung, prostate, and cervix uteri. The researchers also concluded that there were too many unknown factors to make any conclusions as to whether cancer incidence and proximity to the landfill were directly related.

19. Shaw, G. et al. Congenital malformations and birth weight in areas with potential environmental contamination. *Archives of Environmental Health* (March/April 1992) 47: 147-154.

Due to the public's increasing concern about reproductive damage as a result of exposure to environmental contamination, a study was conducted to determine if mothers living near contaminated sites were at a greater risk of having children with congenital malformations. This study did not reveal lower birth weight or increased risks

for most malformations among women who lived in contaminated areas. It did, however, show an elevated risk for infants with malformations of the heart and circulatory system.

20. Upton, A. et al. Public health aspects of toxic chemical disposal sites. *Annual Review of Public Health* (1989) 10:1-22.

This article provides a summary and overview of past health studies conducted around toxic waste disposal sites. The results of 16 published epidemiological studies of residential exposures to toxic waste sites are summarized in this report, many of which are landfills operated by local, state or federal agencies. Although many weaknesses were identified in this review, several adverse health impacts were also identified. These included decreased weight at birth, increase in the frequency of congenial malformations, increase in the occurrence of certain forms of cancer, decrease in the growth and maturation of children, and increased prevalence of central nervous system symptoms. Overall, this article provides evidence that health problems associated with exposure to toxic waste disposal sites are underestimated and poorly studied.

21. Hertzman, C. et al. Upper Ottawa Street landfill site health study. *Environmental Health Perspectives* (1987) 75:173-195.

As of 1987, there were few health studies conducted that found health problems in communities living around landfills that were published in the medical or scientific literature. To this day, there is still a lack of conclusive studies giving evidence that adverse health effects are caused by landfills alone. In a study conducted by Clyde Hertzman et al. a number of health problems in workers and residents living near the Upper Ottawa Street Landfill in Hamilton, Ontario were identified. A few of the problems found with the highest credibility included clusters of respiratory, skin, narcotic, and mood disorders. Evidence is presented in their study that supports the hypothesis that vapors, fumes or particulate matter emanating from the landfill site, as well as direct skin exposure, may have lead to the health problems found in excess in this particular area.

22. Paigen, B. et al. Growth of children living near the hazardous waste site, Love Canal. *Human Biology* (June 1987) 59(3): 489-508.

This is the third of a series of three studies that were conducted on children living near the Love Canal landfill. This study examined whether living near a hazardous waste site had an adverse impact on the growth patterns of children. Children are especially vulnerable to environmental contamination and it was hypothesized that exposed children would be smaller in comparison to control groups of children within a similar socioeconomic status. In earlier studies it was found that there was a significant effect between health problems and the closeness of homes near Love Canal, but in this study the difference in stature associated with birth and residence near Love Canal was not statistically significant. These findings suggest that length of exposure to chemicals may be more important to study rather than point of exposure.

23. Goldman, L., and Paigen, B. Low birth weight, prematurity and birth defects in children living near the hazardous waste site, Love Canal. *Hazardous Waste & Hazardous Materials* (1985) 2(2):209-223.

This is the second of a series of three studies that were conducted on children living near the Love Canal landfill. This study assessed birth weight, prematurity, gestational age, and birth defects in 239 children who were living in the Love Canal neighborhood before and shortly after birth. Overall the results showed no significant difference in prematurity, but there was an increase in low birth rate and birth defects. The outcomes of this study suggest that low birth weight is a good indicator of adverse health effects caused by exposure to low levels of chemicals.

24. Paigen, B., and Goldman, L. Prevalence of health problems in children living near Love Canal. *Hazardous Waste & Hazardous Materials* (1985) 2(1):23-43.

This is the first of a series of three health studies that were conducted on children living near the Love Canal landfill. This particular study looked at the overall health of children. The parents of 523 Love Canal and 440 control children were given questionnaires. It was found that children that lived near Love Canal had an increased prevalence of seven major health problems including, seizures, learning problems, hyperactivity, eye irritation, skin rashes, abdominal pain, and incontinence. This paper addresses many of the difficulties involved with conducting community health studies and recognizes the limitations of science when there are so many variables to contend with.

Updated September 2010

CHEJ Center for Health, Environment & Justice

USEFUL WEBSITES ABOUT LANDFILLS

Please note that web addresses change frequently. We apologize if you are not able to access a particular site and hope that you are still able to gain useful information from the other materials provided in this Fact Pack.

- Zero Waste, Landfill Page: http://www.zerowasteamerica.org/Landfills.htm

  Zero Waste America (ZWA) is an Internet-based environmental research organization that promotes the recycling of all materials back into nature or the marketplace. ZWA's Landfill page highlights the hazards associated with landfills and provides evidence as to why landfills always fail. This page has excellent statistics and provides links to numerous organizations, experts, and publications.

- Grassroots Recycling Network, End Landfilling Page: http://www.grrn.org/landfill/index.html

  The Grassroots Recycling Network helps to promote corporate accountability and encourages public policies to manage resources in order to achieve zero waste. This web page outlines how landfills are flawed and makes the argument that landfills are just wasting our resources and polluting our environment. GRRN has several campaigns and resources that are described on this site as well.

- Dr. Fred Lee's Home Page: http://www.gfredlee.com/

  Dr. G. Fred Lee and Dr. Anne Jones-Lee have prepared professional papers and reports about various issues surrounding domestic water supply, water quality, water and wastewater treatment, water pollution control, and the evaluation and management of the impacts of solid and hazardous wastes. Their web page allows readers to download the papers and reports they have written, many of which relate to the failures and risks of landfills.

- The Basics of Landfills: http://www.ejnet.org/landfills/

  This site is maintained by the Activists' Center for Training in Organizing and Networking and provides a basic understanding of what landfills are and why they fail. This page hasseveral links to useful articles and organizations that deal with landfill issues.

- The Alliance for a Clean Environment: http://www.acereport.org/

  The Alliance for a Clean Environment (ACE) is a local group from Pottstown, PA that has been fighting for the health and safety of their community, which is being threatened by a local hazardous waste landfill. Their site provides an example of how a local group can make a difference and provides proof that "people power" is effective in winning a fight.

- Concerned Citizens of Cattaraugus County, Inc. Home Page: http://www.homestead.com/concernedcitizens

  Concerned Citizens of Cattaraugus County is a larger than local nonprofit corporation located in New York State that advocates for clean air, soil and water through the implementation and enforcement of laws and policies that promote a clean and healthful environment. CCCC's main goal is to keep the public informed, especially about issues concerning waste disposal on the local and state level. Their web site addresses several of the issues being addressed in NY surrounding landfills and waste problems in general.

References

Agency for Toxic Substances and Disease Registry, U.S. Department of Health and Human Services. (2001). Landfill Gas Primer - An Overview for Environmental Health Professionals. Available at: http://www.atsdr.cdc.gov/HAC/landfill/html/intro.html

At least 160 bodies recovered from avalanche of garbage dump in Philippines. (2000, July 16). *CNN International.com*. Available at: http://edition.cnn.com/2000/ASIANOW/southeast/07/15/philippines.landslide.01/index.html

Bailey, Jeff. (1996, November 14). Plastic Dump Liners Have Been Slow in Coming. *Wall Street Journal*. A4.

Cohen Milstein Attorneys Score Public Health Win in Lipari Landfill Settlement; Landfill Once Termed the Nation's Worst Toxic Dump. (2001, May 19). *Business Wire*. Available at: http://findarticles.com/p/articles/mi_m0EIN/is_2001_May_19/ai_74730068

Elliot, P., Briggs, D., Morris, S., de Hoogh, C., Hurt, C., Jensen, T.K., Maitland, I., Richardson, S., Wakefield, J. & Jarup, L. (2001). Risk of Adverse Birth Outcomes in Populations Living Near Landfill Sites. *British Medical Journal 323*: 363-368. Available at: http://dx.doi.org/10.1136/bmj.323.7309.363

Environmental Research Foundation. The Basics of Landfills: How They Are Constructed and Why They Fail. Available at: http://www.zerowasteamerica.org/BasicsOfLandfills.htm

Fretwell, Sammy. (2002, February 17). Threat of Landfill Leak into Major South Carolina Reservoir Studied. *The State*. Columbia, SC.

Gardinier, Bob. (2002, January 22). Plans for Dump are a Big Waste, Town Says. *The Times Union*. Albany, NY. Available at: http://tinyurl.com/6xxqd9

Gelberg, Kitty H. (1997). Health Study of New York City Department of Sanitation Landfill Employees [abstract]. *Journal of Occupational and Environmental Medicine 39*(11): 1103-10. Abstract available at: http://www.ncbi.nlm.nih.gov/pubmed/9383721

Greenpeace. (1998, November 27). Vinyl in Landfills Most Likely to Blame for Toxic Gases [press release]. Available at: http://archive.greenpeace.org/majordomo/index-press-releases/1998/msg00333.html

Johnson, Annysa. (2001, January 5). 2 Landfills Want Permit Changes. *Milwaukee Journal Sentinel*. Available at: http://www.jsonline.com/news/state/jan01/pcb06x010501a.asp

Kore Para Aotearoa. (1999). Current Issues: Landfills. Palmerston North, New Zealand. Available at: http://www.converge.org.nz/kpa/issues.htm

Lee. G. Fred. (1998, March). Assessing the Potential of Minimum Subtitle D Lined Landfills to Pollute: Alternative Landfilling Approaches. Proceedings of the Air and Waste Management Association 91st Annual Meeting, San Diego, CA. Available at: http://www.gfredlee.com/alternative_lf.html

Lee, G. Fred. (1999, November). Detecting Failure of Subtitle D Landfill Liner Systems. G. Fred Lee & Associates, El Macero, CA. Available at: http://www.gfredlee.com/detecting_failure.pdf

Lee, G.Fred and Jones-Lee, Anne. (1994). Impact of Municipal and Industrial Non-Hazardous Waste Landfills on Public Health and the Environment: An Overview. Prepared for California EPA Comparative Risk Project, Sacramento, CA. Available at: http://www.gfredlee.com/cal_risk.htm

Lee, G. Fred and Jones-Lee, Anne. (1996). Evaluation of the Potential for a Proposed or Existing Landfill to Pollute Groundwaters [abstract]. Report of G. Fred Lee & Associates, El Macero, CA.

Lee, G.Fred and Jones-Lee, Anne. (1998, July). Deficiencies in Subtitle D Landfill Liner Failure and Groundwater Pollution Monitoring. Presented at the National Water Quality Monitoring Council National Conference, "Monitoring: Critical Foundations to Protect Our Waters." US Environmental Protection Agency, Washington, D.C. Available at: http://www.gfredlee.com/nwqmcl.html

Lee, G. Fred and Sheehan, William. (1996). Landfills Offer False Sense of Security. *BioCycle* 37(9):8.

Lewis, Gregory. (2002, July 17). Study to Examine For Lauderdale, Fla., Landfill's Effect on Public Health. *Sun-Sentinel*. Fort Lauderdale, FL.

Montague, Peter. (1982, September). Hazardous Waste Landfills: Some Lessons From New Jersey. *Civil Engineering Magazine*. American Society of Civil Engineers. Available at: http://www.rachel.org/files/document/Hazardous_Waste_Landfills_Some_lessons_from_Ne.pdf

Montague, Peter. (1988, December 26). The Catch-22s of Landfill Design. *Rachel's Environment & Health News* #109. Available at: http://www.rachel.org/en/node/4354

Montague, Peter. (1989, March 7). Leachate Collection Systems: The Achilles Heel of Landfills. *Rachel's Environment & Health News* #119. Available at: http://www.rachel.org/en/node/4344

Montague, Peter. (1991, January 23). Plastics Part 2: Why Plastic Landfill Liners Always Fail. *Rachel's Environment & Health News* #217. Available at: http://www.rachel.org/en/node/4235

Montague, Peter. (1992, December 16). New Evidence That All Landfills Leak. *Rachel's Environment & Health News* #316. Available at: http://www.rachel.org/en/node/4131

Raloff, Janet. (1989, March 18). Unexpected Leakage Through Landfill Liners. *Science News.* 135(11).

Raloff, Janet. (2001, July 7). Landfills Make Mercury More Toxic. *Science News* 160(1): 4. Available at: http://sciencenews.org/view/generic/id/1777/

U.K. Department of Health, Media Office. (2001, August 16). Largest Ever Study Into Health of Populations Around Landfill Sites Published [press release]. London. Available at: http://www.dh.gov.uk/en/Publicationsandstatistics/Pressreleases/DH_4010837

U.S. Environmental Protection Agency, Region 5, Office of Public Affairs. (1999, June 25). EPA Cites CDT Landfill for Clean-Air Violations. Press Release No. 99-OPA177.

Vrijheid, Martine. (2000). Health Effects of Residence Near Hazardous Waste Sites: A Review of Epidemiologic Literature. *Environmental Health Perspectives 108*, Supplement 1: 101-112. Available at: http://www.ehponline.org/members/2000/suppl-1/101-112vrijheid/vrijheid-full.html

Wood, Lindsay. (2001). Old PCs Toxic in Landfill Sites. *The Galt Global Review*. Available at: http://www.galtglobalreview.com/business/toxic_pcs.html







"CHEJ is the strongest environmental organization today – the one that is making the greatest impact on changing the way our society does business."

Ralph Nader

"CHEJ has been a pioneer nationally in alerting parents to the environmental hazards that can affect the health of their children."

New York, New York

Center for Health, Environment & Justice
P.O. Box 6806, Falls Church, VA 22040-6806

From:	Ken Eklund
To:	Benton Public Comment
Subject:	I oppose LU-24-027: reference articles and opinions in the press - 5 of 12
Date:	Thursday, May 8, 2025 2:35:36 PM
Attachments:	writerguy-cube2.png 10 Ill wind sours plans to sell Emerson Vineyards News polkio.com.pdf 11 Your Ecological House Slow global warming by cutting methane emissions now.pdf 11b Letter Dump's toxic brew poisons the river.pdf 12 Benton task force Coffin Butte expansion should be tied to monitoring.pdf 13 Letter We need a plan, not bigger landfill.pdf 14 Environmental Groups Urge EPA Action on Methane Emissions From Landfills Truthout.pdf 15 As I See It We all owe it to them to draw the line now.pdf 16 Coffin Butte landfill mechanics on strike.pdf

CAUTION: This email originated from outside of the organization. Do not click links or open attachments unless you recognize the sender and know the content is safe.

More history of Coffin Butte Landfill in the press, covering many of the same issues that have come up in public testimony: PFAS, leachate, methane, EPA and DEQ investigations and actions, labor issues, Republic cover-ups of problems and information, fire hazards, misleading and dubious information about the economics of the landfill, and so on. – K

Ken Eklund, writerguy

37340 Moss Rock Dr
Corvallis OR 97330
408.623.8372

Creator of
World Without Oil
Ed Zed Omega
FutureCoast
and other storymaking games

https://www.polkio.com/news/ill-wind-sours-plans-to-sell-emerson-vineyards/article_3224d8c4-b936-11ed-bb64-076dd08dd060.html

TOP STORY

Ill wind sours plans to sell Emerson Vineyards

By David Hayes
Mar 2, 2023



In better times, Tom Johns touts a bottle of Emerson Vineyards' 2019 pinot noir.

YouTube video image

Itemizer-Observer

If all goes to plan, Emerson Vineyards will cease all operations by the end of April and owners Tom and Jane Johns will move on to their next adventure life – retirement.

However, as always for the couple, not everything in their lives went according to their carefully laid out plans. Plan A is they downsize to the quiet life. Plan B, they have to harvest one more season of grapes themselves.

The change in plans actually follows about a 20-year cycle for the couple. After the Vietnam War,

Johns went to college and got a degree in medical technology. He would work at, and eventually run, medical labs across the U.S. over the next couple decades – the last as senior vice president of manufacturing at a lab in Boca Raton, Florida.

By the year 2000, he was looking for something else to do. That's when he called his son Elliott, attending school at Oregon State University pursuing a degree in fermentation science.

"I asked him what do you want to do when you grow up?" Johns recalled. "He said own a small winery."

With experience working at the Elk Cove Winery in Gaston, Oregon, and time overseas at a winery in Spain and a harvest in New Zealand, Elliott envisioned owning a 10-acre vineyard.

So, Tom called a realtor and a month later found 127 acres with the right slope to plant grapes just off Airlie Road, just west of Highway 99. They purchased the property in 2001 and planted grapes in 2002. Tom said it took a while to get through the "morass" of paperwork from the county, state and federal governments to launch a vineyard.

"My first business plan back in Florida was having us profitable in three years, not knowing that once you plant grapes it takes about six years to grow once you plant them," Tom said. "I was off a little bit. It wasn't until 2014 that we actually broke even. My big nest egg from my previous job was gone."

Now "retired" and moved into a home at the edge of the vineyard, the Johns named the operation after his grandfather on his mother's side – Emerson Waldo Fisher.

Emerson Vineyards harvested about 3,500 cases of wine a year and never had problems selling out, Tom said. They even won in 2015 a Best in Show at the Newport Seafood and Wine Festival. Tom thought they had grown pretty popular over the years.

"We had a couple come in one day, just back from a trip to France. They tasted our Pinot (noir) and said, oh it's so good to come back and have a good pinot," he recalled.

Tom added it's been a fun ride going from just trying to get people through the door.

"In fact, we were the first non-grass seed farm in this valley by growing our grapes. Since,

filberts have bloomed up all over, blueberries, Christmas trees. This little valley is kinda cool," he said.

Tom eventually joined the board of directors at Visit Corvallis and worked with them trying to focus on wineries in the area. And Emerson was the second group to join the Willamette Winery Association. It now has almost 30 members, wineries, cideries and distilleries.

Next, the Johns became members of Harvest Host about 12 years ago, a self-contained RV travel company that encourages members to stay at vineyards for free with the promise to make purchases.

"It was good, especially during the pandemic, when everybody was out in their own bubble," Tom said. "That kept this thing going. Of course, it's hard to sip wine with a mask on."

To attract even more oenophiles, Emerson Vineyards started offering Friday Night Music.

"It was a big hit. It took a while. The last two years, it was kinda nice, seeing them under the trees, watching the show," Tom said.

Then, that 20-year landmark rolled around, and things began to change.

"Two years ago, I'd just turned 76, I had open heart surgery. So, it seemed about the right time to say, 'You know, I don't have to do this. It's time to try something else, you know, like retire, take naps, those kinds of things,' " Tom said.

In addition, his son Elliott was growing tired of the commute where his wife had a CPA business out of McMinnville. He gave his parents eight months' notice. With no one else to pass the business on to, that left the only option for Tom and Jane to sell.

So, the Johns put the entire property on the market as acreage and a vineyard, hoping to get a $1.5 million offer.

Two weeks ago, they had their buyers. A couple offered to buy the property but not the winery. The Johns accepted, decided to shut down and let all their employees go. Then a literal ill wind scuttled the deal.

“The day they decided to quit was the day a south wind blew up from the dump. He was allergic to it and got violent migraines. They cried about it, just couldn’t make it work,” Tom said, totally understanding, not wanting the potential buyers to discover the ailment after he and Jane were gone. “So, we’re back to square one.”

Tom said the buyers left behind “a chunk of money” after pulling out of the deal, so they’re okay for now. They’ve since re-listed the property but face the same problem – it’s too small for the big guys (who wanted 300 acres) and too big for the little guys.

So far, the only potential clients brought out had the false notion of buying the place, sitting by and letting the grapes take care of themselves. Tom said that doesn’t work.

“You have to touch each plant six times a year,” he said. “A couple from Shanghai didn’t want to do the work.”

If he can find a deal that does go through, Tom said he already has mapped out his next phase of retirement. He learned OSU has free classes for seniors 65 and older, just with no grades.

“I’m actually thinking about going back and trying large format photography,” Tom said. “We’re looking forward to not doing anything.”

With the land sale falling through, so too had the purchase of a house in north Albany. So, the downsizing plan is on hold for now. But the Johns realize the problems with downsizing from 127 acres to quarter acre are twofold. They have two dogs that were “raised with the coyotes” and free to roam. And Jane’s studio in the back barn grew to encompass seven sewing machines, bolts of crafting materials and mounds of painting supplies.

“We haven’t quite figured out how to put her 900-square-foot studio, the dogs and me in a 1,400-square-foot house,” Tom explained. “We may have to find a trailer for me, or a tent.”

Meanwhile, he’s left liquidating the inventory left, including a large “garage sale” inside their main barn. Additionally, he still has a 2019 pinot noir that distributors want more than they currently have. He’s sold their Bijou Viognier port to Harris Bridge winery and is working another winery for the rest. That includes judging nearby Airlie Winery’s interest in what remains in their four big tanks. And there’s still three pallets of bottled wine to distribute. Tom said his Oregon Liquor and Cannabis Commission license expires at the end of April.

“So, have to get rid of it by then,” he added.

The options are shrinking.

“Worst case scenario is having to stay in business to tend the latest crop still on the vine,” Tom said. “Eew, we’re going to have to prune the grapes, mow, tie down the trees, all that stuff in the field. That’s not my expertise. Nor do I want it to be. Gee, we may have to harvest again. So, if anyone wants to manage about 30 acres of grapes and buy them, that’s fine. I’ll work with you.”

ALERT

Your Ecological House: Slow global warming by cutting methane emissions now

"Acting now to reduce methane emissions will have immediate benefits for the climate ..." — The Environmental Defense Fund

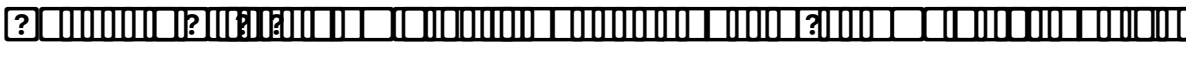
We need to hurry if we're to slow global warming.

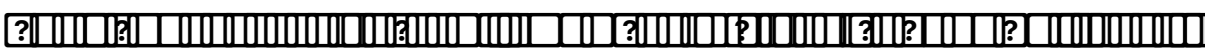
But why would we want to only slow warming, rather than completely stop it?

We must do both, of course, but trying to reverse the current warming trend is a long-term project. It will take at least until 2050 to cut global greenhouse gas emissions to nearly zero.

It will likely take much longer to remove our prior emissions from the atmosphere. And we don't have that kind of time to prevent global climate chaos from becoming "the new normal."

Which brings us to methane — because drastically curbing our methane emissions is the easiest and fastest way to slow warming, buying us precious time for tackling the larger problem of carbon dioxide (CO_2) emissions.





To understand why, we must look at the roles CO2 and methane, the primary greenhouse gases, play in warming. CO2 constitutes about 79% of all U.S. greenhouse gas emissions, while methane accounts for just 11%.

But although we emit far less methane than CO2, methane's "global warming potential" — the amount of heat it can trap — is, pound for pound, 80 times that of CO2 when it first enters the atmosphere.

However, over the course of 12 years, methane breaks down in the atmosphere — but mostly it turns into CO2, which can stay airborne for hundreds of years. Thus, methane's overall global warming potential over a century is still 30 times that of simple CO2.

Also, we keep emitting more methane, replenishing and gradually adding to its supply at its original potency. To date, methane has been responsible for a whopping 30% of all global warming.

There is some good news. Because there is much less methane than CO2 emitted, containing it could require fewer resources. Also, 54% of American methane emissions are from just three sources: Fossil fuel infrastructure (35%); landfills (16%); and buildings (3%).

Although these sources are widely distributed, they are relatively easy to pinpoint, and therefore amenable to repair or the capture of escaping emissions.

For example, much of the fossil fuel industry's methane emissions are from leaky pipes or storage facilities and improperly capped abandoned wells. These sources can be found and fixed.

Similarly, much landfill methane can be captured and used to power the very waste facilities emitting it. The smaller, but still important, role of methane from buildings — where it's usually called "natural gas" — can be greatly reduced by repairing pipes, but also by adjustments residents can make to their lifestyles, a topic we'll explore in upcoming columns.

Finally, according to a 2022 International Energy Institute report, "based on recent elevated natural gas prices, almost all of the (alternative energy) options to reduce emissions from oil and gas operations worldwide could be implemented at no net cost."

We should note that 41% of U.S. methane emissions are from widespread agriculture sources. Agricultural emissions are likely to subside only incrementally and gradually as agricultural practices evolve.

So, because we need quick results, we should primarily target the "low-hanging fruit" of fossil fuel infrastructure, landfill and building emissions.

While these facts about methane have been known for decades, controlling its emissions only recently has been seen as key to slowing climate change.

Fortunately, the current U.S. administration has taken note and is leading the way, pushing in 2021 for international rules and agreements on methane reduction, and in 2022 passing the Infrastructure Investment and Inflation Reduction Acts with their strong methane mitigation provisions, while empowering the EPA to establish a new Methane Emissions Reduction Program.

Unfortunately, instead of adjusting their business models to help slow global warming, most fossil fuel companies are pushing back, hard — a topic we'll explore next at our ecological house.

Philip S. Wenz

Philip S. Wenz is an environmental researcher and writer. Read more articles from his series *Your Ecological House* on his website at .

Letter: Dump's toxic brew poisons the river

What do you get when you take a huge pile of garbage (30% of our state's total tonnage) and let the heavy rainfall of Western Oregon percolate through it?

Answer: About 30 million gallons a year of toxic liquid contaminated with heavy metals and per- and polyfluorinated substances.

A 2020 industry study found nearly one-third of the PFAS in garbage flows out of landfills in the leachate. Cells closed 50 years ago at the dump are still producing millions of gallons of leachate each year. This is but one of the toxic legacies of Benton County's hosting one of the largest landfills in the Pacific Northwest.

The dump's toxic effluent is sent to both the Corvallis and Salem waste treatment plants. Since the PFAS and heavy metals are not removed by the treatment process, the city of Corvallis is making serious money (about $800,000 in fiscal year 2021-22) by essentially dumping this toxic brew into the Willamette River.

On March 14, the Environmental Protection Agency proposed drinking water

regulations for six PFAS. Research has shown that roughly 200 million Americans are impacted by PFAS in their drinking water, leading to thousands of deaths each year.

With pending regulation of PFAS in drinking water, it will become increasingly unconscionable for Corvallis and Salem to send these poisons into the Willamette River — the source of drinking water for a number of downstream communities, including Adair Village. Please urge our elected leaders and Corvallis Public Works to stop accepting this toxic brew!

Doug Pollock

Corvallis

https://gazettetimes.com/news/local/govt-and-politics/article_f0094390-d4dc-11ed-a843-c7169623bb4d.html

ALERT FEATURED TOP STORY

Benton task force: Coffin Butte expansion should be tied to monitoring

A Benton County task force has released its **full findings from months of research into Coffin Butte Landfill**, recommending — among many suggestions — that the local government proactively monitor the dump's operator as a condition of any expansion.

Work group members found county officials do not actively monitor whether some landowners are meeting the conditions tied to their operating permits, as outlined in local law. The landfill's operator is among them.

Instead, the county relies on complaints to enforce those conditions, despite having no readily accessible means to lodge and track those complaints.



A Republic Services tanker truck pulls away from a loading facility near Coffin Butte landfill.
Andy Cripe Mid-Valley Media

Republic Services, operating Coffin Butte as a regional landfill that serves as many as 39 counties via a franchise agreement with Benton County, assumed the company complied with Benton County upon purchasing the dump in 2008,

according to a draft report.

“County staff and (Republic Services) were working from alternate views,” report authors wrote.

The 14 voting members — including **delegates from county trash and planning advisory bodies**, Republic Services and the public — comprising the task force broadly agreed Benton County can do better ahead of drafting the plan that will guide the agency in how it oversees solid waste in the county, regardless of Republic expands the landfill or not.

Republic withdrew its expansion plans a year ago after the county Planning Commission denied the landfill operator a new permit. Initially, the company was going to appeal.

Shortly after, the county formed a task force to make recommendations about the landfill, which it calls Benton County Talks Trash. The work group has a draft circulating of its vision for solid waste management.





Quality journalism doesn't happen without your help

The workload ballooned as the task force broke into subcommittees examining solid waste and Coffin Butte through lenses of county process, state law and history.

County officials budgeted about $63,000 for the contractor hired to facilitate the task force before work ran about three months beyond the scheduled end date of December.

Benton's elected leadership approved infusions, bringing the final Trash Talks budget to about $236,000.

As recently as late March, participants said they weren't comfortable with how fast they felt the group was moving through its task in guiding how Benton County should manage the flow of solid waste in the region.

Marge Popp, who represented the appointed body advising county commissioners on solid waste and disposal, said in a Thursday, April 6 interview that she felt Benton County has signaled the government isn't taking seriously its commitments laid out in the 2040 Thriving Communities Initiative.

“I certainly wish that the county did take those values more seriously,” Popp said.

Benton County has not received another application from Republic for an expansion and had committed on holding off until hearing elected official and public input on the Talks Trash findings.

The Board of Commissioners is scheduled to hear a report from the work group on Tuesday, April 11, which will open a period of public comment, expected to end May 26.

- **Benton County to advisers about landfill: Stop advising us**
- **Benton dump findings take shape**
- **County awards more time, money to Coffin Butte workgroup; fires member**
- **Tour provides peek into landfill operations, Benton workgroup dynamics**
- **Republic Services pulls appeal on Coffin Butte landfill expansion**
- **Benton County commission unanimously rejects Coffin Butte landfill expansion plan**
- **More Benton County news**

Alex Powers (he/him) covers agri-business, Benton County, environment and city of Lebanon for Mid-Valley Media. Call 541-812-6116 or tweet @OregonAlex.

Letter: We need a plan, not bigger landfill

[redacted]

A petition circulating about the landfill is causing quite the kerfuffle in county government.

So much so that a subcommittee of the Benton County Talks Trash workgroup created six new “findings” in an attempt to discredit it. The commissioners even issued a media release selectively changing the petition’s wording — and its meaning — thereby rejecting the concerns of nearly a thousand petition signers.

In a nutshell, the petition asks the commissioners to oppose any landfill expansion until the county has a sustainable materials management plan to guide them.

The twisted rewording says the petition asks them to delay consideration of any new land use at the landfill.

This is smoke and mirrors. The petition does not ask them to delay consideration.

The landfill already seriously interferes with uses on adjacent properties and the character of the area, and imposes an undue burden on public improvements, facilities and services. An expanded landfill will only make things much worse.

[redacted]

Landfilling here forever is not the only option. There are alternatives that can and must be explored and implemented before the dump is full (15 years).

Approving an expansion now renders moot any future materials management plan. Denying it this go-round (based on evidence — there will be plenty) allows the county time to gather the facts needed for a better future.

Curious? See for yourself. Search the internet for “VNEQS” (name of the group circulating the petition) and/or “Coffin Butte Landfill petition.”

Debbie Palmer

Corvallis

truthout

NEWS | ENVIRONMENT & HEALTH

Environmental Groups Urge EPA Action on Methane Emissions From Landfills

Methane has been identified by international climate experts as a key driver of planetary heating.

By Julia Conley, COMMON DREAMS
June 22, 2023



A San Francisco Recology truck drops about 20 tons of trash at the Waste Management landfill in Livermore, California, on December 26, 2012.

MICHAEL MACOR / THE SAN FRANCISCO CHRONICLE VIA GETTY IMAGES

Joined by two residents of a community where emissions from landfills have forced them to live in the "center of a toxic wasteland," more than a dozen environmental and community advocacy groups on Thursday filed a petition (https://environmentalintegrity.org/wp-content/uploads/2023/06/FINAL-Petition-for-Rulemaking-CAA-111-Landfills.pdf) with the Biden administration calling for a number of specific regulations to address the United States' third-largest source of methane pollution.

A month after the Environmental Integrity Project (EIP) published a report (https://www.commondreams.org/news/landfill-methane) detailing how the nation's roughly 1,100 city and county landfills emitted at least 3.7 million metric tons of methane in 2021, the group was joined by the Sierra Club (https://www.commondreams.org/tag/sierra-club), Black Warrior Riverkeeper,

Chesapeake Climate Action Network (CCAN), and several other organizations to demand the Environmental Protection Agency (EPA) take action.

Javian Baker and Gilda Hagan-Brown, residents of Waggaman, Louisiana, which is adjacent to a landfill, also joined the petition. The emissions coming from the landfill mean that residents' "right to a healthy, safe and clean environment [is] jeopardized," said Hagan-Brown in a statement, and that their "aspirations have been destroyed."

"The foul gassy smell lurking in our neighborhood inhibits me from bringing my fifteen-month-old outside to play," said Baker. "This petition offers a glimpse of hope when politicians in Jefferson Parish and landfill officials have yet to get to the root of the problem impacting our predominately Black community."

