

APPENDIX

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- ATSDR. Landfill Gas—Fact Sheet
- Connecticut Department of Public Health. Fact Sheet: Municipal Waste Landfill Gases
- Missouri Department of Natural Resources. Landfill Gas Facts
- Connecticut Departments of Public Health and Environmental Protection, the Danbury and Bethel Health Departments, and the Bethel Citizens Coalition. Danbury Landfill Update
- Connecticut Department of Public Health. Fact Sheet: Reproductive Health and the Danbury Landfill
- Connecticut Department of Public Health. Draft Response Plan for Elevated H₂S Levels
- Missouri Department of Natural Resources. Design and Construction of Landfill Gas Monitoring Wells
- Missouri Department of Natural Resources. Procedures for Sampling Landfill Gas Inside Buildings
- Missouri Department of Natural Resources. Sampling of Landfill Gas Monitoring Wells



Landfill Gas—Fact Sheet

Municipal solid waste (MSW) landfills emit gas that may reach surrounding neighborhoods. This fact sheet contains general information about the sources of landfill gas, where it goes, and the possible health and safety concerns that may be associated with it.

Where does landfill gas come from?

Bacterial activity causes the wastes in landfills to decompose over time. As these wastes decompose, gas is produced. The amount of gas created varies and depends on factors such as: the amount and type of waste; moisture content of the landfill; amount of oxygen present; landfill size and characteristics; and temperature. Also, certain chemical reactions and the evaporation of some chemicals produce landfill gas.

Most landfill gas is created within a few years after waste is dumped, when the rate of decomposition is highest. Almost all gas is produced within 20 years after waste is dumped.

Where does landfill gas go?

Gas is created under the landfill surface and generally moves away from the landfill, either by rising up through the landfill surface or migrating underground to surrounding areas.

Three factors influence where gas goes:

- (1) Permeability. Gas flows through areas of least resistance. If one side of the landfill is very permeable, then gas will likely leave the landfill from that area. Artificial channels such as drains and trenches can act as pipelines for gas movement.
- (2) Diffusion. Gas moves to areas with lower gas concentrations. Gas concentrations are generally lower in areas surrounding the landfill.
- (3) Pressure. Gas moves to areas of lower pressure. This means that the pressure of the surrounding areas (e.g., changing weather conditions) will affect gas movement from the landfill.

Gas that is released into the air is carried by wind. While wind dilutes the gas with fresh air, it can also move gas into neighboring communities. Wind speed and direction determine how much gas reaches nearby residents, so the degree of the problem varies greatly from day to day. At locations near the landfill, the worst time of the day is often early morning because winds tend to be gentle, providing the least dilution of the gas.

What types of gas are produced?

Landfill gas is typically about 50% methane and 50% carbon dioxide, and less than 1% sulfides (e.g., hydrogen sulfide, dimethyl sulfide, mercaptans) and non-methane organic compounds (NMOCs) (e.g., trichloroethylene, benzene, and vinyl chloride). The amount of sulfides and NMOCs varies from landfill to landfill and depends on whether the landfill receives wastes containing these chemicals and whether chemical reactions are occurring which create or remove them.

What causes the odor?

Sulfides are the source of the "rotting" smell often noticed near landfills and can cause this unpleasant odor even at very low concentrations. Some NMOCs also have recognizable odors. Methane and carbon dioxide are odorless. Odors can be destroyed by collecting and flaring the landfill gas or by venting it through special filters. Also, certain chemicals can be used to mask landfill gas odors.

In addition to landfill gas, there are three other common sources of landfill odor:

- New waste being dumped
- Special wastes with strong odors such as manures and fermented grains
- Leachate (liquid within the landfill) coming to the surface

Odors from the dumping of new and special wastes do not tend to last long and are usually not noticeable beyond a few hundred feet of the dump site.

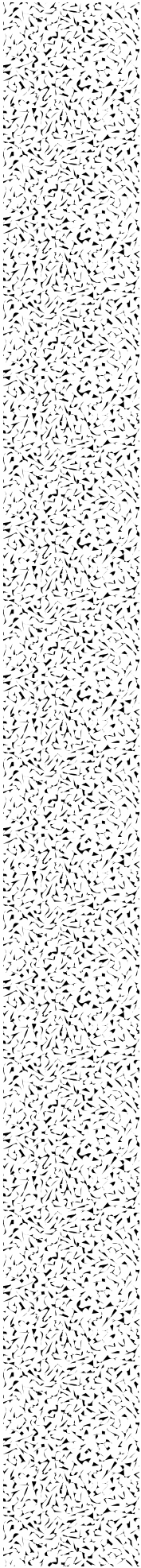
Note: Although certain types of gas cause odors, odor is not a good indicator of whether gas is present in surrounding areas because: (1) many gases do not have strong or distinctive odors, and (2) people get used to odors quickly so that they stop noticing them. Periodic monitoring is necessary to determine the nature and extent of landfill gas emissions.

What health and safety hazards are associated with landfill gas?

Health Concerns. Landfill gas generally represents more of an odor nuisance than a community health hazard; however, there are some potential health concerns you should be aware of: Some people may experience slight nausea or headache when they smell a bad odor. Although this is highly undesirable, the effects usually reverse when the odor goes away and do not require medical attention.

There is some concern that hydrogen sulfide might precipitate asthmatic attacks in highly sensitive people. However, a controlled study of asthmatics found that exposure to levels of hydrogen sulfide higher than those found at most landfills did not trigger an asthmatic attack or alter respiratory function.

Certain NMOCs are known carcinogens (e.g., vinyl chloride, benzene, and chloroform), and some NMOCs may have adverse effects on organ systems such as the kidney, liver, pulmonary, reproductive, and central nervous systems. However, the levels of NMOCs likely to reach surrounding communities are far below levels known to cause any ill effects. In most cases, landfills do not emit enough NMOCs to increase their concentration above the background levels commonly found in the community. Current research efforts are looking into the potential cumulative effects of being exposed to low levels of the types of NMOCs emitted from landfills.



Methane Gas Explosions. The accumulation of methane gas in structures both within and beyond the landfill (e.g., basements, crawl spaces, utility ducts) has resulted in explosions and fires which have caused personal injury and death. Accumulation is often the result of underground gas migration. EPA regulations require large landfills to monitor and control methane emissions.

How Can Explosion Risks and Odors be Reduced?

Passive vents and active gas pumping systems can be used to control the migration of methane gas. Passive systems use natural pressure gradients and trenches or pipes to vent landfill gas to the atmosphere. These vents can be equipped with flares to burn off gas (Note: this control can also be used to destroy odorous gases). If there is a high risk of methane accumulating in nearby structures, active gas collection systems are used to literally pump gas out of the landfill and recover it. A growing trend at landfills across the country is to use the recovered methane gas as an energy source. Collecting methane gas for energy use greatly reduces the risk of explosions, provides financial benefits for the community, and conserves other energy resources.

Connecticut Department of Public Health
****** FACT SHEET ******
MUNICIPAL WASTE LANDFILL GASES

Introduction: Where Do Landfill Gases Come From?

Gases released from municipal waste landfills have the potential to cause odors in neighborhoods surrounding the landfill. The household and commercial wastes brought to landfills decompose over time largely through the action of bacteria. This process produces odorous gases, the amount formed depends upon a variety of factors: nature and moisture content of the waste, amount of oxygen present, and temperature inside the landfill. Less odorous gases can also be generated at landfills due to chemical reactions and due to the evaporation of chemicals put into the landfill. Any gases generated tend to rise through the landfill and reach the air above, although the rate at which this occurs is affected by landfill content and by the weather. The amount of gases emitted will vary from landfill to landfill and will be different for a single landfill at different times (e.g., due to changing weather, changing landfill content).

