Health Consultation

Review of Environmental Monitoring and Sampling Data

IESI BETHLEHEM LANDFILL
LOWER SAUCON TOWNSHIP
BETHLEHEM, NORTHAMPTON COUNTY, PENNSYLVANIA

Prepared by
Pennsylvania Department of Health

DECEMBER 12, 2016

Prepared under a Cooperative Agreement with the
U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Agency for Toxic Substances and Disease Registry
Division of Community Health Investigations
Atlanta, Georgia 30333

Health Consultation: A Note of Explanation

A health consultation is a verbal or written response from ATSDR or ATSDR's Cooperative Agreement Partners to a specific request for information about health risks related to a specific site, a chemical release, or the presence of hazardous material. In order to prevent or mitigate exposures, a consultation may lead to specific actions, such as restricting use of or replacing water supplies; intensifying environmental sampling; restricting site access; or removing the contaminated material.

In addition, consultations may recommend additional public health actions, such as conducting health surveillance activities to evaluate exposure or trends in adverse health outcomes; conducting biological indicators of exposure studies to assess exposure; and providing health education for health care providers and community members. This concludes the health consultation process for this site, unless additional information is obtained by ATSDR or ATSDR's Cooperative Agreement Partner which, in the Agency's opinion, indicates a need to revise or append the conclusions previously issued.

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Foreword

The Pennsylvania Department of Health (PADOH) evaluates the public health threat of hazardous waste sites through a cooperative agreement with the federal Agency for Toxic Substances and Disease Registry (ATSDR) in Atlanta, Georgia. This health consultation is part of an ongoing effort to evaluate environmental data and its health effects on the people living near the Independent Environmental Solutions Incorporated (IESI) Bethlehem Landfill located in Lower Saucon Township, Bethlehem, and Northampton County Pennsylvania. The PADOH evaluates site-related public health issues through the following processes:

- **Evaluating exposure:** PADOH and ATSDR begin by reviewing available information about environmental conditions at the site. The first task is to find out how much contamination is present, where it is, and how human exposures might occur. The Pennsylvania Department of Environmental Protection (PADEP) provided the information for this assessment.
- **Evaluating health effects:** If PADOH finds evidence that exposures to hazardous substances are occurring or might occur, PADOH and ATSDR will determine whether those exposures could be harmful to human health. PADOH focuses this report on public health; that is, the health impact on the community as a whole, and bases it on existing scientific information.
- **Developing recommendations:** In this report, the PADOH outlines its conclusions about any potential health threat posed by environmental conditions at the site and offers recommendations for reducing or eliminating the exposure. The role of the PADOH is primarily advisory. For that reason, the evaluation report will typically recommend actions for other agencies, including the U.S. Environmental Protection Agency (EPA) and the PADEP. If, however, an immediate health threat exists or is imminent, PADOH will issue a public health advisory warning people of the danger and will work to resolve the problem.
- **Soliciting community input:** The evaluation process is interactive. The PADOH starts by soliciting and evaluating information from various government agencies, individuals or organizations responsible for cleaning up the site, and those living in communities near the site. PADOH shares conclusions about the site with the groups and organizations providing the information.

If you have questions or comments about this report, please contact us.

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Summary

Introduction

On May 8, 2015, the Pennsylvania Department of Health (PADOH) received a letter from the Lower Saucon Township council manager requesting an environmental exposure study on residential areas surrounding the Independent Environmental Solutions Incorporated (IESI) Bethlehem Landfill. PADOH responded to the request on May 13, 2015, stating that PADOH and the Agency for Toxic Substances and Disease Registry (ATSDR) will prepare a health consultation to evaluate the health implications of exposure to the environmental contaminants and make conclusions and recommendations to protect health, if needed. Afterwards, PADOH requested that the Pennsylvania Department of Environmental Protection Agency (PADEP) conduct air sampling near the IESI landfill to identify landfill-related chemicals that could cause potential health effects or nuisance odors. As a result, PADEP conducted limited air monitoring during June 2 – 4, 2015 at six locations, and shared the results with PADOH and ATSDR. PADEP also shared the results of the water samples collected from two residential wells located down gradient from the landfill.

PADOH prepared this health consultation under cooperative agreement with ATSDR by reviewing the available environmental data provided by PADEP. This document provides an evaluation of the available data, conclusions based on this data, and recommendations for future actions to protect the public's health.

Conclusions PADOH and ATSDR reached three important conclusions based on the limited environmental data available.

Conclusion 1

PADOH and ATSDR cannot currently conclude whether airborne chemicals in the Lower Saucon Township areas adjacent to the IESI landfill could harm people's health, because of the limited monitoring information.

Basis for Conclusion Open Path Fourier Transform Infrared (OPFTIR) spectrometry was used to monitor the air in this community. This method can be helpful to rapidly identify the presence of chemicals in the air in different locations of a community. However, this method has limited utility for public health exposure assessment, because its detection limits are too high and its instantaneous readings cannot be converted into appropriate exposure values for the evaluation of health effects.