Only livestock and natural gas cause more methane emissions than landfills in the U.S., the petitioners noted. Methane has been identified (https://www.commondreams.org/news/2021/08/06/ipcc-say-drastic-methane-cuts-necessary-avert-climate-hell) by international climate experts as a key driver of planetary heating. It is 80 times more potent than carbon dioxide in its first two decades in the atmosphere and 28 times more potent over a 100-year period. Nearly 12% of the United States' contribution to climate change comes from methane emissions, *The Hill* reported (https://thehill.com/policy/energy-environment/4061660-environment-groups-ask-biden-to-crack-down-on-methane-emissions-from-landfills/) Thursday.

The yearly methane emissions from landfills are equivalent to 295 million metric tons of greenhouse gases over 20-year period, or 66 million gasoline-powered vehicles over a year.

Edwin LaMair, attorney for the Environmental Defense Fund, noted that technological advances in recent years, including the ability to conduct aerial surveys of methane emissions at landfills, offer the EPA "an enormous opportunity to update and strengthen its standards for landfill pollution."

"Landfill pollution poses serious public health threats, and protective landfill standards are an urgently needed addition to other significant actions EPA has recently taken to reduce climate-destabilizing and health-harming pollution," said LaMair.

In its report, *Trashing the Climate*, last month, EIP noted that landfills contribute to methane emissions mainly due to rotting food waste. Americans throw away roughly 40% of their food and food waste has soared in the last three decades.

The petition calls on the EPA to encourage composting and waste reduction to reduce landfill methane emissions.

The Rocky Mountain Institute, which was not involved in the petition, explained on social media earlier this week how diverting waste from landfills not only reduces emissions, but also allows the waste to be converted into valuable resources for communities.

> The most direct way to fight methane emissions?
>
> Keep organic matter out of landfills in the first place. 👋
>
> This can be done through upstream methods like reducing food waste and donating surplus, and downstream efforts to recycle the remaining organic waste. pic.twitter.com/uOJY90Ehg2 (https://t.co/uOJY90Ehg2)
>
> — RMI (@RockyMtnInst) June 20, 2023 (https://twitter.com/RockyMtnInst/status/1671266747431936000?ref_src=twsrc%5Etfw)

The groups on Wednesday also called on the EPA to:

- Require more landfills to install gas collection and control systems, including pipes that collect methane from garbage and covering materials, such as soil, that help absorb and destroy methane;
- Require flares that burn methane at landfills to have at least a 99% destruction efficiency, meaning they burn up almost all of the pollution;
- Require landfills to install gas capture systems within one year after the dumping of waste; and
- Impose better requirements for direct measurement of methane and support the development of equipment that can continuously monitor landfill emissions.

The petition also pointed out that many of the country's landfills are situated in predominantly low-income towns and communities of color.

"Virginia is home to eight 'mega-landfills,' many of which are sited in low-income communities of color," said Anne Havemann, general counsel for CCAN. "These landfills emit huge amounts of methane, a potent greenhouse gas, but have not received the attention they deserve for all the pollution they release. We look forward to EPA taking action on this under-the-radar issue."

IN THE FACE OF TRUMP'S THREATS, WE'LL NEVER CAPITULATE.

At this moment, we are witnessing a terrifying array of anti-democratic tactics to silence political opposition, increase surveillance and expand authoritarian reach.

Truthout is appealing for your support as Trump and his sycophants crack down on political speech. Nonprofits like Truthout could be caught in Trump's crosshairs as he attacks dissenting groups with bad faith lawsuits and targeted harassment of journalists.

As well, these attacks come at a time when independent journalism is most needed. The right-wing corporate takeover of media has left reliable outlets few and far between, with even fewer providing their work at no cost to the reader. **Who will be there to hold the fascists to account, if not media like Truthout?**

© 2025 Truthout

We ask for your support as we doggedly pursue justice through our reporting. Truthout is funded overwhelmingly by readers like you. **Please make a tax-deductible one-time or monthly donation today.**

Donate

This piece was reprinted by Truthout with permission or license. It may not be reproduced in any form without permission or license from the source.

JULIA CONLEY (HTTPS://TRUTHOUT.ORG/AUTHORS/JULIA-CONLEY/)

Julia Conley is a staff writer for *Common Dreams*.

As I See It: We all owe it to them to draw the line now

As a member of Subcommittee E ("Community Education") of the "Benton County Talks Trash" process that took place over the past year, I learned a great amount regarding Coffin Butte Landfill's history and possibilities.

As a person who drives past the landfill multiple times per week and an avid user of the E.E. Wilson Wildlife Area, I have been observing developments of the facility for 25 years. Based on these experiences, I would like to clarify three things regarding the specter of expanding the landfill to the south of Coffin Butte Road.

First, no careful neutral analysis would have chosen this place for such a massive landfill. Coffin Butte Landfill began in the 1940s, when Benton County sought to divert people from privately dumping their refuse in the woods and rivers, as was practiced in the early 1900s.

There was no vision that this would be a massive industrial complex that receives over 88% of its nearly 1.1 million tons of refuse from outside the county.

The Benton County Trash Talks history notes that even when it was designated as one of several regional landfills in 1974, Coffin Butte was anticipated to close before 2000.

For contrast, Republic Services notes that its Roosevelt Landfill in Washington was specifically chosen for the low local population, relatively small or distant aquifers, and precipitation of 6 to 9 inches per year.

Second, Coffin Butte Landfill is already scheduled to expand to the west, where a quarry operates right now. The southward expansion is necessary only because the amount of waste going into the facility has nearly doubled in recent years, with nearly all of the increase coming from beyond Benton County, and much from beyond the mid-valley.

According to the Benton County Trash Talks final document, the amount deposited at Coffin Butte has increased from 552,978.53 tons in 2015 to 1,046,066.96 tons in 2021.

I recommend you go to E.E. Wilson sometime during the work week and observe the magnitude of the operation and the number of trucks coming from all over Western Oregon droning up the hill. I am not sure what is in each load, but last Friday I happened to watch a truck at the top of the heap unloading, surrounded by red dust or smoke.

Third, county officials make it sound as though Benton County residents may just have to accept the southward expansion because of previous commitments. This is not true. If Benton County officials all do their best, the expansion can be stopped.

The expansion does not fit the county's existing policy goals, nor is it in sync with the environmental and sustainability goals of many residents; it would significantly affect the livability of surrounding areas.

We should all expect or demand that Benton County officials oppose any

southward expansion, and do whatever it takes to make it so. Even if you disagree with this, it seems only reasonable for Benton County to have an approved long-term solid waste policy in place before we allow Republic Services to double in size by expanding to the east side of the landfill.

Whatever goes into that facility stays there forever, unless it leaches into our aquifers, is pumped out to be deposited in local sewage facilities or escapes as greenhouse gases (some of which does generate energy, but according to the BCTT, gas capture is about 57%).

I do not know if my descendants will live in Benton County, but someone's will, and we all owe it to them to draw the line now.

Mark Henkels

Mark Henkels is a longtime resident of the Lewisburg area. He has taught public policy and administration at Western Oregon University since 1988, with a specialization in Oregon politics and

government.

https://gazettetimes.com/news/local/business/employment/article_0c558480-51a8-11ee-b637-434909e9601d.html

ALERT FEATURED TOP STORY

Coffin Butte mechanics protest alleged unfair labor practices

. .. . - .. . .
. ...



Workers stand in picket line, on strike, at the Coffin Butte Landfill on Tuesday, Sept. 12. Workers allege that attempt to stop operating engineers from unionizing.

Jess Hume-Pantuso, Mid-Valley Media

Kosiso Ugwuede

A seven-man unit of heavy-duty equipment mechanics are on an indefinite strike, picketing in front of the Coffin Butte Landfill in Corvallis.

The walkout, which began early on Monday, Sept 11, is in protest of what they say are unfair labor practices by Valley Landfills Inc., a subsidiary of the waste management company, Republic Services, which runs the Benton County dump.

Workers stand in picket line, on strike, at the Coffin Butte Landfill. Workers allege that Valley Landfills Inc has violated federal law in attempt to stop operating engineers from Local 701 from unionizing.

Jess Hume-Pantuso Mid-Valley Media

The employees make diesel, hydraulic and electrical repairs, as well as do welding and fabrication on Caterpillar D-9 bulldozers, Caterpillar compactors, and Caterpillar wheel-loaders, which are used for moving and compacting the landfill waste.

The striking unit first approached the International Union of Operating Engineers Local 701 around November last year with intentions to unionize. According to Jacob Stallings, attorney for Local 701, that desire has since been met with all kinds of typical union-busting responses from the employer.

"Additionally, their regional director engaged in some conversation with our members that we interpret as intimidation tactics," Stallings said by phone.

According to Stallings, one of the mechanics who initiated contact with Local 701 about unionizing "had several disciplinary incidents that conveniently lined up with the same time as unionizing."

And a review-based bonus that staff received in the first quarter of the year was also withheld for the unionized unit while nonunionized staff received an unusually high bonus, he said.

"The company has violated federal law and is being investigated by the National Labor Relations Board right now," Local 701 Business Manager and Financial Secretary James Anderson said by phone.

Phoenix-based Republic Services has seen its share of controversies out of Coffin Butte. With predictions that the landfill is filling up fast, the company hopes to expand.

But Republic withdrew its plans at Coffin Butte in 2022 after the county Planning Commission denied the landfill operator a new permit to use land on the opposite side of Coffin Butte Road for storing trash.

The company first had sought to appeal the commission's decision **before reversing course and pulling its application**. Since then, a county-convened task force spent nearly a year looking at the region's trash needs.

The striking mechanics are non dues-paying union members following an election

last year. Stallings said bargaining efforts between the union and Valley Landfills has been an uphill task. Since November 2022, the company has sat for six sessions with the union to review the working conditions and wages of the unit.

Three of those meetings have been canceled by the company, the most recent being a session that was scheduled for Wednesday, Sept. 6.

The company offered no reason for canceling, he said.

"Each time we've tried to schedule a new session with them, they've been dragging their feet," Stallings said.

The contractual demands of the seven-person unit are not outrageous, according to Stallings, and agreements have been reached on all of the union's proposed changes except for wages, health and welfare, and pension.

The health insurance negotiations have been most contentious, Stallings said, although an agreement could be a win for both Valley Landfills and the mechanics.

"We have very affordable health insurance," Anderson said of the Local's insurance.

"We can save the company around $8,000 a year in health insurance, but they don't want to take our health insurance. They want to keep the guys paying $400 a month out of pocket," Anderson said.

Stay up to date on mid-Willamette Valley news, wherever you go

Stallings agreed that the company has been averse to considering the change in health insurance.

. …. .. … …. . . ….

The health concerns of the striking mechanics go beyond insurance.

Stallings said welfare negotiations are crucial, especially with recent exposures at

the Coffin Butte Landfill, from medical wastes like syringes to **body parts** and other kinds of biohazard risks.

"Getting all these safety issues addressed and having good health and welfare when they are not important to the members, and it does not seem like it's been taken seriously by the employer," Stallings said.

Wage-wise, Stallings said many of the heavy-duty mechanics in its network who work on the construction side earn around $50 per hour.

The mechanics employed by Valley Landfills earn around $35 per hour.

"We've been told at least one time that we're not going to see any proposals from the employer that include union health and welfare and union pension," Stallings said.

When contacted, officials with Republic Services declined to comment but eventually said via email: "Republic Services is in the early stages of contract negotiations with the union representing some of our technicians in Benton County. We respect the rights of our employees to engage in collective bargaining and look forward to reaching a fair and competitive contract that is beneficial for them, our company and the community."

Stallings said though bargaining was "early" considering the typical timeline for contract bargaining sessions such as this one, the union believed it was at the finish line.

Quality journalism doesn't happen without your help

The goal of the strike action is to bring the employer back to the bargaining table and a meeting is scheduled for Thursday, Sept. 14.

Stallings said he hopes that it isn't canceled without reason.

"We're hopeful that we can have a good conversation at that point," he said.

- **Benton County commission unanimously rejects Coffin Butte landfill expansion plan**
- **Republic Services appeals county decision on Coffin Butte landfill expansion**
- **Republic Services pulls appeal on Coffin Butte landfill expansion**
- **Benton dump findings take shape**
- **More Benton County news**

From:	Ken Eklund
To:	Benton Public Comment
Subject:	I oppose LU-24-027: reference articles and opinions in the press - 6 of 12
Date:	Thursday, May 8, 2025 2:36:14 PM
Attachments:	writerguy-cube2.png 17 Coffin Butte mechanics on strike rally with union leaders.pdf 18 Communities struggle with hazardous waste from vaping.pdf 19 Coffin Butte Landfill methane leaks exceed state, federal limits.pdf 20 Exploding lithium batteries are causing fires in Oregon's landfills - OPB.pdf 22 EPA Methane levels at Coffin Butte are concerning.pdf

CAUTION: This email originated from outside of the organization. Do not click links or open attachments unless you recognize the sender and know the content is safe.

Some more history of Coffin Butte Landfill in the press, covering many of the same issues that have come up in public testimony: PFAS, leachate, methane, EPA and DEQ investigations and actions, labor issues, Republic cover-ups of problems and information, fire hazards, misleading and dubious information about the economics of the landfill, and so on. – K



Ken Eklund, writerguy

37340 Moss Rock Dr
Corvallis OR 97330
408.623.8372

Creator of
World Without Oil
Ed Zed Omega
FutureCoast
and other storymaking games

https://gazettetimes.com/news/local/business/employment/article_abb4c5f2-6951-11ee-b1de-e7cb9266d4ca.html

ALERT FEATURED TOP STORY

Union leaders, House Speaker show support for Coffin Butte mechanics at rally



Mechanics, fellow employees, and community members lined the sidewalk in front of Republic Services in s

Jess Hume-Pantuso, Mid-Valley Media

Kosiso Ugwuede

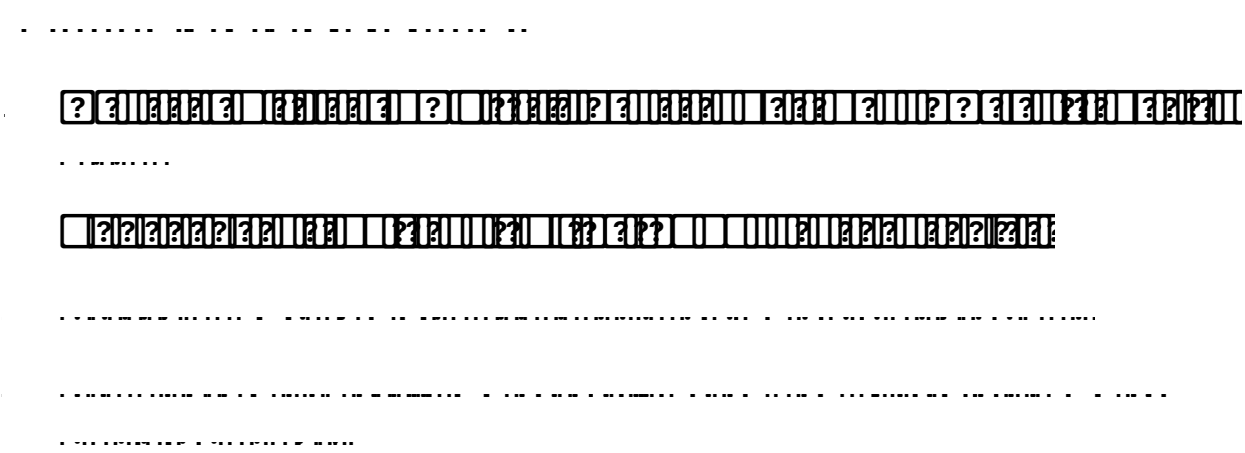
Striking Coffin Butte mechanics were joined by several union leaders, elected officials and concerned community members at a rally on Thursday, Sept. 12,

in front of the Corvallis Republic Services office.

Carrying placards, with an inflatable "Scabby the Rat" mascot standing guard, a small group came out in support of the seven heavy duty mechanics **who have been striking since Sept. 11** at various locations around the Coffin Butte Landfill.

A Place to Sleep, episode 2: Albany, part II
Mid-Valley Media

The mechanics — who operate and maintain machinery used in moving and compacting the landfill — are protesting alleged unfair labor practices and unsafe work environment by Valley Landfills Inc. a subsidiary of the waste management company, Republic Services, which operates the Benton County-owned facility.



Since November 2022, the mechanics, who unanimously voted to join the International Union of Operating Engineers Local 701, have been in negotiations with the company to review their working conditions and wages.

According to one mechanic, Troy Paul, the negotiations were productive until conversations shifted into economic benefits, including pensions, wages and health insurance, which remains the knottiest issue on the table.

Jacob Stallings, attorney for Local 701, said last month that the company is rejecting the mechanics' proposal which would allow them to access insurance provided by the union. The plan offers them and their families more benefits for less money, an obvious win-win, he said.

An inflatable rat wielding a large banner highlighting the differences between the EPO900 United Healthcare Family Plan and I.U.O.E Family Healthcare Plan

Jess Hume-Pantuso, Mid-Valley Media

So far, Valley Landfills has responded to the demands of the mechanics with union-busting behavior, including intimidation, retaliation and canceled bargaining sessions, Stallings said last month.

"These workers have been demanding adequate and affordable health care, while being exposed to toxic chemical and dangerous machinery," Graham Trainor, Oregon chapter president of the AFL-CIO, said at the Thursday rally.

"It is our duty as Oregon labor to stand strong, shoulder-to-shoulder with them in this fight for however long it takes," Trainor said. "Whether it's a group of seven workers or 7,000, their fight matters."

- ---.. -------

Republic Services, when contacted repeated its earlier statement to Mid-Valley Media, saying via email: "Republic Services is in contract

negotiations with the union representing six maintenance technicians at our landfill in Benton County.

Graham Trainor, Oregon chapter president of the AFL-CIO, speaks at a rally for striking mechanics was held outside of the Republic Service office building, 110 NE Walnut Blvd. in Corvallis on Thursday, Oct. 12, 2023.

Jess Hume-Pantuso, Mid-Valley Media

"We respect the rights of our employees to engage in collective bargaining and look forward to reaching a fair and competitive contract that is beneficial for our employees, our customers, and our company."

Questions about the tenuous health insurance negotiations went unanswered.

Ed Eby, another mechanic who has been with the company for three years and on the maintenance unit for a year, said that so far, it has felt like the company wants to look the other way and ignore the mechanics.

"Stuff we're exposed to is just terrible, and then we take it home to our families who then get sick," said Lorne Nash, another mechanic who joined the company about a half-month before the strike began.



Rob Perdue gives a quick interview about the rally

regarding Republic Services and what comes next for the mechanics on strike.

Jess Hume-Pantuso, Mid-Valley Media

"We don’t have the compensation to be able to afford to go to the doctor and when we have to go, it’ll just cripple us," Nash said.

He said he believes the pushback from the company stems from a lack of appreciation as well as a show of power. Without the backing of the union, Valley Landfills can exert control over the mechanics and keep them working in unsafe conditions, he added.

"We all understand that there is risk involved with our job, but some of that risk can be mitigated. But they refuse to," Nash said.

"Whether we’re breathing it in or laying down in it, we’re always exposed to something," said Logan Carter, who has been at the company for a year.

The mechanics, who work 10-hour shifts, said that they were exposed to all kinds of contaminants one might imagine results from a dump. Without a decontamination facility, the mechanics work only with basic personal protective equipment.

.

Paul accused the company of valuing profits over people and being solely focused on attracting more trash to the landfill.

"As long as the money is flowing in then they don’t really care, and that needs to change," Paul said at the Thursday rally.

Oregon House Speaker Dan Rayfield, who was at the rally, expressed his support for the striking mechanics.

"It can feel alone being on the picket line," Rayfield, D-Corvallis, said during brief remarks. "As someone who lives in this community, we appreciate what you do for this community, and we appreciate what you're fighting for."

Rayfield and a few colleagues have written to Republic Services in support of the mechanics' demands.

"Because having a fair contract is not an option and having safe workplace conditions especially in Oregon is not an option," Rayfield said.

Other elected officials at the event included state Sens. James Manning, D-Eugene, and Deb Patterson, D-Salem. Representatives and leaders from local chapters of the AFL-CIO and United Auto Workers were also at the rally.

"It's incredible to see the support that we have," Carter said about the turnout.

Quality journalism doesn't happen without your help

"Labor has to support labor, that's what it's all about," Rob Perdue, UAW Local 492 president, said. "An injury to one is an injury to all."

Perdue and Local 492 have been striking in Beaverton for 21 days after UAW President Shawn Fain asked the unit to join the ongoing auto worker strike against Detroit car makers Stellantis, Ford and GM.

"It's kind of sad but it seems to be the norm over the last 20 or 30 years," Perdue said of the manner in which billion-dollar companies treat their workers.

"We've seen that companies have their investors and interests in mind more than their workers," Perdue said.

- **Coffin Butte landfill mechanics on strike**
- **Who repressed speech at Coffin Butte event?**
- **Benton County commission unanimously rejects Coffin Butte landfill expansion plan**
- **Republic Services appeals county decision on Coffin Butte landfill expansion**
- **Republic Services pulls appeal on Coffin Butte landfill expansion**
- **Benton dump findings take shape**
- **More Benton County news**
- **More Corvallis news**

Kosisochukwu Ugwuede (she/her) covers the cities of Corvallis, Philomath & Millersburg. She can be reached via e-mail at [redacted] or by phone at 541-812-6091

SPOTLIGHT

Communities can't recycle or trash disposable e-cigarettes. So what happens to them?

[illegible]

WASHINGTON — With the growing popularity of disposable e-cigarettes, communities across the U.S. are confronting a new vaping problem: how to safely get rid of millions of small, battery-powered devices that are considered hazardous waste.

For years, the debate surrounding vaping largely centered on its risks for high school and middle school students enticed by flavors like gummy bear, lemonade and watermelon.

But the recent shift toward e-cigarettes that can't be refilled has created a new environmental dilemma. The devices, which contain nicotine, lithium and other metals, cannot be reused or recycled. Under federal environmental law, they also aren't supposed to go in the trash.

Law enforcement members of New York Sheriff's Joint Compliance Task Force (SJCTF) confiscate and bag illegal vaping products, during raid of a tobacco shop, Wednesday Sept. 27, 2023, in New York. Communities across the U.S. are confronting a new vaping problem: how to get rid of millions of disposable e-cigarettes that are considered hazardous waste. The devices contain nicotine, lithium and other materials that cannot be reused or recycled. (AP Photo/Bebeto Matthews)

Bebeto Matthews

U.S. teens and adults are buying roughly 12 million disposable vapes per month. With little federal guidance, local officials are finding their own ways to dispose of e-cigarettes collected from schools, colleges, vape shops and other sites.

"We are in a really weird regulatory place where there is no legal place to put these and yet we know, every year, tens of millions of disposables are thrown in the trash," said Yogi Hale Hendlin, a health and environmental researcher at the University of California, San Francisco.

In late August, sanitation workers in Monroe County, New York, packed more than 5,500 brightly colored e-cigarettes into 55-gallon steel drums for transport. Their destination? A giant, industrial waste incinerator in northern Arkansas, where they would be melted down.

Sending 350 pounds of vapes across the country to be burned into ash may not sound environmentally friendly. But local officials say it's the only way to keep the nicotine-filled devices out of sewers, waterways and landfills, where their lithium batteries can catch fire.

"These are very insidious devices," said Michael Garland, who directs the county's environmental services. "They're a fire risk and they're certainly an environmental contaminant if not managed properly."

Elsewhere, the disposal process has become both costly and complicated. In New York City, for example, officials are seizing hundreds of thousands of banned vapes from local stores and spending about 85 cents each for disposal.

Law enforcement members of New York Sheriff's Joint Compliance Task Force (SJCTF) carry bags of confiscated vaping products, during a spot raid of a tobacco shop, Wednesday Sept. 27, 2023, in New York. Communities across the U.S. are confronting a new vaping problem: how to get rid of millions of disposable e-cigarettes that are considered hazardous waste. The devices contain nicotine, lithium

and other materials that cannot be reused or recycled. (AP Photo/Bebeto Matthews)

Bebeto Matthews

Vaping critics say the industry has skirted responsibility for the environmental impact of its products, while federal regulators have failed to force changes that could make vaping components easier to recycle or less wasteful.

Among the possible changes: standards requiring that e-cigarettes be reusable or forcing manufacturers to fund collection and recycling programs. New York, California and several other states have so-called extended product responsibility laws for computers and other electronics. But those laws don't cover vaping products and there are no comparable federal requirements for any industry.

Environmental Protection Agency rules for hazardous waste don't apply to households, meaning it's legal for someone to throw e-cigarettes in the garbage at home. But most businesses, schools and government facilities are subject to EPA standards in how they handle harmful chemicals like nicotine, which the EPA considers an "acute hazardous waste," because it can be poisonous at high levels.

New York Sheriff's Chief of Detectives Philip Schaffroth, Jr., left, and Detective Veronica Robles, right, confiscate illegal vaping products, during a spot raid by New York Sheriff's Joint Compliance Task Force (SJCTF) of a tobacco store, Wednesday Sept. 27, 2023, in New York. Communities across the U.S. are confronting a new vaping problem: how to get rid of millions of disposable e-cigarettes that are considered hazardous waste. The devices contain nicotine, lithium and other materials that cannot be reused or recycled. (AP Photo/Bebeto Matthews)

Bebeto Matthews

In the U.S., the push to manage disposable e-cigarettes has chiefly come from schools, which can face stricter regulation if they generate more than a few pounds of hazardous waste per month. Monroe County schools pay $60 to dispose of each one-gallon container of vapes. More than two thirds of the e-cigarettes collected by the county come from schools.

"Our schools were very relieved because they had confiscated so much of this material," Garland said. "If you think of all the high schools across the country, they are in a very difficult place right now."

Lithium in e-cigarette batteries is the same highly sought metal used to power electric vehicles and cellphones. But the quantities used in vaping devices are too small to warrant salvage. And nearly all disposable e-cigarette batteries are soldered into the device, making it impractical to separate them for recycling.

Disposable e-cigarettes currently account for about 53% of the multi-billion U.S. vaping market, according to U.S. government figures, more than doubling since 2020.

Their rise is a study in unintended consequences.

Vaping products are bagged and confiscated, during a spot raid of a tobacco store by members of New York Sheriff's Joint Compliance Task Force (SJCTF), Wednesday Sept. 27, 2023, in New York. Communities across the U.S. are confronting a new vaping problem: how to get rid of millions of disposable e-cigarettes that are considered hazardous waste. The devices contain nicotine, lithium and other materials that cannot be reused or recycled. (AP Photo/Bebeto Matthews)

Bebeto Matthews

In early 2020, the Food and Drug Administration banned nearly all flavors from reusable e-cigarettes like Juul, the cartridge-based device blamed for sparking a nationwide surge in underage vaping. But the policy didn't apply to disposables, opening the door to thousands of new varieties of fruit and candy-flavored vapes, almost all manufactured in China.

In recent months the FDA has begun trying to block imports of several leading disposable brands, including Elf Bar and Esco Bar. Regulators consider them all illegal, but they have been unable to stop their entry to the U.S. and the devices are now ubiquitous in convenience stores, gas stations and other shops.

FDA's tobacco chief, Brian King, said in a statement that his agency "will continue to carefully consider the potential environmental impacts" of vaping products.

[illegible]

In 2020, New York City outlawed the vast majority of e-cigarette types, banning flavors that can appeal to youngsters.

City employees conduct thousands of inspections annually, and last year issued more than 2,400 citations to corner stores and bodegas selling illegal flavored products. Adding to the challenge are THC vapes sold at hundreds of unlicensed marijuana shops, a separate but related problem that has mushroomed since New York's legalization of recreational pot.

Since last November, officials have seized more than 449,000 vape units, according to city figures. New York City is spending about $1,400 to destroy each container of 1,200 confiscated vapes, but many more remain in city storage lockers.

"I don't think anyone ever considered the volume of these in our community," said New York Sheriff Anthony Miranda, who leads a task force on the issue. "There's a tremendous amount of resources going into this effort."

New York City's Sheriff Anthony Miranda, left, watches as members of New York Sheriff's Joint Compliance Task Force (SJCTF) carry bags of confiscated vaping products, during a spot raid of a tobacco shop, Wednesday Sept. 27, 2023, in New York. Communities across the U.S. are confronting a new vaping problem: how to get rid of millions of disposable e-cigarettes that are considered hazardous waste. The devices contain nicotine, lithium and other materials that cannot be reused or recycled. (AP Photo/Bebeto Matthews)

Bebeto Matthews

A recent lawsuit against four large vaping distributors aims to recoup some of the city's costs.

For now, New Yorkers who vape can bring their used e-cigarettes to city-sponsored waste-collection events.

Ultimately those vapes meet a familiar fate: They are shipped to Gum Springs, Arkansas, to be incinerated by Veolia, an international waste management firm. The company has incinerated more than 1.6 million pounds of vaping waste in recent years, mostly unsold inventory or discontinued products.

Veolia executives say burning e-cigarettes' lithium batteries can damage their incinerators.

"Ideally we don't want to incinerate them because it has to be done very, very slowly. But if have to, we will," said Bob Cappadona, who leads the company's environmental services division.

Veolia also handles e-cigarettes from Boulder County, Colorado, one of the only U.S. jurisdictions that actively tries to recycle e-cigarette batteries and components.

Historically, Boulder has had one of the highest teen vaping rates in the country,

peaking at nearly 33% in 2017.

"It was like someone flicked the switch. Suddenly e-cigarettes were everywhere," said Daniel Ryan, principal of Centaurus High School.

Beginning in 2019, county officials began distributing bins to schools for confiscated or discarded e-cigarettes. Last year, they collected 3,500.

County staffers sort the devices by type, separating those with removable batteries for recycling. Disposables are packed and shipped to Veolia's incinerator. Shelly Fuller, who directs the program, says managing vape waste has gotten more costly and labor intensive with the shift to disposables.

"I kind of miss the days when we had Juuls and I could take each battery out and recycle them very easily," Fuller said. "No one has time to dismantle a thousand Esco Bars."

___

AP video journalist Joseph Frederick contributed to this story from New York.

The Associated Press Health and Science Department receives support from the Howard Hughes Medical Institute's Science and Educational Media Group. The AP is solely responsible for all content.

___

A new study found insurance may not be the best way to save money on prescriptions, how to keep your pets safe during Halloween, and more videos to improve your life.

statesman journal

Methane leaks at Coffin Butte Landfill in Oregon pose 'potential safety concern,' EPA says

e so high during an inspection that instruments could not measure them.



Tracy Loew
Salem Statesman Journal

Oct. 20, 2023, 5:01 a.m. PT

Key Points

- Methane is a greenhouse gas that's more potent than carbon dioxide and a major contributor to climate change.
- EPA did not publicly release its inspection findings
- Waste disposal company Republic Services is considering significant expansion of the landfill

Coffin Butte Landfill is leaking methane at levels that exceed state and federal limits and what the landfill has publicly reported, a U.S. Environmental Protection Agency inspection has found.

Landfills are among the nation's largest sources of methane, a greenhouse gas that's more potent than carbon dioxide and a major contributor to climate change, according to the EPA.

EPA measured methane exceeding regulatory limits 61 times during its June 2022 inspection of the landfill. Twenty-one of those exceedances measured at more than 10,000 parts per million, or 20 times the 500 ppm limit set by Oregon and the EPA.

In addition to contributing to climate change, the levels measured could cause health problems for neighbors, and in some cases were high enough to potentially cause an explosion and fire, said Lisa Arkin, of the Eugene-based environmental group Beyond Toxics.

Coffin Butte, located off Highway 99W north of Corvallis, is operated by Republic Services, the second-largest waste disposal company in the U.S. The landfill is an integral part of Marion County's solid waste disposal system.

The inspection report noted there were so many exceedances that the inspector ran out of marking flags. In some cases, levels were so high instruments could not measure them. And multiple exceedances were measured several feet in the air, “indicating substantial landfill gas plumes,” according to the report.

Coffin Butte and local Republic Services officials acknowledged an interview request from the Statesman Journal but did not respond to any questions.

“While we have differing perspectives on the testing protocols and analyses from the EPA’s inspections in 2022, the EPA’s observations were addressed," Melissa Quillard a spokeswoman for Republic Services' media relations office in Phoenix said in an emailed statement.

"The landfill was already in the process of expanding the gas collection system at the time of the EPA inspection, which has since been completed. We added additional cover soil in some areas, added soil along the edge of tarps, patched small holes in a liner system, and strengthened seals around gas collection piping," she said.