Once emitted into the air, landfill gases are carried on surface level winds. While this dilutes the gases with fresh air, it can also move them into the community. Naturally, wind speed and direction determine whether local residents will notice landfill odors so that the degree of the problem will vary greatly from day to day. At locations near the landfill, the worst time of the day may be early morning. This is when winds tend to be most gentle, providing the least dilution of the gas. Additionally, this early morning effect is usually greatest in fall and spring.

What is Present in Municipal Waste Landfill Gases?

Methane and carbon dioxide are the major gases produced by the bacterial decay of landfill wastes (USEPA, 1991). Methane present underground is flammable, but it is not associated with odors or hazards once emitted into the air above the landfill. Other gases produced by landfill bacteria are termed reduced sulfur gases or sulfides (e.g., hydrogen sulfide, dimethyl sulfide, mercaptans). These odorous gases give the landfill gas mixture its characteristic "rotting" smell.

Other chemicals can also be present in landfill gases, although their levels are typically very small compared to the levels of methane, carbon dioxide, and sulfides (USEPA, 1991; ERL, 1995). Many different volatile organic chemicals (VOCs) have been found in landfill gases with the amounts varying from landfill to landfill depending upon whether the landfill received wastes containing these chemicals. Also, the amounts of VOCs in landfills depends upon whether chemical reactions are occurring which either remove or create them.

What Health Effects Can Landfill Gases Cause in People Living Nearby?

Sulfides can cause unpleasant odors even at very low concentrations. These concentrations are well below the level needed to produce toxicity (Shusterman, 1992).

This means that landfill odors represent more of a public nuisance than a community health hazard, with the odors not being a good indicator of whether other chemicals are present. However, for some people, simply smelling an unpleasant odor can be sufficient to create an adverse physiological response (nausea, headache, etc.). Although this situation is highly undesirable, the effects usually reverse when the odor dissipates and do not require medical attention. While there is some concern that odors might precipitate an asthmatic attack in highly sensitive people, a controlled study of asthmatics found that exposure to a high level of hydrogen sulfide (2 parts per million - ppm) did not trigger an asthmatic attack or alter respiratory function (Jappinen, 1990).

Other VOCs that might be present in landfill gas are less odorous than sulfides, and the levels that might reach surrounding homes are generally far below that which is known to cause ill effects (USEPA, 1991; ERL, 1995; CTDPH, 1996). In most cases landfills do not emit enough of these VOCs to increase their concentration above the background levels commonly found in the community. Gasoline, household products (e.g., glues, paints), and other sources in the community are usually more significant sources of these VOCs than are landfills. While this is typically the case, it should be noted that the amounts of these VOCs can vary from one landfill to the next depending upon what historically was disposed of in the landfill. At Connecticut landfills where odors have been a concern, air sampling has shown VOC levels to be minimal (CTDEPAir Management Bureau Data).

In summary, this is general information and each landfill needs to be considered separately since they differ widely in composition. While landfill gases are not usually a significant public health hazard, the odors may, at times, be unpleasant and produce discomfort and temporary symptoms. Measures to capture landfill gases and prevent their migration to the community are warranted where odors create a persistent nuisance.

Where Can I Get More Information?

You can contact your local health director to find out more about the landfill in your town. The Connecticut Department of Public Health can be called to discuss the health aspects of landfill gases (860-509-7742), while the Connecticut Department of Environmental Protection Bureau of Waste Management (860-424-3366) can be contacted to discuss landfill testing and management.

Key Sources Used to Develop Factsheet

CTDPH (1996) Health Consultation: Hartford Landfill, Review of Air Emissions Data.

Jappinen, P., et al. (1990) Exposure to hydrogen sulfide and respiratory function.

British Journal of Industrial Medicine, pgs 824-828.

USEPA (1991) Air Emissions from Municipal Solid Waste Landfills - Background Information for Proposed Standards and Guidelines. EPA-450/3-90-011a.

Environmental Risk Limited (1995) Evaluation of Air Emissions at the Hartford Landfill.

ERL Project No. 4100003346.

Shusterman, D. (1992) Critical review: the health significance of environmental odor pollution. Arch. Env. Health 47: 76-87, 1992.

Missouri Department of Natural Resources

Landfill Gas Facts

What is Landfill Gas?

Landfill gas is generated during the decomposition of trash. The major gases generated in a landfill are methane and carbon dioxide. Nitrogen is produced, initially at high levels, then drops rapidly until it stabilizes at low levels.

Additional gases, called trace gases, are produced in much smaller amounts. Hydrogen sulfide is a trace gas that gives landfill gas its characteristic odor. Other trace gases may also be produced, depending on the composition of the waste.

Does Landfill Gas Pose an Immediate Threat?

Methane gas is the constituent of concern in landfill gas. It is a by-product of landfill decomposition and is colorless and odorless. Methane is highly explosive at certain concentrations in air (between 5% and 15% of the total air volume). Methane can become dangerous when it migrates into confined spaces in these concentrations. Confined spaces can range from trenches or holes in the soil to buildings and structures. Additionally, higher concentrations of methane in confined spaces can displace the oxygen and may lead to suffocation.

How Do I Protect Myself From Methane Gas?

An individual can take a number of steps in order to minimize the risk associated with gases migrating from a landfill.

- Step 1:* Properly ventilate all confined spaces. Some examples are removing some of the skirting from around a mobile home or opening basement and garage windows.
- Step 2:* Remove all potential ignition sources (portable heaters, open flames, etc.) in confined spaces which cannot be properly ventilated.
- Step 3:* Install a methane gas detector with an alarm set at or close to 1% methane gas by volume [20% of the Lower Explosive Limit (LEL)] in buildings or structures.



Information Sources

For more information contact these agencies:

Missouri Department of Natural Resources
Solid Waste Management Program
P.O. Box 176
Jefferson City, Missouri 65102
Phone: (573) 751-5401

Missouri Department of Natural Resources
Environmental Services Program/
Environmental Emergency Response
P.O. Box 176
Jefferson City, Missouri 65102
Phone: (573) 526-3315
Emergency: (573) 634-2436

U.S. Environmental Protection Agency
Region VII Office
726 Minnesota Avenue
Kansas City, Kansas 66101
Phone: (913) 236-3884

You can also contact your local fire department or Emergency Planning Commission.

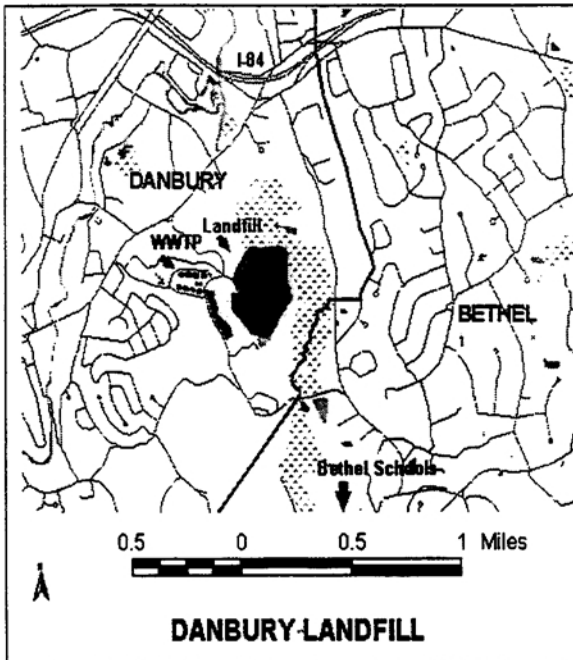


Danbury Landfill Update



February 1997

A Joint Newsletter of the CT Departments of Public Health and Environmental Protection, the Danbury and Bethel Health Departments and the Bethel Citizens Coalition. The articles represent the perspective of the contributing organizations.



