REPORT OF THE COUNCIL ON SCIENCE AND PUBLIC HEALTH

CSAPH Report 4 - A-07

Subject: Expansion of Hazardous Waste Landfills Over Aquifers (Resolution 416, A-06)

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Referred to: Reference Committee D (Elizabeth P. Kanof , MD, Chair)

Resolution 416, introduced by the Illinois Delegation at the 2006 Annual Meeting and referred to the Council on Science and Public Health, asks:

> That the American Medical Association (AMA) oppose new or the expansion of existing hazardous waste landfills over aquifers.

Current AMA policies on waste disposal focus on radioactive waste, biohazardous waste, or medical waste. There are currently no specific policies that focus on landfills, US water quality, or hazardous waste disposal standards.

This report examines the construction and placement of hazardous waste landfills, their impact on the public water supply, and potential health hazards as a result of contamination, and considers the implications should Resolution 416 (A-06) be adopted.

Methods

English-language articles were identified by a PubMed search from 1967 to January 2007 using the key words "landfill expansion," "hazardous waste," and "aquifers." Articles were selected based on information relating to the structure and composition of landfills, including their liner components and leachate collection systems. Additional articles were chosen to identify the quantity and type of aquifers in the United States, the effect of water contamination on the public water supply, and the potential impact of expanding existing landfills. Because of differences in definitions, regulations, and standards, for the purposes of this report only articles applying to the United States were included. In addition, the Web sites of the Environmental Protection Agency (EPA) and the United States Geological Survey were searched for resources on regulations and guidelines for disposal of hazardous waste, landfill placement and construction, and information on aquifers.

Hazardous Waste

Definitions. Hazardous waste is solid waste that has been identified as potentially harmful to human or environmental health.[1] Data from the 2005 National Biennial Resource Conservation and Recovery Act (RCRA) Hazardous Waste Report indicate that more than 43 million tons of hazardous waste are managed in the United States annually, with slightly more than 2 million tons

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deposited in landfills or surface impoundments.[2] The majority of hazardous waste (about 50%) is deposited in deep wells or through underground injection, and the remainder is treated, stabilized, or otherwise recovered in some way, including through aqueous organic treatment, solvent recovery, and incineration. In March 2007, the EPA proposed a revision to the definition of solid waste that would make recycling hazardous secondary material more feasible. Public comment on this proposed revision continues through May.[3]

Although the portion of waste deposited in landfills or surface impoundments comprises only 4.5% of the hazardous waste total, the impact on public and environmental health could be severe, depending on landfill placement. Of primary concern is the effect on public water supplies of failing landfills that leak contaminants into or around the aquifers located below.

To be classified as hazardous, the waste must first be identified as solid. In this case, the term "solid" is not based on the physical form of the material, but rather on the fact that the material is regarded as a waste. As a result, the EPA definition of "solid" includes sludges as well as semisolids, liquids, or gaseous materials (although liquid waste may not be placed in a hazardous waste landfill).[4] Solid waste is hazardous if it falls into 1 of the 4 hazardous waste lists known as the F-list, K-list, P-list, or U-list. The F-list comprises nonspecific source wastes, such as byproducts from manufacturing or industrial processes. This may also include cleaning solvents or supplies that have come in contact with hazardous material. Wastes that are source-specific are placed on the K-list; the P-list and U-list contain discarded commercial chemical products. Wastes also are considered hazardous if they exhibit at least 1 of 4 characteristics: ignitability, corrosivity, reactivity, or toxicity.

The EPA's definitions are as follows[1]:

- <u>Ignitability</u> – Ignitable wastes can create fires under certain conditions, are spontaneously combustible, or have a flash point less than 60 °C (140 °F). Examples include waste oils and used solvents.
- <u>Corrosivity</u> – Corrosive wastes are acids or bases (pH less than or equal to 2, or greater than or equal to 12.5) that are capable of corroding metal containers, such as storage tanks, drums, and barrels. Battery acid is an example.
- <u>Reactivity</u> – Reactive wastes are unstable under "normal" conditions. They can cause explosions, toxic fumes, gases, or vapors when heated, compressed, or mixed with water. Examples include lithium-sulfur batteries and explosives.
- <u>Toxicity</u> – Toxic wastes are harmful or fatal when ingested or absorbed (eg, containing mercury, lead, etc.). When toxic wastes are land disposed, contaminated liquid may leach from the waste and pollute ground water. Toxicity is defined through a laboratory procedure called the Toxicity Characteristic Leaching Procedure (TCLP). TLCP helps identify wastes likely to leach concentrations of contaminants that may be harmful to human health or the environment.

