CDC Workplace Safety and Health ™

NIOSH HEALTH HAZARD EVALUATION REPORT:

HETA #2003-0078-2918
Waste Management, Inc. Outer Loop Landfill
Louisville, Kentucky

November 2003

DEPARTMENT OF HEALTH AND HUMAN SERVICES
Centers for Disease Control and Prevention
National Institute for Occupational Safety and Health

NIOSH

PREFACE

The Hazard Evaluations and Technical Assistance Branch (HETAB) of the National Institute for Occupational Safety and Health (NIOSH) conducts field investigations of possible health hazards in the workplace. These investigations are conducted under the authority of Section 20(a)(6) of the Occupational Safety and Health (OSHA) Act of 1970, 29 U.S.C. 669(a)(6) which authorizes the Secretary of Health and Human Services, following a written request from any employer or authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

HETAB also provides, upon request, technical and consultative assistance to federal, state, and local agencies; labor; industry; and other groups or individuals to control occupational health hazards and to prevent related trauma and disease. Mention of company names or products does not constitute endorsement by NIOSH.

ACKNOWLEDGMENTS AND AVAILABILITY OF REPORT

This report was prepared by Lisa Delaney, MS, of HETAB, Division of Surveillance, Hazard Evaluations and Field Studies (DSHEFS). Field assistance was provided by Kevin L. Dunn of DSHEFS. Analytical support was provided by Ardith Grote of NIOSH, Rhonda Halliday of Microbiology Specialists, Inc MSI, and DataChem Laboratories. Desktop publishing was performed by Deborah Gibson and Shawna Watts. Review and preparation for printing were performed by Penny Arthur.

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Highlights of the NIOSH Health Hazard Evaluation

Evaluation of Exposure to Microorganisms at Waste Management Inc. Outer Loop Landfill

In 2003, NIOSH assisted the Environmental Protection Agency (EPA) at the Waste Management Inc., (WMI) Outer Loop Landfill in Louisville, Kentucky, to look at exposures during the disposal of sewage sludge (biosolids). NIOSH evaluated exposures to bacteria and endotoxin. Workers did not report any health problems.

What NIOSH Did

- We met with WMI and EPA employees.
- We observed the unloading and compacting of waste and sewage sludge.
- We took air samples to measure the levels of bacteria and endotoxin (a component of some cell walls of bacteria).
- We looked at work practices and personal protective equipment (PPE).

What NIOSH Found

- Levels of culturable bacteria in samples collected at the open face were much higher than in samples we collected at other areas of the landfill.
- Bacteria that cause digestive tract illness were identified in the samples.
- Endotoxins in two samples were at levels which may cause illness.
- There are no shower facilities and employees do not change work clothes before leaving work.
- No employees reported health problems.

What WMI Managers Can Do

- Ensure PPE is provided and worn correctly.
- Conduct employee training on good hygiene practices.
- Provide on-site showers and laundry services for washing employee clothes to prevent contaminating their vehicles or homes.
- Ensure employees wipe down and vacuum the cabs of their equipment on a regular basis.

What the WMI Employees Can Do

- Wash your hands frequently and before eating, drinking, or smoking.
- Wipe down and vacuum the cabs of your equipment on a regular basis.
- Report possible work-related health effects to management.

CDC Workplace Safety and Health

What To Do For More Information:
We encourage you to read the full report. If you would like a copy, either ask your health and safety representative to make you a copy or call 1-513-841-4252 and ask for HETA Report # 2003-0078-2918

National Institute for Occupational Safety and Health NIOSH

Health Hazard Evaluation Report 2003-0078-2918
Waste Management, Inc. Outer Loop Landfill
Louisville, Kentucky
August 2003

Lisa J. Delaney, M.S.

SUMMARY

On November 25, 2002, the National Institute for Occupational Safety and Health (NIOSH) received a request for technical assistance from the U.S. Environmental Protection Agency (EPA) regarding a landfill bioreactor study at the Waste Management, Inc. (WMI), Outer Loop Landfill in Louisville, Kentucky. The request concerned landfill dozer and compactor operators' potential exposures during the dumping and spreading of biosolids and sewage sludge at the working face of the landfill. No health effects were reported. In response to this request, NIOSH investigators conducted an initial site visit on December 3, 2002. During a follow-up site visit on June 3-5, 2003, NIOSH conducted air sampling which included the collection of area and personal breathing zone (PBZ) samples for culturable bacteria, endotoxin (a component in cell membranes of Gram-negative bacteria), and volatile organic compounds (VOCs). Samples were collected at the active site of the landfill where waste is disposed and at a capped site no longer receiving waste for comparison.