EPA did not publicly release its inspection findings. Beyond Toxics, working with the climate group Industrious Labs, received a copy of the report in response to a request under the federal Freedom of Information Act.

The groups have since filed a complaint about the excessive methane emissions with EPA’s environmental violations tip line. Their complaint included photos taken by neighbors living near the landfill of holes and tears in tarps covering the landfill, which can allow methane to leak.

The findings come as Republic Services is considering a significant expansion of the landfill, which currently is permitted for 178 acres.

Coffin Butte Landfill's role in Marion County’s solid waste system

Much of Marion County’s garbage is burned at the Covanta municipal waste incinerator in Brooks.

About a quarter of the garbage burned at Covanta ends up as ash, which is trucked to Coffin Butte, to be used as “alternative daily cover.” Landfills are required to cover their active area at the end of each day to control vectors, fires, odors, blowing litter and scavenging.

About half of Coffin Butte's leachate — rainwater that trickles through the ash and garbage, picking up contaminants — then is trucked to the city of Salem's wastewater system, where it's treated and discharged to the Willamette River. The other half is treated by the city of Corvallis, which also discharges to the Willamette.

Salem began taking the landfill's leachate in 2012. During the three years between January 2020 and December 2022, the city was paid $1.28 million to treat 42.6 million gallons of leachate from Coffin Butte, as well as a Republic Services' garbage transfer station in Benton County.

Salem also processes leachate from LRI Landfill in Graham, Washington, and Recology Organics compost facilities in Aumsville and North Plains.

Marion County garbage that doesn't go to Covanta is taken to Coffin Butte, as is garbage from West Salem residents, who live in Polk County.

According to the landfill's most recent annual report, Coffin Butte accepts more waste from Marion County than from any other county it serves. In 2021, the landfill accepted 326,000 tons of waste from Marion County, 143,000 tons from Linn County, 115,000 tons each from Benton and Lincoln counties, and 73,000 tons from Polk County.

Oregon's new landfill rules strictest in nation

Coffin Butte, along with other landfills, operates a gas capture system for the methane, which is created as organic waste decomposes. The landfill partners with PNGC Power to generate 5.66 megawatts of power from gas collected on site, providing enough electricity for about 4,000 homes.

In October 2021, the Oregon Department of Environmental Quality Commission adopted new rules regulating landfill gas emissions. Oregon now has the strictest monitoring and methane reduction standards in the nation.

But landfill operators are basically on an honor system to test and report, said Katherine Blauvelt, of Industrious Labs.

"The landfill has to follow through and conduct effective monitoring," Blauvelt said. "That, in a nutshell is the real problem that this (EPA inspection report) is highlighting."

EPA questions Republic Services' monitoring

EPA environmental scientist Daniel Heins expressed concerns in the report about Republic Services' monitoring procedures.

In its monitoring reports, the company reported finding a total of six methane exceedances. Some reports had zero exceedances.

That compares with the 61 exceedances the EPA inspector found, "with 26 exceedances at gas collection wells that Republic should have specifically been monitoring on a quarterly basis," Heins wrote.

"Many flagged exceedances represented clusters of exceedances at multiple points or broad areas of exceedances," he wrote.

Heins found an area where a tarp was visibly inflated with and leaking landfill gas.

"Along the top of this section of tarp … every post or tarp hole Daniel Heins monitored exceeded the surface methane standard, with readings of up to 7% (methane) shown before the instrument maxed out," the report reads.

Heins noted "such an accumulation of flammable gas creates a potential safety concern."

Heins was accompanied by Republic Services environmental specialist Phil Caruso. Neither could identify any place where the wind could be lifting the tarps, but Republic officials later "disputed that the tarps were inflated with landfill gas, claiming that the wind has blown them up," according to the report.

Heins also found methane exceedances in areas of the landfill that are supposed to be under final closure and sealed, so that nothing can escape.

The inspection was pre-scheduled, and EPA had offered Republic Services the opportunity to take its own readings to check EPA's monitoring results. Republic officials responded that it was company policy not to do so, according to the report.

"Phil Caruso did not dispute any of the readings, though noted that he would not have checked many of the exceedance locations, that he would have spent less time monitoring, or that he would have considered a higher location to be 'the ground' when placing his probe 5 to 10 centimeters above the ground per the surface emissions monitoring regulations," Heins wrote in the report.

Further action on monitoring methane

EPA requested additional information from the company, but it's unclear what further action the agency has taken.

"EPA is still in the process of evaluating compliance at the Coffin Butte Landfill based, in part, on the inspection report you referenced," EPA Region 10 spokesperson Sam Lovell said in an email to the Statesman Journal.

"EPA works closely with state and local Clean Air Act permitting agencies on these and other issues, and the agency will continue coordinating with Oregon DEQ regarding any next steps at this landfill," Lovell said.

Blauvelt said she filed a FOIA request with the EPA for additional legal documents associated with the case and was told none were available.

DEQ spokesman Dylan Darling referred specific questions about the report's findings to the EPA.

But, he said, "As part of DEQ's new landfill rules and regulations, the company has indicated to DEQ that it is working on expanding its collection-and-control system. The company continues to provide monthly and semiannual reports to DEQ as required under their Title V air permit."

Advocates say Oregon and the EPA should require better methane monitoring with off-the-shelf technology such as drones or satellites.

"You can deploy technology that will act as reconnaissance and spot these super-emitter events, significant methane leaks, and then fix them," Blauvelt said.

"We can use technology to at least overcome this baseline issue, which is we have no way of knowing whether you're living next to a landfill that has really significant issues," she said.

Tracy Loew covers the environment at the Statesman Journal. Send comments, questions and tips:tloew@statesmanjournal.com or 503-399-6779. Follow her on Twitter at@Tracy_Loew

Already a Sustainer?
Click here to increase now

Exploding lithium batteries are causing fires in Oregon's landfills



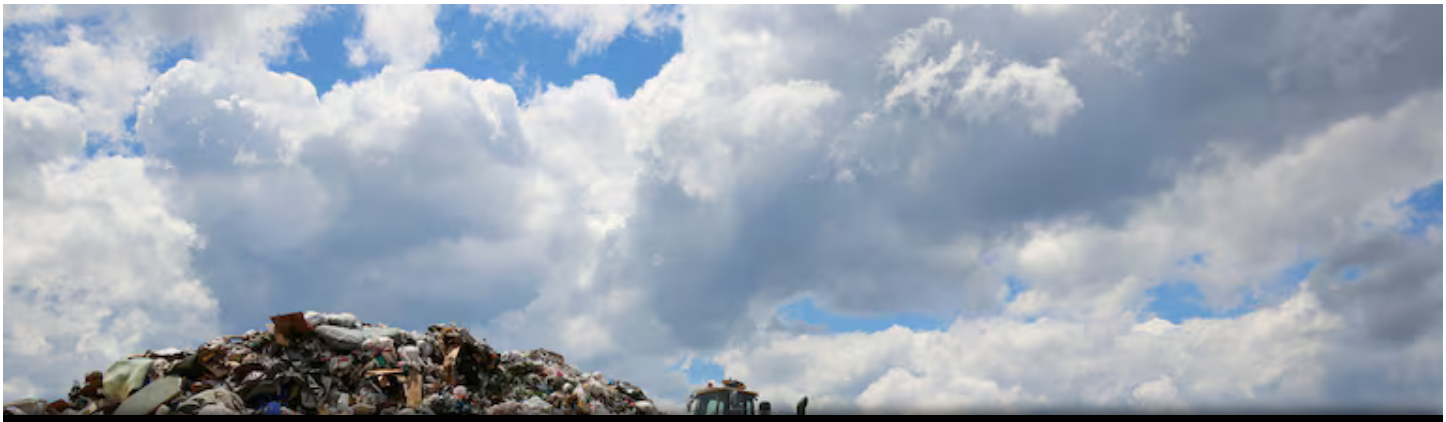
By Joni Auden Land (OPB)
Oct. 21, 2023 6 a.m.

Exploding lithium-ion batteries are leading to more fires in Oregon's landfills and recycling centers, prompting action from state and local governments.

Deschutes County Solid Waste Director Tim Brownell said his county's landfill has seen 21 lithium-related fires in the past three months. Staff went from seeing battery fires once a month to multiple times a week.

"(Lithium batteries) are everywhere in the system," Brownell said. "It's a public safety concern and it's a concern for the infrastructure that are taxpayer investments."

Lithium batteries can be found in a variety of household objects, ranging from cars to power tools and from e-bikes to birthday cards that play music when opened. When run over by tractors or crushed in a trash compactor, they have the potential to explode and catch fire.



STREAMING NOW
Here and Now



A mound of garbage at the Knott Landfill in Deschutes County in 2022. This landfill has seen 21 fires from exploding lithium batteries in the past three months.
Joni Land / OPB

Because of this, the batteries are considered hazardous and aren't allowed in the landfill. Many end up there anyway. Brownell said many people simply don't know that they shouldn't throw the batteries in the garbage.

In some cases, it's leading to potentially dangerous situations. On multiple occasions, garbage trucks have arrived at the Deschutes County landfill with a fire smoldering in the back, Brownell said.

It's unclear how many injuries these types of fires have caused in Oregon.

As for which objects are causing fires, Brownell has seen cellphones, tablets and large batteries found in e-bikes and cars. Those larger ones are of particular concern because the fires are bigger.

"You might get flames that are three or four feet up in the air," Brownell said. "Once you get flames like that, you start to get concerned about it starting to catch the adjacent materials around it."

Battery fires aren't a new issue.

The federal Environmental Protection Agency issued a report in 2021 analyzing the impact of these batteries on fires in waste management facilities. The agency found 245 separate fires across 28 states, some of which led to entire buildings burning down. Recycling centers were at particular risk of fire damage.

The report mentioned Pacific Coast Shredding in Vancouver, Washington, which

STREAMING NOW
Here and Now

The problem appears to be worsening, which Brownell said could be related to lithium batteries appearing more widely in the marketplace. Reuters reported earlier this year that demand for lithium batteries is on the rise, with the market in the U.S. expected to rise six times by 2030.

State agencies have started taking notice. Earlier this year, the Oregon State Fire Marshal's Office started tracking fires stemming from lithium battery explosions, according to spokesperson Alison Green.

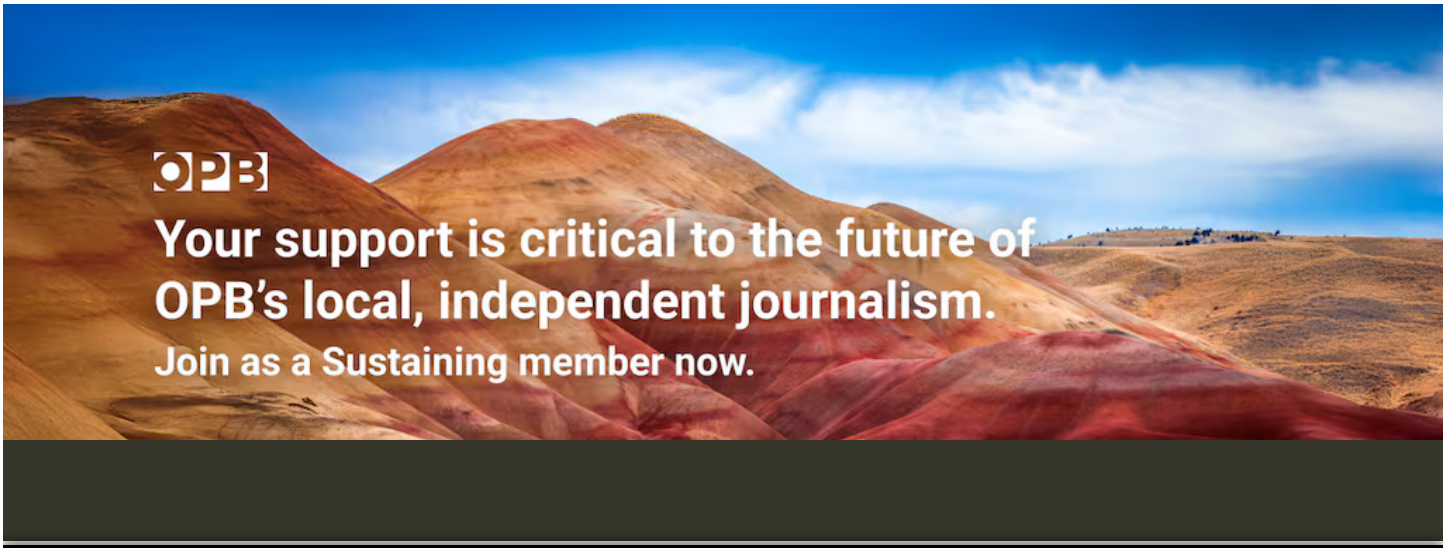
Green said it's still early to pull any findings from the data. The agency collects data on all structural fires in the state, and Green said the agency's hoping to understand how often lithium batteries are causing fires, what's causing them to explode and how that can be prevented.

At this early stage, it's still unclear how many fires lithium batteries are causing in Oregon. Brownell said more data is key to getting the public to understand the severity of the problem.

"If we're going to speak publicly about it, we have to get a better sense of how often it is happening," Brownell said.

Brownell said people looking to throw away lithium batteries should bring them directly to the landfill, where operators can discard them properly.

He said he hopes, in the future, "people who put (lithium batteries) into the marketplace bear some of the responsibility" for the fires.



STREAMING NOW
Here and Now

Thanks to our members, public media thrives in the Pacific Northwest.

Contribute Now

Daily news in your inbox

Sign up today for OPB's "First Look" – your daily guide to the most important news and culture stories from around the Northwest.

EMAIL

Sign up

Tags: Deschutes County, Oregon, Recycling, Cell Phones, Fire, Environmental Protection Agency

Stand with OPB and protect independent journalism for everyone.

Make a Sustaining contribution now

STREAMING NOW
Here and Now

https://gazettetimes.com/news/article_d88109e6-74f1-11ee-bd5b-23358933e746.html

EPA: Methane gas levels at Coffin Butte landfill are concerning



A sign reminding Republic Services employee to "protect the environment and other driver by properly covering and securing you loads" stands in front of the Coffin Butte Landfill managed by Republic Services.

Jess Hume-Pantuso, Mid-Valley Media

Kosiso Ugwuede

It is no surprise that Coffin Butte, like many municipal landfills, produces high quantities of methane gas: Landfills are the third largest source of human-related methane emissions in the United States, **according** to the U.S Environmental Protection Agency.

But a 2022 report by the agency reveals that the level of methane gas emissions at Coffin Butte is not only very concerning, but contradicts figures reported by landfill operator, Republic Services, at the time.

A Place to Sleep, episode 4: Sweet Home

During a June 23, 2022, surface emission monitoring at the landfill, agency environmental scientist Daniel Heins identified 61 instances in which emissions went beyond the 500 parts per million threshold the agency has set as a safety line.

In 21 of those instances, emissions exceeded 10,000 parts per million, according to the report, which was obtained through a Freedom of Information Act request made by environmental justice nonprofit Beyond Toxics and think tank, Industrious Labs.

Reached by phone, Lisa Arkin, executive director at Beyond Toxics, said landfill neighbors had contacted her organization following its advocacy role in passing **Senate Bill 488** to require emissions monitoring at Covanta Marion, a large municipal waste incinerator in northeast Salem.

The organization quickly began to see connections in the handling of waste at both facilities, Arkin said.

First, they tried to gather quantitative data to measure the experiences of residents.

"Because once you're armed with data, you can take the appropriate action. You cannot take action in ignorance," Arkin said.

A view of the Coffin Butte Landfill managed by Republic Services on Oct. 31, 2023.

Jess Hume-Pantuso, Mid-Valley Media

As a nonprofit, gathering data was going to come at a steep cost, so they **worked with Corvallis High School students to measure air quality** in the area. It was during this process that they learned about and were urged to get in touch with Katherine Blauvelt, circular economic director at Industrious Labs.

Together, they put out a public request to the U.S. Environmental Protection Agency for data regarding air quality at the landfill.

- -- ---- --

What the report revealed is quite troubling, according to Blauvelt.

In the report seen by Mid-Valley Media, the agency carried out the inspection in two phases on June 23, 2022: first in a loop across the western portion of the landfill for about three hours in the morning, and later, another wider loop across the eastern portion of the landfill for about another three hours in the afternoon.

Exceedances, when emissions surpassed the 500 parts per million threshold, were measured both in clusters as well as over broad areas of the landfill.

Twenty-six times, exceedances were recorded at or near gas collection wells both active and abandoned/decommissioned. Eight times, exceedances were recorded at **leachate cleanouts**.

Six times, exceedances were recorded in what is known as final cover areas, that is, areas which have reached capacity and are being phased out.

During the afternoon monitoring, Heins found that not only were exceedances above the 500 parts per million threshold at various points, but multiple feet in the air and several feet from their source revealed "substantial landfill gas plumes," which Heins concluded posed safety concerns because of how easily flammable methane is.

One of the points where significant emissions were recorded was near an area with a tarp covering that was visibly inflated. Neither Heins nor Phil Caruso, an environmental scientist with Republic Services who accompanied the agency on the inspection, could identify wind as the cause of the ballooning.

Along this section, every point inspected by Heins exceeded surface methane

standards and readings went so high they maxed out the monitoring instrument, a ThermoFisher Toxic Vapor Analyzer 2020.

In reports supplied by Republic Services ahead of the monitoring exercise, the company said its own surface emission monitoring exercise had only shown six exceedances and in one instance, zero exceedances.

Caruso did not dispute the readings conducted by the agency, but the report showed that the company's inspection protocol differed greatly from that of the agency.

For instance, while the agency inspected leachate cleanouts, "Caruso stated that he does not monitor at these, and they are not fully penetrating the cover," according to the report.

In cell five's leachate rise, where Heins measured multiple exceedances, Caruso said he would not have measured it as it was outside of the waste mass, the report said.

When contacted, a Republic Services representative said that though the testing protocols and analyses differed, the company has since taken corrective actions to address the EPA's concerns.

"There were no violations issued against Coffin Butte as part of the 2022 report, and the landfill remains in compliance with all state and federal regulations," Melissa Quillard, senior manager, external communications, said in an email.

At the time, Quillard said, company officials were in the process of expanding the gas collection system at the landfill, which has now been completed.

"We added additional cover soil in some areas, added soil along the edge of tarps, patched small holes in a liner system, and strengthened seals around gas collection piping," Quillard wrote.

In 2019, the agency said the gas collection system at the landfill was converting 57% of its methane to carbon dioxide, a less potent greenhouse gas, as compared to other Oregon landfills such as Columbia Ridge (85%) and Dry Creek (80%), according to the recently released **Benton County Trash Talks report**.

But the company said in the report that by 2021, its gas collection system was 91.2% efficient.

Quillard said via email that the landfill currently meets and exceeds federal requirements of gas collection and control, and though not required, its gas collection and control system is evaluated annually to "ensure everything is operating as it should."

Beyond Toxics and Industrious Labs have since filed a complaint about the methane levels at the landfill to the agency.

According to Blauvelt, methane is a super pollutant that immediately begins to heat the planet once it is released. Compared to carbon dioxide, it is at least 28 times better at trapping heat in the atmosphere over a 100-year period, according to an Intergovernmental Panel on Climate Change **report**. Its effect is instant and universal.

Methane is also odorless, but is the precipitator of gasses like hydrogen sulfide and others that fall under the category of volatile organic compounds, like benzene. They come together to produce a stinky cocktail of gasses, according to Joel Geier, a landfill neighbor and member of the Benton County Disposal Site Advisory Committee.

"And every time an apple core or, you know, a banana peel is put in that landfill, that will contribute to more methane coming out of that landfill," Blauvelt said.

The size of the Coffin Butte landfill and its thus unsuccessful requests to expand

have become cause for great concern for many neighbors and community members. Many say are **concerned about the amount of waste that the landfill continues to attract** from other counties outside of Benton and Linn counties.

"The question is what keeps coming in," Geier said.

In 2022, Benton County **formulated a workgroup**, called Benton County Talks Trash, to look into several aspects of the landfill with the goal of developing a solid waste plan for the future. But Geier said a lot of the conversations focused on the landfill as an asset.

In addition, Geier said that at the time a neighborhood tour was organized as part of the workgroup's tasks, Republic Services was aware its methane emissions report was disputed by the federal environmental agency. But nobody **during the September 2022 tour** learned of it.

Ironically, comments by a neighbor on the tour, Kevin Higgins — who fought landfill fires at Coffin Butte in the 1990s and 2000s standing on tarps bubbling with gases underneath — were condensed in the final report, Geier said.

All the report says is "At the historic Soap Creek Schoolhouse, Kevin Higgins, a firefighter and employee with the Benton County Sherriff's Office, gave a talk on growing up in the area, landfill fires, types of items in landfill, and DEQ."

Mark Yeager who participated in two subcommittees within the workgroup said that in the course of devising its findings, it was clear mitigating conditions placed on the landfill were not enforced.

Quality journalism doesn't happen without your help

"There are explicit findings in the BCTT report that specify that the county has never and does not now monitor any of the conditions of approval that they've issued as part of any prior land use decisions," Yeager said by phone.

After several calls to the state Department of Environmental Quality, Yeager said there is still nothing to show that the agency is concerned about the experience of the landfill neighbors and the danger the landfill may pose both to those near the site and the rest of the community.

"It doesn't have to be something where you actually smell it to know that your life's being impacted," he said.

Beyond Toxics's Arkin said that the Environmental Protection Agency has not responded to the complaint yet, but she has been in touch with the Department of Environmental Quality to complain about the lack of oversight at Coffin Butte.

"For the record, the EPA sets the national standards for landfills across this country through the Clean Air Act standard, so this adds to the mountain of evidence that the EPA is overdue to act to update those standards to have monitoring that is more effective," Blauvelt said.

"The great news is that there is technology like drones, like remote direct sensing measurement technologies out there, that can help remove human error and provide transparency," she said.

"Unfortunately, regulation just hasn't caught up with the technology," she said. "That will at least be a game-changer from a transparency standpoint."

Geier hopes the concerns of the landfill neighbors will be taken more seriously and for the county to "really think about what they're getting into with an expansion."

. …- -. .. - .. -.-.-.

- **'Complex chemical stew': Leachate concerns in Corvallis**

- **Benton task force: Coffin Butte expansion should be tied to monitoring**
- **Benton County trash report: Next step is charting a new plan**
- **Tour provides peek into landfill operations, Benton workgroup dynamics**
- **Students measure pollution around Corvallis' glass fiber plant**
- **More Benton County news**

Kosisochukwu Ugwuede (she/her) covers the cities of Corvallis, Philomath & Millersburg. She can be reached via e-mail at . ... or by phone via 541-812-6091

. .. .

From:	Ken Eklund
To:	Benton Public Comment
Subject:	I oppose LU-24-027: reference articles and opinions in the press - 7 of 12
Date:	Thursday, May 8, 2025 2:36:54 PM
Attachments:	writerguy-cube2.png 23 Montana PBS Reports IMPACT Special Investigation Dangerous Chemicals in Compost Season 2 Episode 6 PBS.pdf 24 Mechanics, Republic Services still at odds over health care.pdf 25 As I See It Coffin Butte Landfill expansion.pdf 26 Methane From Landfills Is a Big Driver of Climate Change, Study Says - The New York Times.pdf 27 Quantifying methane emissions from United States landfills Science.pdf

CAUTION: This email originated from outside of the organization. Do not click links or open attachments unless you recognize the sender and know the content is safe.

Even more history of Coffin Butte Landfill in the press, covering many of the same issues that have come up in public testimony: PFAS, leachate, methane, EPA and DEQ investigations and actions, labor issues, Republic cover-ups of problems and information, fire hazards, misleading and dubious information about the economics of the landfill, and so on. – K



Ken Eklund, writerguy

37340 Moss Rock Dr
Corvallis OR 97330
408.623.8372

Creator of
World Without Oil
Ed Zed Omega
FutureCoast
and other storymaking games

Urge Congress: Protect PBS Funding

The federal funding that supports Public Media is at risk of being eliminated. Your PBS viewing experience is in danger of going away. Now is a critical time to act.

Contact Congress Now



MONTANA PBS REPORTS: IMPACT

Special Investigation: Dangerous Chemicals in Compost

Season 2 Episode 6 | 28m 40s| CC

A Special Investigation over concerns of dangerous chemicals in biosolid compost.

Aired 12/14/2023 | Rating TV-G

Problems with Closed Captions? **Closed Captioning Feedback**

For decades, cities and states have been using treated human sewage, called "biosolids", to create composts and fertilizers. They've also applied millions of gallons of biosolids to farmland across the United States. But now, the EPA is taking a closer look at the myriad contaminants that end up in biosolids. Are they safe to put in our gardens and on our crops? Tests reveal the shocking truth.

GENRE

News And Public Affairs

MATURITY RATING

TV-G

SHARE THIS VIDEO

How to Watch Montana PBS Reports: IMPACT

Montana PBS Reports: IMPACT is available to stream on pbs.org and the free PBS App, available on iPhone, Apple TV, Android TV, Android smartphones, Amazon Fire TV, Amazon Fire Tablet, Roku, Samsung Smart TV, and Vizio.

Stream Here on PBS.org

Download the PBS App

Check Your Local Listings for Broadcast Schedules

Montana PBS Reports: IMPACT is a local public television program presented by Montana PBS



Copyright © 2025 Public Broadcasting Service (PBS), all rights reserved. PBS is a 501(c)(3) not-for-profit organization.

https://gazettetimes.com/news/local/article_51be900e-a5b1-5f88-b10f-74f3976f8fc4.html

ALERT FEATURED TOP STORY

Coffin Butte mechanics still seeking adequate health care from Republic



Signs pointing residents toward the landfill with patches of snow still visible at the Coffin Butte Landfill after several days of impassable roads in Corvallis after a winter storm in January.
Jess Hume-Pantuso, Mid-Valley Media

Kosiso Ugwuede

Several bargaining meetings later, and the Coffin Butte Landfills' seven-man heavy-duty equipment mechanics have failed to reach an acceptable health care insurance agreement with Valley Landfills Inc., a subsidiary of the trash

company, Republic Services, which runs the landfill.

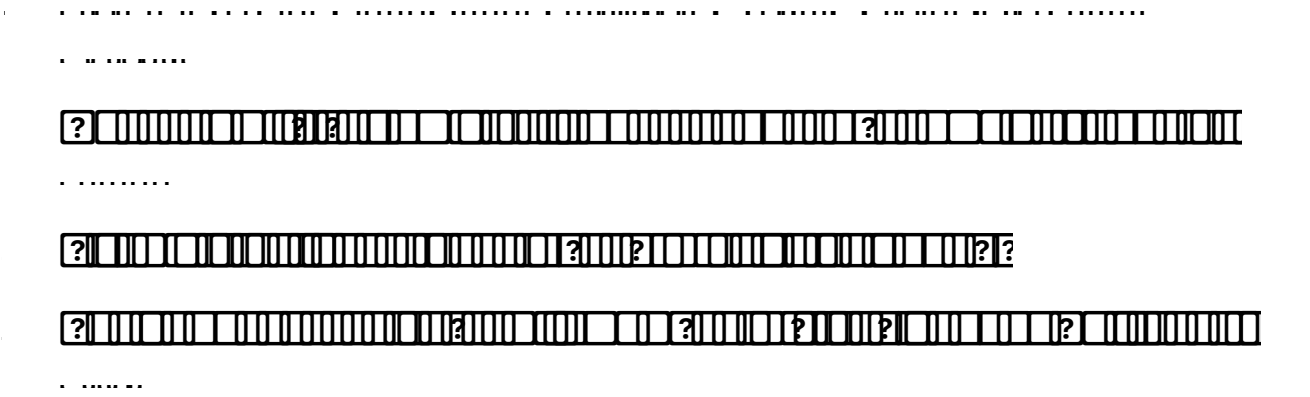
Last September, **the mechanics embarked on an indefinite strike** in protest of what they alleged were unsafe working conditions and unfair labor practices.

A Place to Sleep, episode 3: Corvallis

The employees make diesel, hydraulic and electrical repairs, as well as do welding and fabrication on Caterpillar D-9 bulldozers, Caterpillar compactors, and Caterpillar wheel-loaders, which are used for moving and compacting the landfill waste.

The strike, which lasted about two months, **included a rally which drew Oregon House Speaker Dan Rayfield** and several union leaders in attendance.

As an "olive branch," the **mechanics returned to work last November after some improvements** were made to their working conditions while negotiations continued with the company.



During a Jan. 3 bargaining meeting, the mechanics were presented with a potential new contract by Valley Landfills. It included a 17% wage increase spread out over a five-year period but failed to adopt the health care insurance plan offered by the International Union of Operating Engineers Local 701, which the mechanics joined after an election last year.

Union spokesperson Aurora Biggers said the union did not recommend the ratification of the contract, and when it was brought to a vote by the mechanics, it was unanimously rejected.

The family health care plan the union has offered the mechanics is a "self-insured" plan which adopts the same guidelines as Premera Blue Cross Blue Shield, according to Biggers.

Valley Landfills' health care insurance offer is through **UnitedHealthcare which severed ties with Samaritan Health Services last September**, impacting about 18,000 patients mostly in the mid-Willamette Valley.

Mechanics and union representatives have said that the company's plan is not only unaffordable, it does not offer the mechanics accessible and robust health care services that address the contaminants they are exposed to at the dump site on a daily basis.

To receive medical attention, mechanics now have to drive an hour to reach eligible providers, Biggers said in a statement.

"Medical care in the area is critical," Robert Orton, one of the landfill's heavy-duty mechanics, said via phone. But colleagues are coming in sick, forgoing or delaying the drive to Eugene or Salem to access health care services.

According to the union's representatives, the monthly premium for the mechanics excluding vision and dental care costs $2,020.43. A spokesperson for Republic Services said the cost is less than $1,000 per month.

Deductibles and out-of-pocket costs are also more expensive on the company's UnitedHealthcare plan compared to the union's self-packaged insurance, according to the union's representatives.

The union has said that the company stands to save money if it allows the mechanics to adopt the union's health care plans. Everyone at the bargaining table agrees that the union's insurance offers robust care at lesser costs, Orton said, "but even after admitting that, they say 'no'."

Republic Services, when contacted via its spokesperson, declined to respond to questions regarding health care sticking point between the union and the company.

Aside from the health care insurance, Orton said the last hurdle for the mechanics remains negotiating a bump in their wages, enough to get the mechanics to the lower end of the standard rates obtainable in the industry.

Quality journalism doesn't happen without your help

It is unclear if the mechanics will return to the picket lines, but Orton said: "Nothing is off the table at this time," adding, "Our families, ourselves, our co-workers, we deserve to be healthy."

Editor's Note: This article has been updated to clarify that the 17% wage increase was spread out over a five-year period, and to include the monthly premium reported by Republic Services.

Related stories:

Benton County: New Coffin Butte expansion app is imminent

. ...

Samaritan patients to lose United Healthcare as in-network provider

Kosisochukwu Ugwuede (she/her) covers the cities of Corvallis, Philomath & Millersburg. She can be reached via e-mail at [redacted] or by phone via 541-812-6091

As I See It: Coffin Butte Landfill expansion

Republic Services may soon seek to expand the Coffin Butte Landfill.

Benton County citizens must carefully consider whether the facility's benefits outweigh its costs and risks. We should not consider opposition to the expansion as mere NIMBYism. This is our place, our home.

We are still discovering new problems related to the landfill, such as previously unrecognized methane emissions.

Meanwhile, Benton County officials seem more concerned with business arrangements than the ongoing and unending impacts of the facility. By contrast, neighboring Linn County officials listened and responded to their residents in a similar situation.

There is not enough room in a year's worth of this newspaper to fully explore the costs, risks and benefits. The "Benton County Talks Trash" final report's historical section, particularly pages 21 and 22, provides a useful perspective on how we got to this point. This report is available through the county's website.

Ultimately, Benton County residents bear the costs vis-à-vis property values, road conditions and litter cleanup related to waste transportation, as well as the risks associated with liquid and gas leakage, the management of leachate, and possible fires (as happened in the past here) — and earthquakes.

In exchange, Benton County government receives fees from Republic Services, between $2.5 million to $3.5 million per year. County officials seem to place this revenue and the company's interests foremost.

The Benton County Talks Trash report, which was reviewed by Republic Services and county staff, states: "The 2020 franchise agreement over landfill operations enhanced the financial incentive for the county to support increased solid waste intake" (page 37).

County staff justified these questionable incentives partially because Republic Services' "ability to pay higher fees was dependent on reducing cost or increasing capacity" (page 38). For perspective, Republic Services itself reported its net income for 2022 was $1.5 billion, or 11.2% of revenue.