We have received hundreds of calls about the situation.

This newsletter has been produced to provide you with information concerning the on-going investigation and activities to eliminate the odor. It is a product of a collective effort involving the Department of Public Health (DPH), the Department of Environmental Protection (DEP), Danbury, Bethel and the newly formed Bethel citizen's coalition. This first issue includes an overview of recent developments and responds to the major health and environmental issues raised by residents.

Bethel Health Department has taken a pro-active stance and has actively sought the participation of the Commissioner of the DEP, the Commissioner of Health, Governor Rowland, our Congressmen, State Representatives and the residents of the Town of Bethel to help resolve the odor problem.

The DEP is charged with the regulatory authority under the State of Connecticut general statutes to regulate landfills for air quality and solid waste issues. The DPH is responsible to assist with public health issues related to the odor. This odor problem is not an environmental health problem directly under the control of either the Bethel Health Department or the Board of Selectmen for the Town of Bethel. Our role has been to coordinate activities with the city of Danbury and the various state agencies to bring this matter to an end. Both municipalities are obviously interested in a solution to this odor problem.

Introduction from the Bethel Health Department

*Laura Vasile, Bethel Health Director
Charles Steck, Bethel 1st Selectman*

Since approximately August 1996, the Town of Bethel has been grappling with a serious odor problem originating from the Danbury landfill. The Bethel areas which appear to be affected the most are Shelter Rock, Payne Road, Castle Hill, Meckauer Circle, Brookview Court, Chimney Heights and the school complex. Some days the odor permeates an even larger portion of the town.

Due to concern for their children's health at home and at school, residents requested a public meeting be held to address the odor. The first public information meeting was held at Bethel High School on December 12, 1996. Residents spoke of short term ill health effects they were experiencing when the odor was present in their homes and on their property. They also voiced concerns about the odor in the school buildings, and asked specific questions of state environmental and health specialists and Danbury officials.

On December 17, 1997, the DEP and DPH came to a Bethel Citizen's meeting at the Bethel Municipal Center to address issues raised by Bethel and Danbury residents at the first public informational meeting. At that time, DEP technical specialists from the Water, Waste and Air Bureaus each took time to set forth a strategy to address residents requests. Groundwater sampling was requested to assure there was no contamination of the water within the vicinity of the landfill. Four wells have been tested and results are pending. Residents took a tour of the Danbury sewage treatment plant and Danbury has offered this to any other interested groups. The DEP has requested that Danbury speed up the process for installation of the gas recovery system at the landfill and requested installation of a temporary system to begin burning off the odor. This system should be in place by April 15, 1997. The DEP committed to conducting representative air sampling data of the odor as it exists in the community. Random samples will be conducted on private properties, in several homes and at the Bethel school complex. Air data is being made available to the public as it becomes available.

Bethel Health Department has been maintaining an odor registry since August, 1996. Many area residents still complain of itchy, watery eyes, scratchy throats, runny noses, headaches, stomach aches and an increase in asthma episodes, inhaler use,

sinusitis, ecetera. We are advising everyone with medical concerns to see their primary physician. The primary physician can refer you to a specialists in environmental medicine for further evaluation if necessary.

A third meeting was held on January 29, 1997 at the Bethel Municipal Center to discuss placement of a cap over the landfill and provide an update on the air monitoring sampling strategy. We encourage your active participation in future meetings. If you would like to participate and more actively monitor the odor resolution process we encourage you to contact the Bethel Citizen's Coalition.

Update from the Department of Environmental Protection (DEP)

Background Information

In 1993 the DEP informed Danbury officials that the landfill would require closure in accordance with Federal regulations. A consent order with the City of Danbury issued prior to the odor problem (12/19/95) required the following items:

- ◆ Stop receipt of waste by 12/ 31/96;
- ◆ Submit design of gas recovery system by 12/19/96;
- ◆ Complete the final cover and vegetation by 7/31/97; and
- ◆ Complete wetland mitigation and compensation actions by 10/1/97.

Closure Plan Requirements

- Requires the City of Danbury to cover the landfill with 18" of cover soil.
- Cover landfill with a synethic cap over the top 9 and 1/2 acres.
- Cover the entire landfill with an additional six inches of top soil and seeded.
- Install a gas recovery system.

Odor Controls

During November 1996 DEP requested the City of Danbury to expedite the covering of the landfill with 12" of cover soil and to

install a temporary gas recovery system before completion of final cover. This system will be operational by April, 1997.

Also during November, the City of Danbury began applying soil onto the landfill to mitigate odors at a rate of 1,000 cubic yards per day. As of January 26, 1997 approximately 77,500 cubic yards of final intermediate cover has been applied to the landfill by the City of Danbury.

In December 1996, DEP approved a request by the City of Danbury to apply lime to the landfill in an attempt to control odors.

On December 19, 1996, DEP received from the City of Danbury plans for the installation of the temporary and permanent gas recovery system. These plans were reviewed on Jan. 3rd with Danbury officials.

At a Jan. 30th meeting Danbury officials submitted a preliminary schedule which will result in eleven gas collection wells and a temporary flare operational by April 30, 1997. The permanent flare which will incorporate a scrubber system to remove sulfur will be operational by August 1, 1997. The DEP is drafting a Consent Order which will incorporate the above schedule and other interim dates regarding installation of the gas recovery system.

On February 3, 1997, the DEP issued an "Authorization for Disruption" which authorizes the City to perform the final grading of the landfill in preparation for the installation of the gas recovery system and flare, and the final landfill capping.

Water Sampling Activities

On Jan. 30, 1997, staff from the DEP and the Bethel Health Director conducted sampling of four homes, one of which is supplied by a system that services multiple homes. Target analytes are volatile organic compounds, metals and leachate parameters. Samples were split between the State Health

Department Lab and a private lab selected by Bethel Citizens Coalition. DEP will review the analysis with the Bethel Health Director.

Groundwater Monitoring Wells Adjacent to the Landfill

Groundwater wells are monitored on a quarterly basis by a Danbury consulting firm. At the request of the Bethel Citizens Coalition, during the next sampling event by Danbury's consultants, DEP will conduct split sampling analysis on selected groundwater monitoring wells at the landfill.

Leachate Collection System

Leachate is rainwater which passes thru the landfill and reaches groundwater if not collected. DEP has reviewed design of the leachate collection system and provided comments to the City of Danbury. DEP is awaiting response to those comments. The City has been made aware of the general permit process requirements.

Sewage Treatment Plant Tour

On December 20, 1996 the DEP conducted a two hour Danbury Sewage Treatment Plant tour with representatives from the Bethel Citizens Coalition, EPA Officials, Sewage Treatment Operators, Danbury Officials, and the Bethel Health Director. The tour consisted of a review of the sewage treatment plant operations including sludge process, odor controls, and computerization of the plant processes.