<u>Landfills</u>. All waste, hazardous and nonhazardous, is regulated by the RCRA, which was enacted in 1976.[3] The EPA was charged with creating regulations to implement the RCRA standards, and it oversees the entire waste management system. Specifically, the RCRA established standards for location, design construction, and operation of all hazardous waste landfills. Amendments to the RCRA standards in 1984 created further treatment regulations for hazardous waste intended for landfills. These regulations increased the treatment processes that are required before waste is

deposited, but did not change disposal standards.[4]

In addition to meeting the RCRA standards, hazardous waste landfills must also meet any state standards, which may be stricter than federal standards. Through the "State Authorization Process," the EPA designates implementation of the RCRA hazardous waste program to individual states. In addition to the RCRA standards, the Land Disposal Restriction (LDR) program, also administered by the EPA, outlines treatment procedures for hazardous wastes before they are deposited in landfills or other repositories.[5] Any waste deposited in these land facilities must meet certain criteria as established in the LDR program. States may not allow requirements that are less stringent than those in the RCRA. For tracking purposes, all waste is assigned a federal code. As states may further regulate the storage and disposal of hazardous waste, waste may also be given a state code.[2]

By EPA definition, "[l]landfills are excavated or engineered sites where non-liquid hazardous waste is deposited for final disposal and covered…units are non-liquid and designed to minimize the chance of release of hazardous waste into the environment."[6] Design standards for hazardous waste landfills require a double liner, and double leachate collection and removal systems (LCRS); a leak detection system; run on, runoff, and wind dispersal controls; and a construction-quality assurance (CQA) program. The hydrogeologic setting of the landfill is also a component of the landfill system, and is evaluated prior to site selection.[6,7] Operators must comply with inspection, monitoring, and release response requirements. Because landfills are permanent disposal sites and are closed with waste in place, closure and post-closure care requirements include installing and maintaining a final cover, continuing operation of the LCRS until leachate is no longer detected, maintaining and monitoring the leak detection system, maintaining ground water monitoring, and preventing storm water run on and runoff.

While landfills designed for nonhazardous waste may contain a single or double layer liner design, hazardous waste landfills must contain double liners. Liners may be either a compressed soil (usually clay); plastic (high density polyethylene [HDPE] is standard); or a composite material, usually a plastic and composite clay material combined. Plastic liners are also sometimes referred to as geomembranes or as flexible membrane liners (FML). The majority of liners used in hazardous waste landfills are a composite dual liner design. Other filtering layers in addition to the liners may be present in landfill construction. These include geotextiles, which are used to filter soil and other small particles out of leachate collection layers and which also serve to protect the geomembrane layers from puncture. A geonet is sometimes used instead of sand or gravel to collect leachate.[8] Leachate is water that has been tainted with hazardous materials from a landfill. Leachate collection systems are installed between the liners of hazardous waste landfills and also beneath the landfill to collect leachate for treatment and disposal. Leachate collection systems are designed to capture any leaking materials from the landfills before they reach the groundwater supply or other aquifer source.

Liners and their protection systems have a limited lifetime, and according to one estimate, may crack or leak after as little as a few decades, depending on environmental conditions and on the waste contained within the system.[9] Generally, it is accepted that landfills, and their components, will degrade and cease to be functional after a period of time. The EPA's position on landfill liner longevity has been summarized as follows:

> Eventually synthetic liners will degrade and leachate collection systems will cease operation… [N]o liner can be expected to remain impervious forever. As a result of

> interactions with waste, environmental effects, installation problems, and operating practices, liners eventually may degrade, tear, or crack and allow liquids to migrate out of the unit…. [T]hese technologies (double liners and leachate collection systems) may not effectively reduce the longer-term risk for landfills, especially for persistent and mobile compounds, because the containment system may only delay leachate release from the landfill until after post-closure, when the cap and leachate collection system begin to fail. [10]