The focus here should be on the interests of Benton County residents. Criticizing the opposition to expansion as simply NIMBYism is a distraction, and minimizes the current and permanent costs and risks the landfill poses.

Benton County's elected officials and staff should prioritize citizen interests before those of Republic Services or the refuse needs of the Metro area. We need to develop responsible policies regarding our waste, about 12% of the content placed in Coffin Butte.

We should work in collaboration with regional governments to reduce and properly dispose of local waste. Our recent contract with Republic Services that raised the limit to 1.1 million tons per year does not reflect local or regional

demands, but Republic Services' opportunities to expand its market.

Meanwhile, Linn County official responded strongly to the concerns of local farmers regarding how specific corporate poultry farms could destroy their quality of life and, possibly, their economic livelihood.

As this newspaper reported on Dec. 13, Linn County officials respected the NIMBY interests of their residents. Linn County legislators pushed state legislation enabling local governments to require setbacks on confined animal feeding operations.

Then Linn County commissioners passed a 1-mile setback requirement, effectively killing the current Foster Farms proposals and greatly limiting future ones. Linn County officials placed the interests of their citizens ahead of those of Foster Farms. The county will forego some property taxes, employment and other revenues as a result.

Benton County officials should take a cue from Linn County regarding their priorities. Let's extricate ourselves from a pattern of waste disposal that undervalues Coffin Butte Landfill's present and permanent local environmental impacts and risks, and the associated reduced property values.

Mark Henkels

Mark Henkels is a longtime resident of the Lewisburg area. He has taught public policy and administration at Western Oregon University since 1988, with a specialization in Oregon politics and government.

The New York Times https://www.nytimes.com/2024/03/28/climate/landfills-methane-emissions.html

'Garbage Lasagna': Dumps Are a Big Driver of Warming, Study Says

Decades of buried trash is releasing methane, a powerful greenhouse gas, at higher rates than previously estimated, the researchers said.



By Hiroko Tabuchi

Published March 28, 2024 Updated March 31, 2024

They're vast expanses that can be as big as towns: open landfills where household waste ends up, whether it's vegetable scraps or old appliances.

These landfills also belch methane, a powerful, planet-warming gas, on average at almost three times the rate reported to federal regulators, according to a study published Thursday in the journal Science.

The study measured methane emissions at roughly 20 percent of 1,200 or so large, operating landfills in the United States. It adds to a growing body of evidence that landfills are a significant driver of climate change, said Riley Duren, founder of the public-private partnership Carbon Mapper, who took part in the study.

"We've largely been in the dark, as a society, about actual emissions from landfills," said Mr. Duren, a former NASA engineer and scientist. "This study pinpoints the gaps."

Methane emissions from oil and gas production, as well as from livestock, have come under increasing scrutiny in recent years. Like carbon dioxide, the main greenhouse gas that's warming the world, methane acts like a blanket in the sky, trapping the sun's heat.

And though methane lasts for a shorter time in the atmosphere than carbon dioxide, it is more potent. Its warming effect is more than 80 times as powerful as the same amount of carbon dioxide over a 20-year period.

The Environmental Protection Agency estimates that landfills are the third largest source of human-caused methane emissions in the United States, emitting as much greenhouse gas as 23 million gasoline cars driven for a year.

But those estimates have been largely based on computer modeling, rather than direct

measurements. A big reason: It can be difficult and even dangerous for workers with methane "sniffers" to measure emissions on-site, walking up steep slopes or near active dump sites.

Organic waste like food scraps can emit copious amounts of methane when they decompose under conditions lacking oxygen, which can happen deep in landfills. Composting, on the other hand, generally doesn't produce methane, which is why experts say it can be effective in reducing methane emissions.

For the new study, scientists gathered data from airplane flyovers using a technology called imaging spectrometers designed to measure concentrations of methane in the air. Between 2018 and 2022, they flew planes over 250 sites across 18 states, about 20 percent of the nation's open landfills.

At more than half the landfills they surveyed, researchers detected emissions hot spots, or sizable methane plumes that sometimes lasted months or years. That suggested something had gone awry at the site, like a big leak of trapped methane from layers of long-buried, decomposing trash, the researchers said.

"You can sometimes get decades of trash that's sitting under the landfill," said Daniel H. Cusworth, a climate scientist at Carbon Mapper and the University of Arizona, who led the study. "We call it a garbage lasagna."

Many landfills are fitted with specialized wells and pipes that collect the methane gas that seeps out of rotting garbage in order to either burn it off or sometimes to use it to generate electricity or heat. But those wells and pipes can leak.

The researchers said pinpointing leaks doesn't just help scientists get a better picture of emissions, it also helps landfill operators fix leaks.

Overseas, the picture can be less clear, particularly in countries where landfills aren't strictly regulated. Previous surveys using satellite technology have estimated that globally, landfill methane makes up nearly 20 percent of human-linked methane emissions.

"The waste sector clearly is going to be a critical part of society's ambition to slash methane emissions," said Mr. Duren of Carbon Mapper. "We're not going to meet the global methane pledge targets just by slashing oil and gas emissions."

A growing constellation of methane-detecting satellites could provide a fuller picture. Last month, another nonprofit, the Environmental Defense Fund, launched MethaneSat, a satellite dedicated to tracking methane emissions around the world.

Carbon Mapper, with partners including NASA's Jet Propulsion Laboratory, Rocky Mountain Institute, and the University of Arizona, intends to launch the first of its own methane-tracking satellites later this year.

Hiroko Tabuchi covers the intersection of business and climate for The Times. She has been a journalist for more than 20 years in Tokyo and New York.

A version of this article appears in print on , Section A, Page 16 of the New York edition with the headline: Dumps Are Big Drivers of Warming, Study Says

RESEARCH ARTICLE | METHANE EMISSIONS

Quantifying methane emissions from United States landfills

DANIEL H. CUSWORTH, RILEY M. DUREN, ALANA K. AYASSE, RALPH JIORLE, [...], AND SUSAN THORNELOE +12 authors Authors Info & Affiliations

SCIENCE • 28 Mar 2024 • Vol 383, Issue 6690 • pp. 1499-1504 • DOI: 10.1126/science.adi7735

6,994 33 CHECK ACCESS

Editor’s summary

Methane is the most important trace greenhouse gas after carbon dioxide, and anthropogenic emissions account for more than half of the global total. Landfills containing solid waste are potentially major sources of methane, but their importance has remained poorly constrained. Cusworth *et al*. report data gathered by airborne imaging spectrometers from about 20% of open US landfills to show that considerable point source emissions can be detected at a majority of sites. These results underline the need for better monitoring of landfill emissions to help guide climate change mitigation policy. —H. Jesse Smith

Abstract

Methane emissions from solid waste may represent a substantial fraction of the global anthropogenic budget, but few comprehensive studies exist to assess inventory assumptions. We quantified emissions at hundreds of large landfills across 18 states in the United States between 2016 and 2022 using airborne imaging spectrometers. Spanning 20% of open United States landfills, this represents the most systematic measurement-based study of methane point sources of the waste sector. We detected significant point source emissions at a majority (52%) of these sites, many with emissions persisting over multiple revisits (weeks to years). We compared these against independent contemporaneous in situ airborne observations at 15 landfills and established good agreement. Our findings indicate a need for long-term, synoptic-scale monitoring of landfill emissions in the context of climate change mitigation policy.

Register and access this article for free

As a service to the community, this article is available for free.

LOG IN CREATE A FREE ACCOUNT

Access the full article

View all access options to continue reading this article.

CHECK ACCESS

ALREADY A SUBSCRIBER OR AAAS MEMBER? SIGN IN AS AN INDIVIDUAL OR VIA YOUR INSTITUTION

Supplementary Materials

This PDF file includes:

Materials and Methods

Supplementary Text

Figs. S1 to S8

References (*31*, *32*)

DOWNLOAD **484.94 KB**

Other Supplementary Material for this manuscript includes the following:

Carbon Mapper Emission Data

SA Data

DOWNLOAD | **11.84 MB**

References and notes

1

M. Saunois, A. R. Stavert, B. Poulter, P. Bousquet, J. G. Canadell, R. B. Jackson, P. A. Raymond, E. J. Dlugokencky, S. Houweling, P. K. Patra, P. Ciais, V. K. Arora, D. Bastviken, P. Bergamaschi, D. R. Blake, G. Brailsford, L. Bruhwiler, K. M. Carlson, M. Carrol, S. Castaldi, N. Chandra, C. Crevoisier, P. M. Crill, K. Covey, C. L. Curry, G. Etiope, C. Frankenberg, N. Gedney, M. I. Hegglin, L. Höglund-Isaksson, G. Hugelius, M. Ishizawa, A. Ito, G. Janssens-Maenhout, K. M. Jensen, F. Joos, T. Kleinen, P. B. Krummel, R. L. Langenfelds, G. G. Laruelle, L. Liu, T. Machida, S. Maksyutov, K. C. McDonald, J. McNorton, P. A. Miller, J. R. Melton, I. Morino, J. Müller, F. Murguia-Flores, V. Naik, Y. Niwa, S. Noce, S. O'Doherty, R. J. Parker, C. Peng, S. Peng, G. P. Peters, C. Prigent, R. Prinn, M. Ramonet, P. Regnier, W. J. Riley, J. A. Rosentreter, A. Segers, I. J. Simpson, H. Shi, S. J. Smith, L. P. Steele, B. F. Thornton, H. Tian, Y. Tohjima, F. N. Tubiello, A. Tsuruta, N. Viovy, A. Voulgarakis, T. S. Weber, M. van Weele, G. R. van der Werf, R. F. Weiss, D. Worthy, D. Wunch, Y. Yin, Y. Yoshida, W. Zhang, Z. Zhang, Y. Zhao, B. Zheng, Q. Zhu, Q. Zhu, Q. Zhuang, The global methane budget 2000–2017. *Earth Syst. Sci. Data* **12**, 1561–1623 (2020).

CROSSREF • WEB OF SCIENCE • GOOGLE SCHOLAR

2

US Environmental Protection Agency, "Inventory of US greenhouse gas emissions and sinks: 1990-2020" (EPA, 2024); https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks.

GOOGLE SCHOLAR

3

US Environmental Protection Agency, "Background information document for updating AP42 section 2.4 for estimating emissions from municipal solid waste landfills (EPA, EPA/600/R-08-116, 2008); https://cfpub.epa.gov/si/si_public_record_report.cfm?

SHOW ALL REFERENCES

eLetters (0)

eLetters is a forum for ongoing peer review. eLetters are not edited, proofread, or indexed, but they are screened. eLetters should provide substantive and scholarly commentary on the article. Neither embedded figures nor equations with special characters can be submitted, and we discourage the use of figures and equations within eLetters in general. If a figure or equation is essential, please include within the text of the eLetter a link to the figure, equation, or full text with special characters at a public repository with versioning, such as Zenodo. Please read our Terms of Service before submitting an eLetter.

LOG IN TO SUBMIT A RESPONSE

No eLetters have been published for this article yet.

CURRENT ISSUE



Enhanced ERK activity extends ketamine's antidepressant effects by augmenting synaptic plasticity

BY Z. ZACK MA, NATALIE J. GUZIKOWSKI, *ET AL.*

Pseudogap and Fermi arc induced by Fermi surface nesting in a centrosymmetric skyrmion magnet

BY YUYANG DONG, YUTO KINOSHITA, *ET AL.*

Pancreatic cancer–restricted cryptic antigens are targets for T cell recognition

BY ZACKERY A. ELY, ZACHARY J. KULSTAD, *ET AL.*

TABLE OF CONTENTS >

LATEST NEWS

NEWS | 8 MAY 2025

AI predicted the next pope. Did it get it right?

NEWS | 8 MAY 2025

Bronze Age leprosy hitched rides along ancient copper and pottery trade route

SCIENCEINSIDER | 7 MAY 2025

Ambitious project to revive Louisiana coastline runs aground

NEWS | 7 MAY 2025

Dangerous fungal spores can surf the stratosphere—and survive

SCIENCESHOTS | 7 MAY 2025

Scientists 'blow up' brains 16 times their size to map neurons with superfine detail

SCIENCESHOTS | 6 MAY 2025

Meet a worm that can stretch like an accordion

RECOMMENDED

RESEARCH ARTICLE | APRIL 2020

Quantifying methane emissions from the largest oil-producing basin in the United States from space

RESEARCH ARTICLE | AUGUST 2022

Using satellites to uncover large methane emissions from landfills

LETTER | JULY 1986

Acid Deposition in the Western United States

LETTER | JULY 1986

Acid Deposition in the Western United States

SPONSORED WEBINAR | SCIENCE AND LIFE | 8 MAY 2025

Redefining Connection: How young people are shaping the future of the rare disease community through technology and innovation

View full text | Download PDF

© 2025 American Association for the Advancement of Science. All rights reserved. AAAS is a partner of HINARI, AGORA, OARE, CHORUS, CLOCKSS, CrossRef and COUNTER. *Science* ISSN 0036-8075.

From:	Ken Eklund
To:	Benton Public Comment
Subject:	I oppose LU-24-027: reference articles and opinions in the press - 8 of 12
Date:	Thursday, May 8, 2025 2:37:56 PM
Attachments:	writerguy-cube2.png 28 Benton County residents report odor and fire risks at Coffin Butte landfill.pdf 29 A huge landfill in Oregon is spewing methane. Its… Canary Media.pdf

CAUTION: This email originated from outside of the organization. Do not click links or open attachments unless you recognize the sender and know the content is safe.

Still more history of Coffin Butte Landfill in the press, covering many of the same issues that have come up in public testimony: PFAS, leachate, methane, EPA and DEQ investigations and actions, labor issues, Republic cover-ups of problems and information, fire hazards, misleading and dubious information about the economics of the landfill, and so on. – K



Ken Eklund, writerguy

37340 Moss Rock Dr
Corvallis OR 97330
408.623.8372

Creator of
World Without Oil
Ed Zed Omega
FutureCoast
and other storymaking games

Benton County residents report odor and fire risks at Coffin Butte landfill

KLCC | By Nathan Wilk

Published August 4, 2024 at 6:22 AM PDT

LISTEN • 1:01



Nathan Wilk / KLCC

The Coffin Butte landfill is permitted to accept 1.1 million tons of waste each year.

Residents in rural Benton County say they're concerned about odor and fire risk at the Coffin Butte landfill.

The site accepts over 1 million tons of garbage annually from across Oregon and Washington. It's located about 8 miles north of Corvallis along Oregon Highway 99W near the town of Adair Village.

Neighbors report experiencing frequent "bad-air days," when a strong acrid or

KLCC spoke to those community members during a tour led by the Eugene-based environmental group Beyond Toxics.

Mark Yeager lives about five miles from the landfill. He said the odor has become far more frequent over the last decade.

“This past winter, there were probably two dozen times that I would walk out on the deck and say ‘I can't go outside to run today,” said Yeager. “Or I don't think it's appropriate for me, because I really don't know what I'm breathing.”

Kate Harris, who lives in the Soap Creek community southwest of the landfill, has children who attend school in Adair Village.

“You're like, ‘oh, it's a dump day,’” said Harris, “and deciding whether or not we’re going to do recess outside, or take the kids home.”

In an unattributed statement emailed to KLCC, the landfill’s owner, Republic Services, said it provides daily coverage to its garbage, and it’s invested in state-of-the-art gas collection technology.

“We make every effort to limit on-site odors and offsite impacts,” the company wrote.



Nathan Wilk / KLCC

Soap Creek Valley resident Joel Geier said he nearly had to evacuate his home last month. He said the

KLCC
Here & Now

Reducing Fire Risk

On July 24, firefighters responded to a grass fire near a flare stack which burns off methane gas from the landfill. The exact cause of the blaze is unknown.

“The obvious cause is the open flame stack that was close by,” said Adair Rural Fire & Rescue Chief Aaron Harris. “But there's no way to corroborate that.”

Nearby resident Joel Geier said he nearly had to evacuate. He believes that if the fire jumped to nearby trees, it may have been just minutes before it reached his home.

“We've been aware for a while it could be a risk,” said Geier. “But when you're actually in the situation, it's extremely stressful, and you're trying to make immediate decisions on what you should grab, and are you going to have to leave some animals behind?”

Emergency responders extinguished the blaze within minutes, according to Harris. Republic said its operating manager arrived around 12 minutes after fire officials.

“We have robust monitoring and emergency management systems in place to protect employees, the community and the environment in the event of a fire,” Republic wrote in an email. “That system worked as designed.”

However, neighbors argue Republic should be doing more to monitor the area, shield the flare stacks, and reduce the density of trees on its property.

Geier said the company was slow to trim fuel on the landfill, even as the area experienced triple-digit temperatures this summer.

“Everyone in this area knows that you're supposed to mow, and not leave tall grass standing like that,” said Geier. “The fact they left that all the way into almost the end of July is a sign that they're not being diligent.”

Republic told KLCC it’s trying to prevent future fires by clearing away grass and undergrowth on its property. Company representatives have also said they’re working to comply with environmental standards.

KLCC
Here & Now

highly flammable concentrations. According to Republic, an unreleased EPA follow-up from June of this year also found surface emissions beyond the legal limit.



Nathan Wilk / KLCC

Completed covering at the Coffin Butte Landfill. Beneath the grass, there are filled-up garbage cells.

The Attempt to Expand

Last month, Republic submitted an application to Benton County to expand the landfill. The company said it needs more space, or the site will be full within around 13 years.

However, Harris—one of the nearby residents—said she's worried about the site's impact on efforts to expand housing in the area.

"The developer may have a hard time selling the homes and they may not be willing to expand Adair Village itself, if things go too far in the wrong direction," she said.

Geier said neighbors have long expected that the landfill would close once it was full.

"This makes us feel that this landfill is never going away, and instead their plan is just to keep expanding," said Geier. "That's really a different scenario than we were expecting when we moved here, and frankly, it makes me worry about the future of the whole neighborhood."

KLCC
Here & Now

expansion application. The decision could later be appealed to the Board of County Commissioners.

Tags Economy & Business | Environment | Beyond Toxics | Benton County | landfills | Coffin Butte

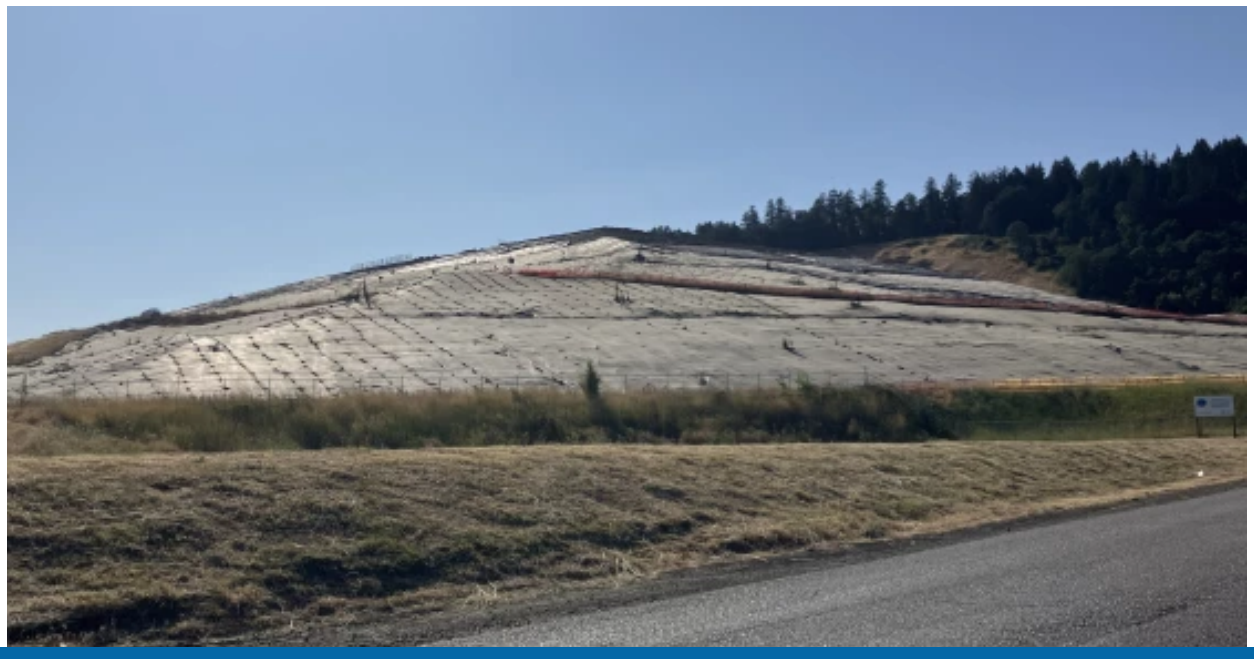


Nathan Wilk

Nathan Wilk joined the KLCC News Team in 2022. He is a graduate from the University of Oregon School of Journalism and Communication. Born in Portland, Wilk began working in radio at a young age, serving as a DJ and public affairs host across Oregon.

See stories by Nathan Wilk

Related Content



KLCC
Here & Now

Environment

Proposed landfill expansion in Benton County sees second attempt

Nathan Wilk, July 12, 2024

The owner of the Coffin Butte landfill in Benton County is once again trying to expand.

LISTEN • 1:01

Stay Connected

© 2025 KLCC

KLCC
136 W 8th Ave
Eugene OR 97401
541-463-6000
klcc@klcc.org

Contact Us

FCC Applications

KLCC
Here & Now

CANARY MEDIA
Clean energy journalism for a cooler tomorrow



6 August 2024

A huge landfill in Oregon is spewing methane. Its owners want to expand.

Numerous safety violations have been detected at the fast-growing landfill. It's part of a larger pattern of problems with how the U.S. handles waste.



ISOBEL WHITCOMB
Isobel Whitcomb is a science and environmental journalist based in Portland, Oregon.

In rural Benton County, brigades of waste-collection vehicles lumber through forested hills and wheat fields, each truck trailed by an acrid stench. They're hauling trash from across the western half of the state to Coffin Butte Landfill. The site accepts waste from nearly two dozen of Oregon's 36 counties, and the pile towers high enough that some locals call it "the Great Pyramid of Benton County." Joel Geier, who lives half a mile away from Coffin Butte, prefers the moniker "Coughing Butte," due to the noxious, chemical smell that sometimes emanates from it.

"It can be nauseating," Geier said. The smell, sweet like nail polish remover, reminds him of the Monsanto plant near his childhood home in St. Louis, Missouri. "There's the offensiveness of it, and the knowledge that you're breathing in something that probably

landfills emit a cocktail of chemicals known to irritate the lungs, increase the risk of cancer, and cause reproductive issues.

Over the past decade, the amount of garbage imported by Coffin Butte Landfill has more than doubled. To continue to accommodate Oregon's garbage, Republic Services, the company that owns Coffin Butte, says that the landfill needs to expand. Neighbors of the landfill, concerned about its climate impact and the community's safety, believe that there are better ways to deal with all the incoming refuse.

Coffin Butte Landfill rises between steep hillsides at the opening of Soap Creek Valley, a lush basin scattered with homes. Just a mile down highway 99 is Adair Village – a former World War II training camp where about 1,000 people now live. The roughly 3,000 residents of these two communities drive past Coffin Butte on their way to work, school, or nearby Corvallis to run errands. And in recent decades, they have seen the landfill grow in size. "It has quite literally risen into view," said Ken Eklund, a resident who moved to Soap Creek Valley in 2015. Since then, Eklund says that the landfill has doubled in height. Now, its tarped face is visible from his driveway.

CANARY MEDIA
Clean energy journalism for a cooler tomorrow

Coffin Butte Landfill is covered to prevent gases like methane from escaping, but EPA inspections found that the cover was eroding in places. (E.J. Harris)

For many residents of Soap Creek Valley and Adair Village, Coffin Butte Landfill wasn't a major concern until about a decade ago. Under the ownership of Republic Services, which had acquired Coffin Butte in 2008, the landfill was taking trash from a larger swath of Oregon – and even occasionally Washington state. Then in 2016, the closure of another regional landfill led to an unprecedented amount of waste being diverted to Coffin Butte: an addition of more than 400,000 tons over the next year. Geier and other residents started noticing more and more trucks moving through their neighborhoods. On some days the stench was unbearable. "I wouldn't let my kids play outside on those days, I wouldn't go on a walk," said Kate Harris, a resident of Soap Creek Valley.

In early 2021, Republic Services submitted an application for a permit to expand the landfill. At that point, the company was importing more than 1 million tons of trash to Coffin Butte each year – close to Benton County's 1.1-million-ton cap on waste deposited there annually. At this rate, the landfill would reach capacity within five years. The application proposed adding a second, 270-foot-tall pile of waste across Coffin Butte Road, which would buy the landfill another 12 years but close off what is the area's primary evacuation route in the event of wildfire. The proposal also sought to remove the tonnage cap on waste deposited at Coffin Butte.

In response, more than 100 community members rallied to oppose the expansion, giving testimony at hearings and writing letters to local newspapers. "The county thought that this was just going to slide in under the radar. They were completely caught off guard," Eklund said. "They were not ready for the scrutiny."

In December 2021, the Benton County Planning Commission denied the expansion request, but residents considered it only a temporary victory. Earlier this year, they began

The 2021 expansion proposal was a catalyst for activism in Benton County. Outside an old one-room schoolhouse, the tight-knit community of Soap Creek Valley began meeting to organize and share information about Coffin Butte's hazards.

When plastic, food scraps, and other waste get thrown into landfills, they're compacted, covered in dirt or ash, and then blanketed under tarps. As the waste piles up, aerobic bacteria, which live only in the presence of oxygen, consume food scraps and oxygen, producing carbon dioxide. Over time, these bacteria deplete the oxygen in the landfill, creating the perfect environment for methanogens. These microbes feed on the carbon dioxide produced by aerobic bacteria, churning out methane.

The methane and carbon dioxide created through this process make up 90 percent of the gases released by landfills, said Steve Gerritson, a board member at the Institute for Energy and Resource Management and former member of President Bill Clinton's Clean Air Advisory Committee. Neither methane nor CO_2 poses an immediate risk to human health, but the other 10 percent of landfill gases, emitted by waste more resistant to decomposition, do. Plastic water bottles emit vinyl chloride, a sweet-smelling gas associated with liver, brain, lung, and blood cancers. Cosmetics break down to form benzene, which is associated with leukemia. Finally, as the wind blows the landfill's dirt covering, tiny waste particles also get pulled along on the breeze, including heavy metals and dioxins. "These are very dangerous to human health," said Gerritson. "They're not easily controlled." Multiple studies have found elevated rates of cancer and reproductive complications among people living near landfills.

As the residents fighting the Coffin Butte Landfill expansion researched these effects, they turned to environmental nonprofit Beyond Toxics, based in the nearby city of Eugene. Beyond Toxics began setting up air-quality monitors around houses near the landfill to track emissions of nitrogen dioxide, or NO_2. In the short term, this gas, a byproduct of methane combustion, can cause respiratory irritation, increasing the risk of infections and asthma. In the long term, chronic exposure to NO_2 emissions can increase the risk of developing chronic lung disease. The monitors recorded NO_2 concentrations as high as

working near the landfill. One concerning discovery: Operators of Coffin Butte were using ash from a nearby waste incinerator as daily cover for the landfill. This practice isn't inherently unsafe, according to Philipp Schmidt-Pathmann, founder and CEO of the Institute for Energy and Resource Management, a nonprofit that advocates for sustainable waste management. However, the Oregon Department of Environmental Quality safety protocol states that landfill cover should be wetted down before application to prevent particulates from becoming airborne. Beyond Toxics found that landfill operators were skipping this step – photo and video evidence showed plumes of ash blowing from the landfill.

"The problem with incinerator ash is it's full of heavy metals," said Mason Leavitt, a cartographer and GIS technician at Beyond Toxics. "These can accumulate in the environment over time." Another airborne waste product detected at the landfill was dry fiberglass dust. "It can cause microtears in your lung tissue," Leavitt said. "It's technically not a hazardous substance, but it's a huge concern for workers and ... anyone working nearby."

In a statement to Canary Media, Republic Services noted that incinerator ash is approved as landfill cover by the Oregon DEQ and that it arrives at Coffin Butte in a wetted-down, cement-like form. "It is not an airborne, flyaway material," the statement read.

CANARY MEDIA
Clean energy journalism for a cooler tomorrow

The landfill viewed from Coffin Butte Road, Soap Creek Valley's primary evacuation route in case of wildfire. (Isobel Whitcomb)

Robert Orton, a former mechanic at Coffin Butte Landfill, has experienced acute health effects from exposure to waste and its byproducts: breathing issues, skin and eye irritation, rashes, and chemical burns. He says that poor handling of waste contributed to these unsafe conditions. Typical safety protocol involves pressure-washing equipment, which becomes caked in waste, on top of the landfill each day. That location is critical to containing harmful contaminants. However, Orton says that mechanics at Coffin Butte were instructed to wash the equipment at their shop to avoid wetting down the landfill and producing runoff that Republic Services would then have to remediate. Trash and human feces accumulated on the unlined and uncovered soil next to the shop. “There was no way to contain these things within the shop floor. There was no procedure for it,” Orton said. (Republic Services denies that trucks are cleaned on unlined soil, stating that all equipment is pressure-washed atop the landfill.)

In 2022, an EPA inspection found explosive levels of methane at Coffin Butte Landfill. While the federal limit for methane concentrations is 500 parts per million, the EPA reported 21 readings exceeding 10,000 parts per million.

Orton said the unusually high readings were likely due to the large volume of waste being collected and the lack of maintenance to the landfill’s methane-extraction system – a network of pipes running through the landfill that pumps methane and other gases to flares. Waste clogs the extraction system, and over time, as the contents of the landfill

methane indicated a major fire hazard. Fire isn't unusual at Coffin Butte – the last one took place this May. So far, fires have remained isolated to the landfill, but residents of Soap Creek Valley fear that the increasing severity of wildfire conditions in Oregon could cause one of these blazes to spread to the surrounding hills. "We're in a valley with limited ways out," Eklund said. He worries that if the landfill caught fire, Coffin Butte Road would be impassable due to flames and toxic smoke from burning waste. "It's a nightmare scenario."

Republic Services denies many of the criticisms raised by residents, including claims that its gas-collection system is poorly maintained. In a February 2024 memo, Director of Public Affairs Ginger Rough wrote that Coffin Butte has three times more gas-collection wells than industry best practices and that Republic Services has invested $7 million since 2019 to upgrade and expand the gas-collection system, including 57 new wells and 22,000 new feet of piping. She added that the company planned to add 4,500 more feet of piping in 2024.

However, the memo didn't alleviate residents' concerns. "None of these address the landfill's known problem with methane, which is … *it's leaking out of everywhere*," Eklund told Canary Media by email. "The large number of gas collection wells is just evidence that the landfill has a methane problem that they've been working to fix."

Carbon Mapper, a tool that tracks CO_2 and methane emissions, has detected plumes of methane over Coffin Butte exceeding 1,000 kilograms per hour. A plume exceeding even 100 kilograms per hour is designated by the EPA as a "super-emitter event," said Katherine Blauvelt, the circular-economy campaign director for Industrious Labs, a nonprofit working to clean up heavy industry.

disturbing results."

In the case of Coffin Butte, inspectors didn't just find explosive methane levels, they found malfunctioning extraction systems and eroding covers. Similar violations have repeatedly been discovered elsewhere. At Brent Run Landfill outside Flint, Michigan, an EPA inspector detected failures in the gas-extraction system and 19 methane leaks exceeding EPA limits. After an expansion of Los Angeles County's Chiquita Canyon Landfill, an EPA inspection uncovered 14 violations of national emissions standards, including failure to maintain the gas extraction system leading to the release of hazardous air pollutants. An Industrious Labs analysis published in May examining landfills across eight states found that nearly 96 percent of EPA inspections reported methane emissions exceeding the safe limit of 500 parts per million.

The EPA has committed to addressing these widespread regulatory failures – on July 23, the agency announced that it would update emissions standards for landfills in 2025. But tighter emissions standards don't address a major root cause of the problem.

There are financial incentives for landfill operators to minimize maintenance costs while bringing in more waste, says Schmidt-Pathmann of the Institute for Energy and Resource Management. "Waste is a profit-oriented business in the U.S.," he added. For landfills like Coffin Butte, more waste means more revenue. According to Beyond Toxics' Leavitt, Coffin Butte Landfill trucks in 30 percent of Oregon's market share of waste. Less than 6 percent of that waste originates in Benton County. Some municipalities like Benton County, which receives compensation from Republic Services for hosting the landfill, also have a financial incentive to maintain landfills. "It pays the bills," Schmidt-Pathmann said.