The OPFTIR method did detect some chemicals in the air of this community. Five of these detected chemicals (benzene, methylamine, methyl mercaptan, nitrogen dioxide, and ozone) may be of potential health concern if exposures occurred at concentrations high enough and long enough, because the detected concentrations exceeded acute health-based comparison values.

Further, for many chemicals (including common odor-causing chemicals like hydrogen sulfide), the OPFTIR detection limits were above health-based comparison values. Therefore, we do not know if additional chemicals were present but at concentrations lower than can be detected by this monitoring method.

Conclusion 2

PADOH and ATSDR conclude that the chemicals detected in the air at community monitoring locations at this site could cause odor-related symptoms but could not be specifically associated with the landfill or the water treatment plant based on the current monitoring. Odor-related symptoms usually resolve when the odor goes away. These odor-related symptoms could include eye, nose, and throat irritation; headache; nausea; diarrhea; hoarseness; sore throat; cough; chest tightness; nasal congestion; palpitations; shortness of breath; stress; drowsiness; and alterations in mood.

Basis for Conclusion

Monitoring identified five chemicals (dimethyl sulfide, methylamine, methyl mercaptan, nitrogen dioxide, and ozone) above their odor threshold levels at community sampling locations. Note, not all of these chemicals were detected at the landfill or the wastewater treatment plant monitoring locations. Monitoring did not detect three odor-causing chemicals commonly associated with landfills (i.e., hydrogen sulfide, acetaldehyde, and carbon disulfide) at any of the six monitoring locations during the June 2015 monitoring event; however, the instrument's minimum detection limits were higher than odor threshold values for these chemicals.

Conclusion 3

PADOH and ATSDR conclude that consuming the chemicals detected in the two residential drinking water wells near the IESI landfill is not expected to harm people's health, except possibly for individuals who are on a reduced-iron diet for medical reasons.

Basis for Conclusion

Based on multiple rounds of sampling from two residential drinking water wells downgradient of the landfill, the maximum levels of chemicals detected in the private well water did not exceed ATSDR health-based comparison values or state or federal primary drinking water standards established for municipal drinking water supplies. Manganese and iron exceeded secondary drinking water standards in one well, which indicates poor water quality (e.g., color, taste, and smell) at that location. Water from this well may have a rusty color that can stain clothes and dishes after washing and may also have a metallic taste that can make it unsuitable for drinking.

For people with a rare genetic disease called hemochromatosis, the consumption of this water may cause iron overload. It is recommended that anyone with hemochromatosis using this well water consult their health care professionals to discuss the potential for additional iron exposures from consuming their well water.

Data were only available for two private residential wells located nearby the landfill, which limits conclusions about impacts to the groundwater in the IESI landfill area.

Next Steps

To reduce the potential for unhealthy air exposures and nuisance odor events in this community, PADOH and ATSDR recommend implementing robust engineering controls at the nearby sources of air/odor emissions (e.g., landfill, wastewater treatment plant) as a proactive approach. If additional engineering controls are not implemented, PADOH recommends more rigorous environmental sampling and analytical methods be used to identify and quantify specific chemical emissions and better characterize exposures to these chemicals in the surrounding community's ambient air.

PADOH and ATSDR also recommend PADEP continue oversight, permit enforcement, and timely nuisance odor event response, including maintaining an odor complaint log (e.g., frequency, intensity, duration, odor characteristics, and weather conditions such as wind direction) to ensure that the safety, health, and welfare of the community are protected. The ATSDR website provides additional information on effects of odors on health as well as resources for residents who are concerned about odors in their community: http://www.atsdr.cdc.gov/odors/index.html.

PADOH and ATSDR recommend PADEP continue to oversee groundwater monitoring for landfill contaminant migration, including sampling of residential wells near the landfill.

Background and Purpose

IESI Bethlehem Landfill is located in a rural setting at 2335 Applebutter Road in Northampton County, Bethlehem, Pennsylvania, 18015. The landfill has been in operation since 1950 (Figure 1). On January 21, 2015, IESI filed an expansion application to PADEP and requested an expansion of 6 acres towards the south, with 22.5 acres overtopping existing landfill areas. The last expansion was approved in 2003. On June 1, 2015, PADOH, ATSDR, and PADEP visited the landfill and met with local township officials, who noted that residents believe that odors and health issues are related to the IESI Bethlehem Landfill. Because of these concerns, the community requested that PADEP and PADOH conduct a "health study to test the air and water quality." In this health consultation, PADOH and ATSDR evaluate the limited air and water data available for potential health concerns and provide recommendations based on this evaluation.