The Danbury Plant utilizes enclosed digesters to process sludge. Gases produced by this process are destroyed prior to being released to the air. Under certain weather conditions a water vapor cloud can be formed by the trickling filters. This cloud has not been identified as a source of odor.

Air Sampling Activities

DEP has been conducting field surveys using its recently acquired hydrogen sulfide

sampling equipment. Initial efforts included determining the operational capabilities of the equipment and establishing sampling procedures.

The equipment has been utilized to provide round-the-clock, multi-day sampling of the air at a private residence near the landfill in Bethel. This sampling included a period with strong odors. Results to date have shown that levels are below the World Health Organization community air guideline, but above nuisance odor levels.

The hydrogen sulfide sampling program will be continued and expanded by DEP in coordination with the Bethel Citizens Coalition. Various locations and conditions will be sampled on a 24 hour, multi-day basis to provide information to the state Health Department for their evaluation. In addition, DEP is preparing to conduct sampling for other volatile compounds which may be in the landfill gas.

Dept of Public Health Activities

The CT Department of Public Health, Division of Environmental Epidemiology and Occupational Health (EEOH) first became involved with the Danbury Landfill last fall at the request of the Danbury and Bethel Health Departments. Local health departments are the primary vehicle for resolving community odor or health complaints. The state health department becomes involved when additional expertise, information or general support are needed. We at EEOH recognize the problem the landfill has become for the community, especially for Bethel residents living nearest to the landfill and for the Bethel schools. The complaints received by the Bethel Health Director make it obvious that the odor is having an impact on the quality of life in these neighborhoods. **Hydrogen sulfide is the major odorant gas released at the landfill.**

One of the first efforts undertaken by EEOH was to map the complaints received by the Bethel Health Director. This information has been useful in focusing air monitoring now underway by DEP. EEOH has reviewed the air monitoring data collected to date, which includes data taken from the landfill proper, from the neighborhoods surrounding the landfill, and from the Bethel High School. The sampling results have been consistent in showing low or non-detectable hydrogen sulfide levels in the community. This takes into consideration DEP's recent sampling (1/31-2/4) from the yard of a Bethel resident near the landfill during a period with strong odors. DPH will continue reviewing sampling data as it is collected by DEP or other parties.

EEOH has reviewed the scientific literature related to hydrogen sulfide and landfill gases. The landfill gases fact sheet developed by EEOH summarized our review. This fact sheet has been widely distributed to residents of Bethel and Danbury. The major point is that the strong sulfur odor experienced in parts of Danbury and Bethel occurs at very low hydrogen sulfide levels. The odors, on their own, can be unpleasant and make people sick (e.g., nausea, headache). However, much higher levels than those so far found in Danbury or Bethel are required to cause toxic effects (irritant damage to eyes or respiratory tract). Hydrogen sulfide is not known to cause chronic effects such as cancer, and does not pose a risk to pregnant women or their offspring.

Sampling data so far collected suggests that other chemicals which might be present at landfills are not a concern in the air coming from the Danbury landfill. EEOH is working with DEP in developing an air sampling program that will better characterize community levels of hydrogen sulfide and other landfill-related chemicals.

As part of our role in assessing public health, we have contacted area physicians to find out if they have patients who feel the landfill may have affected their health.



***Area Physicians Discuss
Danbury Landfill***

***Dr. Edward Volpintesta
Chair, Primary Care Roundtable***

Our January 30th Primary Care Roundtable at Danbury Hospital focused upon odor and health issues associated with the Danbury Landfill. Presentations were made by Dr. Mary Lou Fleissner of the Connecticut Dept. of Public Health and by Dr. Michael Hodgson who is in Environmental and Occupational Medicine at the University of Connecticut. Approximately 25 of our area physicians attended; also in attendance was Representative James Maloney. Everyone agrees that the odor has created a major nuisance which at times might prompt symptoms in certain patients. However, the physicians were reassured that long-term health problems are unlikely given the large margin of safety between the levels so far measured in the community and the much higher levels of hydrogen sulfide required to cause toxic effects.

This meeting increased understanding of the issues, enabling physicians to better address the concerns of their patients. Working with patients whose health may be affected by the odors is important during this period where landfill odors still occur. Area physicians can consider patient referrals to occupational and environmental medicine specialists.



Bethel Citizens Coalition

Joanne Kirk

The Bethel Citizens Coalition (BCC) consists of Bethel residents (and nearby Danbury residents) who have been adversely affected by the unremitting emissions of hydrogen sulfide gases from the Danbury Landfill. BCC began to evolve as residents aggressively pursued local and state officials in search of answers. As residents made phone calls, wrote letters, sought out other vocal residents and shared information, the coalition began to solidify.

BCC is working with local and state officials in moving this environmental crisis toward a speedy and complete resolution. BCC's primary focus is to ensure that the capping and installation of the gas recovery system will be properly designed, executed and will operate effectively, thus affording the affected community with the highest level of safety and finality. To elaborate, the final cap (originally proposed to only cover the top ten acres) is intended to 1) minimize infiltration of precipitation into the landfill, 2) reduce erosion and infiltration of oxygen which can affect the gas collection wells, 3) minimize leachate generation, and 4) reduce the impacts of the landfill on groundwater quality. In consideration of the severity of the odor problem, BCC is primarily concerned with *complete closure*. It has been determined that a synthetic cap over the entire landfill will offer the additional level of protection needed and offset the likelihood of re-occurrence.

Moreover, the BCC is committed to obtaining further comprehensive air and water testing in response to residents' existing, short term health effects and any potential long term health effects. Other issues BCC continues to address include,

but are not limited to, health and safety plans for well excavations and testing of excavated materials, capping and gas collection design and review, CTDEP permitting process (including materials), restoration of surrounding wetlands, establishment and publication of capping and installation timetable, property values, current market conditions and legal recourse.

In addition to other informational vehicles provided by local and state officials, BCC has initiated and organized two public informational meetings. These forums were held on October 10, 1996 at the Shelter Rock Elementary School in Danbury and December 12, 1996 at the Bethel High School and were attended by Bethel and Danbury residents, officials, CT DEP, health officials and engineering consultants. BCC encourages the media to provide coverage of these and other related events as a means of disseminating clear and accurate information to the public.



Landfill Update from Danbury

The City of Danbury has accelerated the pace of closure of the Landfill. The Landfill was closed for waste disposal on December 31, 1996. Since November, the City has been working to install a final layer of impermeable soils over the entire landfill. The City is using private contractors in addition to City crews to deliver the final cover. The application of final cover will reduce water infiltration and should lower the production of leachate, which is one of the sources of odors. Additionally, a layer of lime is being applied to the surface of the landfill in an attempt to neutralize the production of odor producing gases.

On December 19, 1996, the City submitted its final design of the gas collection system to the DEP for approval. DEP is actively reviewing this design. The gas collection and recovery system is considered to be the ultimate solution to the odor problem. The permanent gas collection and recovery system will be operational by summer.

Additionally, the City has applied to DEP to install a temporary flare, which, if approved, could be installed by early spring. Although a temporary flare will not be as effective as the permanent system, it should have a substantial effect in reducing the odors as a temporary measure while the permanent system is being installed.

Air monitoring at the landfill and in the communities around the site is continuing. Periodic measurements taken at 21 commercial and residential locations consistently show that hydrogen sulfide levels are less than 0.1 parts per million. This level is the instrument's lowest detection limit. The City will continue this monitoring program until the gas collection system is shown to be fully effective.