CANARY MEDIA
Clean energy journalism for a cooler tomorrow

Coffin Butte Landfill viewed from overhead, with Soap Creek Valley in the background. (E.J. Harris)

Activists believe there are alternatives to expanding Coffin Butte – and to landfills in general. Schmidt-Pathmann points out that most U.S. municipalities have little infrastructure in place to properly sort waste. As a result, recyclable materials easily become contaminated and wind up in landfills. But other countries, such as Germany and the Netherlands, have successfully implemented waste-sorting systems that have decreased the amount of waste disposed of at landfills to just 1 percent, while some German cities have achieved a zero-waste designation. A few municipalities in the United States are following that example.

In December 2023, Lane County, Oregon, which neighbors Benton County, voted to build a new resource recovery facility that will sort garbage, comingled recycling, and organic waste to produce biogas and marketable recycled materials. Advanced equipment will be able to recover recyclables that would otherwise head to the landfill. According to Lane County, it will be "the most technologically advanced waste processing facility in the country," diverting an estimated 80,000 tons from the county's landfill annually. If Benton County adopted this approach, the Coffin Butte expansion wouldn't be necessary, Beyond Toxics' Leavitt pointed out.

The 2024 application for expansion of Coffin Butte Landfill appears to take into

Schmidt-Pathmann believes it's in Benton County's best interest to consider the long-term costs – both monetary and nonmonetary – of hosting Coffin Butte. Long after that landfill runs out of space, it will need to be managed. "You will have to maintain a landfill forever. It's like taking a loan from the bank without ever planning to pay it back," Schmidt-Pathmann said. "At some point, the bank – or the environment – will come collecting."

CANARY MEDIA

Subscribe to our daily newsletter

Canary headlines plus top energy news, on weekdays

Your email address

Subscribe

© 2025 Canary Media

CANARY MEDIA
Clean energy journalism for a cooler tomorrow

From:	Ken Eklund
To:	Benton Public Comment
Subject:	I oppose LU-24-027: reference articles and opinions in the press - 9 of 12
Date:	Thursday, May 8, 2025 2:39:15 PM
Attachments:	writerguy-cube2.png 29b Pressure mounts on methane-polluting Oregon landfill… Canary Media.pdf 30 Letter Two recent fires at landfill reported.pdf 31 Benton officials Landfill report omits methane concerns.pdf 32 As I See It The gentlefolk of the landfill.pdf 33 Wyden, Merkley, Hoyle Urge EPA to Investigate Landfill Concerns in Benton County U.S. Senator Ron Wyden of Oregon.pdf 34 Oregon lawmakers call for investigating Coffin Butte Landfill.pdf 35 Government Local Landfill Shemozzle Goes Federal, Marriott Parking Appeal Nixed Again, City Plans Web Service Outage - The Corvallis Advocate.pdf 36 US landfills are major source of toxic PFAS pollution, study finds Pfas The Guardian.pdf 37 Residents, environmental groups oppose expansion of Coffin Butte Landfill News kezi.com.pdf 38 Oregon warns Coffin Butte Landfill over methane emissions.pdf

CAUTION: This email originated from outside of the organization. Do not click links or open attachments unless you recognize the sender and know the content is safe.

Still more history of Coffin Butte Landfill in the press, covering many of the same issues that have come up in public testimony: PFAS, leachate, methane, EPA and DEQ investigations and actions, labor issues, Republic cover-ups of problems and information, fire hazards, misleading and dubious information about the economics of the landfill, and so on. – K



Ken Eklund, writerguy

37340 Moss Rock Dr
Corvallis OR 97330
408.623.8372

Creator of
World Without Oil
Ed Zed Omega
FutureCoast
and other storymaking games

CANARY MEDIA
Clean energy journalism for a cooler tomorrow

Pressure mounts on methane-polluting Oregon landfill to clean up its act

Nearby residents have been sounding the alarm about Coffin Butte Landfill for years. Now Sen. Jeff Merkley and other members of Congress are demanding action.



By **Isobel Whitcomb**
19 August 2024



Coffin Butte Landfill (E.J. Harris)

Coffin Butte, a rapidly growing landfill in Oregon that is leaking explosive levels of methane, has caught the attention of state and federal officials. On August 8, Oregon's U.S. senators, Jeff Merkley and Ron Wyden, and one of its U.S. House members, Val Hoyle,

found 21 spots on the landfill where methane emissions exceeded 10,000 parts per million (ppm) – far over the federal limit of 500 ppm. Residents are concerned about the climate impacts of these emissions, the risk of wildfires posed by this highly flammable gas, and the health effects of exposure to toxic chemicals emitted alongside methane.

Merkley first learned about Coffin Butte Landfill at a town hall this February, where residents spoke about the landfill's effects on their day-to-day lives and how its emissions contribute to climate change (methane is a potent greenhouse gas that over 20 years traps 80 times as much heat in the atmosphere as carbon dioxide).

"Certainly, their concerns resonated with me, their concerns about fires, about the smell, and concerns about their health," Merkley told Canary Media. At a May hearing, the senator raised the issue with EPA Administrator Michael Regan. In response, Regan said he couldn't comment because Coffin Butte is the subject of an "active enforcement situation," but he assured Merkley that the EPA is "laser-focused" on the landfill. In June, the EPA conducted a second inspection of Coffin Butte Landfill, the results of which are forthcoming.

Republic Services, the company that operates Coffin Butte, "has had a lot of time to become a good community member and address all of this methane leakage. And now we're going to find out in this new report whether or not they have done so," Merkley said.

Meanwhile, Oregon's Department of Environmental Quality has issued warnings to Republic Services for not complying with 2021 state regulations mandating that landfills reduce methane emissions. The regulations required Republic Services to conduct emissions testing at two flares by March 2023. In July, the DEQ concluded that the testing was not "completed or attempted" and that Republic Services committed a Class I violation – the most serious level – of the requirement.

CANARY MEDIA
Clean energy journalism for a cooler tomorrow

+ Canary Media Daily

+ more options

More about our newsletters

By subscribing, you agree to our Privacy Policy.

Local advocacy has focused largely on a proposed landfill expansion that would add a second, 270-foot-tall pile of trash across the road from the original site. Republic Services initially filed an application for an even larger expansion in 2021, but that application was denied due to residents' concerns. A second application for a scaled-down expansion was filed on July 19, but on Friday it was deemed incomplete by Benton County. Republic Services has 180 days to refile.

The recent attention from state and federal officials, as well as increased media coverage, has bolstered the movement against the expansion, said Debbie Palmer, a resident of Benton County who lives 4 miles down the road from Coffin Butte. Environmental nonprofit Beyond Toxics and local advocacy group Valley Neighbors for Environmental Quality and Safety recently held a meeting to discuss the landfill. More than 100 people attended. "It was standing room only," Palmer said.

Coffin Butte isn't an anomaly among landfills. An Industrious Labs analysis published in May found that across eight states, 96 percent of EPA landfill inspections reported methane levels higher than federal standards. "It's a real example of what we're finding in landfill after landfill," Merkley said.

Over the past two years, Merkley has secured $5 million in federal funding to study methane emissions from landfills. Earlier this summer, he submitted an appropriations request to fund a pilot program that would continuously monitor methane at one landfill in the United States. The 2025 appropriations bill for the EPA and Interior Department, which includes funding for the program, passed the Senate on July 25. While the EPA

"If the problem persists, I'm going to be very much following up on the EPA's regulatory authorities and asking them to use those authorities to protect the community and the environment," Merkley said.

Methane | Policy & regulation

Isobel Whitcomb is a science and environmental journalist based in Portland, Oregon.

Hide Comments

Login

Add a comment

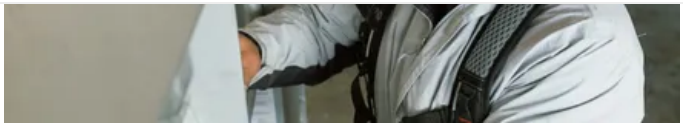
M↓ MARKDOWN

Add Comment

Powered by **Commento**

READ NEXT

CANARY MEDIA
Clean energy journalism for a cooler tomorrow





Clean energy

Chicago Teachers Union secures clean energy wins in new contract



Offshore wind

The bid to kill Empire Wind is Trump's biggest swipe at offshore wind yet



Energy efficiency

Louisiana kills energy-efficiency program in eleventh hour

CANARY MEDIA

Clean energy journalism for a cooler tomorrow

Canary headlines plus top energy news, on weekdays

Your email address

Subscribe



© 2025 Canary Media

https://democratherald.com/tncms/asset/editorial/76f3b0ca-543e-11ef-ac14-d7df7ec16e97/

Letter: Two recent fires at landfill reported



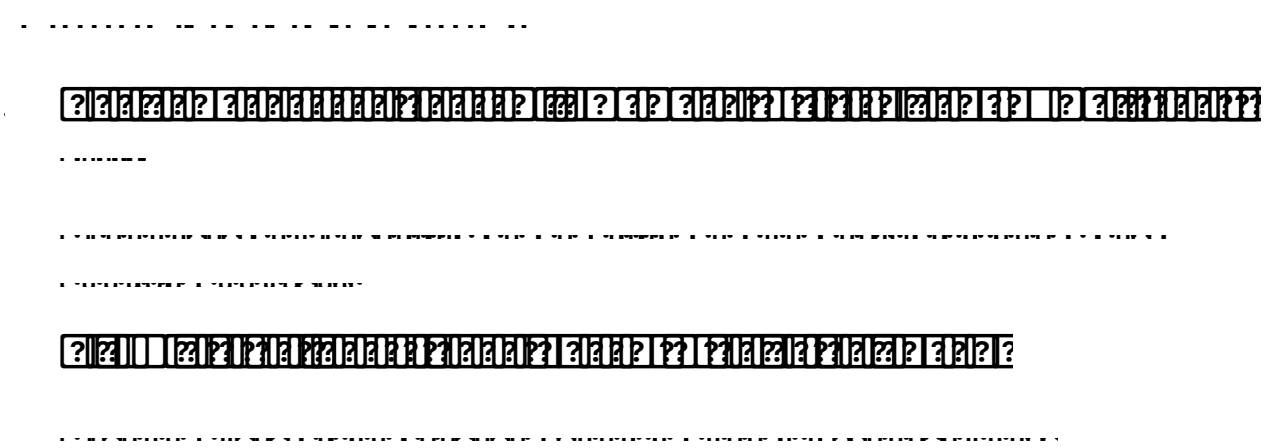
I appreciate that there has been significant attention to Republic Services' application to expand the Coffin Butte Landfill.

The consequences of this decision will affect local lives for decades, or longer. As the major source of local news, I think you should also report on the two fires that have taken place at the landfill in recent months.

As noted on the Adair Village Fire Department Facebook site, "At 7:04 p.m. Saturday, May 18, Adair Fire was dispatched to a smoke investigation at the top of

the Coffin Butte Landfill. Firefighters arrived to find burning trash damaging both hydraulic transfer truck lifts."

Just last month, KLCC news reported that "on July 24, 2024, firefighters responded to a grass fire near a flare stack which burns off methane gas from the landfill. The exact cause of the blaze is unknown. 'The obvious cause is the open flame stack that was close by,' said Adair Rural Fire & Rescue Chief Aaron Harris. 'But there's no way to corroborate that.'"



Benton County is fortunate, and should be thankful, that the Adair Village and Corvallis Fire departments responded so quickly and effectively to these fires. We all have to hope that the next fire does not ignite the "uncontrolled" methane leaks noted in this paper on Nov. 2, 2023.

I hope that you enhance reporting on these issues as the county and its citizens consider the expansion request.

Mark Henkels

Corvallis

https://gazettetimes.com/news/local/government-politics/article_aadf8320-e537-53e3-a037-b329ccfb4442.html

ALERT FEATURED TOP STORY

Benton officials want landfill report to include methane concerns



Benton County resident Carrie Norris speaks to elected leaders Tuesday, Aug. 6, during a meeting of the Be expansion, I want to remind you of your obligation to represent the citizens of Benton County as opposed t company," Norris said.

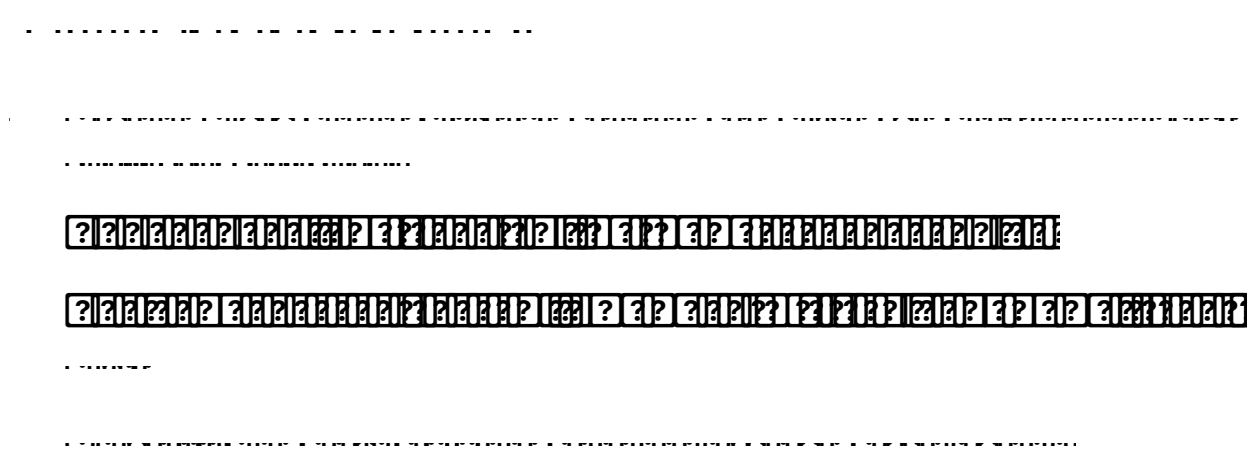
Alex Powers, Mid-Valley Media

Alex Powers

n the recommendation of a Benton County committee **often critical of Coffin**

O**Butte Landfill**, and the county, elected leaders this week declined to approve an annual report about the dump until its operator adds verbiage about **possible trouble ahead from federal regulators**.

Landfill neighbors and opponents of Republic Services' **proposed expansion of Coffin Butte** have railed for months in public meetings and **town hall-style seminars** about the dump operator's historically slow or opaque response to complaints about methane gas.



The 30-page, high-level report before the Board of Commissioners was supposed to include an overview of complaints, dump statistics and policy changes at Coffin Butte in 2023. But it didn't discuss methane.

"Send it back to be rewritten. And this time, don't forget the methane," said Ken Eklund, who chairs the **embattled county Disposal Site Advisory Committee**.

Eklund and others spoke for an unusually long 40 minutes to the Benton County Board of Commissioners at a meeting Tuesday, Aug. 6, during the time set aside for anyone to speak.

Commissioner Xan Augerot said the Disposal Site committee previously vetted Republic's report "very carefully, with a lot of questions asked."

Augerot said she herself pushed for the company to include more, and more thorough, data.

“My leaning is to hear the report from Republic today but to leave the record open and not to accept the report until the Disposal Site Advisory Committee has had time to actually get their questions answered,” Augerot said.

“I agree with that,” Commissioner Nancy Wyse said.

The county is receiving advice about the landfill from several groups now that commissioners have **demolished the appointed bodies** meant to advise them about trash and its disposal.

Public furor has grown since Republic Services applied in 2021 with Benton County’s land use department to expand Coffin Butte to the south, across Coffin Butte Road, near Adair Village.

Republic withdrew its expansion plans in 2022 after the county Planning Commission denied the application.

That was around the time commissioners appointed Eklund to the Disposal Site Advisory Committee.

Eklund said the county’s land use process netted around 300 complaints, and that the Disposal Site Advisory Committee is supposed to compile those complaints in an annual community concern report.

“There was an outpouring" because of the first application, Eklund said.

Commissioners empaneled a task force to determine what the local government's policy should look like ahead of Republic’s next attempt, sending some planning and trash advisers as liaisons to group it named "Benton County Talks Trash."

Except Talks Trash didn't accept public landfill complaints," "which was one of DSAC's core functions," Eklund said.

Talks Trash went well beyond its slated duration as members dug up thousands of local and state records. Along the way, the county dismissed two workgroup members who live near the dump.

Then the workgroup found Benton County had not adhered to its own policies in interacting with the private company franchised to haul trash and intern it north of Corvallis.

Workgroup participants clashed with Darren Nichols, head of the county's planning department. And commissioners suspended Eklund's committee, then permanently disbanded a related group, the Solid Waste Advisory Committee.

The county placed Nichols on administrative leave before he quit his post in late June.

Rachel McEneny, the county's top employee, confirmed in July that Nichols had resigned.

On July 19, Republic **applied again** to expand Coffin Butte.

Less than two weeks later, the Disposal Site Advisory Committee met for the first time in nearly a year, just a week before Tuesday's meeting when four ranking Republic Services workers sat before commissioners.

Benton County hasn't filed annual landfill reports from 2021, 2022 or 2023.

- - -- --- -

Meanwhile, in 2022 the Environmental Protection Agency released a report that said the level of methane gas emissions independently tested at Coffin Butte is not only very concerning, it contradicted figures reported by Republic Services at the time.

A company public affairs director said Republic learned of possible EPA enforcement after a field representative for U.S. Sen. Jeff Merkley approached the company. The company received no formal notice, Republic Services' Ginger Rough said.

“We are not trying to withhold information from you,” Rough told commissioners Tuesday. “We are not trying to be inaccurate in our report.”

Rough also represented Republic during the Talks Trash process.

"We did pledge increased transparency, being cognizant that we need to be aggressive in our efforts to make the community aware of what's going on at the landfill," she said to commissioners.

An EPA spokesperson in early July told Mid-Valley Media that the agency is still investigating Coffin Butte and is “not anywhere close” to resolving its case. He would not say that penalties are pending against its operator.

“We’ve not completed our investigation. I don’t think we are going to be announcing anything any time soon,” Bill Dunlop said.

In its report, Republic mentions nine odor complaints. Users dumped about 11,150 tons more than the landfill’s 1 million-ton annual cap, according to the report.

A county employee provided another 25 complaints made locally.

There’s no mention of the 2022 **EPA report** when an environmental scientist recorded methane emissions well beyond explosive concentrations.

The agency clocked methane above its 500 parts per million safety threshold in 61 instances. In 21 of those, missions exceeded 10,000 parts per million.

“Republic Services was aware of the issue, so in the future it would be nice to see in the report an acknowledgement of past mistakes and maybe how you have gone to

remedy those," Wyse said to the company's representatives on Tuesday.

Augerot added that she's "really looking forward" to the company coming to the table to talk with Disposal Site Advisory Committee members.

That the company has not been able to answer to questions, "it generates a certain amount of skepticism," Augerot said, "especially in this community, where we have so many Ph.D.s and so many engineers, and they know how to look at all this."

. ...

More Benton County news

Alex Powers (he/him) covers agri-business, Benton County, environment and city of Lebanon for Mid-Valley Media. Call 541-812-6116 or tweet @OregonAlex.

. .. [illegible]

. ...

https://democratherald.com/tncms/asset/editorial/da2d7168-5104-11ef-93ca-87cfc50549e0/

TOP STORY EDITOR'S PICK

As I See It: The gentlefolk of the landfill



JOEL GEIER

In the parable “The Gentlemen of the Jungle” by Jomo Kenyatta, the first president of Kenya, an elephant asks to put his trunk inside a man’s hut to keep it out of the rain.

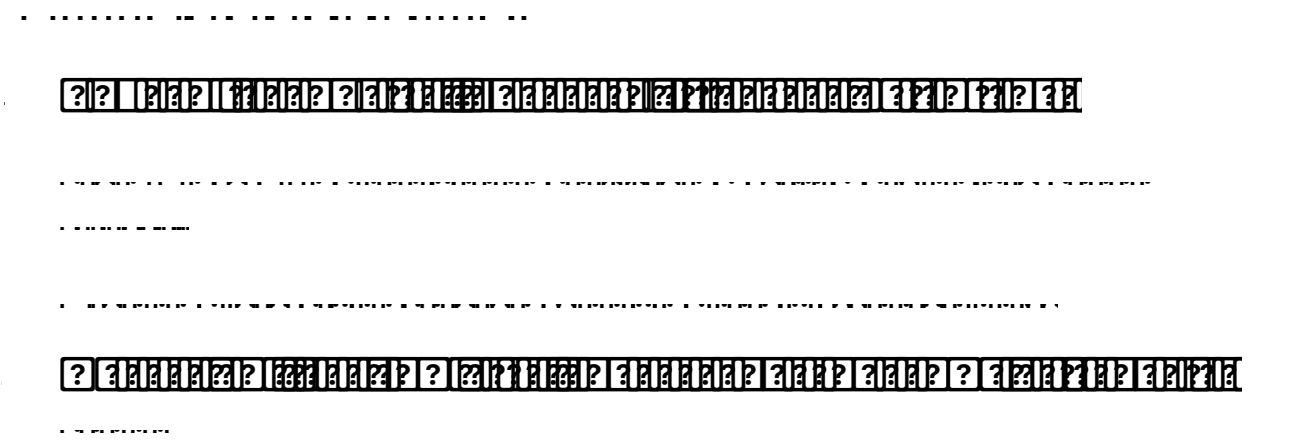
But once Mr. Elephant gets his trunk inside, he keeps pushing until he takes over

the entire hut.

Such is the situation facing Benton County, as the corporate behemoth Republic Services seeks to open a new landfill to the south of its existing landfill on Coffin Butte. Republic tried to expand southward twice before and was rejected, first in 1994 and again in 2021.

Now it's proposing "a much smaller" free-standing new landfill, but don't be fooled. Republic knows that if it can get a toehold in this new area, that will give it traction for further expansions in what will become an ever-growing mountain of trash.

In Kenyatta's tale, the aggrieved man appeals to local officials who appoint a Commission of Enquiry. But the commissioners — Mr. Rhinoceros, Mr. Buffalo, etc. — turn out to have interests aligned with Mr. Elephant's.



So, first they let Mr. Elephant speak: "I considered it necessary … to turn the undeveloped space to a more economic use by sitting myself in it."

When the man tries to speak, the jungle commissioners tell him, "My good man, please confine yourself to relevant issues. All we wish you to tell us is whether the undeveloped space in your hut was occupied …", and then they silence him entirely.

Here our Benton County government is already restricting avenues for public comment. It has removed dissenters from committees, and even dissolved one committee.

Lately the government realized the committee it had dissolved, the Solid Waste Advisory Council, had a defined role in county code. No problem; they swapped in a new entity, the Environmental and Natural Resource Committee, which has never previously dealt with landfill issues.

The members of this new committee have specifically been instructed not to hold any public hearings, no matter if they believe they could benefit from such hearings to inform their decision.

Residents will be allowed to testify only to the Planning Commission — and then only within narrow sidewalls of land-use criteria that were agreed on by county-appointed attorneys in concert with Republic's lawyers.

So, we can expect to hear, in some form, "Please confine yourself to relevant issues," in particular if we start to talk about the environmental issues that people are really concerned about:

- How will methane emissions affect climate?
- How will leachate from the landfill pollute the Willamette River?
- What will be the impact on groundwater, when the landfill starts to leak?

Kenyatta's story was an allegory of the colonial process in his homeland, where an outside empire imposed itself on the local society. Here we face corporate profiteerism, where an Arizona-based business empire built on trash is exploiting our community, with both tacit and overt assistance from Benton County officials.

In the story, the man finally sits down and says, "Ng'enda thi ndeagaga motegi." Or, as Kenyatta paraphrases, "You can fool people for a time, but not forever."

The people of Benton County are now awake to the motivations behind this new

landfill scheme. We will not be fooled.

Joel Geier is a hydrogeologist who works on evaluating risks of environmental contamination due to waste disposal. He grew up on a Minnesota dairy farm but has lived with his family in the Camp Adair area since 1995, and is active in prairie and grassland bird conservation efforts.

Submit A Whistleblower Complaint (https://www.wyden.senate.gov/whistleblower-complaint)

Resources for Terminated Federal Employees (https://www.wyden.senate.gov/resources-for-terminated-federal-employees)

August 08, 2024

Wyden, Merkley, Hoyle Urge EPA to Investigate Landfill Concerns in Benton County

Washington D.C.—U.S. Senators Ron Wyden and Jeff Merkley and U.S. Representative Val Hoyle today urged the U.S. Environmental Protection Agency (EPA) to thoroughly and expeditiously complete its investigation into concerns about Republic Services Coffin Butte Landfill in Benton County.

"This 178-acre landfill accepts over 1 million tons of waste annually from nearly two dozen Oregon counties and southwest Washington. Surrounding communities have long been concerned about methane leakage that contributes to fire risk and climate change, strong odors, and ultimately jeopardizes worker safety and public health," the members wrote in a letter to EPA Administrator Michael S. Regan.

"We are aware that EPA's investigation in 2022 revealed dozens of methane leaks, a number of which reached highly flammable concentrations. We appreciate EPA Region 10's reinspection in June 2024 and its continued attention to concerns raised by our constituents. As Republic Services and Benton County consider the

potential for expansion of the landfill, it is more important than ever to have all the facts."

The full letter is below.

August 7, 2024

The Honorable Michael S. Regan Administrator
U.S. Environmental Protection Agency
1200 Pennsylvania Avenue NW
Washington, D.C. 20460

Dear Administrator Regan,

We know the Environmental Protection Agency is in the process of an ongoing enforcement investigation of the Republic Services Coffin Butte Landfill in Benton County, Oregon, and we urge your thorough and expeditious completion of that process.

This 178-acre landfill accepts over 1 million tons of waste annually from nearly two dozen Oregon counties and southwest Washington. Surrounding communities have long been concerned about methane leakage that contributes to fire risk and climate change, strong odors, and ultimately jeopardizes worker safety and public health.

We are aware that EPA's investigation in 2022 revealed dozens of methane leaks, a number of which reached highly flammable concentrations. We appreciate EPA Region 10's reinspection in June 2024 and its continued attention to concerns raised by our constituents. As Republic Services and Benton County consider the potential for expansion of the landfill, it is more important than ever to have all the facts.

Thank you for your steadfast commitment to protecting the environmental and public health of communities in Oregon and across the nation. We stand ready to support in any way possible.

statesman journal

ENVIRONMENT

Wyden, Merkley, Hoyle call for EPA investigation into Coffin Butte Landfill



Tracy Loew
Salem Statesman Journal

Updated Aug. 8, 2024, 5:24 p.m. PT

Members of Oregon's congressional delegation are calling for the U.S. Environmental Protection Agency to complete an investigation into concerns about Coffin Butte Landfill, north of Corvallis.

"This 178-acre landfill accepts over 1 million tons of waste annually from nearly two dozen Oregon counties and southwest Washington," U.S. Sens. Ron Wyden and Jeff Merkley and U.S. Rep. Val Hoyle wrote in an Aug. 7 letter to EPA Administrator Michael S. Regan.

"Surrounding communities have long been concerned about methane leakage that contributes to fire risk and climate change, strong odors, and ultimately jeopardizes worker safety and public health," they wrote.

Merkley also has submitted an appropriations request for fiscal year 2025 that would fund a pilot project to monitor methane at Coffin Butte, according to Sophia Francia, a field representative for Merkley's office.

The landfill, near Adair, takes more than half of Marion County's municipal solid waste. Benton, Polk and Lane counties also send waste to the landfill. It's owned by Phoenix-based Republic Services, the second-largest waste disposal company in the U.S.

Need a break? Play the USA TODAY Daily Crossword Puzzle.

In October 2023, the Statesman Journal was the first to report on an EPA investigation into massive methane leaks at the landfill. In April 2024, the Statesman Journal published an investigation into worker complaints about health, safety and environmental violations at the landfill.

The lawmakers' request comes as Coffin Butte is trying for a second time to expand the landfill.

The Benton County Planning Commission unanimously denied a previous expansion application in 2021, following public testimony in opposition.

"As Republic Services and Benton County consider the potential for expansion of the landfill, it is more important than ever to have all the facts," the lawmakers wrote in their letter to Regan.

It also comes as the Oregon Department of Environmental quality is preparing to update the landfill's air quality permit, which expired a decade ago. The landfill has been allowed to continue operating under its previous permit because the company filed a timely renewal application with DEQ in 2014.

In response to an interview request, Republic Services sent the Statesman Journal a written, unattributed statement.

"Coffin Butte Landfill provides essential waste disposal services to the community, and its state-of-the-art gas collection and control system is three-times the industry standard. Since 2019, we have invested $9.4 million to upgrade the system and will invest an additional $1.2 million this year to further enhance it," the statement reads.

Methane leaks at Coffin Butte Landfill

In October 2023, the Statesman Journal reported a U.S. Environmental

Protection Agency inspection found the landfill was leaking methane at levels that exceed state and federal limits and what the landfill had publicly reported.

EPA measured methane exceeding regulatory limits 61 times during its June 2022 inspection of the landfill. Twenty-one of those exceedances measured at more than 10,000 parts per million, or 20 times the 500 ppm limit set by Oregon and the EPA.

In addition to contributing to climate change, the levels measured could cause health problems for neighbors and in some cases were high enough to potentially cause an explosion and fire, said Lisa Arkin, of the Eugene-based environmental group Beyond Toxics.

EPA officials told the Statesman Journal in April that the case still was open and likely would result in a negotiated settlement requiring changes at the landfill.

On May 1, Merkley questioned Regan, the EPA director, about the investigation during a Senate subcommittee hearing on the agency's 2025 budget request.

"This is now 23 months ago that the field inspection occurred. If you have a landfill which maxes out the instrumentation, which I think is quite rare, it should probably rise to the top of the list of places to act on," Merkley said.

Regan responded that he could not speak about an active enforcement case.

"But I can tell you that we are coordinating with the state of Oregon. It's an active case and we are laser-focused on this case," he said.

EPA conducted a follow-up inspection at Coffin Butte in June 2024 but has not released any information about its findings.

The Oregon Department of Environmental Quality attended the June 2024 inspection and will continue to coordinate with EPA on enforcement follow-up, DEQ spokesman Dylan Darling said.

EPA Region 10 spokesman Bill Dunbar declined to comment Thursday, citing the ongoing investigation.

Safety concerns at Coffin Butte Landfill

In April 2024, the Statesman Journal reported on landfill worker complaints around air and water quality and exposure to dangerous waste.

Oregon OSHA has completed two investigations into the complaints and cited the company for three "serious" violations and one "other than serious" violation.

The violations include not evaluating employee respiratory hazards, not providing proper safety training, not ensuring floors are dry and not preventing fall hazards.

The state agency recommended Coffin Butte address additional hazards workers complained about, warning that the company could be cited and fined for the items in future inspections.

OR-OSHA opened a third investigation concerning the site March 28. That investigation did not result in any citations, OR-OSHA spokesman Aaron Corvin said.

Workers say some of the concerns they've raised also could impact the landfill's neighbors.

Benton County Commission concerns about Coffin Butte

Benton County commissioners are concerned about the methane leaks, and water quality issues and worker safety, chairwoman Xan Augerot told the Statesman Journal on Thursday.

However, commissioners don't have authority over most of those issues, Augerot said.

“We’re really grateful to Senators Merkley and Wyden and Congresswoman Hoyle for elevating the issue with EPA administrator Regan,” Augerot said. “We’ll see whether that helps."

At a board meeting Tuesday, commissioners did not accept Republic Services annual report on the landfill, asking for more information about environmental monitoring.

“They omitted any mention of the EPA investigation,” Augerot said.

Commissioners ultimately will decide on the conditional use permit for the landfill’s proposed expansion.

But, Augerot said, “We cannot look at any current practices on the current site as part of our criteria. It has to be a look at the proposed action on the proposed site.”

“That makes it difficult to take into account the long-term record of the land owner and operator. But that’s the way the system is structured.”

Coffin Butte Landfill expansion plans

Coffin Butte’s proposed expansion is 50% smaller than proposed in 2021 and would take place entirely on land owned by Coffin Butte and zoned for a landfill. It would add six years of life to the landfill, about half of what was requested in 2021.

Company officials say there is less than one year of space left in the cell currently being used for disposal.

The proposal would improve, rather than close, Coffin Butte Road. That was a point of contention during the previous proposal, with neighbors saying the road could be their only escape route in the event of fire or other natural disaster.

The company also plans to expand into a bordering quarry, which would add

another 11 years, but that space is not yet ready, officials said.