Total bacteria concentrations for the comparison samples and active site samples ranged from 96 colony forming units per cubic meter of air (CFU/m^3) to 144 CFU/m^3 and from 108 CFU/m^3 to >62,304 CFU/m^3 respectively. The following enteric bacteria (bacteria present in the intestinal tracts of humans and animals) were identified: *Klebsiella oxytoca, Leclercia adecarboxylata, Enterobacter cloacae*, and *Citrobacter freundii*. Exposure to these enteric organisms may result in disease (e.g., gastroenteritis) or in a carrier state in which an infection does not clinically manifest itself in the individual but can be spread to others. Occupational exposure criteria for culturable bacteria have not been established. Area endotoxin samples collected at the active site of the landfill ranged from 2.9 endotoxin units per cubic meter (EU/m^3) to 170 EU/m^3. The personal breathing zone (PBZ) time-weighted average (TWA) exposure of the dozer operator was 27.9 EU/m^3. Occupational exposure criteria for endotoxin, based on observed health effects at measured endotoxin levels, have been suggested at 200 EU/m^3 for airway inflamation with increased airway activity, 2000 EU/m^3 for over-shift decline in forced expiratory volume in one second, 3000 EU/m^3 for chest tightness, and 10,000-20,000 EU/m^3 for toxic pneumonitis. NIOSH has not established any recommended exposure limits.

Major VOCs detected were ethanol, various aliphatic hydrocarbons, toluene, ethyl benzene, xylenes, trimethyl benzenes, styrene, limonene, and siloxanes.

Employees working in the landfill did not report any health problems. A locker room for employees is located in the maintenance shop. Shower facilities are not provided and employees wear their work clothes home. An employee reported they received training on proper hygiene precautions. Suggestions to improve personal hygiene, personal protective equipment, and training are provided in the recommendations section of this report.

The environmental monitoring data show that exposure to culturable enteric organisms and endotoxin may occur. Although exposure criteria to evaluate the health implications of these exposures are lacking, reasonable precautions to minimize exposures should be taken. Recommendations are provided to help minimize exposure to sewage sludge and to increase employee awareness of the importance of good hygiene and the appropriate use of personal protective equipment.

Keywords: 4953 (Refuse Systems), biosolids, sewage sludge, endotoxin, bioaerosol, bacteria, landfill, volatile organic compounds, thermal desorption

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INTRODUCTION

On November 25, 2002, the National Institute for Occupational Safety and Health (NIOSH) received a request for technical assistance from the U.S. Environmental Protection Agency (EPA) regarding a landfill bioreactor study at the Waste Management, Inc., (WMI) Outer Loop Landfill in Louisville, Kentucky. The request concerned landfill dozer and compactor operators' potential exposures to bioaerosols during the dumping and spreading of biosolids and sewage sludge at the working face of the landfill. No health effects were reported. In response to this request, NIOSH investigators conducted an initial site visit on December 3, 2002. During a follow-up site visit on June 3-5, 2003, NIOSH conducted air sampling.

BACKGROUND

The Outer Loop Landfill is a waste disposal facility that has been in operation for approximately 35 years. WMI purchased the landfill in 1984. Waste disposal occurs in discrete areas of the 794-acres site; the total waste footprint is approximately 390 acres. WMI accepts residential waste, industrial special waste (e.g., biosolids, latex paint, fly ash), and autoclaved medical waste. In October 2000, WMI partnered with the EPA under a Cooperative Research and Development Agreement (CRADA) to compare conventional Subtitle D designed and operated landfills with bioreactor landfills. Bioreactor landfills require more liquid additions, such as biosolids, to create an environment that allows anaerobic microorganisms to degrade the waste more rapidly. It is thought that the bioreactor process extends the life of the landfill.

The WMI Outer Loop Landfill has approximately 30 employees including office personnel. Heavy equipment operators, mechanics, and maintenance employees work an 8-hour shift. Hourly employees are represented by the International Brotherhood of Teamsters Local 783.