For More Information:

Bethel Health Department

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(203) 794-8539

Danbury Health Department

William Campbell, Director
(203) 797-4625

Bethel Citizen's Coalition

Joanne Kirk
(203) 748-0324

CT DEP

Dick Barlow, Chief
Bureau of Waste Management
(860) 424-3021

Carmine DiBattista, Chief
Bureau of Air Management
(860) 424-3026

CT Department of Public Health

Mary Lou Fleissner, Dr.P.H., Director EEOH
Gary Ginsberg, Ph.D., EEOH
(860) 509-7742

REPRODUCTIVE HEALTH AND THE DANBURY LANDFILL

Introduction

Health concerns have been raised by residents in the town of Bethel due to their exposure to odors stemming from the Danbury Landfill. Odors from the landfill have increased since August, but this situation should be improved when a gas collection system and flare are installed (expected in spring, 1997). One of the health concerns expressed by community residents is that pregnant women or their offspring may be affected by the gases emanating from the landfill. The following sections summarize what is known about these gases and their implications for risk during pregnancy.

What is in the gases Coming from the Danbury Landfill?

Most of the gas emitted from typical municipal waste landfills consists of methane and carbon dioxide. These gases are non-odorous and not toxic at concentrations that can be reached in community air. Odorous gases that can come from landfills are hydrogen sulfide and other reduced sulfur gases. The air monitoring data thus far available at the Danbury Landfill suggests that hydrogen sulfide is the major cause of odor in the communities around the landfill. A variety of different volatile organic chemicals (VOCs) can also be released from municipal waste landfills, but these levels are usually quite low. The limited sampling data from Danbury supports the concept that VOC emissions from the landfill are too low to present a public health threat. Follow-up air sampling is being planned by state and local officials in conjunction with citizens.

Is Exposure to Hydrogen Sulfide a Risk Factor During Pregnancy?

Given that hydrogen sulfide seems to be causing strong odors around the landfill, it is relevant to consider whether exposure to this gas could be a risk during pregnancy. This possibility has been addressed in laboratory animal studies involving daily exposure during pregnancy to hydrogen sulfide at relatively high concentrations (up to 150 ppm; for comparison the highest level measured in the neighborhood around the landfill to date is 0.015 ppm). In these studies, hydrogen sulfide did not cause birth defects, pregnancy loss, or decrease in birthweight. This evidence has led the US Environmental Protection Agency (EPA) to conclude that hydrogen sulfide does not appear to alter fetal development.

Although human exposures occur to hydrogen sulfide in occupational settings and in communities surrounding landfills, there has been very little evaluation of reproductive outcomes in these populations. The few studies that have been conducted have had too

many limitations to be useful. Therefore, the animal studies form the basis for evaluating reproductive risks associated with hydrogen sulfide.

Is the Danbury Landfill a Risk to Pregnant Women?

The air sampling data thus far collected suggest that the levels of hydrogen sulfide in the community are low, and in fact, far below the levels tested in the animal studies. Additional sampling is being planned to provide more detailed air quality data around the landfill. While the sulfide gases coming from the landfill are unlikely to affect reproduction, the levels are high enough to produce strong odors. These odors may be highly unpleasant and at times, may be sufficient to make people feel ill. It should be kept in mind that such illness is a reaction to the odor and should improve once the odor dissipates.

The only criterion for hydrogen sulfide levels in the community is the World Health Organization (WHO) level of 0.11 ppm. This level is meant to protect the general public from any toxic effects (including reproductive effects) from hydrogen sulfide, although it is recognized that odors will be unpleasant at this level. Air testing conducted thus far in the community around the Danbury Landfill have found levels well below the WHO criterion.

In summary, the Danbury landfill is unlikely to be a reproductive risk to pregnant women in the surrounding community for the following reasons:

- Hydrogen sulfide is not considered to be a significant reproductive risk factor;
- The levels of hydrogen sulfide in the community appear to be low;
- Testing for other landfill gases have found that VOCs were either not present or at levels too low to be a public health risk.

If you would like additional information, contact the State Department of Public Health at 860-509-7742, your health care provider, or the Pregnancy Risk Hotline (1-800-325-5391).

DRAFT

RESPONSE PLAN FOR ELEVATED H₂S LEVELS

The response tiers established below would be triggered by readings on the Jerome H₂S analyzer that surpass the indicated concentration for the specified length of time in areas where human exposure to these concentrations is likely (e.g., residential/retail areas). The indicated response would only occur if these levels are likely to continue for at least one additional hour based upon the time-frame for mitigative measures. Tiers 2 and 3 involve public alerts that advise the public in the area to alter their behavior, on a voluntary basis, to avoid landfill-related odors. While a GasTech analyzer will also be in use for H₂S monitoring, this is a screening type device and will be confirmed with the Jerome analyzer before response actions are initiated.

Tier 1 H₂S Level: ≥ 0.1 ppm for 2 hours or 0.5 ppm for 15 minutes
(up to Tier 2 levels)

Tier 1 Response: The Danbury Health Director alters the telephone message for medical/emergency response personnel to indicate that H₂S concentrations in the community, while below a toxic effects level, are elevated to a range where strong odors may affect sensitive individuals (e.g., transient nausea, headache). In addition, it would be noted that strong odors of any kind may prompt increased symptoms in some asthmatics.

Tier 2 H₂S Level: ≥ 0.5 ppm average for 2 hours or 2 ppm for 15 minutes
(up to Tier 3 levels)

Tier 2 Response: The Local Health Directors will alert the public in the exceedance area (areas delineated by monitoring that have the exceedance) that sensitive individuals (e.g., asthmatics, young children) stay indoors and cease performing work or physical exercise; alternatively, such individuals may want to temporarily leave the area surrounding the landfill where the odors are strongest. If the exceedance area includes the Bethel school complex, and if it occurs during school hours, the Local Health Director will notify school officials. The Danbury Health Director will also change the phone message for medical personnel to indicate an increase in H₂S to a level that, while below a toxic effect level for the general public, may possibly produce reversible effects in sensitive individuals (increased airway resistance, irritation).

Tier 3 H₂S Level: ≥ 5 ppm average for 30 minutes

Tier 3 Response: The Local Health Directors will alert the public in the exceedance area (areas delineated by monitoring that have the exceedance) that all individuals may consider temporarily leaving the area. The Danbury Health Director will also change the phone message for medical personnel to indicate that H₂S concentrations are in a range where reversible irritative and biochemical effects are possible in exposed individuals.

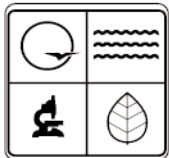
Notes: For Tiers 1 thru 3 the Local Health Directors will notify all parties that the exceedance has ended once verification of this has been obtained. The exact trigger points for these tiers may shift if it is found that the community has a more pronounced response to a given H₂S concentration than what is expected based upon the literature.

SUPPORTING INFORMATION

DPH has reviewed the H₂S toxicology and epidemiology literature, as well as H₂S exposure guidelines developed by other states, by the World Health Organization, and by OSHA/NIOSH. DPH's assessment factored in the animal and human H₂S database but relies more heavily upon the human studies (occupational studies, controlled exposure chamber studies, epidemiology studies) than upon animal studies. The available evidence suggests that H₂S effects begin to occur at concentrations as low as 5 ppm in healthy subjects (irritation, elevated blood lactate levels) and as low as 2 ppm in asthmatics (increased airway resistance and decreased conductance in 2 of 10 subjects). NIOSH has a workplace ceiling of 10 ppm meaning that workers should not be exposed to this level for more than occasional, brief periods.