Tracy Loew covers the environment at the Statesman Journal. Send comments, questions and tips:tloew@statesmanjournal.com or 503-399-6779. Follow her on Twitter at@Tracy_Loew

The Corvallis ADVOCATE
(https://www.corvallisadvocate.com)

GOVERNMENT: LOCAL LANDFILL SHEMOZZLE GOES FEDERAL, MARRIOTT PARKING APPEAL NIXED AGAIN, CITY PLANS WEB SERVICE OUTAGE

AUGUST 9, 2024

If there's an irony to the downtown Marriott seeking to replace an old bike shop with a few new parking spaces, it was lost on our fair burgh's city councilors as they tentatively nixed the hotel's ask at their meeting on Monday.

Originally, City staff had recommended an approval contingent on a long list of conditions, but last month the Corvallis Planning Commission voted unanimously to reject the proposal – so the hotel appealed to the City Council.

The Marriott is located on 1st Street, and they want to replace two buildings across the alley behind their hotel with 12 new parking places. They bought the buildings – one of which had housed Cyclotopia – in 2022 for $1.25 million.

The company has argued they have 176 guestrooms and meeting space for 120 with only a total of 133 parking spaces – which means they don't have enough parking for high and full occupancy. And, they have said their guests regularly complain about the lack of parking, and that their customers

don't feel safe at the suggested backup parking location, which is at the skate park and bridge area. They also said their senior citizen guests need more parking at the hotel.

Four councilors voted against a motion to reject: Napack, Cadena, Chaplen and Lytle.

Five councilors voted in favor of a rejection: Ellis, Lewis, Shepherd, Schaffer and Yee.

Among councilors, some of the arguments for allowing the project focused on supporting downtown business activity and showing support for the Marriott's investment in the downtown area. Arguments against centered on supporting bike and pedestrian safety – and that practically speaking, cars and trucks would wind up backing out of the spaces onto the sidewalk, or even the street.

Next up, City staff will prepare formal findings for the Council's final decision. After that, the Marriott could appeal to the state's Land Use Board of Appeals.

Republic Services Omits Key Info in Benton County Report

Republic Services lit a dumpster fire at Tuesday's Benton County Board of Commissioners meeting – where they submitted their 2023 Annual Hauling Report and the 2023 Annual Coffin Butte Pacific Region Compost Operational Report.

The basics: Republic's Coffin Butte landfill is being investigated by the EPA for overly high methane emissions, which they left out of their report. Also, their spokesperson said it was left out of the report because they were unaware they were being investigated when they submitted the report.

However, EPA Administrator Michael Regan said they were being investigated as early as during a May 2 hearing in Washington DC. Also, a field representative directly told Republic on June 28 they were being looked at for an enforcement action.

Anyhoo… Corvallis being an engineering town, there was plenty of public comment that was worth a listen, most all of it critical of Republic, and their landfill operation. But props to the Republic spokesfolks for keeping a straight face while talking themselves up after the big reveal that all those methane worries just happened to not make into their report to the Board, which we should note, is our community's publicly elected body.

Really, even if you don't usually view Board of Commissioners meetings, which is perfectly understandable, you really-really should view this one – click here to do that, you'll want to start at 16 minutes, 50 seconds. Even though it's two hours, we suggest listening to the public comments and the report, so think popcorn.

Skip (hold Ctrl) and click to open this link: https://www.youtube.com/watch?v=Wbwfb3nu-eQ)

The Disposal Site Advisory Committee hasn't yet made any recommendations about accepting Republic's report – so the Commissioners will wait on their guidance before deciding for themselves.

But then, On Wednesday, Oregon's Congressional Delegation Chimed in: U.S. Senators Ron Wyden and Jeff Merkley and our U.S. Representative Val Hoyle urged the U.S. Environmental Protection Agency, or EPA, to thoroughly and expeditiously complete its investigation into concerns about Republic Services Coffin Butte Landfill.

In a joint letter to EPA Administrator Michael Regan, they wrote:

“We know the Environmental Protection Agency is in the process of an ongoing enforcement investigation of the Republic Services Coffin Butte Landfill in Benton County, Oregon, and we urge your thorough and expeditious completion of that process.”

“This 178-acre landfill accepts over 1 million tons of waste annually from nearly two dozen Oregon counties and southwest Washington. Surrounding communities have long been concerned about methane leakage that contributes to fire risk and climate change, strong odors, and ultimately jeopardizes worker safety and public health.”

“We are aware that EPA’s investigation in 2022 revealed dozens of methane leaks, a number of which reached highly flammable concentrations. We appreciate EPA Region 10’s reinspection in June 2024 and its continued attention to concerns raised by our constituents. As Republic Services and Benton County consider the potential for expansion of the landfill, it is more important than ever to have all the facts.”

And, a Big Credible Rumor: The scuttlebutt is that Republic’s application for a landfill expansion may not be complete. An outside land use planning consultant, Winterbrook Planning (https://cobentonorus-my.sharepoint.com/personal/cory_grogan_bentoncountyor_gov/Documents/hyperlink), is reviewing the application.

Legally, the County has until Friday, August 16 to determine if the application is complete and notify Republic in writing. If it’s incomplete, the company will have the option to fulfill whatever is required, and then resubmit its application.

We’re getting this from a high-ranking County official – but even they are saying it’s a rumor, even if they’re viewing it as a credible rumor.

City of Corvallis Web Services – Planned Outage

First, this has nothing to do with consumer internet services. Just making sure we’re clear.

Okay, most City of Corvallis web services (vendor and employee portals, utility billing and court payments, Accela – permits and GIS/map services) will be down for maintenance from 8 pm August 13 through 4 am August 14. The City says these resources and services will not be available as the City internet access will be down for the duration. They also apologize for the inconvenience – no, really – the apology is in their press release.

Do you have a story for The Advocate? Email editor@corvallisadvocate.com (mailto:editor@corvallisadvocate.com)

(HTTPS://WWW.FACEBOOK.COM/SHARER/SHARER.PHP?U=HTTPS://WWW.CORVALLISADVOCATE.COM/2024/GOVERNMENT-LOCAL-LANDFILL-SHEMOZZLE-GOES-FEDERAL-MARRIOTT-PARKING-APPEAL-NIXED-AGAIN-CITY-PLANS-WEB-SERVICE-OUTAGE/)

(HTTPS://TWITTER.COM/INTENT/TWEET?URL=HTTPS://WWW.CORVALLISADVOCATE.COM/2024/GOVERNMENT-LOCAL-LANDFILL-SHEMOZZLE-GOES-FEDERAL-MARRIOTT-PARKING-APPEAL-NIXED-AGAIN-CITY-PLANS-WEB-SERVICE-OUTAGE/)

PREVIOUS ARTICLE (HTTPS://WWW.CORVALLISADVOCATE.COM/2024/EXPECT-OREGON-WILDFIRES-TO-BURN-UNTIL-FALLS-WET-WEATHER-SAY-FIRE-MANAGERS/)

EXPECT OREGON WILDFIRES TO BURN UNTIL FALL'S WET WEATHER, SAY FIRE MANAGERS (HTTPS://WWW.CORVALLISADVOCATE.COM/2024/EXPECT-OREGON-WILDFIRES-TO-BURN-UNTIL-FALLS-WET-WEATHER-SAY-FIRE-MANAGERS/)

NEXT ARTICLE (HTTPS://WWW.CORVALLISADVOCATE.COM/2024/CORVALLIS-CALENDAR-HAPPENING-MONDAY-TO-WEDNESDAY/)

CORVALLIS CALENDAR: HAPPENING MONDAY TO WEDNESDAY (HTTPS://WWW.CORVALLISADVOCATE.COM/2024/CORVALLIS-CALENDAR-HAPPENING-MONDAY-TO-WEDNESDAY/)



Pfas

This article is more than **8 months old**

US landfills are major source of toxic PFAS pollution, study finds

New research shows toxic 'forever chemicals' gas may escape landfills and threaten the environment

Tom Perkins

Fri 9 Aug 2024 08.00 EDT

Toxic PFAS "forever chemicals" that leach from landfills into groundwater are among the major pollution sources in the US, and remain a problem for which officials have yet to find an effective solution.

Now new research has identified another route in which PFAS may escape landfills and threaten the environment at even higher levels: the air.

PFAS gas that emits from landfill waste ends up highly concentrated in the facilities' gas treatment systems, but the systems are not designed to manage or destroy the chemicals, and much of them probably end up in the environment.

The findings, which showed up to three times as much PFAS in landfill gas as in leachate, are "definitely an alarming thing for us to see", said Ashley Lin, a University of Florida researcher and the lead author of the study.

"These findings suggest that landfill gas, a less scrutinized byproduct, serves as a major pathway for the mobility of PFAS from landfills," the paper's authors wrote.

PFAS are a class of about 16,000 compounds used to make products resistant to water, stains and heat. They are called "forever chemicals" because they do not naturally break down and have been found to accumulate in humans. The chemicals are linked to cancer, birth defects, liver disease, thyroid disease, plummeting sperm counts and a range of other serious health problems.

As researchers have begun to understand the chemicals' dangers in recent years, the focus has largely been on water pollution, and regulators have said virtually all leachate from the nation's 200 landfills contain PFAS. But scientists are beginning to understand that PFAS air pollution is also a significant threat.

The chemicals concentrate in landfills because they are widely used across dozens of industries and are in thousands of consumer products that end up in the facilities at their lives' end. As the products decompose, the chemicals can turn into gas and be released into the air.

Much of that can be captured by landfills' gas collection systems. The captured gas in some cases is run through filters or burned off in a flare. However, PFAS are notoriously difficult to destroy, and flares are not an effective way to eliminate them.

Sign up to Down to Earth

Free weekly newsletter

The planet's most important stories. Get all the week's environment news - the good, the bad and the essential

Enter your email address

Sign up

Privacy Notice: Newsletters may contain info about charities, online ads, and content funded by outside parties. For more information see our Privacy Policy. We use Google reCaptcha to protect our website and the Google Privacy Policy and Terms of Service apply.

Typically, flares or incineration will simply break down PFAS into smaller forms of the chemicals instead of fully destroying them, and that waste will be sent into the air. For now, there is no clear picture of the levels, or how landfills can get a handle on the problem.

“That is a good question,” Lin said. “We need to understand that management aspect and what can happen with the different types of treatment technologies in place.”

Most viewed

https://www.kezi.com/news/residents-environmental-groups-oppose-expansion-of-coffin-butte-landfill/article_8c201812-56b9-11ef-a0e6-a72ae181fb85.html

Residents, environmental groups oppose expansion of Coffin Butte Landfill

By: Julio Mora Rodriguez
Aug 9, 2024



Residents and environmental groups oppose expansion of the Coffin Butte Landfill by Republic Services citing health and environmental concerns.

CORVALLIS, Ore -- Over a million tons of waste are deposited every year in the Coffin Butte Landfill in Benton County. Republic Services is seeking to expand the site, but

faces stiff opposition.

Residents and environmental groups have come out against the expansion. Joel Geier is a hyrdrogeologist who lives in the area close to the landfill in north Benton County. He fears if Republic Services manages to expand the landfill, they'll continue until the whole area becomes a massive dumping ground. Geier initially moved into the area because he believed the landfill wouldn't last forever.

"They have no intention of closing it down ever. You can see there is tarps over the face of it that shows they're not planning to actually close it, that should have grass over it by now, but they just leaving it as it is now and that leaves their options open so they can keep expanding," he said.

According to the Environmental Protection Agency, they have investigated the site and

found dozens of methane leaks. The environmental group Beyond Toxics also cited issues with air pollution, most notably dust being kicked up into the air and descending on residents laced with arsenic, metals, and plastics. As a hydrogeologist, Geier worries about the ground water in the area.

"For folks down in Eugene, arsenic is a natural occurring problem in the ground water, especially around Spencer Butte, but in this area it's almost unheard of and we're getting levels of arsenic that are showing up that are really now close to what people worry about down by Eugene," he said.

The site covers 178 acres, and the high methane levels also make it vulnerable to wildfires. In a statement, Republic Services said:

"Gas collection and control system exceeds industry standards by three times. Since 2019, we have invested $9.4 million to upgrade the system and will invest an additional $1.2 million this year for further enhancements. We have implemented several improvements, including a new odor reporting portal on the landfill’s website and new enclosed flares to burn off excess methane gas more efficiently. We are also researching the latest technology, such as infrared cameras, to enhance our monitoring capabilities."

Residents and environmental groups have recommendations for the site. The prime thing is to stop sending organic waste and materials to the site. They want more sites built where metals, plastics, and food waste can be separated, Lisa Arkin, Executive Director of Beyond Toxics spoke in favor of one such site.

"And I'm really excited and proud that Lane County has committed itself to clean Lane project, which is building an advanced sorting facility." She said.

They also recommend using captured methane as a way of powering cars and homes as renewable gas.

Benton County government receives new application to expand Coffin Butte landfill

Julio Mora Rodriguez joined the KEZI 9 News team in October of 2022 as a news reporter. If you have any story ideas, you can email Julio at jrodriguez@kezi.com.

Julio Mora Rodriguez

Julio Mora Rodriguez joined the KEZI 9 News team in October of 2022 as a news reporter. If you have any story ideas, you can email Julio at jrodriguez@kezi.com.

statesman journal

OREGON

Oregon warns Coffin Butte Landfill over methane emissions



Tracy Loew
Salem Statesman Journal

Updated Aug. 14, 2024, 8:28 a.m. PT

Oregon environmental regulators have issued a formal warning to Coffin Butte Landfill for not complying with new requirements to reduce methane emissions from the state's landfills.

Coffin Butte, located north of Corvallis, is operated by Phoenix-based Republic Services, the nation's second-largest waste disposal company. It takes more than half of Marion County's municipal solid waste.

The methane gas emission rules, which took effect in October 2021, required Coffin Butte to test emissions from its two gas flares by March 30, 2023. The flares are part of the landfill's gas collection system.

"The design of your current shrouded flare does not easily lend itself to be tested, and testing of the current flare was not completed or attempted," DEQ wrote in its warning letter, which concluded the landfill had committed a Class I violation, the most serious of three violation levels.

"In order to meet the testing requirement described above, the shrouded flare should have been fully enclosed to allow testing or replaced with a new enclosed flare. In early 2023 during multiple phone calls, DEQ informed you that you would need to install a new enclosed flare," the warning reads.

DEQ approved the company's plans to install a new, enclosed flare on Nov. 9, 2023, but that had not happened by July 10, when DEQ issued its warning.

In the warning, DEQ ordered the company to either install and operate enclosed flares by July 31 and test the flares by Oct. 31; or enclose the existing flares in a way that they can be tested, and do so by Oct. 31.

The company asked for an extension to the July deadline, saying a recent fire at the landfill destroyed some equipment needed for the enclosed flare to operate, DEQ spokesman Dylan Darling said. DEQ granted an extension until Aug. 6.

If the company doesn't perform the corrective actions, the matter is referred to DEQ's Office of Compliance and Enforcement for formal enforcement and civil penalty assessment, Darling said.

In a written, unattributed statement issued in response to the Statesman Journal's interview request, Republic Services said it has installed a new, enclosed flare and plans to test it in October. It will remove the existing flares within a few weeks, the company said.

New Oregon rules address landfill emissions

Landfills are the second-largest source of methane emissions in Oregon, accounting for about 25% of the state's total methane emissions.

In October 2021, the Environmental Quality Commission adopted new rules regulating landfill gas emissions. The rules require many landfills in Oregon to obtain an Air Contaminant Discharge Permit, to submit data on the landfill's characteristics and to conduct monitoring.

One of the specific requirements of these rules is that landfills with gas control devices must test those devices within a specified timeframe, Darling said.

"Like many landfills, Coffin Butte operates a gas control device called a flare,

which combusts excess methane and turns it into carbon dioxide — a less potent greenhouse gas. The flare must be tested to demonstrate that it can meet a 99% methane destruction efficiency," Darling said.

"The environmental consequence of Coffin Butte not timely complying with the flare testing requirement is that DEQ cannot determine whether the flare meets the methane destruction efficiency requirement," he said.

Methane leaks, worker complaints at Coffin Butte Landfill

The warning letter is the latest issue at the landfill, which is trying to expand for the second time.

In October 2023, the Statesman Journal reported on an EPA investigation that found massive methane leaks at the landfill. The EPA has not yet completed its investigation.

In April 2024, the Statesman Journal published an investigation into worker complaints about health, safety and environmental violations at the landfill. The Oregon Occupational Safety and Health Division cited the company for several of those issues.

Since then, neighbors have organized to oppose the proposed landfill expansion. In addition to concerns about the methane leaks, neighbors have complained about odors, excessive truck traffic, fire danger and possible groundwater contamination.

On Aug. 7, members of Oregon's congressional delegation called on the U.S. Environmental Protection Agency to complete an investigation into concerns about the landfill.

"This 178-acre landfill accepts over 1 million tons of waste annually from nearly two dozen Oregon counties and southwest Washington," U.S. Sens. Ron Wyden and Jeff Merkley and U.S. Rep. Val Hoyle wrote to EPA Administrator Michael S.

Regan.

The Benton County Planning Commission is expected to decide Friday whether Republic's application for a conditional-use permit to expand the landfill is complete. The decision whether to approve the expansion would be made by the Benton County Board of Commissioners.

Tracy Loew covers the environment at the Statesman Journal. Send comments, questions and tips:tloew@statesmanjournal.com or 503-399-6779. Follow her on Twitter at@Tracy_Loew

From:	Ken Eklund
To:	Benton Public Comment
Subject:	I oppose LU-24-027: reference articles and opinions in the press - 10 of 12
Date:	Thursday, May 8, 2025 2:39:36 PM
Attachments:	writerguy-cube2.png 39 Letter Landfill leachate ended up in water.pdf 40 Forest Service study links heavy metals to Oregon incinerator.pdf 41 Oregon pauses Coffin Butte Landfill air quality permit process.pdf 42 In a First, the E.P.A. Warns of 'Forever Chemicals' in Sludge Fertilizer - The New York Times.pdf 42b Marion County"s incinerator closed, where"s the trash going .pdf 43 Oregon bill would require landfills to improve methane monitoring.pdf 44 Oregon landfills use loophole to avoid methane monitoring Study.pdf 45 Landfill Expansion Editorial Sometimes, NIMBY is the Right Answer - The Corvallis Advocate.pdf 46 This "limited" expansion is another ruse.pdf 47 As I See It The not-so-free revenues from Coffin Butte.pdf 48 Game over for expansion If only.pdf 49 Benton County staff recommend denying Coffin Butte expansion.pdf 50 Benton County staff recommend denying Coffin Butte Landfill expansion.pdf 51 Benton County urged to reject Coffin Butte Landfill expansion.pdf

CAUTION: This email originated from outside of the organization. Do not click links or open attachments unless you recognize the sender and know the content is safe.

I'm continuing to provide the Planning Commission the history of Coffin Butte Landfill in the press, covering many of the same issues that have come up in public testimony: PFAS, leachate, methane, EPA and DEQ investigations and actions, labor issues, Republic cover-ups of problems and information, fire hazards, misleading and dubious information about the economics of the landfill, and so on. – K



Ken Eklund, writerguy

37340 Moss Rock Dr
Corvallis OR 97330
408.623.8372

Creator of
World Without Oil
Ed Zed Omega
FutureCoast
and other storymaking games

statesman journal

LOCAL

US Forest Service moss study links heavy metal pollution to Brooks incinerator



Tracy Loew
Salem Statesman Journal

Updated Nov. 13, 2024, 12:40 p.m. PT

Key Points AI-assisted summary

- The study identified rare earth elements linked with burning medical waste.
- The researchers said the findings validate community concerns about emissions from the incinerator, located near a school, food processing plant and residences.

(This story has been updated to add new information).

A new study of pollutants in moss near the Reworld Marion garbage incinerator north of Salem in Brooks shows higher concentrations in samples taken closer to the facility and identified "signature" rare earth element concentrations linked with burning medical waste.

"The results, showing heavy metal contamination around this particular facility, which is located near a school, a food processing plant, and a rural community, validates the concerns community members have had for years about what is being emitted from waste incinerators," said Sen. Deb Patterson, D-Salem.

The study's lead author, U.S. Forest Service scientist Sarah Jovan, led similar testing in Portland a decade ago that uncovered high levels of heavy metals around two glass factories operating in residential neighborhoods.

Those findings led to a class-action lawsuit filed by neighbors and prompted

then-Gov. Kate Brown to launch the Cleaner Air Oregon program in 2016, to better evaluate companies' toxic air emissions and their health risks.

Reworld Marion was among the first companies called into that program, in March 2019, but has had multiple extensions and delays and has not yet completed its risk assessment.

The moss study was published Nov. 7 in the peer-reviewed scientific journal "Environmental Monitoring and Assessment." It was funded by the Forest Service and supported by the USDA National Institute of Food and Agriculture and the National Institute of Environmental Health Sciences.

"To the best of our knowledge, these results provide the first evidence of trace element contamination in the area, serving as an empirical starting point for stakeholders to discuss regulatory and community concerns," the researchers wrote.

"What we saw were pretty high associations for three of the elements that are most often associated with medical waste incineration: mercury, cadmium and lead," Joven told the Statesman Journal.

Company officials did not respond to the Statesman Journal's interview request Tuesday.

The 38-year-old incinerator, formerly called Covanta Marion, is owned by New Jersey-based Reworld, which operates more than 40 incinerators in North America, Europe and the United Kingdom.

Testing near Brooks incinerator finds heavy metals, MRI contrast material

Scientists have used moss as a biological indicator of air pollution since the late 1960s.

Moss data is an indicator of pollution levels but doesn't carry health thresholds. For that, the state Department of Environmental Quality would need to perform air monitoring, as it did following the Portland moss study.

“The moss data, they’re moss, they’re not humans so it’s hard to make connections directly to health. We can say some basic things about what contaminants are getting into the moss,” Jovan said. “The strength of correlation with the facility suggests to me maybe it’s worth looking into that more.”

This is the second study using moss as an indicator of pollution near the incinerator.

In 2022, Beyond Toxics, a Eugene environmental justice nonprofit, funded a small study of moss near the facility, using the same methods as in the Portland study.

It showed elevated levels of heavy metals from samples taken closest to the facility.

That study was too small to be conclusive, its authors said, but indicated a need for further testing. Beyond Toxics asked DEQ to follow up with air sampling, but the department did not act.

The latest study also began in 2022. Researchers collected 36 samples of moss along an approximately 20-mile transect running from the incinerator in Brooks northeast through Gervais and Woodburn to Canby. The path followed the dominant winds and did not include any other permitted polluters.

Researchers measured 40 elements in the moss, including 14 rare earth elements previously unexplored for solid waste incineration.

Concentrations of most elements correlated with distance from the facility, the study found, with most pollutants deposited within 3 to 6 miles.

“The chemical signatures in moss pointed to solid waste incineration as a source, through both stack and fugitive dust emissions,” the researchers wrote.

“These are powerful findings, considering that there is no safe dose of mercury, lead and other toxic metals this study shows are elevated near the incinerator,” Mike Ewall, executive director of the national nonprofit Energy Justice Network, told the Statesman Journal.

Elements often associated with soil and dust, such as arsenic and chromium, peaked within an eighth of a mile of the facility, possibly indicating fugitive emissions, the study showed.

“The key issue is there’s just not an easy way to monitor emissions around a pollution source. There just isn’t with the current technology. A lot of times we’re just guessing what those emissions are,” Jovan said.

With moss analysis, “Suddenly you can see something that’s normally invisible. It makes it apparent that there are emissions of these heavy metals,” she said.

The study also found gadolinium, a contrast agent for MRIs, likely reflecting medical waste incineration.

“Now we know much more about the heavy metals being emitted and that it definitely comes from the incinerator, I think it’s reasonable to conclude that burning medical waste is not a healthy practice, especially near people,” said Susann Kaltwasser, founder of Clean Air Now, which works on solid waste issues in the region.

DEQ does not have immediate plans to monitor or test to confirm the study's findings, spokesman Chris Varley said.

"However, many of the pollutants listed in it will be tested for as part of Senate Bill 488, legislation passed last year regulating municipal waste incinerators in Oregon. Reworld has also been called into Cleaner Air Oregon and was required

to perform extensive source testing for a number of heavy metals and other pollutants," Varley said.

Reworld Marion incinerator partnership with Marion County now ended

The incinerator was built as a partnership between Marion County and the company. A state law passed just before the burner opened in 1986 requires Marion County garbage collectors to take waste there.

Marion County issued $56 million in revenue bonds to build the burner, which is owned by Reworld. The county repaid those bonds with revenue from franchise fees, electricity sales and tipping fees, which garbage haulers pay to bring waste to the facility. Those fees were passed on to ratepayers in their garbage bills.

In July 2021, Reworld, then called Covanta Holding Corp., announced it would be acquired by Sweden-based investment conglomerate EQT Infrastructure. The $5.3 billion deal took the company private.

That same month, Marion County left the partnership, signing a three-year contract that paid Reworld a flat fee to take a set amount of the county's garbage.

In October 2024, EQT Infrastructure announced it would sell 25% of Reworld to Singaporean sovereign wealth fund GIC.

The incinerator now burns about half of Marion County's residential and commercial waste, less than required by the company's contract with the county. The rest goes to Coffin Butte Landfill in Adair, just north of Corvallis.

In addition to municipal waste, Reworld holds private contracts to burn industrial and medical waste, at higher rates, at the incinerator. It takes that waste from all over the western U.S. and Canada, a 2021 Statesman Journal investigation found.

Last month, the company told Marion County it would stop taking the county's waste on Dec. 31. Company officials have declined to say what will happen to the facility.

At the time, county commissioners said they were told the move was in response to increasing regulatory pressures, including Cleaner Air Oregon requirements and the requirements of Senate Bill 488, which requires Reworld Marion to continuously monitor 15 of the pollutants measured in the moss study.

After receiving a number of extensions, the company has missed the deadline to begin that monitoring.

"These heavy metals are associated with negative health effects for people who are exposed, which is why they were included in the emissions to be monitored," said Patterson, who sponsored the bill.

Jon Heynen, a spokesman for Marion County's three commissioners, said in an email that the county had not been made aware of the moss study results.

Neither Heynen nor the individual commissioners responded to the Statesman Journal's interview requests.

Tracy Loew covers the environment at the Statesman Journal. Send comments, questions and tips:tloew@statesmanjournal.com or 503-399-6779. Follow her on Twitter at@Tracy_Loew

statesman journal

LOCAL

Oregon regulators pause Coffin Butte Landfill air quality permit process



Tracy Loew
Salem Statesman Journal

Updated Jan. 10, 2025, 3:02 p.m. PT

The Oregon Department of Environmental Quality has paused work on a new air quality permit for Coffin Butte Landfill, saying the state needs more information before proceeding.

The permit regulates air pollution from the 178-acre landfill, located north of Corvallis near Adair Village.

DEQ has canceled a Jan. 14 public hearing on Coffin Butte's proposed air quality permit. It also has closed a public comment period that had been scheduled to run through Jan. 29.

Coffin Butte currently takes most of Marion and Polk counties' municipal waste, including waste that previously went to the Reworld Marion incinerator in Brooks. Reworld stopped taking Marion County waste on Dec. 31.

The landfill, owned by Phoenix-based Republic Services, also is in the middle of a controversial process to expand the landfill.

Why did DEQ pause Coffin Butte's air quality permit process?

DEQ has asked the company to provide a copy of a land use compatibility statement, or LUCS, that Benton County granted it in 1997 for the property where the landfill's flare is located.

The flare burns methane that is generated when solid waste in the landfill breaks down.

“They just haven’t been able to track down the actual copy of it,” DEQ spokesman Dylan Darling said.

The company has not provided an estimate of when it can provide the document, he said.

Coffin Butte’s air quality permit expired more than a decade ago. The landfill has been allowed to continue operating under its previous permit because the company filed a timely renewal application with DEQ in 2014.

The landfill will continue to operate under the expired permit while the process is on hold.

The permitting pause is not related to the expansion process, which is running in parallel, Darling said.

What is the status of the Coffin Butte’s expansion application?

Coffin Butte also has asked Benton County for a conditional use permit (CUP) that would allow it to expand.

The attempt comes two years after the Benton County Planning Commission unanimously denied the company’s request for a conditional use permit to expand, following public testimony in opposition. Among concerns were plans to close an access road and impacts on those who live nearby.

The planned expansion is 50% smaller than proposed in 2021 and would be on land owned by Coffin Butte and zoned for a landfill, according to the company.

In August 2024, Benton County officials told Republic Services its application was incomplete and gave the company until Jan. 15 to provide additional

information, including more information about potential impacts on the landfill's neighbors.

Once the county deems the application "complete," it will hold public hearings on the proposal.

Why is Coffin Butte's air quality permit and expansion controversial?

The permit renewal and expansion request come in the middle of a U.S. Environmental Protection Agency investigation into massive methane leaks at the landfill, employee complaints about health and safety, and neighbors' concerns about air and water pollution, and fire risks.

In October 2023, the Statesman Journal reported an EPA inspection found the landfill was leaking methane at levels that exceed state and federal limits and what the landfill had publicly reported.

EPA measured methane exceeding regulatory limits 61 times during its June 2022 inspection of the landfill. Twenty-one of those exceedances measured at more than 10,000 parts per million, or 20 times the 500 ppm limit set by Oregon and the EPA.

In April 2024, the Statesman Journal published an investigation into worker complaints about health, safety and environmental violations at the landfill. The Oregon Occupational Safety and Health Division cited the company for several of those issues.

In August 2024, members of Oregon's congressional delegation called for the U.S. Environmental Protection Agency to complete an investigation into concerns about the landfill.

Also in August 2024, DEQ issued a formal warning to Coffin Butte for not complying with new requirements to reduce methane emissions from the state's

landfills.

And landfill neighbors have organized to oppose the proposed landfill expansion. In addition to concerns about the methane leaks, neighbors have complained about odors, excessive truck traffic, fire danger and possible groundwater contamination.

Tracy Loew covers the environment at the Statesman Journal. Send comments, questions and tips:tloew@statesmanjournal.com or 503-399-6779. Follow her on Twitter at@Tracy_Loew

The New York Times https://www.nytimes.com/2025/01/14/climate/epa-pfas-forever-chemicals-sludge-fertilizer.html

In a First, the E.P.A. Warns of 'Forever Chemicals' in Sludge Fertilizer

Levels of PFAS in sewage sludge used as fertilizer can pose risks that sometimes exceed safety thresholds "by several orders of magnitude," the agency said.

Listen to this article · 8:54 min Learn more



By Hiroko Tabuchi

Jan. 14, 2025

For the first time, the Environmental Protection Agency on Tuesday warned that "forever chemicals" present in sewage sludge that is used as fertilizer can pose human health risks.

In an extensive study the agency said that, while the general food supply isn't threatened, the risk from contaminated fertilizer could in some cases exceed the E.P.A.'s safety thresholds "sometimes by several orders of magnitude."

A growing body of research has shown that the sludge can be contaminated with manmade chemicals known as per- and polyfluoroalkyl substances, or PFAS, which are used widely in everyday items like nonstick cookware and stain-resistant carpets. The chemicals, which are linked to a range of illnesses including an increased risk of cancer, do not break down in the environment, and, when tainted sludge is used as fertilizer on farmland, it can contaminate the soil, groundwater, crops and livestock.

Last year, The New York Times reported that 3M, which for decades has manufactured PFAS, found as early as 2000 that the chemicals were turning up in sludge samples from municipal wastewater plants across the country. In 2003, 3M told E.P.A. of its findings.

The E.P.A. has for decades encouraged the use of sludge from treated wastewater as inexpensive fertilizer with no limits on how much PFAS it can contain. But the agency's new draft risk assessment sets a potential new course. If finalized, it could mark what could be the first step toward regulating PFAS in the sludge used as fertilizer, which the industry calls biosolids. The agency currently regulates certain heavy metals and

pathogens in sewage sludge used as fertilizer, but not PFAS.

The Biden administration has tackled PFAS contamination elsewhere, setting limits on PFAS in drinking water for the first time and designating two kinds of PFAS as hazardous under the nation's Superfund cleanup law. Those rules came after the agency said in 2023 that there is no safe level of exposure to those two PFAS.

The new E.P.A. assessment "provides important information to help inform future actions by federal and state agencies," as well as sewage treatment plants and farmers, "to protect people from PFAS exposure," Jane Nishida, the E.P.A. acting administrator, said in a statement.

It's unclear what further steps the incoming Trump administration might take. President-elect Trump has been hostile to regulations. However, he spoke on the campaign trail of "getting dangerous chemicals out of our environment," and concerns about PFAS contamination in fertilizer have reached some deeply red states.

The E.P.A.'s risk study comes as farmers across the country have been discovering PFAS on their land.