Risk Assessment

Risk assessment modeling has been used to assess the probability of what, how, and when waste may leak from a landfill, usually attributed to liner failure. However, because there are numerous variables that require assumptions in these modeling exercises, the value of such studies is limited. As the authors of one study state: "…[liners'] aging characteristics … [have] not been examined in a way that would allow us to use such information in national policy modeling. There has been significant materials science research focusing on the chemistry of aging, stress, and bonding; but this is of limited use for developing national scale profiles of liner performance."[11] Additionally, historical data from studies may not be applicable because of landfill design differences and/or differences in the materials used for construction and monitoring.[12] Other factors such as the combinations of waste placed in the landfill can also affect leachate composition and degradation rate. Municipal solid waste and household hazardous waste may be co-dispersed. This combination of waste may produce leachate that contains byproducts of municipal or manufacturing processes, and may potentially mask the hazardous effects of household hazardous wastes that are placed in landfills. Biological and chemical transformations of waste fostered by interactions with plant-derived matter, anaerobic conditions, and cap placement all affect leachate transfer. The amount of dissolved organic carbon will also affect toxic metal mobility through the landfill liner. [13]

Leachate may contain volatile organic compounds (VOCs) that have adverse health effects and can escape landfills through geomembranes or the clay component.[14,15] There are many different VOCs, with different sources and effects on human and environmental health. In general, they are produced as gases from solid or liquid waste, and mostly contain aldehyde, hydrocarbon, and ketone derivatives, although there are exceptions. Benzene, trichloroethlyne, and styrene are examples. [16] Health effects include symptoms, such as nausea, dizziness, and headache, and increased rates of certain cancer types. Because rates of diffusion of VOCs through geomembranes, composite liners, and clay soils are unpredictable, consistent monitoring of leachate for these compounds is advised.[14]

Although toxic inorganic compounds also may be present in leachate, VOCs are more troubling because of their relative toxicity and diffusability. In the few studies that measured VOC concentrations in exposed populations, results were mixed. One study measured levels of 31 VOCs; statistically significant differences existed for only 1 compound, acetone. Some rates of VOCs were found to be higher in nonexposed vs. exposed populations.[15] Similar results have been observed for the effects of toxic heavy metals, such as arsenic, lead, chromium, beryllium, and mercury; the adverse health effects of high doses of these elements is well documented.[16,17]

In addition to the VOCs found in landfill leachate, other chemical compounds such as xenobiotic organic compounds (XOCs), or toxic heavy metals may exert adverse health effects. Toxic heavy metals include lead, mercury and cadmium, among others. Both XOCs and heavy metals can be classified as hazardous and can be toxic, carcinogenic, teratogenic or mutagenic in nature. At least 1000 distinct chemical compounds have been identified from various leachate samples, further emphasizing the variability in leachate composition and transport potential.[12]

Water Quality

Because the hydrogeologic setting of the landfill is a component of the landfill system, this factor is arguably more important when the hydrogeological setting is near or connected to an aquifer that supplies a public water system. The United States Geological Survey (USGS) identifies aquifers as "a water-bearing rock that readily transmits water to wells and springs." The EPA estimates that a majority of water withdrawn in the United States comes from ground water sources that are sourced by aquifers. Because large metropolitan areas are usually served by surface water sources, only approximately 44% of US residents receive their water from ground water sources. It is estimated that 10% to 20% of people have their own well that serves as their primary drinking water source.[17]

The geology of aquifer systems is complex and varied. The origin of the word is Latin, a combination of the roots "aqua" (water) and "ferre" (to bear or carry).[18] The USGS classifies the principal water-yielding aquifers of North America into 5 types: unconsolidated and semiconsolidated sand and gravel aquifers, sandstone aquifers, carbonate-rock aquifers, aquifers in interbedded sandstone and carbonate rocks, and aquifers in igneous and metamorphic rocks.[18] Aquifers can be contained or uncontained, isolated geologic formations, or connected to 1 or multiple geologic systems horizontally or vertically. Currently, 62 principal aquifers have been identified. An aquifer attains "principal" status if it is determined to be a "regionally extensive aquifer or aquifer system that has the potential to be used as a source of potable water."[17]