Large trucks containing sewage sludge enter the site through the receiving area/weigh station. Drivers are directed to the location of the cell receiving waste on that particular day. The active site of the landfill receiving waste is referred to as the working face. The compactor and bulldozer operators direct traffic from their equipment and if necessary exit the equipment for additional instruction. The drivers exit their trucks to open the back gate of the truck to empty the contents of the load. Once empty, the driver closes the back gate and exits the facility. This process usually takes 10 to 15 minutes. Multiple semi tractor trailers, personal vehicles, and smaller trucks can be at the working face unloading a variety of wastes at the same time. WMI bulldozer operators spread the recently unloaded waste across the working face and a compactor compresses the trash. Typically, 1 compactor and 2 to 3 bulldozers work the open face.

Sewage sludges are the organic residues resulting from the treatment of commercial, industrial, and municipal wastewater (sewage). WMI accepts sewage sludge in various stages of pathogen reduction treatment. WMI accepts "wet" biosolids and sewage sludge from the City of Louisville and smaller municipalities in the area. The City of Louisville has the ability to process their biosolids to a small, dry pellet form which WMI also accepts. On June 4, 2003, WMI received 1 truckload of wet sewage sludge (11.2 tons) in the morning and 1 truckload of pellets (14.4 tons) in the afternoon. On the morning of June 5, 2003, WMI received 4 truckloads of pellets (69.38 tons) and 1 truckload of wet sewage sludge (13.32 tons). The volume of sewage sludge received varies by season. Receiving records for the month of May showed that WMI received 2,204 tons of pelletized and 678 tons of wet sewage sludge. Documentation from WMI verifying that the sewage sludge was U.S. EPA Class B biosolids was not available.

METHODS

Culturable Bacteria

To determine concentrations of culturable airborne bacteria, an Anderson single-stage viable cascade impactor set at a calibrated flowrate of 28.3 liters per minute (Lpm) and a Surface Air System (SAS) Super 100 microbial air sampler pre-programmed to draw a volume of 100 L of air were used. Samples were collected at the edge of the open face of area 7 on Unit 7 of the landfill approximately 30 yards from the location of the sewage sludge. Samples were collected before, during, and after sewage sludge unloading. Comparison samples were collected at Unit 6 which is a capped landfill no longer receiving waste. The Anderson single-stage impactor is designed to collect particles 0.65 micrometers (µm) or larger. Samples using the Anderson sampler were collected over a 3-minute time period. The SAS sampler is estimated to collect particles 2 µm or larger and was programmed for a total air volume of 100 L in one run.[1] Sample collection times were approximately 1 minute. Samples were collected in sets of three replicates using buffered charcoal yeast extract agar, trypticase soy agar, and columbia nalidixic acid agar. The samples were shipped overnight to the contract laboratory which is an American Industrial Hygiene Association Environmental Microbiology Accredited Laboratory. Samples were incubated at 23° Celsius and colony count readings were taken on day 4 and day 6. The results are expressed as colony forming units per cubic meter of air (CFU/m^3). Organisms were isolated and morphological characteristics, gram stain reaction, and oxidase or catalase reaction were determined.

Endotoxin

Two personal breathing zone (PBZ) and 5 area air samples were collected for endotoxin (component in cell membrane of Gram-negative bacteria). The samples were collected on 1 dozer operator, at the edge of the working face, and at a control site (Unit 6). The samples were collected on tared 5.0 µm pore size, 37 millimeter (mm) polyvinyl chloride filters using a calibrated flowrate of 2 Lpm. The samples were weighed and analyzed for endotoxin content with the Kinetic-QCL instrumentation using the *Limulus* amebocyte lysate (LAL) assay. For these analyses, 10 endotoxin units (EU) are equivalent to one nanogram of endotoxin. The limit of detection (LOD) for the analyses was 0.005 EU per sample, which equates to a minimum detectable concentration of 0.02 EU/cubic meter (m^3) based on a sample volume of 230 L.

Volatile Organic Compounds

Area samples that screen for VOCs were collected at the edge of the working face during sewage sludge unloading and at the Unit 6 control site. The samples were collected on thermal desorption (TD) tubes attached by Tygon® tubing to sampling pumps calibrated at a flow rate of 50 cubic centimeters per minute (cc/min). The TD tubes contained three beds of sorbent material: a front layer of Carbopack Y™, a middle layer of Carbopack B™, and a back section of Carboxen 1003™. The TD tubes were analyzed by the NIOSH laboratory in a Perkin-Elmer ATD 400 automatic thermal desorption system. The thermal unit was interfaced directly to an HP5890A gas chromatograph with an HP5970 mass selective detector according to NIOSH method 2549.[2]