In Maine, the first and only state that is systematically testing its farmland for PFAS, dozens of dairy farms have been found to be contaminated. In Texas, a group of ranchers sued the provider of sludge fertilizer last year after a neighboring farm used the fertilizer on its fields. County investigators found several types of PFAS in the ranchers' soil, water, crops and livestock, and the ranchers have since sued the E.P.A., accusing the agency of failing to regulate PFAS in biosolids. In Michigan, state officials shut down a farm where tests found particularly high concentrations in the soil and in cattle that grazed on the land.

The E.P.A. said its analysis did not suggest the general food supply was at risk. Sewage sludge is applied to less than 1 percent of the fertilized acreage of agricultural land a year, it said, a number that roughly aligns with industry data. And, not all farms where sewage fertilizer was used would present a risk.

Still, studies have found that, because PFAS is so persistent in the environment, tainted sludge applied years or even decades ago can continue to be a source of contamination. More than 2 million dry tons were used on 4.6 million acres of farmland in 2018, according to the biosolids industry. Farmers have obtained permits to use sewage sludge on nearly 70 million acres, or about a fifth of all U.S. agricultural land, the industry said.

Christopher Higgins, a professor of civil and environmental engineering at the Colorado School of Mines who has researched biosolids, said it was notable that the E.P.A. had

concluded that concentrations in sludge fertilizer posed risks at relatively low levels.

Historically, he said, sludge had been applied at concentrations greater than the levels now deemed risky by the E.P.A. “That implies there’s going be a lot of places where there might be an unacceptable risk,” he said.

The E.P.A. hasn’t changed its policy of promoting sludge fertilizer, which has benefits along with the risks. It is rich in nutrients, and spreading it on fields cuts down on the need to incinerate it or put it in landfills, which would have other environmental costs. Using sludge fertilizer also reduces the use of synthetic fertilizers that are based on fossil fuels.

The agency said that farmers who may be concerned about their use of sewage sludge should consult with local health officials, get their drinking water tested as a first step, and consider switching to an alternative fertilizer.

The E.P.A. said that, at farms which have used contaminated sludge, the highest human risks involved drinking milk from pasture-raised cows raised on a contaminated farm, from drinking contaminated water, from eating eggs from pasture-raised hens or beef from cattle raised on contaminated land, or from eating fish from lakes and ponds contaminated with runoff.

Particularly at risk were households that live near or relied on products from a contaminated source, for example milk or beef from a family farm contaminated with PFAS from sewage sludge, the agency said. It said in certain conditions, risks exceeded the E.P.A.’s acceptable thresholds by several orders of magnitude.

The general public, which is more likely to buy milk from a grocery store that sources its produce from many farms, was at less risk, the agency said. For its assessment, the E.P.A. focused on the two most commonly detected types of forever chemicals, called PFOA and PFOS, though many others exist.

The Food and Drug Administration does not set limits on PFAS levels in food. Since 2019, however, the agency has tested nearly 1,300 samples and said the vast majority were free of the types of PFAS the agency is able to test for.

Some public health experts and advocacy groups have questioned the testing methodology, and the agency itself says that “PFAS exposure from food is an emerging area of science and there remains much we do not yet know.” Last year, Consumer Reports said it had detected PFAS in some milk, including organic brands. Packaging is another source of PFAS in food.

Kyla Bennett, director of science policy at the Public Employees for Environmental Responsibility, an advocacy group working with the Texas ranchers, said the E.P.A.'s assessment was a good first step, but noted the agency had looked at only two kinds of PFAS, even as more were being detected on farmland. "Because we don't fully know how they interact with each other, and how they affect human health, I think the E.P.A. needs to do more," she said.

The National Association of Clean Water Agencies, which represents wastewater treatment plants across the country, said the findings reinforced that sludge fertilizer was not a risk to the public food supply. Sludge providers have argued that they should not be held responsible for PFAS contamination, saying the chemicals are simply passed onto them.

"Ultimately, the manufacturers of these chemicals must bear the responsibility and cost to remove these chemicals" from their products and environment, said Adam Krantz, the group's chief executive.

In the absence of federal action, states have started to take their own measures. Maine banned the use of sewage sludge on agricultural fields in 2022 and remains the only state to have done so. In December, a Texas lawmaker introduced a bill that would place limits on levels of certain kinds of PFAS in sewage sludge applied to farmland. Oklahoma lawmakers have also introduced a bill that would place a moratorium on the use of sludge on farmland.

An outright ban on the use of sludge as fertilizer would bring its own problems. Wastewater sludge still needs somewhere to go. Since Maine's ban, some wastewater treatment plants say they have been forced to ship sewage sludge out of state.

Environmental experts say what's important is limiting the amount of PFAS that ends up in wastewater and sewage in the first place. That could come from phasing out the use of PFAS in everyday products, or requiring manufacturers to treat polluted wastewater before sending it to municipal wastewater treatment plants.

Hiroko Tabuchi covers pollution and the environment for The Times. She has been a journalist for more than 20 years in Tokyo and New York.

A version of this article appears in print on , Section A, Page 1 of the New York edition with the headline: E.P.A. Warns of 'Forever Chemicals' in Fertilizer

https://gazettetimes.com/news/local/government-politics/article_245014e9-3341-5124-b237-3486d8dbe65a.html

TOP STORY EDITOR'S PICK

With Marion County's incinerator closed, where's the trash going?

. ...

Following the recent closure of the state's only municipal garbage incinerator, Marion County will not send an additional 100,000 tons of trash to Coffin Butte Landfill, north of Corvallis, instead diverting waste to the Columbia River Gorge.

The local government serving the about-1,200-mile jurisdiction around Salem already is Coffin Butte Landfill's largest customer, hauling in about 230,000 tons each year. Marion County officials agreed in January not to increase that after they expected the tall, red-white-striped stack of Reworld Marion to fall silent.



The Reworld Marion Inc. incinerator, previously known as Covanta, is visible from near Interstate 5 on Thursday, Dec. 12, in Salem. Owners were slated to shutter the trash burning facility at the end of December.

Alex Powers, Mid-Valley Media

"We didn't want to put an additional burden on Coffin Butte," Marion Environmental Services Division Manager Brian May said by phone Jan. 27.

Currently Coffin Butte is caught up in two regulatory processes: Its corporate owners have applied with Benton County **to expand the dump** and with Oregon for a **new air pollution permit**.

Arizona-based trash hauler Republic Services has proposed a cap on annual tonnage at the dump, near Adair Village, and floated a 2037 closure date based on the company's projected annual trash intake.

Trash trucks, builders and industrial customers dump about 1.1 million tons at Coffin Butte each year. Marion County accounts for around 21% of the dump's tonnage.

"I think we are all pretty aware of their current circumstances, where they have around 12 years of life left," May said.

So trash that would have gone to the now-closed Reworld incinerator, formerly known as Covanta, is heading to the Wasco County Landfill, near The Dalles and nearly 130 miles via interstates 5 and 84.

Oregonians each generated an average 7.8 pounds of trash per day in 2022, according to the state's most recent figures.

Both statewide population and per-person trash generation rates have increased in the 30 years since 1992, when Oregonians made 5.6 daily pounds of garbage.

"The volume has increased significantly," May said.

In a report published in May, the Oregon Department of Environmental Quality estimated that some resident, like those in Marion County, generated more: 3,591 pounds per person in a year, compared to 2,761 pounds per person in Linn County; and 2,426 pounds in Benton County.

Critics of Coffin Butte's role as a regional dump have argued for years that uneven use of the landfill is unjust and disproportionately burdens Benton County residents with environmental fallout, such as gas or **trash-infused rainwater** leaking from inside the dump.

Counties, including Benton, Linn, Marion, Polk and Yamhill, designated Coffin Butte as their destination landfill in 1974 despite pushback from the dump's neighbors.

"That was always our plan — to move that material out to Coffin Butte," May said.

Since 2020 Republic Services has been trying to expand its landfilling operation near Adair Village. The Arizona-based trash hauler applied with Benton County's planning department for permission to inter waste on land the company owns and effectively move the working face of the dump to the south, across Coffin Butte Road.

The incinerator literally burned through landfilling figures. People north of Albany and Corvallis sent all their trash to Reworld after Marion officials partnered with the company to site the incinerator near Brooks in 1984.

"Our generation was low enough that the incinerator was able to take all of our waste," May said.

Near the peak of its operation, the Marion County incinerator could burn around 187,000 tons and took household trash from Portland.

"To keep that fire lit, so to speak," May said.

Covanta's fires burned at 2,000 degrees and powered a steam turbine that generated 13 megawatts of electricity each year — enough to power Woodburn, according to Marion County's website, the city north of Salem with a population of more than 29,000 people.

The Reworld Marion Inc. incinerator, previously known as Covanta, visible from near Interstate 5

Nearly four decades later, Covanta

destroyed as much as 4% of waste generated statewide, according to the report.

on Thursday, Dec. 12, in Salem. Owners were slated to shutter the trash burning facility at the end of December.

Alex Powers, Mid-Valley Media

But the incinerator started showing its age. Oregon's environment department issued $15,722 in fines in 2022 to Covanta for emitting more pollution than allowed under state air quality permit; and $22,800 during summer 2024.

Oregon has sought tougher rules for air polluters as the state attempts to lower its emissions of greenhouse gases to levels below those in the early 1990s.

Industrial and medical waste found its way to Covanta, as did narcotics held as police evidence and retired uniforms.

Ashes from medical waste were laid down as daily cover at Coffin Butte. Republic Services now won't use the Covanta leftovers to layer over trash on the landfill's working face, where residents complained they could see ash billowing during the summer.

- ... - .. .. -.- - -

Then Oregon legislators clamped down on Covanta.

"All of a sudden, we jumped a process where DEQ and the state had a very good process to not pick on just one entity," May said.

Sen. Deb Patterson, a health care executive and Democrat from Salem, introduced a law requiring incinerators to continuously monitor emissions for airborne pollution and capping their intake of medical waste. Signatories included Corvallis Sen. Sara Gelser Blouin.

Covanta rebranded as Reworld the following April, in 2024, and announced the incinerator's closure later that year.

"I think there are a lot of unintended consequences," May said. "We're hearing

from medical providers whose disposal costs have gone up 170%."

In December Marion County's elected officials blamed the state Legislature for hindering Reworld Marion.

County Commissioner Danielle Bethel said Reworld had been a financial risk and great investment return for Marion County, but Marion County couldn't stop the rollout of state law, according to meeting minutes.

Countywide, Marion waste collection generated more than 625,000 tons of trash in 2022. The local government sent 145,000 to 160,000 tons, more than 23%, to Covanta as recently as 2021, according to a contract.

May said he believes Marion County made the right decision not sending the trash to Coffin Butte. May and another commissioner, Kevin Cameron, participated in Benton County's wayfinding process in 2022 after planning officials denied Republic's last expansion attempt.

That workgroup, Benton County Talks Trash, recommended overhauling the county's waste stream to encourage polluters to generate less trash.

Subsequent meetings and committees have started talks that could last for years about potential financial incentives for packagers, or attempts to educate trash-makers about what happens to their garbage after they wheel a bin to the curb each week.

"Being led by the entity that feels like they're being dumped on is very proactive," May said.

. ...- -. .. - .. -...-.

150-day timer starts on Coffin Butte expansion application

Pause in effort to update pollution permit for Coffin Butte more than a short one

Corvallis to stop accepting chemical soup from Coffin Butte Landfill

More Benton County news

Alex Powers (he/him) covers agri-business, Benton County, environment and city of Lebanon for Mid-Valley Media. Call 541-812-6116 or tweet @OregonAlex.

statesman journal

POLITICS

Oregon legislation would require aerial, drone or satellite landfill monitoring



Tracy Loew
Salem Statesman Journal

Feb. 25, 2025, 4:03 a.m. PT

Key Points

- SB 726 proposes stricter methane monitoring and reporting requirements for landfills.
- The bill was introduced in response to methane leaks at Coffin Butte Landfill.
- Opponents argue alternative methods for measuring methane are not yet standardized or readily available.

Oregon landfills would have to improve methane monitoring and reporting under a bill being considered by the state Legislature.

Sen. Sara Gelser Blouin, D-Corvallis, introduced the bill in response to ongoing concerns about methane releases at Coffin Butte Landfill, near Adair Village.

In 2022, the U.S. Environmental Protection Agency found Coffin Butte was leaking methane at levels that exceed state and federal limits and what the landfill had publicly reported.

EPA investigators returned in 2024 and found more than 40 locations where methane exceeded limits, including at holes in the cover material.

“What this bill talks about is how we are able to track and measure the amount of methane that is leaking from our landfills,” Gelser Blouin said Monday during a hearing on the bill. “We want to encourage the use of these advanced technologies so that we can get more accurate information about specifically

where leaks might be."

Landfills are among the nation's largest sources of methane, a greenhouse gas that's more potent than carbon dioxide and a major contributor to climate change, according to the EPA.

The levels measured at Coffin Butte also could cause health problems for neighbors, and in some cases were high enough to potentially cause an explosion and fire, experts said.

Oregon could require aerial, drone or satellite landfill monitoring

Senate Bill 726 would require municipal solid waste landfills to use advanced technology, such as drones, planes or satellites, to measure methane releases.

It would require landfill owners to report the results to the state Department of Environmental Quality, in GIS software, which would make it easier to visualize.

And it would require landfills to fix any areas exceeding limits, and monitor that area again.

The bill calls for the state's Environmental Quality Commission to adopt rules for the program, which would begin by July 1, 2026.

More than 100 people testified in support of the bill, in person and in writing.

"Satellites and drones don't fudge results. They are impartial. Not only would they monitor the entire landfill, they can also pinpoint leaks at their source in such a way that cannot be denied or otherwise explained away by landfill operators," wrote Debbie Palmer, of Benton County-based Valley Neighbors for Environmental Quality and Safety.

Lane County Public Works Director Dan Hurley told the committee he started his career doing methane monitoring at Short Mountain Landfill near Eugene.

“The current method is a joke. It was developed over 40 years ago,” Hurley said. “The method only requires someone to carry around a handheld monitor. There are lots of opportunities to game these measurements.”

The bill’s opponents include the Oregon Refuse and Recycling Association and the Association of Oregon Counties. They argued the EPA does not have standards for alternative methods of measuring methane.

“The bill would make it a requirement for us to use technologies that are not available yet,” said Craig Campbell, government affairs director for ORRA. “It’s great if there’s a technology out there that’s perfect, but if you can’t get your hands on it, it’s useless.”

Coffin Butte Landfill expansion, air permit pending

The 178-acre Coffin Butte Landfill is owned by Phoenix-based Republic Services.

Coffin Butte currently takes most of Marion and Polk counties’ municipal waste, including some waste that previously went to the Reworld Marion incinerator in Brooks. Reworld stopped taking Marion County waste on Dec. 31.

Republic Services is in the process to trying expand the landfill.

Two years ago, the Benton County Planning Commission unanimously denied the company’s request for a conditional use permit to expand, following public testimony in opposition.

In July 2024, the company resubmitted its proposal, cutting the planned expansion in half. It is currently waiting for the county to decide whether the application is complete.

Meanwhile, in January, DEQ paused work on a new air quality permit for the landfill, saying the company had not provided all the information it needed to proceed.

The move, just days before a public hearing was scheduled, means Coffin Butte can continue operating under its existing permit, which expired more than a decade ago.

The landfill has been allowed to continue operating under the expired permit because the company filed a timely renewal application with DEQ in 2014.

Tracy Loew covers the environment at the Statesman Journal. Send comments, questions and tips:tloew@statesmanjournal.com or 503-399-6779. Follow her on Twitter at@Tracy_Loew

statesman journal

ENVIRONMENT

Oregon corporate landfills using loophole to avoid methane monitoring, study finds



Tracy Loew
Salem Statesman Journal

March 6, 2025 | Updated March 7, 2025, 8:55 p.m. PT

Key Points AI-assisted summary

- Beyond Toxics found that corporate-owned landfills in Oregon are avoiding methane. monitoring on about half of their operating areas
- The study analyzed quarterly emission reports from eight out of 11 Oregon landfills subject to new methane regulations.
- Private landfills are more likely to exempt areas from monitoring than county-owned facilities.

This story has been updated with new information from the Oregon Department of Environmental Quality.

Oregon's corporate-owned landfills are using a loophole in state law to avoid methane monitoring on an average of about half of their operating surfaces, a new study concludes.

County-owned landfills, meanwhile, are exempting an average of 10% of their surfaces, according to the report released Thursday by the Eugene-based environmental group Beyond Toxics.

The researchers set out to determine how well Oregon's new landfill methane emission standards, the strictest in the nation, are working.

Landfills are among the nation's largest sources of methane, a greenhouse gas more potent than carbon dioxide and a major contributor to climate change, according to the U.S. Environmental Protection Agency.

Need a break? Play the USA TODAY Daily Crossword Puzzle.

Oregon's new rules, part of a larger state effort to curb greenhouse gas emissions, went into effect in October 2021.

The rules require quarterly monitoring of the landfill, by walking the surface with a handheld gas analyzer. Identified leaks measuring over 500 parts per million must be fixed within 10 days.

The rules allow landfills to use "alternative compliance options," including changing walking paths, to exclude monitoring where there are potential safety and other issues, such as steep or slippery slopes and physical obstructions.

Mason Leavitt, data analytics specialist for Beyond Toxics, said companies appear to be abusing that exemption.

For example, the 178-acre Coffin Butte Landfill, near Corvallis, exempted 40 acres in the third quarter of 2022 and 30 acres in the fourth quarter of the same year, citing "high vegetation," according to the report. The landfill continued to exempt those areas in 2023 without citing a reason.

Alternative options must be submitted in writing and receive written approval from the Oregon Department of Environmental Quality before they may be implemented, according to state rules. But Leavitt found no evidence that was happening.

"The reports we analyzed did not include information or details on alternative monitoring plans approved by DEQ, so it's difficult to evaluate exactly what agreements are made between private owner-operators and DEQ," the Beyond Toxics report states.

“Half of private landfill surface area is going completely unmonitored for methane leaks,” Leavitt told the Statesman Journal. “We’re blind to what’s happening in those sections of the landfill.”

The Oregon Department of Environmental Quality just received the report and is reviewing it, spokesman Dylan Darling said.

The findings come as the Oregon Legislature considers a bill to improve landfill methane monitoring and reporting.

Senate Bill 726 would require municipal solid waste landfills to use advanced technology, such as drones, planes or satellites, to measure methane releases.

It would require landfill owners to report the results to the DEQ, in GIS software, which would make it easier to visualize.

And it would require landfills to fix any areas exceeding limits, and monitor that area again.

No methane monitoring data for 3 Oregon landfills

Oregon’s new quarterly surface emissions monitoring rules apply to landfills with more than 200,000 tons of accumulated waste and methane emissions modeled to be greater than 664 tons.

Eleven landfills statewide met that criteria, according to the report.

Beyond Toxics asked DEQ for quarterly emission reports for all 11 landfills for 2023, the first full year of monitoring.

In response, the group received the reports for eight of those landfills.

Roseburg Landfill, managed by Douglas County, had not complied with the new rules. DEQ has issued a pre-enforcement notice to the landfill, warning that it could be cited and fined, Darling said.

The landfill began monitoring in second quarter 2024 and found two exceedances of the methane emission limits, he said.

Because of that, DEQ has given the landfill until June to submit a design plan to DEQ and until December 2026 to install and begin operation of a gas collection and control system. At that time, it will be required to resume methane emissions monitoring.

Hillsboro Landfill, owned by Waste Management, has until April to begin modeling under the terms of its air quality permit, according to DEQ.

And Baker Landfill, managed by a local private company, argued that it actually was two landfills, with each separately falling under the threshold for monitoring. One of the landfills, which are next to each other, closed in 2002, Darling said.

Beyond Toxics found companies exempted as much as 69% of landfill

Landfills provide data in their quarterly monitoring reports in print form, rather than using GIS software.

Leavitt, working with university students, spent about 300 hours translating it into spatial data, to map the areas monitored at each landfill each quarter. Without that work, it's difficult to know which areas of a landfill are unmonitored.

That's another shortcoming of the current rules, Leavitt said.

"That arcane system is currently what DEQ would have to rely on to be able to look at all of this in one place," he said.

The researchers determined the percentage of each landfill that was unmonitored each quarter. Here are the results:

Dry Creek Landfill, in Eagle Point, operated by Waste Connections: 69% each

quarter
Coffin Butte Landfill, near Adair Village, operated by Republic Services: Between 53% and 62%
Wasco County Landfill, in The Dalles, operated by Waste Connections: Between 46% and 62%
Finley Buttes Landfill, in Boardman, operated by Waste Connections: Between 27% and 58%
Columbia Ridge Landfill, in Arlington, operated by Waste Management: Between 12% and 19%
Knott Landfill, in Bend, operated by Deschutes County: Between 12% and 16%
Short Mountain Landfill, near Eugene, operated by Lane County: 8% each quarter
Crook County Landfill, in Prineville, operated by Crook County: Between 7% and 8%

U.S. EPA finds problems with methane monitoring

Beyond Toxics' conclusions mirror those in a recent U.S. Environmental Protection Agency report.

More than 100 EPA inspections over the past three years found that many municipal solid waste landfills across the country were not properly monitoring emissions.

"While the regulations allow municipal solid waste landfills to exclude certain areas from the surface emissions monitoring (e.g., areas with steep slopes or other dangerous areas), the EPA observed during recent inspections that areas that are not dangerous are improperly excluded from monitoring," the EPA report states.

"If a municipal solid waste landfill excludes areas from the surface emissions monitoring, the facility should document and explain the basis for excluding each area from monitoring in the surface emission design plan and SEM reports. The

regular side slopes of the landfill may not be excluded from monitoring per the regulations," the report reads.

Coffin Butte Landfill was among those the EPA inspected.

In 2022, the EPA found Coffin Butte was leaking methane at levels that exceed state and federal limits and what the landfill had publicly reported.

EPA investigators returned in 2024 and found more than 40 locations where methane exceeded limits, including at holes in the cover material.

EPA, rather than DEQ, is continuing to lead that investigation, Darling said.

Coffin Butte expansion decision expected by August

The findings come as Coffin Butte Landfill, which takes waste from Marion and Polk counties, has just passed a major hurdle in its yearslong effort to expand.

On Feb. 28, Benton County deemed the company's application for a conditional use permit for the expansion "complete."

Sometime this spring, the county will open a two-week public comment period and a public hearing on the application. The county's planning commission is expected to decide on the application by Aug. 11.

Tracy Loew covers the environment at the Statesman Journal. Send comments, questions and tips:tloew@statesmanjournal.com or 503-399-6779. Follow her on X at@Tracy_Loew

The Corvallis ADVOCATE
(https://www.corvallisadvocate.com)

LANDFILL EXPANSION EDITORIAL: SOMETIMES, NIMBY IS THE RIGHT ANSWER

MARCH 24, 2025



Not always, but sometimes, NIMBY, or not in my backyard, is the right answer, and we suspect that's how our county should answer Republic Services' application to expand their Coffin Butte landfill facility.

In a perfect world, we might suspect differently, but that's not the world we're living in.

Landfills need substantive regulation and robust monitoring. They emit mixes of biogas and bioaerosols, they are a breeding ground for disease vectors, and they can discharge leachate into the area ground water supply. Communities that host these facilities can see increased incidences of cancer and respiratory diseases. And then there are the environmental impacts; some of them global, many of them local, and too many of them dauntingly long-lasting.

(
h
t
t
p
Mel's Barber Shop
962 NW Circle Blvd, Corvallis
Walk-in Only
$21 Haircut
$18 for Seniors • $7 Beard Trim

So, what is the County to do. Regulation could be an answer, but we no longer live where County officials might, with a straight face, tell themselves or anyone else that we locals can rely on the EPA or Oregon's DEQ to monitor and regulate much of anything going into the future, including a landfill in our fair and small county. Maybe, back in the day, but not now.

The feds are going all-out chainsaw massacre on their own agencies – and a third of Oregon's budget comes from federal dollars. So, what happens to the state's DEQ if the flow of federal monies slows is anyone's guess.

If state budget writers suddenly need to scramble, the ongoing monitoring of a dump may seem like a lower priority than say, keeping schools open and needy children fed.

Some might think the County could take over regulation and monitoring. But promulgating the right regulations and monitoring regimen for a facility like this one isn't in the County's current wheelhouse. And even if they could cut-and-paste rules and practices from elsewhere, they are unlikely to have the right experts and equipment in place anytime soon.

Standing up a regulatory framework and staffing and a pay-for plan to fund all of that would likely be, optimistically, a couple yearslong process. None of this will happen before the legal deadline for the County to make a decision on Republic's expansion application.

In short, even with its past resources, the EPA has been slow to investigate problems at Coffin Butte over the years. And now state and federal regulatory resources are in flux and will almost certainly be reduced in the future.

We don't think County officials can demonstrate the appropriate know-how and capacity to regulate the landfill on their own, given they could not have anticipated the unprecedented prospective reductions in state and federal regulatory capacity.

The County could leave the door open for Republic to reapply. However, desperately needed housing has been envisioned for areas in the dump's proximity. So, the company may be better off seeking a new site in a slower growing county that could offer a location that is more remote. We also think that if Republic does approach another County, they should expect them to want adequate time to build an appropriate regulatory structure.

Do you have a story for The Advocate? Email editor@corvallisadvocate.com
(mailto:editor@corvallisadvocate.com)

www.yellowbirdhoppercoverall

(HTTPS://WWW.FACEBOOK.COM/SHARER/SHARER.PHP?U=HTTPS://WWW.CORVALLISADVOCATE.COM/2025/LANDFILL-EXPANSION-EDITORIAL-SOMETIMES-NIMBY-IS-THE-RIGHT-ANSWER/)

(HTTPS://TWITTER.COM/INTENT/TWEET?URL=HTTPS://WWW.CORVALLISADVOCATE.COM/2025/LANDFILL-EXPANSION-EDITORIAL-SOMETIMES-NIMBY-IS-THE-RIGHT-ANSWER/)

PREVIOUS ARTICLE (HTTPS://WWW.CORVALLISADVOCATE.COM/2025/DC-REPORT-WHAT-YOUR-CONGRESSIONAL-DELEGATION-HAS-BEEN-DOING/)

DC REPORT: WHAT YOUR CONGRESSIONAL DELEGATION HAS BEEN DOING (HTTPS://WWW.CORVALLISADVOCATE.COM/2025/DC-REPORT-WHAT-YOUR-CONGRESSIONAL-DELEGATION-HAS-BEEN-DOING/)

NEXT ARTICLE (HTTPS://WWW.CORVALLISADVOCATE.COM/2025/AMID-HEFTY-RATE-INCREASES-GOV-KOTEK-QUESTIONS-STATE-PUBLIC-UTILITIES-COMMISSION/)

AMID HEFTY RATE INCREASES, GOV. KOTEK QUESTIONS STATE PUBLIC UTILITY COMMISSION (HTTPS://WWW.CORVALLISADVOCATE.COM/2025/AMID-HEFTY-RATE-INCREASES-GOV-KOTEK-QUESTIONS-STATE-PUBLIC-UTILITIES-COMMISSION/)

This 'limited' expansion is another ruse

AS I SEE IT

. . ..



MARGE POPP

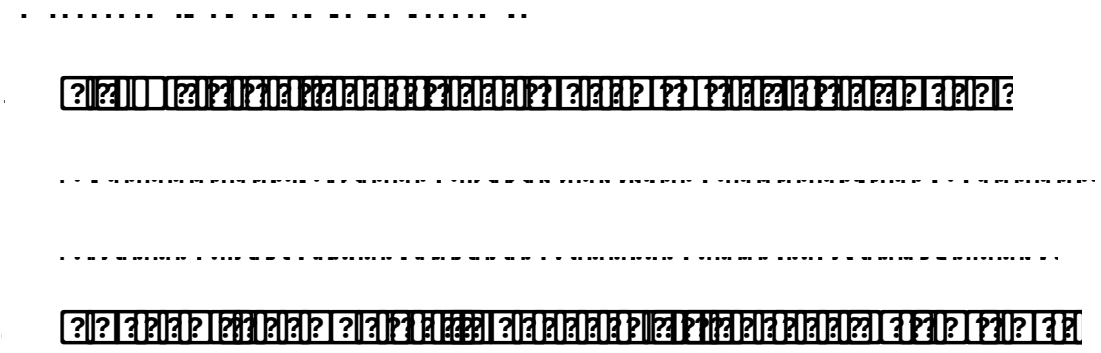
Proponents of Coffin Butte Landfill expansion claim Re-public Services' conditional use permit application requests only a "limited" expansion. This characterization is misleading and obscures the true impact of the project.

Republic Services aims to exploit a loophole in the 2020 franchise agreement to lift the 1.1 million-ton annual cap on trash intake, paving the way for importing

unlimited amounts of waste. This move would increase the profitability of its operations at the expense of our community and environment.

The expansion involves significant expenditure, with tens of millions of dollars allocated to moving leachate ponds and millions of pounds of dirt on the south side of Coffin Butte Road. This investment is purportedly for only six additional years of landfill lifespan?

The current landfill footprint already has an estimated 14 to 16 years of capacity remaining at current trash intake levels, making the economic rationale behind this expansion questionable.



Far from being "limited," this project is a large-scale endeavor designed to maximize landfill capacity, potentially leading to the eventual closure of Coffin Butte Road and transforming the valley into a vast waste disposal site for other counties.

An email exchange between Benton County Attorney Vance Croney and Republic Services employee Julie Jackson, dated Oct. 14, 2020 (obtained via a Public Records Request), reveals Republic Services' long-term ambitions for the site.

Vance Croney writes, "Hmm. Republic has a chunk of land south of Coffin Butte that is already zoned Landfill which only requires conditional use approval to begin use as a landfill cell. It also has many acres of EFUzoned land that certainly can be

used for additional cells, but would require rezoning. Are we both talking about the Landfill zoned acreage as creating an additional 15-20 years of life?"

Julie Jackson replies: "Vance, This is just the estimate for the cell area we are asking to rezone. We have many acres that could hold waste and that will likely be a future discussion with the County."

Republic Services has a history of inaccurate reporting and noncompliance with the conditions of use for the Coffin Butte Landfill, and Benton County has not taken appropriate action. The lack of consequences for noncompliance suggests a failure of our local government to protect our community and natural resources.

A 2023 EPA investigation revealed significant methane leakage exceedances, further underscoring Republic Services' lack of transparency and accountability. Recent communications between the EPA and Republic Services indicate further issues with the accuracy of information provided by the company.

The EPA's subpoena requiring written verification concludes with this sternly worded caution for the signatory:

"I am aware that there are significant penalties for submitting false information in response including the possibility of fine and imprisonment."

Interestingly, the landfill manager responsible for signing this document resigned about this time.

It is imperative that we demand honesty and transparency from both our county government and Republic Services. This requires a capable and proactive staff that can think critically and independently as well as engaged participation from the community.

Our county government and commissioners have become overly reliant on Republic Services to act responsibly, prioritizing the status quo over diligent oversight.

Similarly, complacent residents have placed too much trust in elected officials and county staff to act in their best interests.

With Benton County staff being well-compensated, we should expect and demand experienced and dedicated individuals who are committed to serving the community's interests.

It is time for us to recognize the true consequences of this expansion to our community and environment, and we must demand responsible governance and environmental stewardship.

We need to wake up and smell the dump!

Marge Popp is a retired information systems consultant. She is a longtime resident of Corvallis and Benton County.

TOP STORY EDITOR'S PICK

As I See It: The not-so-free revenues from Coffin Butte

In anticipation of coming economic headwinds, Benton County has implemented a hiring freeze. That's wise. But in addition to looking at expenses, it would also be wise to look at the cost of some revenues, specifically landfill revenues.

There is a lot of misinformation about landfill revenues; here are some facts:

Landfill revenues are not a big part of total revenues. Per the 2023-25 budget, Benton County's total revenues are roughly $185 million. Revenues from the landfill make up less than 1.6% of that total, or about $2.9 million. That's not much. And Benton County gets that money whether or not the landfill expands.

Whether or not the landfill expands, Benton County is guaranteed to receive $2.5 million per year through the year 2039. Per the 2020 franchise agreement, the landfill is obligated to pay Benton County a minimum of $2.5 million dollars a year through 2039. This amount is guaranteed even if the landfill stops accepting ANY waste.

[illegible]

At current volumes, an expansion will not result in much additional revenue for Benton County. If an expansion is approved, revenues increase by only about $500,000-$600,000 per year. That is less than one-third of 1% of total Benton County revenues.