To our knowledge, the only state that has produced a risk assessment addressing emergency response actions is Hawaii. Based upon the human data, the Hawaii Health Environmental Management Division recommended three tiers: 0.1 ppm as a public alert level; 1 ppm as a public warning level; 10 ppm as a public emergency level. Based upon the H₂S animal toxicology literature, their recommendations were approximately 10 fold more conservative (lower H₂S levels needed to trigger action). The state of Nebraska just completed a risk assessment to establish an H₂S health-based (as opposed to odor-based) ambient standard. Their assessment developed a standard of 0.1 ppm as a 30 minute average, above which the source must be controlled (this proposed standard has recently been released for public review). The World Health Organization developed an ambient guideline for Europe of 0.1 ppm H₂S (24 hour average concentration) based upon ocular irritation effects and a 100 fold safety factor. Additionally, ATSDR's draft Toxicological Profile for Hydrogen Sulfide is supportive of limiting exposures to the general public in the concentration ranges outlined in DPH's 3 tiers.

Review of these data sources suggests that an average H₂S concentration of 0.5 ppm for 2 hours or a 15 minute peak of 2 ppm would be sufficient to put sensitive subjects at risk for health effects. The first level of public notification (Tier 2) is intended to avoid these risks. The 2nd level of public notification (Tier 3) is intended to also avoid health effects in the general population which may begin as low as 5 ppm. Tier 1 would be established to notify medical and emergency response personnel that H₂S concentrations are elevated into a range where certain members of the community may be in distress (due to strong odors) and may report with readily reversible symptoms.



MISSOURI DEPARTMENT OF NATURAL RESOURCES

Design and Construction of Landfill Gas Monitoring Wells

Technical Bulletin

10/1999

Division of Environmental Quality
Solid Waste Management Program

Overview

This document was prepared by the Missouri Department of Natural Resources' Solid Waste Management Program (SWMP) to provide guidance for the proper design and construction of gas monitoring wells to comply with the quarterly monitoring required by 10 CSR 80-3.010(14) and 10 CSR 80-4.010(14).

Well Designs

Proper design and construction of gas monitoring wells is critical in obtaining true soil gas concentrations. All wells should be designed to minimize air intrusion into the system so accurate soil gas samples can be collected. All monitoring wells that are deeper than 10 feet are regulated by the department's Division of Geology and Land Survey (DGLS) and must be installed by a certified well driller. For further information on this subject, call (573) 368-2100. The SWMP recommends the following well designs:

- Code Well - This design meets current well drilling codes required by 10 CSR 23-4. Refer to figure 1, which illustrates major components.
- Micro Well - This design is not permitted under current well drilling codes but permission to install this type of well can be obtained through the department's Division of Geology and Land Survey. Refer to figure 2, which illustrates major components.
- Spike Probe - This is not actually a monitoring well by definition since its use is confined to a maximum of 10 feet below ground surface. For this reason no variance is required from DGLS. Refer to figure 3, which illustrates major components.

Well Selection and Location

The location of gas monitoring wells should be based on a characterization of geologic and hydrologic conditions at the landfill site and on the adjacent land uses, which must be approved by the Solid Waste Management Program.

This technical bulletin discusses factors that should be considered before selecting a certain type of well for installation.

For landfills applying for a disposal area permit, and existing landfills with gas migration problems, in-ground monitoring for gas migration must be performed using gas monitoring wells. Spike probes may be used where shallow groundwater, approximately 10 feet or less below the

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surface, prevents construction of a drilled well. The SWMP does not consider bar punch testing for shallow soil migration to be an effective monitoring method for other than instantaneous monitoring to evaluate the extent of shallow lateral gas migration.

Subsurface monitoring for methane should be conducted around the perimeter of the disposal area. The point of compliance for regulatory limits of methane migration is at the landfill property boundary. However, at sites where the edge of the fill area is far from the property boundary, additional gas monitoring locations may be chosen to provide early detection so that corrective action can be taken to prevent gas migration from the landfill property.

Monitoring wells should be located along the property boundary in areas where gas migration is most likely to occur or to become a threat to the public or the environment. These wells should be located in critical areas such as between the landfill and adjacent buildings, groves of trees and sand or gravel bedded utility lines. Wells should be screened across geologic features that would be likely to transmit gas (sand seams, fracture zones, karst features, mine shafts, etc.). Monitoring locations should be spaced 100 to 500 feet apart, with the spacing dependent on the permeability of the ground (the more permeable, the closer the spacing) and on the number of nearby features that could be potentially damaged. Gas monitoring wells should not be placed directly opposite gas extraction wells on the fill area; monitoring wells may give a falsely low reading if they are in the zone of influence of the extraction well. Monitoring may not be necessary for areas where the potential for gas migration is low. For example, a stream or a valley may form a natural cutoff to prevent the flow of gas through the ground.

Monitoring wells should be designed to monitor unsaturated soil and rock down to an elevation equal to the bottom elevation of the landfill. Wells can be designed with a single riser perforated from just below the well seal to the bottom of the well, or can consist of a well cluster with each riser monitoring a different depth. Well clusters are valuable for detecting gas migration through separate distinct permeable zones.

Gas monitoring wells must be designed to prevent intrusion of atmospheric air into the wells at all times; the cap should have a valved sampling port for the direct attachment of the gas sampling instrument, so that samples may be drawn directly from the well.

Conclusions

All wells should be designed to minimize air intrusion into the system, which can dilute the sample, making it unrepresentative. Selection of well designs should be based upon what zones are to be monitored. Code and Micro wells work best for monitoring screened intervals more than 10 feet below the ground surface. Spike Probe wells work best in monitoring zones that are 10 feet or less below the ground surface.

References

Farquhar, Grahame, Monitoring and Controlling Methane Gas Migration, course notes presented at April 1993 Sanitary Landfill Design and Management training, offered by the University of Wisconsin, Madison, College of Engineering.

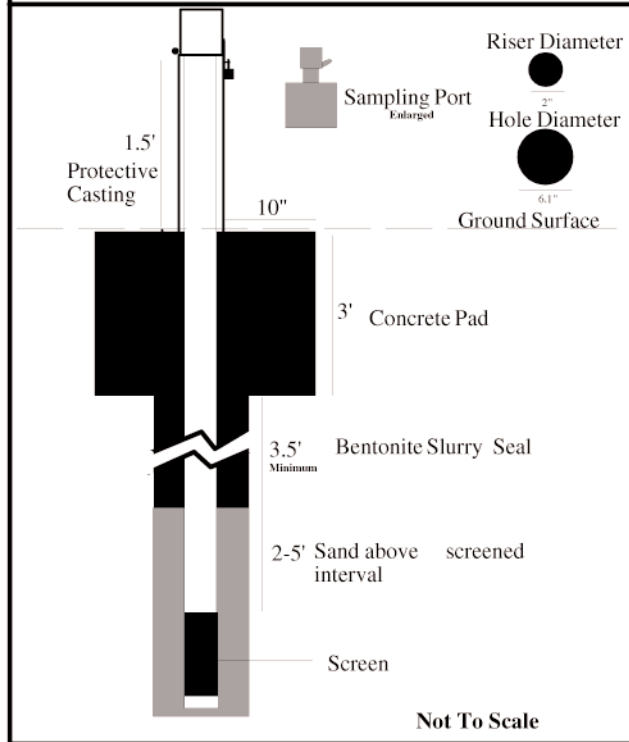
Missouri Department of Natural Resources, Flood Grant Team, An Analysis of Landfill Gas Monitoring Well Design and Construction.