Several water monitoring systems surround hazardous waste landfills. Sites are required, at a minimum, to report constituent releases into the uppermost aquifer quarterly, and to follow up any detection with further investigation. Concentrations of constituent releases into the groundwater must be compared to the Clean Water Act maximum contaminant levels (MCLs).[19] Additionally, the Safe Water Drinking Act sets requirements for monitoring public water systems, and requires an annual report of both source and water quality for each water system.[20] In November 2006 the EPA also issued its final Ground Water Rule, although this will predominantly monitor ground water supplies for viral and bacterial contamination. This rule became effective on January 8, 2007. Of note, the rule advocates that states specifically monitor what the state identifies as "high risk" sites: aquifers with restricted geographic extent, such as barrier island sand aquifers; sensitive aquifers (eg, karst, fractured bedrock, and gravel); shallow unconfined aquifers; and aquifers with thin or absent soil cover. These sites may be more susceptible to viral and bacterial contamination. The rule does not address monitoring of chemical levels for these sites.[21]

Contamination Data and Adverse Health Effects

Probably the most extensive and well known incident of waste degradation and contamination occurred in the Love Canal neighborhood of Niagara Falls, NY. Used as a chemical waste site from the 1920s through the early 1950s, the area was eventually developed into a residential community, complete with schools and homes. In the late 1970s, the Love Canal homeowners association launched an investigation because of strange odors and adverse health effects. Due to national media attention and pressure, the Love Canal neighborhood was declared a federal disaster area, and families were relocated. Love Canal residents subsequently discovered they had a higher prevalence of chromosomal abnormalities, which could result in an increased incidence of cancer and reproductive problems. Indeed, long-term studies of Love Canal residents confirmed increased rates of some cancers (leukemia, lymphoma, lung) and low birth weight, prematurity, and some birth defects (cardiovascular, nervous system, muskoskeletal). However, a direct cause-effect relationship between toxic exposure and health outcomes was not conclusive in all studies.[22,23] Inconsistencies were apparent in the rates of specific cancers between exposed and non-exposed populations in all age groups. However, one study did confirm a higher rate of low birth weight and birth defects in the exposed population compared to control populations.[24]

Other studies of health effects in potentially exposed populations have produced results similar to those at Love Canal.[25, 26] A review of 68 studies identified several that reported an increase in self-reported health problems, such as headaches, gastrointestinal problems, sleepiness, and respiratory problems, associated with residence near waste sites and concluded that: "…increases in the 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."[27] Additionally, public knowledge of possible contamination can lead to adverse mental health effects that impact health and well-being.

Summary and Conclusion

There are several categories of hazardous waste and a broad definition of the term aquifer, and it is likely that many hazardous waste landfills are above or near aquifers. Although hazardous waste sites have complex collection and monitoring systems, leakage of leachate from these systems is probable in the long term. The concentration of VOCs, inorganic compounds or heavy metals, or hazardous waste that may potentially be leaked from these sites is difficult to predict. Although the toxicity of these contaminants is recognized, because of confounding factors and problems with study design a direct causal link between contaminants found in leachate and specific adverse health outcomes is not always clear. However, some studies have shown increased prevalence in diseases or conditions in exposed populations that are at least somewhat explained by their proximity to a hazardous waste disposal site.

RECOMMENDATIONS

The Council on Science and Public Health recommends that the following statement be adopted in lieu of Resolution 416 (A-06) and that the remainder of the report be filed:

That our American Medical Association:

1. Recognize that the expansion of hazardous waste landfills or the construction of new hazardous waste landfills over principal aquifers represents a potential health risk for the public water supply, is inconsistent with sound principles of public health policy, and therefore should be opposed. (New HOD Policy)

2. Advocate for the continued monitoring of groundwater sources, including principal aquifers, that may be contaminated by hazardous waste landfill or other landfill leachate. (Directive to Take Action)

3. Support efforts to improve hazardous waste treatment, recycling, and disposal methods in order to reduce the public health burden. (Directive to Take Action)

Fiscal Note: Staff costs estimated at less than $500 to implement.

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