EVALUATION CRITERIA

As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH field staff employ environmental evaluation criteria for the assessment of a number of chemical and physical agents. These criteria are intended to suggest levels of exposure to which most workers may be exposed up to 10 hours per day, 40 hours per week for a working lifetime without experiencing adverse health effects. It is, however, important to note that not all workers will be protected from adverse health effects even though their exposures are maintained below these levels. A small percentage may experience adverse health effects because of individual susceptibility, a pre-existing medical condition, and/or a hypersensitivity (allergy). In addition, some hazardous substances may act in combination with other workplace exposures, the general environment, or with medications or personal habits of the worker to produce health effects even if the occupational exposures are controlled at the level set by the criterion. These combined effects are often not considered in the evaluation criteria. Also, some substances are absorbed by direct contact with the skin and mucous membranes, and thus potentially increases the overall exposure. Finally, evaluation criteria may change over the years as new information on the toxic effects of an agent become available.

The primary sources of environmental evaluation criteria for the workplace are: (1) NIOSH Recommended Exposure Limits (RELs),[3] (2) the American Conference of Governmental Industrial Hygienists' (ACGIH®) Threshold Limit Values (TLVs®),[4] and (3) the U.S. Department of Labor, Occupational Safety and Health Administration (OSHA) Permissible Exposure Limits (PELs).[5] Employers are encouraged to follow the OSHA limits, the NIOSH RELs, the ACGIH TLVs, or whichever are the more protective criterion.

OSHA requires an employer to furnish employees a place of employment that is free from recognized hazards that are causing or are likely to cause death or serious physical harm [Occupational Safety and Health Act of 1970, Public Law 91–596, sec. 5(a)(1)]. Thus, employers should understand that not all hazardous chemicals have specific OSHA exposure limits such as PELs and short-term exposure limits (STELs). An employer is still required by OSHA to protect their employees from hazards, even in the absence of a specific OSHA PEL.

A time-weighted average (TWA) exposure refers to the average airborne concentration of a substance during a normal 8- to 10-hour workday. Some substances have recommended STEL or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from higher exposures over the short-term.

Health Hazards Associated with Sewage Sludge

Sewage sludge, also called wastewater residuals, has been used as a fertilizer and soil conditioner in the U.S. for many years. Biosolids is another name for the beneficially treated residuals from wastewater treatment. The use and disposal of sewage sludge in the U.S. is regulated under 40 CFR Parts 257, 403, and 503- Standards for the Use or Disposal of Sewage Sludge: Final Rules.[6] Landfilling of biosolids with municipal solid waste in a municipal solid waste landfill is regulated under 40 CFR Part 258 Landfill Rule.[7] The U.S. EPA is the lead agency that has regulatory responsibilities for wastewater treatment and sewage sludge disposal.

Pathogens

There are four major types of human pathogenic organisms found in sewage sludge: (1) bacteria, (2) viruses, (3) protozoa, and (4) helminths (parasitic worms).[8] The levels of pathogens present in sewage sludge depend upon the number of microorganisms present in the waste stream and the reduction in pathogenic organisms achieved by the wastewater and sewage treatment processes. Examples of pathogens potentially found in wastewater and sewage sludge are presented in Table 1. Several of these pathogens can cause gastrointestinal illnesses. Some are present infrequently, depending, in part, on geographic area.

There are two separate pathogen reduction requirements for sewage sludge- Class A and Class B.[8]

The goal of Class A requirements is to reduce pathogen levels to below detectable limits. The goal of Class B requirements is to reduce pathogen levels to concentrations that are unlikely to pose a health risk to the public and the environment. There are site restrictions for land application of Class B sludge. Crop harvesting, animal grazing, and public contact are limited to allow environmental factors to further reduce pathogen levels.

Some epidemiological studies of wastewater and sewage workers have shown an increased risk of gastrointestinal symptoms.[9,10,11,12,13] Lundholm and Rylander found that skin disorders and diarrhea and other gastrointestinal symptoms were more prevalent among employees at six Swedish wastewater treatment plants than among workers at three water treatment plants.[14] Scarlett-Kranz and associates also found that sewage workers in New York reported a significantly higher frequency of diarrhea, dizziness, headache, skin irritation, and sore throat than workers at water treatment plants.[15]

In a three-year, prospective epidemiologic study in Ohio, the health status of farming families using sludge on land was compared to families not using sludge.[15] The families using sludge were randomly selected. Each family participated in a monthly family and animal health questionnaire, annual tuberculin skin testing, and quarterly blood sampling for serological testing for 23 viruses.[15] There was no significant difference in the frequency of respiratory illnesses, digestive illnesses, or general symptoms between the two family groups. There were also no observed differences in health status among the farm animals. Viral serological test results were similar, and there were no tuberculin skin test conversions. According to the authors, farmers in the study had a sewage sludge application rate comparable to the practices allowed under the U.S. EPA regulations, and the sewage sludge had undergone accepted digestion procedures.