For more information call or write:

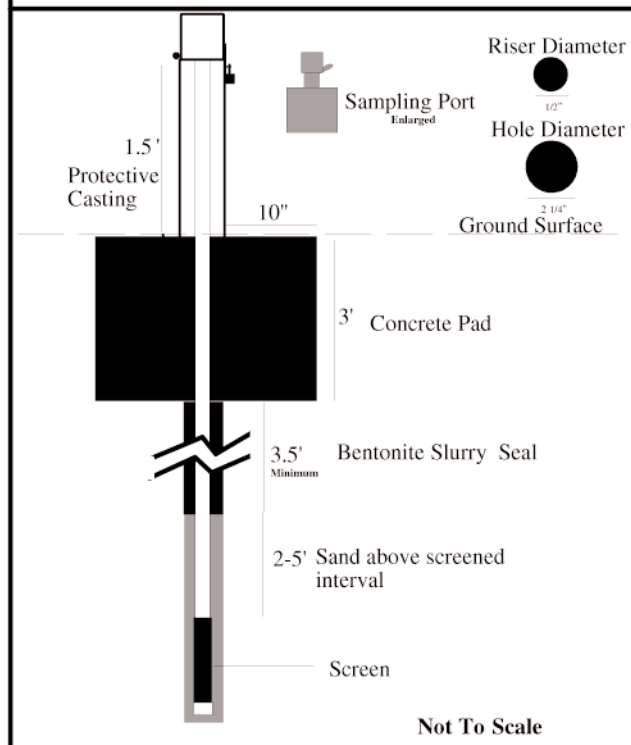
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Technical Bulletin - Figure 1
Typical Code Well



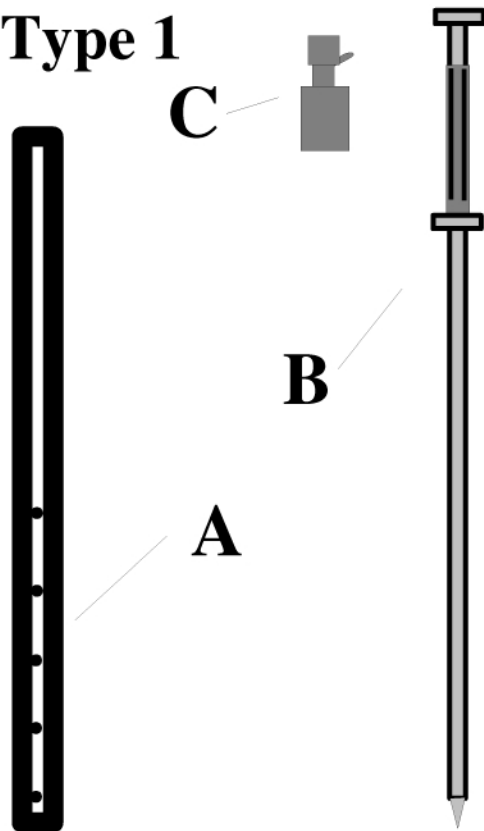
Technical Bulletin - Figure 2
Typical Micro Well



Technical Bulletin - Figure 3

Spike Probe

Type 1



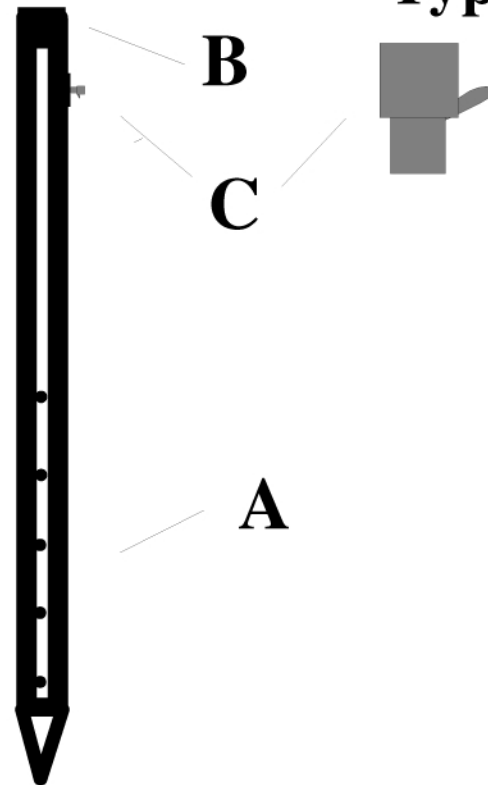
Part A Probe collector - materials copper, steel or galvanized pipe. Holes drilled into pipe to within 1-2' of ground surface point.

Part B Hammer Driver - made of steel in which handle slides on rod to drive point into ground.

Part C Sample Port - made of numerous types; however, must be a compression fitting which remains closed after being disconnected.

Instructions for Use- Insert Part B into Part A. Then using the hammer driver pound Part B into the selected sampling location. Be sure that the last set of holes on the Probe are at least 1' below ground surface. Install Part C onto Part A securely. Recommend solder or using a hot glue gun to insure air tight seal. Wait at least 1 hour before attempting to sample.

Type 2



Part A Probe collector - materials steel or galvanized pipe. Holes drilled into pipe to within 1-2' of ground surface point.

Part B Hammer Cap - made of steel and is use to driving point.

Part C Sample Port - made of numerous types; however, must be a compression fitting which remains closed after being disconnected.

Instructions for Use- Screw Part B onto Part A. Then either hammer or push against Part B until probe is at proper depth. Be sure that the last set of holes on the Probe are at least 1' below ground surface. Install Part C onto Part A securely. Recommend threaded connections to insure air tight seal. Wait at least 1 hour before attempting to sample.



MISSOURI DEPARTMENT OF NATURAL RESOURCES

Procedures for Sampling Landfill Gas Inside Buildings

Technical Bulletin

9/1999

Division of Environmental Quality
Solid Waste Management Program

Overview

This document was prepared by the Missouri Department of Natural Resources' Solid Waste Management Program (SWMP) to provide guidance in how to properly sample for landfill gases in enclosed spaces.

Sampling Equipment

Proper selection of sampling equipment to be used for monitoring buildings is critical to make proper public safety assessments. Explosimeter-type instruments are appropriate for measuring methane in most monitoring in enclosed spaces. You should be aware that in an oxygen free environment some meters are not reliable and can give false readings that are lower than the actual gas concentrations.

It is recommended that detection instruments selected for monitoring buildings have a narrow sensitivity range, from 0-15 percent by volume for methane.

Sampling Procedures

Step 1 - Make sure the instrument has been properly calibrated to methane (Some instruments of this type are calibrated to hexane or propane, which have different combustible limits than methane). Prepare the instrument for sampling by allowing it to properly warm up as directed by the manufacturer.

Step 2 - Attach the hose to the instrument and begin sampling. Some instruments have metal wands that can be attached to the plastic hose to collect air samples. Wands can be made from copper tubing if not made available with the instrument.