Landfill revenues cost money now. Landfill revenues received are gross, not net. These revenues aren't free:

- Landfill trucks damage our roads; road repair costs a lot.
- First responders are called to landfill truck accidents (like the Republic Services truck from Sweet Home that flipped over in Philomath in a one-car accident on June 26, 2024), landfill truck fires (like the recent fire on April 6), and fires at the landfill itself (at least two in the past year alone).
- Finally, these revenues cost the county untold hours of staff/consultant time. The landfill operator, unable to take "no" for an answer in 1994, or again in 2021, has for the third time submitted a proposal to put garbage on the same 59 acres south of Coffin Butte Road. To deal with these repeated expansion requests, Benton County staff has worked probably thousands of hours, and shelled out probably $750,000 in consultant fees.

What do all of these expenditures total? Nobody knows; the county doesn't keep track. But I guarantee you that if it did, landfill revenue would look less attractive.

Finally, the costs cited above are not the big costs. The big costs are intangible costs, opportunity costs, costs of a future environmental disaster, and costs to our own health.

Intangible costs: As the landfill grows larger, smells worse and the health effects of landfilling become more well known, it is certain that the landfill costs Benton County reputationally. The landfill depresses property tax revenue countywide.

The landfill harms farmers of berry and grape crops, and windblown litter fouls agricultural equipment.

Opportunity costs: The landfill chills development of new residential subdivisions for miles, not only in Benton County, but in Linn and Polk counties too.

Environmental costs: Costs of a major fire, earthquake or liner failure could run into the hundreds of millions of dollars.

Health costs: Finally, there is the real possibility that the landfill is making us sick.

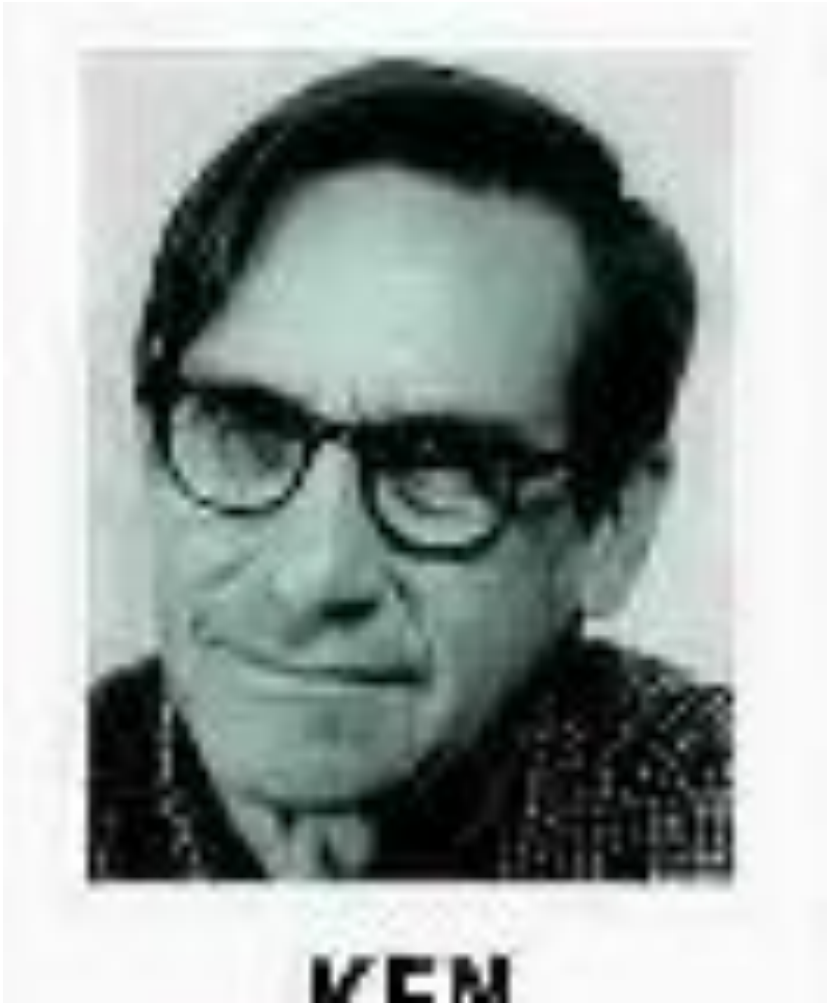
I'm glad that the county is finally starting to be a little more careful in its expenditures, but it's time that it looks more closely at revenues as well. The dollars that the landfill brings in may look like a free lunch, but if the county looked at this meal more closely, it might find that what's on the menu is literally garbage.

Nancy Whitcombe

Nancy Whitcombe likes words and numbers. She is a completely retired architect and a mostly retired accountant.

Game over for expansion? If only

AS I SEE IT



KEN EKLUND

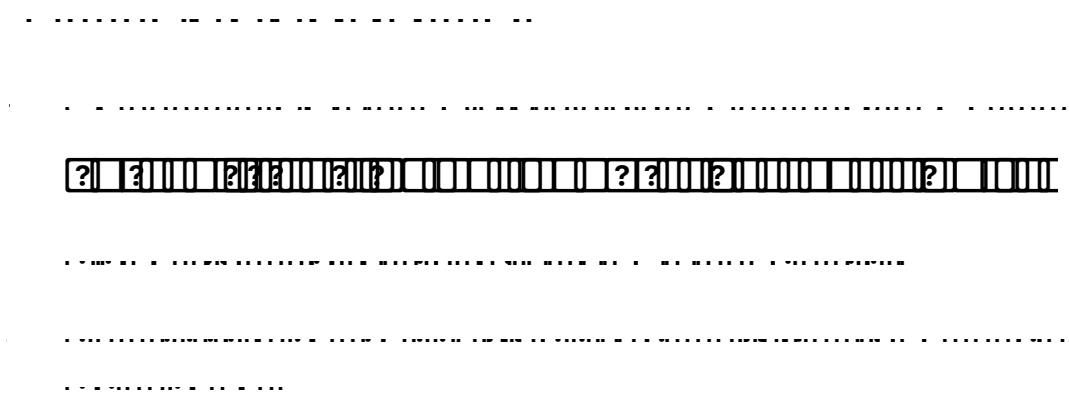
Let's call it Dump Karma. A day after Republic Service's public relations writes a letter to Benton County, assuring us that no enforcement action is pending against Coffin Butte dump, EPA enforcement takes action against Coffin Butte dump.

EPA filed a "Section 114 Information Request," but "request" is misleading; in

effect it's the EPA's equivalent of an IRS audit. We might call it an "Information Request with Benefits," where the benefits are possible fines if you're late and prison time if you lie.

The EPA enforcement action took place in January. Republic updated its expansion application in mid-March. Its update doesn't mention the EPA enforcement. Maybe because ...

The EPA enforcement seems like GAME OVER for the dump expansion. Republic has the burden of proof, i.e., its application must show that the landfill expansion won't cause significant harm to nearby properties, character of the area, etc., or it fails.



Representatives say their proof is "we comply with environmental regulations." So when the EPA said, "Let's see all your compliance records" explicitly to see if Republic really is complying, the EPA slapped big red question marks all over Republic's proof.

And a proof with question marks is no proof at all.

The thing is, Republic's "compliance" is basically self-declared. Like with taxes and the IRS, if you report regularly and they don't say anything, voila! You've "complied." Until you're audited, that is. Then you're not compliant until the auditor says so.

It seems clear the EPA has grounds to question Republic's self-declared compliance. Its inspections consistently turn up serious environmental problems. Last year the EPA administrator said definitively that Coffin Butte Landfill is "an active case, and we are laser-focused on this case."

The EPA's air enforcement officer recently confirmed this. (Neither could say more because it's an active legal action.)

And Republic notably is not trying to clear the air — instead, company officials are filing for delay, delay, delay.

So, as I said, this should be GAME OVER for the dump expansion. To approve it, a planning or county commissioner would have to affirm Republic's proofs as sufficient; they'd have to publicly certify that an expanded dump couldn't pose significant problems. Which seems iffy to do while the EPA is actively investigating the current dump for significant problems.

In case you missed it, a firestorm of protest is raging about the dump polluting nearby neighborhoods and recreation areas, super-emitting greenhouse gases to wreck the climate — which is what jump-started the EPA investigation in the first place. This should be GAME OVER — but never underestimate Republic's commitment to this expansion, or its ability to steamroll reality. Coffin Butte is Republic's only landfill in Oregon, and expanding it every few years is now the only way to keep growing its highly profitable waste disposal business across the state.

So buckle up for truly imaginative takes incoming from Republic PR — "an action by EPA enforcement is not an EPA enforcement action" or suchlike. And watch to see if county government doesn't do some logic and values-defying somersaults of its own regarding the EPA enforcement in its April 22 report to the Planning Commission.

Hey, if Republic won't tell the Planning Commission about the EPA enforcement, maybe we should? You can tell the commissioners:

(a) "There's EPA enforcement goin' on that Republic's not telling you about," and (b) "Deny application LU-24027 to keep Republic's HANDS OFF our local air, water and soil"?

If 50 people step forward, maybe we can reverse Republic's spin. Visit **CoffinButteFacts.org** to learn how to write the Planning Commission and to learn more.

Ken Eklund is a futurist and artist in game design, and a community volunteer on the Benton County Disposal Site Advisory Committee. He lives with his family in the Corvallis area.

https://gazettetimes.com/news/local/government-politics/article_e57bf960-52b3-526e-956d-8d6ee48eb1cc.html

TOP STORY BREAKING

Benton County staff recommend denial of Coffin Butte Landfill expansion

Benton County staff have recommended the Planning Commission deny Republic Service's request to expand Coffin Butte Landfill.

Staff cite odor and noise impacts expected to "seriously interfere" with adjacent land uses and the character of the area as the primary reasoning behind their recommendation.

A hearing is scheduled for next week.

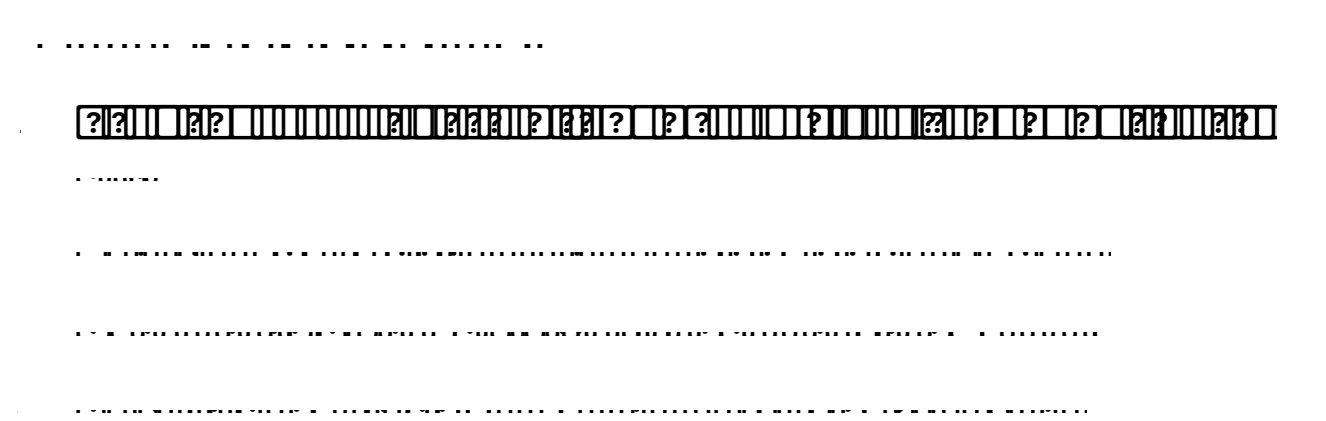
Landfill owner Republic Services has applied for a conditional use permit that would allow for expansion of the existing operations by moving the active disposal area south of Coffin Butte Road, constructing an 1,800-square-foot employee building with off-street parking, adding a shop and maintenance area and more.

A tanker trailer takes on trash-imbued runoff called leachate in August at Coffin Butte Landfill, north of Corvallis. While the landfill's corporate owner has applied for a permit to expand the facility, Benton County staff is recommending against it.

Alex Powers, Mid-Valley Media (File 2024)

The community, particularly members who live close to the landfill located north of Corvallis, has consistently vocalized resistance to the expansion and has raised suspicions the Phoenix-based

company's request was a fait de accompli.



In a staff report made available online, Benton County staff noted that the proposal for expansion seems to exceed the Department of Environmental Quality regulatory noise threshold proposed for use by the applicant.

It also cites concerns with the applicant's odor analysis.

"The analysis does not appear to identify adjacent uses that are likely to be more sensitive to odor impacts. For example, a residential use is likely to be more sensitive to odor impacts than a farmed field," it reads.

It goes on to state that several technical elements of the analysis seem inadequately supported.

This is not the first time Republic Services has struggled to get an expansion proposal off the ground. In 2021, the Benton County Planning Commission **unanimously rejected its first attempt**, expressing concerns about how the then-proposed closure of Coffin Butte Road would impact the surrounding neighborhood.

The Planning Commission also cited concerns — similar to those this go-around — about noise and odor, as well as other public health impacts, environmental and wildlife impacts.

Today's application no longer proposes the closure of Coffin Butte Road, instead proposing to widen a section of the road adjacent to the development site.

Republic Services submitted its new expansion application in July, attempting to preclude critics' concerns. But the next month the county deemed the proposal "incomplete," **citing deficiencies in the application**. It was resubmitted in November.

Benton County Public Information Officer Anne Thwaits told Mid-Valley Media that the county couldn't say much about the recently released staff report, citing the pending public hearing.

"We're just happy that the process is moving along as it should," she said.

The **public hearing** for the proposed expansion begins on April 29, and the public comment period is already open. As of 12 p.m. on April 22, according to the staff report, 135 written comments have already been received.

"We appreciate the county's feedback and are working diligently to address their concerns," a Republic Services spokesperson wrote to Mid-Valley Media. "We look forward to presenting our application at the Planning Commission meeting next week."

The deadline to reach a final decision on the proposed application is Aug. 11.

State pols consider forming a Coffin Butte Landfill task force

Coffin Butte Landfill expansion application deemed complete

Republic Services resubmits landfill expansion, here's what's new

Benton: Coffin Butte Landfill expansion application incomplete

More Benton County news

Ella Hutcherson is a University of Oregon graduate who hails originally from the Southern Oregon coast. She covers Corvallis and Benton County and can be reached at .

statesman journal

OREGON

Benton County staff recommend denying Coffin Butte Landfill expansion



Tracy Loew
Salem Statesman Journal

April 29, 2025 | Updated April 30, 2025, 10:42 a.m. PT

(*This story has been updated to correct an inaccuracy. If the Benton County Planning Commission denies the proposal to expand Coffin Butte Landfill, an appeal would go to the Board of Commissioners.*)

Benton County staff have recommended that the county's planning commission deny an application to expand Coffin Butte Landfill.

Phoenix-based Republic Services has requested a conditional use permit from the county, which would allow it to expand the 178-acre landfill located north of Corvallis.

In a staff report, county officials say Republic Services "did not provide sufficient evidence to support a finding that odor and noise impacts would not 'seriously interfere' with adjacent land uses."

The county has received more than 500 comments opposing the expansion, totaling more than 2,000 pages, ahead of public meetings on the proposal that begin April 29.

Those commenting cited a host of concerns about the expansion, including increased traffic, noise, odors and air pollution, potential landfill fires, documented methane exceedances, recent citations for worker health and safety violations, impacts to groundwater and more.

Coffin Butte Landfill accepts about a third of the Mid-Willamette Valley's garbage. Marion County is its biggest customer.

Coffin Butte Landfill's proposed expansion

Republic Services is the second-largest waste disposal company in the United States.

The expansion attempt comes more than two years after the Benton County Planning Commission unanimously denied a previous request for a conditional use permit, following public testimony in opposition. Among the concerns were plans to close an access road and its impact on those who live nearby.

Now, the planned expansion is 50% smaller than proposed in 2021 and would be on land owned by Coffin Butte and zoned for a landfill, according to the company.

It would add six years of life to the landfill, about half of what the company requested in 2021. And it would improve, rather than close Coffin Butte Road. The road has been a point of contention with neighbors, who say the road is their only escape route in the event of a fire or other natural disaster.

In its staff report, county officials say the proposal would exceed the regulatory noise thresholds set by the state Department of Environmental Quality, a standard the company had asked to be used.

County officials also noted inconsistencies in the model used to determine whether odors would be considered a nuisance. And the analysis didn't identify uses, such as residential use, that would be more likely to be sensitive to odor impacts than others, such as a farmed field.

On April 9, 2025, the Benton County Environment and Natural Resources Advisory Committee voted to recommend denial of the conditional use permit.

Benton County Republicans, Benton County Democrats and Linn-Benton Green

party all passed resolutions opposing the expansion.

State and local environmental groups also are asking the planning commission to deny the application.

Landfilling is not a safe or sustainable option for long-term waste management, the groups, including Beyond Toxics, Sierra Club, 350 Salem and Valley Neighbors for Environmental Quality and Safety (VNEQS), said in a news release.

“Approving this application to expand Coffin Butte would increase local fire hazard and risk, exacerbate local air quality and odor problems, and increase environmental damage done to the Willamette River and all who recreate, fish, and rely on its drinking water. It would be a decisive step in the opposite direction of responsible management of environmental resources for Oregonians,” said Mark Yeager, a landfill neighbor and VNEQS member.

How to weigh in on Coffin Butte Landfill’s expansion proposal

The Benton County Planning Commission will hold a series of public meetings on Coffin Butte Landfill’s expansion proposal beginning April 29.

Members of the public can sign up to give verbal testimony during the hearing. Written testimony will be accepted until the commission decides to close the public hearing.

Information about providing verbal and written testimony is available at www.bentoncountyor.gov/coffin-butte-landfill.

Here is the meeting schedule:

6 p.m. to 9 p.m. April 29: The county will deliver a staff report, Republic Services will deliver a presentation, and, if there is time, public testimony will begin.
6 p.m. to 9 p.m. May 1: Public testimony will start or continue.

6 p.m. to 9 p.m. May 6: Public testimony will continue.
6 p.m. until complete June 17: The planning commission will deliberate and make a decision.

All meetings will be held at the county's Kalapuya Building, at 4500 SW Research Way in Corvallis.

If the planning commission denies the proposal, an appeal would go to the county Board of Commissioners, which also would hold a public hearing before making a decision. The county expects that to happen by Aug. 11.

Tracy Loew covers the environment at the Statesman Journal. Send comments, questions and tips:tloew@statesmanjournal.com or 503-399-6779. Follow her on Twitter at@Tracy_Loew

statesman journal

NEWS

Overflow crowd urges Benton County to reject Coffin Butte Landfill expansion



Tracy Loew
Salem Statesman Journal

Updated May 7, 2025, 2:41 p.m. PT

An overflow crowd turned out May 6 for the third night of public meetings on a proposed expansion of Coffin Butte Landfill.

Phoenix-based Republic Services has asked the county for a conditional use permit that will allow it to expand the 178-acre landfill, located north of Corvallis.

In a staff report, county officials recommended denying the application, citing noise and odor impacts.

The meeting was the first time the public had the chance to speak in person on the proposal, following presentations from county staff and Republic Services. Hundreds of people also have submitted written testimony, totaling more than 2,800 pages, the majority in opposition to the expansion.

More than 70 people signed up to speak on May 6. Most urged the Benton County Planning Commission to reject the expansion.

Opponents cited concerns about increased traffic, noise, odors and air pollution, potential landfill fires, documented methane exceedances, recent citations for worker health and safety violations, impacts to groundwater and more.

Several speakers noted Republic Services is not complying with existing federal, state and county regulations, citing an ongoing U.S. Environmental Protection Agency investigation into methane releases, Oregon OSHA citations for worker safety violations, and the fact that Benton County has not enforced previous conditions it has set on the

landfill, according to a county task force report.

“I don’t believe that Republic Services has really performed to the standards of our community,” said Shelley Su of Corvallis.

Debbie Palmer, who lives near the landfill, pointed out that, unlike most Oregon counties, Benton County does not have a waste management plan.

“It’s absurd to expand this landfill before having a plan,” Palmer said. “It’s our future, not Republic’s that’s important here.”

Three people spoke in favor of the expansion. All accused opponents of having a “not in my backyard” mindset.

“Oregon’s landfills are renowned for their advanced waste handling methods,” said Zachary Dahl, of Dahl Disposal in Toledo.

Coffin Butte Landfill accepts about a third of the Mid-Willamette Valley’s garbage. Marion County is its biggest customer.

Expansion proposal scaled down after denial

The expansion attempt comes more than two years after the Benton County Planning Commission unanimously denied a previous request for a conditional use permit, following public testimony in opposition. Among the concerns were plans to close an access road and impacts on those who live nearby.

The planned expansion is now 50% smaller than proposed in 2021 and would be on land owned by Coffin Butte and zoned for a landfill, according to the company.

It would add six years of life to the landfill, about half of what the company requested in 2021. And it would improve, rather than close Coffin Butte Road. The road has been a point of contention with neighbors, who say the road is their only escape route in the event of a fire or other natural disaster.

What’s next for Coffin Butte Landfill’s expansion application

The planning commission ended its May 6 meeting with more than 30 people still signed

up waiting to speak. As a result, the commission has scheduled another meeting beginning at 6 p.m. on May 8 to hear from those people. No one else will be allowed to sign up.

The planning commission is scheduled to deliberate and make a decision on the application at a public meeting starting at 6 p.m. on June 17.

Both meetings will be held at the county's Kalapuya Building, at 4500 SW Research Way in Corvallis.

If the planning commission denies the proposal, an appeal would go to the county Board of Commissioners, which also would hold a public hearing before making a decision. The county expects that to happen by Aug. 11.

Tracy Loew covers the environment at the Statesman Journal. Send comments, questions and tips:tloew@statesmanjournal.com or 503-399-6779. Follow her on Twitter at@Tracy_Loew

From:	Ken Eklund
To:	Benton Public Comment
Subject:	I oppose LU-24-027: reference articles and opinions in the press - 11 of 12
Date:	Thursday, May 8, 2025 2:40:09 PM
Attachments:	writerguy-cube2.png 21 Landfills in Washington and Oregon leaked "explosive" levels of methane last year Grist 1.pdf

CAUTION: This email originated from outside of the organization. Do not click links or open attachments unless you recognize the sender and know the content is safe.

This is the first part of a Grist article on the Coffin Butte dump that is too big to email in one piece. – K



Ken Eklund, writerguy

37340 Moss Rock Dr
Corvallis OR 97330
408.623.8372

Creator of
World Without Oil
Ed Zed Omega
FutureCoast
and other storymaking games

Landfills in Washington and Oregon leaked ‘explosive’ levels of methane last year

EPA inspection reports find methane exceedances are more common than operators say.



The King County Cedar Hills Regional Landfill near Seattle, where three readings during an EPA inspection showed methane concentrations above federal limits. ***Wolfgang Kaehler / LightRocket via Getty Images***



Joseph Winters
Staff Writer

Published	Oct 26, 2023
Topic	Climate + Accountability
Share/Republish	

Application error: a client-side exception has occurred (see the browser console for more information)

Landfills in Oregon and Washington repeatedly exceeded federal standards for methane emissions last year, according to documents obtained by an environmental group.

Although the Clean Air Act requires that large landfills operators keep methane concentrations below 500 parts per million, Environmental Protection Agency inspection reports from May and June 2022 show that this threshold was exceeded in dozens of readings taken at four landfills in Oregon and Washington. At one landfill near Corvallis, Oregon, there were so many exceedances that an inspector ran out of flags to mark them with. At another, the inspector's measuring instruments maxed out, indicating what he described as "explosive" concentrations of methane.

Reader support makes our work possible. Donate today to keep our site free. All donations DOUBLED!

ONE TIME | **MONTHLY**

$10 | $15 | OTHER | Donate

Katherine Blauvelt, circular economy campaign director for the environmental group Industrious Labs, which obtained the documents through public records requests, said the reports highlight the need for better monitoring and mitigation of landfill methane emissions nationwide. These kinds of methane leaks are likely happening across the country, she said, much more frequently than the public knows, and regulators aren't using the best tools to stop them.

"Everyone's operating under the Windows 2000 system, and it's time for an upgrade," she said. "We've got to do better, because we're in a climate emergency and methane is a super-pollutant."

To support our nonprofit environmental journalism, please consider disabling your ad-blocker to allow ads on Grist. Here's How ➞

Methane, a greenhouse gas 84 times more powerful than carbon dioxide over its first 20 years in the atmosphere, is released from landfills by decomposing organic material like food scraps,

cardboard, and yard trimmings. Already, EPA data pins landfills as the country's third-largest source of anthropogenic methane emissions after oil and gas infrastructure and animal agriculture, and in many states — including all three on the West Coast — landfills account for 80 percent or more of all industrial methane emissions.

Large landfill operators can't stop organic matter from releasing methane as it decomposes. But they are required by law to conduct quarterly monitoring of their facilities and prevent that methane from escaping into the atmosphere — in part due to safety concerns, since methane is highly combustible. When landfill operators find places where methane concentrations exceed 500 parts per million, they're supposed to report it — usually to their state's environmental authority — and take measures to bring that concentration down. These measures can include improving the covers that landfills are required to have — which often include tarps — or installing gas capture systems that transport the methane to a flare or a treatment center, where it can be used to generate electricity or converted into vehicle fuel.





A gas capture system at the King County Cedar Hills Regional Landfill near Seattle. ***Wolfgang Kaehler / LightRocket via Getty Images***

Sometimes, federal inspectors from the EPA visit to take their own measurements. They walk a loop around the landfill and take periodic measurements with a tool called a "toxic vapor analyzer." At minimum, they have to take measurements every 100 feet, but they also take measurements in places where they see potential signs of a methane buildup — for example, where air pressure appears to be lifting up a section of the landfill cover, or at a hole in the cover.

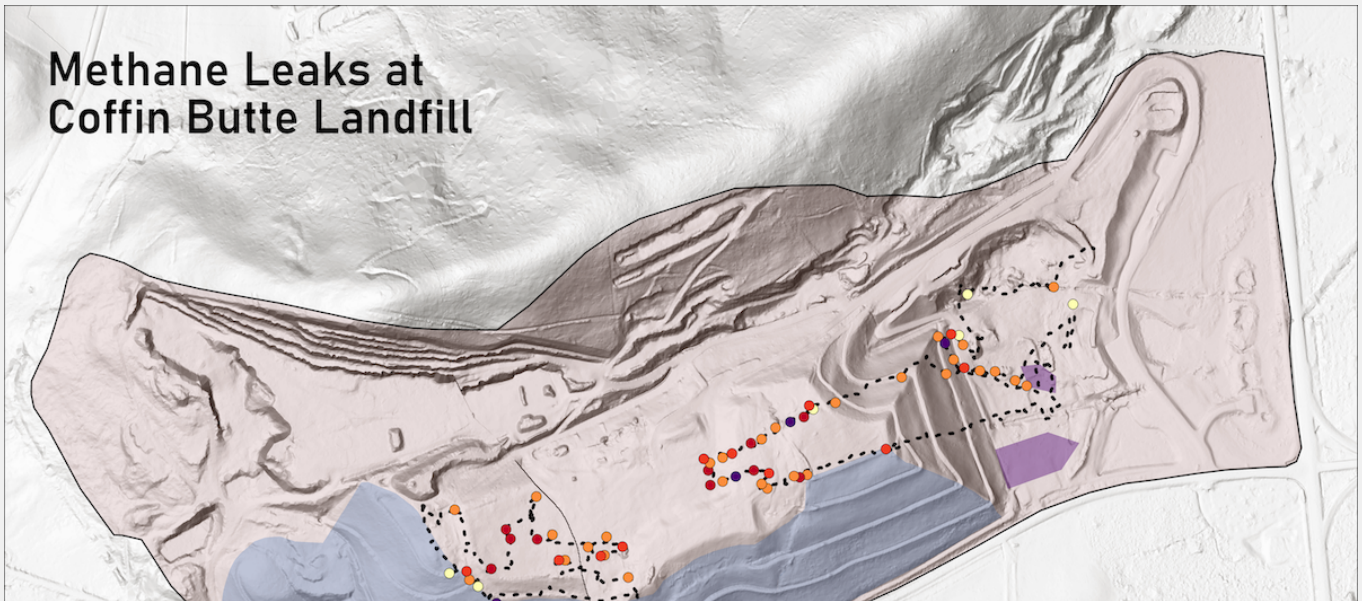
These measurements from the EPA don't always match up with the landfill operators' self-surveys.

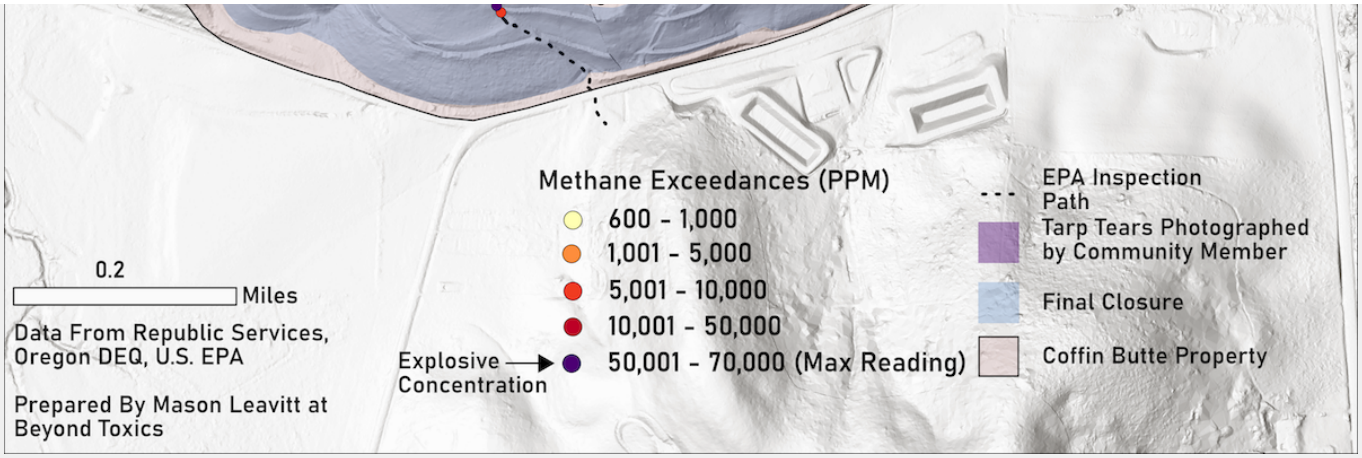
To support our nonprofit environmental journalism, please consider disabling your ad-blocker to allow ads on Grist. Here's How ➞

For example, according to the EPA inspection reports seen by Grist, the company Republic Services found zero methane exceedances over five years of quarterly monitoring of its regional

landfill in Roosevelt, Washington, and between zero and six exceedances in recent quarterly surveys of its Coffin Butte landfill near Corvallis, Oregon. But when the EPA visited these landfills in June 2022, an inspector documented 16 points of exceedance at the Roosevelt facility and more than 60 at the Corvallis one. More than two dozen locations across both landfills showed methane concentrations above 10,000 parts per million, more than 20 times higher than the Clean Air Act limit. At both landfills, the inspector noted visible signs of methane leakage, including areas of the landfill cover that were "inflated with and leaking out landfill gas."

This was also the case at a Graham, Washington, landfill operated by the company Waste Connections, where the EPA inspector logged 38 points of exceedance and noted an "environmental concern and a safety hazard" caused by explosive levels of gas leaking out of the landfill cover. Another landfill near Seattle, operated by King County, showed just three methane exceedances, although one location had a methane concentration of 9,000 parts per million.





Methane leaks at Coffin Butte Landfill near Corvallis, Oregon. ***Courtesy of Beyond Toxics***

In response to Grist's request for comment, Republic Services said it has "differing perspectives" on the EPA's testing protocols and analyses from its inspections in 2022, and that it has "addressed the EPA's observations" at both its Corvallis and Roosevelt facilities. King County said it made immediate repairs to the landfill cover to address the largest exceedance identified by the EPA, and that it "increased the frequency of synthetic cover inspections to identify any potential damage and repair it as soon as possible." Waste Connections did not respond to Grist's request for comment.

The EPA inspection reports appear to reflect the agency's broader difficulties with quantifying and limiting landfill-based methane emissions nationwide. According to a recent study submitted to the journal Atmospheric Chemistry and Physics that has not yet undergone peer review, methane emissions from landfills could be 77 percent higher than the values reported by U.S. operators to the EPA, and the EPA itself has said that "widespread noncompliance" with federal rules for landfill-based methane releases may have contributed to "potentially tens of thousands of tons of unlawful emissions of greenhouse gases and other