Several studies have evaluated concentrations of airborne microorganisms at landfill operations. One study evaluated exposures to airborne microorganisms at a landfill receiving sewage sludge. Samples collected for total bacteria at the landfill site ranged from 70 CFU/m^3 to 58,000 CFU/m^3.[16] The following Gram-negative genera were identified: *Achromobacter, Acinetobacter, Aeromonas, Enterobacter, Escherichia, Hafnia, Klebsiella, Pseudomonas, Serratia,* and *Yersinia.* Another landfill study concluded that concentrations of fungi and mesophilic bacteria were 2 to 30 times higher than background levels.[17]

There is limited information on the presence of airborne microbial pathogens resulting from the application of sewage sludge. One study by Pillai et al. measured airborne bacteria during the land application process.[18] Concentrations for heterotrophic bacteria, which require nitrogen and carbon food sources, averaged 10^5 CFU/m^3. One location, where a major amount of physical agitation of the sewage sludge occurred, had detectable levels of hydrogen sulfide-producing bacteria and *Clostridium spp*. (5×10^2 CFU/m^3) on three of the four days monitored at that site. Fecal coliforms, fecal streptococci, and *Salmonella sp.* were not detected at any of the sampling sites.[18]

Bacterial Endotoxin

Gram-negative bacteria, and endotoxin (which are found in the cell wall of Gram-negative bacteria) are ubiquitous in nature. Endotoxin is released when the bacterial cell is lysed (broken down) or when it is multiplying.[19,20] They are found in water, soil, and living organisms. Endotoxin has been found in various industrial settings and in non-industrial environments associated with bacterial contamination, cooling towers, humidifiers, air-conditioners, and other water-associated processes.[20,21,22,23,24,25]

Clinically, little is known about the response to inhaled endotoxin at levels that would be found in indoor environments. In animal studies, and at workplaces with high levels of exposure to endotoxin (such as animal feed production facilities), researchers have been able to demonstrate some acute changes in workers' pulmonary function.[20,21,22,23] A study by Mattsby and Rylander found that approximately 40% of sewage treatment plant workers reported diarrhea, fatigue, and headache after exposure to an aerosol of sewage dust containing endotoxin.[26] Liesivouri and associates found airborne endotoxin concentrations in wastewater treatment plants to range from 8 nanograms per cubic meter (ng/m^3) to 410 ng/m^3 (equivalent to 80 EU/m^3 to 4,100 EU/m^3) of air.[27]

Currently, acceptable exposure concentrations to endotoxin have not been established. Occupational exposure criteria have not been established for bacterial endotoxin by OSHA, NIOSH, or ACGIH. The ACGIH Bioaerosols committee has identified endotoxin as a biologically derived agent under study and is soliciting information and data that may assist in establishing a TLV for this agent.[4] However, Rylander has reported that sufficient toxicological data exists to establish an occupational exposure limit for endotoxin based on acute changes in pulmonary function.[24] The following eight-hour time weighted average (TWA) concentrations have been suggested: 200 EU/m^3 for airway inflamation with increased airway activity, 2000 EU/m^3 for over-shift decline in forced expiratory volume in one second (FEV_1), 3000 EU/m^3 for chest tightness, and 10,000-20,000 EU/m^3 for toxic pneumonitis. Castellan et al. have reported a calculated zero pulmonary function effect concentration of 90 EU/m^3.[25]

Microorganisms

Microorganisms (including fungi and bacteria) are normal inhabitants of the environment. Fungi comprise 25% of the biomass of earth;[28] therefore, human exposure to fungi is ubiquitous. Although there are thousands of fungal species, reports of human and animal diseases have involved fewer than 100 species.[28] Saprophytic fungi (i.e., those utilizing non-living organic matter as a food source) inhabit soil, vegetation, water, or any reservoir that can provide an ample supply of nutrients. Under the appropriate conditions (optimum temperature, pH, and with sufficient moisture and available nutrients) saprophytic microorganism populations can be amplified. Through various mechanisms, these organisms can then be disseminated as individual cells or with soil or dust particles or water droplets.