Step 3 - To properly assess a building, samples should be collected from:

- A. Around the walls of the building and electrical sockets
- B. Closets or other enclosed wall spaces
- C. Cracks in cement floors
- D. Ceiling areas
- E. Crawl spaces and basements
- F. Areas where below ground utilities enter the building
- G. Any other confined area

Step 4 - If landfill gas is detected by the instrument in any concentration it should be recorded and reported to the department.

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Sampling Times

Sampling times are almost as important as the procedure used to collect the sample. Proper monitoring of the site should include those times when landfill gas is most likely to migrate. For these reasons monitoring should be considered when:

- A. Barometric pressure is low and soils are saturated; or
- B. When snow cover is just beginning to melt; or
- C. The ground is frozen or ice covered.

Regulatory Requirements

Sanitary landfills in operation after April 9, 1994, and all demolition landfills that applied for a construction permit after July 30, 1997, are required to conduct the quarterly monitoring of all buildings on site as required by 10 CSR 80-3.010(14) and 10 CSR 80-4.010(14).

These landfills must implement a gas monitoring program to ensure that regulatory limits for methane are not exceeded - 1.25 percent (25 percent lower explosive limit) by volume in buildings on site. Results must be submitted at least quarterly to SWMP in an electronic format.

The Solid Waste Management Regulations require that monitoring reports be submitted to SWMP at least quarterly. The SWMP recommends that gas monitoring be conducted during the months of February, May, August and November and that the results be submitted within 30 days of sampling. The data must be submitted in electronic form. The results submitted should contain:

1. The location of monitoring points.
2. Sample results obtained should include the date the sampling was performed and the barometric pressure, if available. Methane measurements may be given as a percentage of the total air volume or as a percentage of the Lower Explosive Limit (LEL). The following formula can be used to convert a percentage of LEL into a percentage methane by volume:
$$\% \text{ Methane (by volume)} = \text{LEL (\%)} \div 20$$

The form attached to the end of this bulletin may be used to record the information required by the department.

Corrective Action / Emergency Response

If methane gas levels exceed regulatory limits or are an obvious public safety threat, the landfill owner/operator must:

1. Immediately take all necessary steps to ensure protection of public health and safety. For accumulation of gas in buildings, either on-site or off-site, the operator must take appropriate action to mitigate the effects of the gas accumulation in those structures until a permanent remediation is completed.
2. Comply with the Solid Waste Management law and regulations as required by 10 CSR 80-3.010(14) and 10 CSR 80-4.010(14).

Conclusions

Missouri has stringent regulations governing landfill gas migration. Landfill gases that have the ability to migrate in buildings present a threat to public safety. It is the responsibility of the landfill owner/operator to take any and all steps to protect the public from migrating landfill gases both on- and off-site.

References

Farquhar, Grahame, Monitoring and Controlling Methane Gas Migration, course notes presented at April 1993 Sanitary Landfill Design and Management training, offered by the University of Wisconsin, Madison, College of Engineering.

SCS Engineers, Inc., April 1989, Procedural Guidance Manual For Sanitary Landfills, Volume II: Landfill Gas Monitoring and Control Systems, prepared for the California Waste Management Board.

United States Environmental Protection Agency, November 1993, Solid Waste Disposal Facility Criteria, Technical Manual, EPA 530-R-93-017.

For more information call or write:

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MISSOURI DEPARTMENT OF NATURAL RESOURCES

Sampling of Landfill Gas Monitoring Wells

Technical Bulletin

9/1999

Division of Environmental Quality
Solid Waste Management Program

Overview

This document was prepared by the Missouri Department of Natural Resources' Solid Waste Management Program (SWMP) to provide guidance regarding the quarterly sampling of gas monitoring wells as required by 10 CSR 80-3.010(14) and 10 CSR 80-4.010(14). This guidance applies to all landfills that monitor for methane migration by means of gas monitoring wells. Sampling results must be submitted at least quarterly to SWMP in an electronic format.

Sampling Equipment

Proper selection of sampling equipment is critical in obtaining true soil gas concentrations. Explosimeter-type instruments are not appropriate for measuring methane in gas monitoring wells, because the amount of oxygen which is present in the well may not be sufficient for the sample to "burn." These instruments will typically give false low readings when high concentrations of methane are present.

It is recommended that instruments used to sample gas monitoring wells have an automatic pump that has the ability to withdraw enough volume to bring a fresh sample of soil gas into the well. It is also beneficial that the instrument reads both oxygen and methane concentrations. Some instruments have the ability to read barometric pressure, which is also desirable.

Sampling Procedures

Step 1 - Make sure the instrument is properly calibrated. Prepare the instrument for sampling by allowing it to properly warm up as directed by the manufacturer.

Step 2 - Connect the instrument to the well head and begin collecting a sample.

Step 3 - Continue collecting the sample until the reading stabilizes. A stable reading is one that does not vary more than 0.5 percent by volume on the instrument's scale.

Step 4 - A proper reading should have 2 percent oxygen by volume or less. If levels of oxygen are higher, it may indicate that air is being drawn into the system giving a false reading of the true soil gas concentrations. Possible explanations for this problem are:

- A. The gas monitoring well seal has failed;
- B. Well head connectors are leaking; or
- C. A connection at the instrument is leaking.

When the problem is eliminated repeat Steps 1-3. If the problem cannot be corrected, record those values and make sure that the problem is well documented in the report sent to the department.

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Step 5 - Record the stabilized reading including the oxygen concentration and barometric pressure, if available.

Obtaining true soil gas concentrations from gas monitoring wells is dependent upon using a consistent proven method. If you have problems using the sampling procedures described, you should contact the department as soon as possible.

Sampling Times

Sampling times are almost as important as the procedure used to collect the sample. Proper monitoring of the site should include sampling at those times when landfill gas is most likely to migrate. Scientific evidence indicates that weather and soil conditions influence when gas will migrate. For these reasons sampling should be considered when:

- A. Barometric pressure is low and soils are saturated; or
- B. When snow cover is just beginning to melt; or
- C. The ground is frozen or ice covered.

Records

The Solid Waste Management Regulations require that reports on data collected from wells be submitted to SWMP at least quarterly. The SWMP recommends that gas monitoring be conducted during the months of February, May, August and November and that the results be submitted within 30 days of sampling. The data must be submitted in electronic form. The results submitted should contain:

- 1. The location of monitoring points.
- 2. Sample results obtained should include the date the sampling was performed and the barometric pressure, if available. Methane measurements may be given as a percentage of the total air volume or as a percentage of the Lower Explosive Limit (LEL). The following formula can be used to convert a percentage of LEL into a percentage methane by volume:
$$\% \text{ Methane (by volume)} = \text{LEL (\%)} \div 20$$
- 3. The amount of time a well is pumped before a stabilized methane reading is taken.
- 4. The percent volume of O₂ (if the instrument used is capable of measuring).

The form attached to the end of this bulletin may be used to record the information required by the department.

Conclusions

Missouri has stringent regulations governing landfill gas migration. The department prefers to address the issue of migrating gases before they present a threat to public safety or the environment.

Migrating gases detected above allowable limits at property boundaries do not necessarily mean that there is an immediate threat to public safety. It does mean that there is a potential problem that must be addressed. In order to address such a problem, a permit modification to install a gas collection system may be necessary.

References

Landtec Landfill Control Technologies, Landfill Gas System Engineering Design: A Practical Approach, course notes from Landfill Gas System Engineering Design Seminar, 1994.

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