Fungi can produce adverse health effects by three known mechanisms: (1) immunologic hypersensitivity to the fungus (allergy), (2) fungal infection (i.e., mycosis), and (3) mycotoxicosis, a reaction to toxins produced by the fungus.[29] Health effects related to allergenic responses are based, partly, on a genetic predisposition.[30] Allergic diseases typically associated with exposures in indoor environments include allergic rhinitis (nasal allergy), allergic asthma, allergic broncho pulmonary aspergillosis, and extrinsic allergic alveolitis (hypersensitivity pneumonitis).[31] Allergic respiratory diseases resulting from exposures to microbial agents have been documented in agriculture, biotechnology, office, and home environments.[32,33,34]

VOCs

VOCs are a large class of organic chemicals (i.e., containing carbon) that have a sufficiently high vapor pressure to allow some of the compound to exist in the gaseous state at room temperature. VOCs are emitted in varying concentrations from numerous sources including, carpeting, fabrics, adhesives, resins, solvents, paints, cleaners, waxes, cigarettes, and combustion sources.

RESULTS/DISCUSSION

Culturable Bacteria

The results of the air sampling for bacteria are given in Table 2. Total bacteria concentrations for the control samples and working face samples ranged from 96 CFU/m^3 to 144 CFU/m^3 and from 108 CFU/m^3 to >62,304 CFU/m^3 respectively. Results from four samples, collected at the working face, were approximated due to the heavy bacterial load on the sampling media. The bacterial concentrations were highest for the samples collected in the afternoon of June 4, 2003, during the unloading and spreading of one load of dry sewage sludge. The bacterial concentrations were higher at the working face compared with the control area. The following enteric bacteria (bacteria present in the intestinal tracts of humans and animals) were identified: *Klebsiella oxytoca, Leclercia adecarboxylata, Enterobacter cloacae*, and *Citrobacter freundii*.

Exposure to these enteric organisms may potentially result in disease (e.g., gastroenteritis) or in a carrier state in which an infection does not clinically manifest itself in the individual but can be spread to others. These enteric organisms are usually associated with self-limited gastrointestinal illness but can develop into more serious diseases in sensitive populations such as immune-compromised individuals. The disease risk is a function of the number and types of pathogens in the sewage sludge relative to the exposure levels and infective dose. Because data are sparse on what constitutes an infective dose, it is prudent public health practice to minimize workers' contact with sewage sludge and soil or dusts containing enteric organisms.

We were unable to sample at the working face of a landfill not receiving sewage sludge; as such, no data are available for comparison purposes. Our data consist of culturable bacteria and endotoxin results originating from the sewage sludge and all the other municipal waste present at the landfill at the time of the evaluation. We were unable to identify the contribution the sewage sludge alone had on our sampling results.

Bacterial Endotoxin

The results of endotoxin sampling are given in Table 3. The PBZ TWA exposure of the dozer operator was 27.9 EU/m^3 and the working face area TWA concentration was 4.7 EU/m^3. The morning and afternoon PBZ exposures were 65 EU/m^3 and 1.7 EU/m^3 respectively. The morning and afternoon area samples collected at the working face of the landfill were 6 EU/m^3 and 2.9 EU/m^3 respectively. The work activities of the dozer operator were the same in the morning and afternoon of sampling. Sewage sludge was received in the wet form in the morning and in the dry, pellet form in the afternoon. There was also variation in the type of waste disposed of throughout the day. A similar higher concentration of endotoxin was not measured in the morning area sample. This variation in waste is a possible explanation for the difference in measured exposures. A wide range of endotoxin concentrations were measured. Both control samples measured concentrations less than the minimum detectable concentration of 0.02 EU/m^3 assuming a sample volume of 230 L.

These results are lower than those detected at wastewater treatment facilities. Two samples collected in this study were at concentrations associated with acute health effects in previous endotoxin exposure studies.[22,26,27] In a previous NIOSH HHE evaluating biosolids exposure during land application, area and PBZ endotoxin levels ranged from 20 EU/m^3 to 39 EU/m^3.

VOCs

Major compounds detected were ethanol, various aliphatic hydrocarbons, toluene, ethyl benzene, xylenes, trimethyl benzenes, styrene, limonene, and siloxanes. Other compounds detected included chlorofluorohydrocarbons, naphthalene, pinenes, 4-vinyl-cyclohexene, methyl isobutyl ketone, butyl cellosolve, and butyl alcohols. None of these compounds were identified on the control sample collected on the closed unit. This sample contained water after the initial helium purge which may have prevented the detection of traces of low boiling components.

Observations

Employees working in the landfill did not report any health problems. Operators spent the majority of their day inside the cabs of the dozers and compactors. These cabs are enclosed and are equipped with heaters and air-conditioners. Operators leave their cabs to clear debris from their equipment, clean the windshield of the equipment, or to direct traffic at the working face. The dozers and compactors are not routinely cleaned. WMI management reported that it is common practice to pass down older dozers and compactors to smaller landfills when they are no longer suitable for use at large-scale landfills. The heavy machinery used at this site is state-of-the-art and therefore may represent the best case scenario for cab air filtration and resulting lower employee exposures. A locker room for employees is located in the maintenance shop. Shower facilities are not provided and employees wear their work clothes home. One employee reported they had received training on proper hygiene precautions. This employee reported routine hand washing prior to eating lunch.

CONCLUSIONS

Employees may be exposed to airborne sewage sludge during the disposal and subsequent spreading of it at the working face of the landfill. The detection of enteric bacteria in the air samples collected in this HHE confirms the potential for operators to be occupationally exposed to organisms which have been associated with gastrointestinal symptoms and illnesses. The total bacterial and endotoxin concentrations detected in the air were higher than those found in a previous NIOSH HHE during biosolids land application. Exposure criteria to quantitatively determine health risks associated with these exposure levels are not available.

At the time this HHE was conducted, employees operating heavy equipment at the working face of the landfill did not report any health problems. Based on conversations with employees and workplace observations, work practices such as wearing work clothing home and not cleaning the cab of the equipment may increase exposures to sewage sludge. Actions should be taken to reduce potential exposures.

RECOMMENDATIONS

The following recommendations are provided to help minimize exposure to sewage sludge and increase employee awareness of the importance of good hygiene and the appropriate use of personal protective equipment (PPE).

1. On-site showers should be installed and laundry services for washing work clothes should be provided to prevent contaminating personal vehicles or homes.

2. To reduce exposures to airborne microorganisms and endotoxin, the heavy equipment (dozers and compactors) used at the working face should be retro-fitted with air cleaning devices in conjunction with the air-conditioning units.

3. Appropriate PPE, such as gloves and coveralls, should be required for all job duties likely to result in exposure to sewage sludge. Management and employee representatives should work together to determine which job duties are likely to result in exposure and which type of PPE is needed. A qualified health and safety professional should provide training or retraining in the use of appropriate PPE.

4. Periodic training regarding standard hygiene practices should continue, reviewing issues such as:

- Frequent and routine hand washing. This is the most valuable safeguard in preventing infection by agents present in sewage sludge.
- Removing soiled PPE (such as gloves) after use, proper storage and disposal to avoid contaminating other objects or parts of the facility with soiled PPE, and hand washing after gloves are removed.
- Work clothes and boots should not be worn home or outside the immediate work environment.
- Eating, drinking, or smoking should not be done while working. Employees should always

wash their hands and face before engaging in these activities or using the restroom.

• PPE, such as boots, hard hats, and gloves, should either be properly cleaned after use or discarded.

• Signs and symptoms of illnesses potentially related to sewage sludge.

4. The compactor and bulldozer cabs should be wiped down and vacuumed on a regular basis to reduce potential exposure to contaminated material.

5. Employees should report health effects thought to be caused by work exposures to a designated WMI employee. A mechanism by which employees may report health effects or concerns should be developed. Those employees found to have potential work-related health effects should be referred to a physician knowledgeable in occupational medicine.

6. Since employees are at risk for soil-contaminated injuries, management should insure that all employees are up-to-date on tetanus-diptheria immunizations.

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Table 1
Principal Pathogens of Concern in Domestic Sewage and Sewage Sludge[8]
Waste Management, Inc. Outer Loop Landfill
HETA 2003-0078-2918
June 4-5, 2003

Organism	Disease/Symptom
Bacteria	
Salmonella sp.	Salmonellosis (food poisoning), typhoid fever
Shigella sp.	Bacillary dysentery
Yersinia sp	Acute gastroenteritis (including diarrhea, abdominal pain)
Vibrio Cholerai	Cholera
Escherichia coli	Gastroenteritis (pathogenic strains)
Campylobacter jejuni	Gastroenteritis
Enteric Viruses	
Hepatitis A virus	Infectious hepatitis
Norwalk and Norwalk-like viruses	Epidemic gastroenteritis with severe diarrhea
Enteroviruses- Polioviruses	Poliomyelitis
Enteroviruses- Coxsackieviruses	Meningitis, pneumonia, hepatitis, fever, cold-like symptoms
Enteroviruses- Echoviruses	Meningitis, paralysis, encephalitis, fever, cold-like symptoms, diarrhea
Heovirus	Respiratory infections, gastroenteritis
Astroviruses	Epidemic gastroenteritis
Caliciviruses	Epidemic gastroenteritis
Protozoa	
Cryptosporidium	Gastroenteritis
Entamoeba histolytica	Acute enteritis
Giardia lamblia	Giardiasis (including diarrhea, abdominal cramps, weight loss)
Balantidium coli	Diarrhea and dysentery
Toxoplasm gondii	Toxoplasmosis

Table 1 Continued
Principal Pathogens of Concern in Domestic Sewage and Sewage Sludge[8]
Waste Management, Inc. Outer Loop Landfill
HETA 2003-0078
June 4-5, 2003

Organism	Disease or Symptom
Helminths	
Ascaris lumbrcoides	Digestive and nutritional disturbances, abdominal pain, vomiting, restlessness
Ascaris suum	May produce symptoms such as coughing, chest pain, and fever
Trichuris trichiura	Abdominal pain, diarrhea, anemia, weight loss
Toxocara canis	Fever, abdominal discomfort, muscle aches, neurological symptoms
Taenia saginata	Nervousness, insomnia, anorexia, abdominal pain, digestive disturbance
Taenia solium	Nervousness, insomnia, anorexia, abdominal pain, digestive disturbance
Necator americanus	Hookworm disease
Hymenolepis nana	Taeniasis

Table 2
Culturable Bacterial Air Sampling Results
Waste Management, Inc. Outer Loop Landfill
HETA 2003-0078
June 4-5, 2003

Activity	Sampler Type	Total Bacteria Concentrations (CFU/m^3)*	Enteric Bacteria Concentrations (CFU/m^3)*
Control samples; no sewage sludge activity	Anderson	144	0
	Anderson	96	0
	SAS	110	0
	SAS	110	0
Unloading and spreading of wet sewage sludge	Anderson	108	0
	Anderson	564	0
	SAS	423	20
	SAS	635	50
Unloading and spreading of dry sewage sludge	Anderson	7584	0
	Anderson	>62,304**	0
	SAS	>29,681**	0
	SAS	> 53,152**	0
Unloading and spreading of two loads of dry sewage sludge	Anderson	> 38,753**	0
	Anderson	7344	36
	SAS	671	0
	SAS	2863	0
Unloading of one truckload of wet sewage sludge	Anderson	6348	0
	Anderson	11,556	0
	SAS	9805	0
	SAS	6965	0

* CFU/m^3 = colony forming units per cubic meter
** > indicates approximate concentrations due to heavy bacterial loading

Table 3
Waste Management, Inc. Outer Loop Landfill
Endotoxin Air Sampling Results
HETA 2003-0078-2918
June 4-5, 2003

Job Title	Date	Job Task	Time (minutes)	Sample Volume (Liters)	Concentration (EU/m^3)†
Full-Shift Personal Breathing Zone Samples					
Dozer Operator	06/04/03	Spread sewage sludge at working face and directed traffic	8:30 - 11:36 (126)	252	65
			12:47 - 15:45 (178)	356	1.7
					TWA Exposure 27.9
Full-Shift TWA Area Sample					
Unit 7	06/04/03	Disposal of sewage sludge and other waste at working face	10:00 - 12:47 (167)	334	6
			13:36 - 15:37 (121)	242	2.9
					Area TWA 4.7
Unit 6	06/04/03	Control	9:00 - ???*	---	< 0.02
Unit 7	06/05/03	Disposal of sewage sludge and other waste at working face	8:33 - 10:54 (115)	230	170
Unit 6	06/05/03	Control	8:50 - 10:45 (141)	282	< 0.02

† = Endotoxin units per cubic milligram
* = Pump failure
TWA = Time-weighted average
TWA Calculation = $\frac{C_1T_1 + C_2T_2 + C_nT_n}{T_1 + T_2 + T_n}$,where C = concentration and T = time

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