Air monitoring data collection

During June 2 – 4, 2015, PADEP conducted ambient air monitoring at six different locations using an Open Path Fourier Transform Infrared (OPFTIR) spectrometer (Figure 2). Two monitoring locations were on the landfill property, including IESI Landfill Upper Location (IESI LUL) and IESI Lower Location (IESI LLL). One monitoring location was at the Bethlehem Waste Water Treatment Plant (BWWTP); and, three locations were offsite in the community surrounding the landfill, including the Steel City Mennonite Church (SCC), Hader Lane (Hader), and Steel City Park (SCP). The SCC and SCP are in close proximity to residential properties. The SCP location is a more rural setting. The IESI LUL, IESI LLL, and BWWTP are considered potential sources of airborne contaminants in the community, while the three community locations (SCC, SCP, and Hader) are locations in close proximity to residential areas and where children may be present.

The OPFTIR monitor is used to identify the presence of chemicals from a known library of chemical compounds. Ambient air is instantaneously measured along a linear path. Instantaneous monitoring results vary based on instantaneous environmental conditions, such as humidity and vehicle traffic exhaust, along the linear path being monitored. It is important to note the weather conditions on the days that community air monitoring was conducted. Weather conditions impact the OPFTIR monitoring technology and the wind direction helps to determine where chemicals detected at the monitor may have originated. Each day of monitoring was conducted under cloudy skies, and rain/drizzle was noted during monitoring at the landfill (IESI-LUL, and IESI-LLL), but no rain/drizzle was observed at other locations during monitoring. Wind directions at each of the community monitoring locations were not optimal for measuring potential emissions from the landfill or the wastewater treatment plant. On each day of community monitoring, the landfill was not upwind of the monitor; therefore, based on this data set alone, detections of common landfill chemicals that were detected both on- and offsite (ammonia, dimethyl sulfide, carbon monoxide, methane, methanol, methyl mercaptan) could not be attributed to the landfill.

Out of 46 chemical compounds tested (Table 1, Appendix A) in the ambient air at or near the landfill, 29 compounds were detected (Table 2, Appendix A). Eleven (11) chemicals were detected at one of the community monitoring locations *and* at the landfill or the wastewater treatment plant. Fourteen (14) chemicals were detected in the community but not at either of the potential source locations (landfill or wastewater treatment plant) (Table 3, Appendix A). Other sources of airborne chemical emissions are nearby industrial facilities.

Because OPFTIR monitoring detected some chemicals, we evaluated this preliminary data to determine if any contaminant concentration approached levels of concern. Only chemicals detected in community monitoring results, regardless of their detection at source monitoring locations, were compared to health-based comparison values (CV). Five (5) of the 25 compounds detected at community monitors were above acute health-based CVs, including benzene, methylamine, methyl mercaptan, nitrogen dioxide, and ozone (Table 4, Appendix A). Five of the 25 compounds detected at community monitors exceeded their odor threshold levels, including dimethyl sulfide, methylamine, methyl mercaptan, nitrogen dioxide, and ozone (Table 5, Appendix A). OPFTIR monitoring did not detect (at any locations) three common, landfill-related, odor-causing chemicals with very low odor thresholds (i.e., hydrogen sulfide, acetaldehyde, and carbon disulfide). It is not known whether or not these chemicals were present in the ambient air because the minimum detection limits[1] for these three chemicals were above their odor thresholds.

A number of chemicals were detected both at the landfill and in the community, including ammonia, dimethyl sulfide, methane, methanol, methyl mercaptan, and ozone. However, some of these chemicals (i.e., ammonia, methane, methyl mercaptan, and ozone) were also detected at the wastewater treatment plant, which is also a potential source for these chemicals. Ozone detections were likely a combination of emissions from mobile and fixed industrial sources in the region and not emissions from a single source, such as the IESI landfill. One common landfill chemical, methylamine, was detected in the community but not at the landfill, and some chemicals were detected at the landfill but not at the community monitoring locations (i.e., sulfur dioxide and trimethylamine). See Table 2 for a full listing of the 27 chemicals detected at any of the source or community locations by OPFTIR monitoring between June 2 and 4, 2015.

PADOH and ATSDR cannot make a determination about the public health impacts of exposure to the chemicals detected by OPFTIR spectroscopy in ambient air surrounding the IESI landfill. However, landfill-related chemicals were detected by OPFTIR monitoring indicating some gaseous landfill chemicals may be migrating offsite. This information supports better controls of sources of emissions at the landfill (e.g., open face activities, leachate and landfill gas collection systems) and at other nearby sources, such as the Bethlehem wastewater treatment plant.

If additional and more rigorous sampling were performed to confirm the concentrations detected by OPFTIR spectroscopy, a more detailed assessment and the associated public health

[1] The definition of the minimum detection limit (MDL) for OPFTIR monitoring is the minimum concentration of a target gas that can be detected in the presence of all the usually encountered spectral interferences. Spectral interferences are determined by analyzing "background" ambient air (i.e., not affected by the emissions source of concern) near the site to be monitored where meteorological conditions and other ambient air interferences (e.g., water vapor) may be present. Fifteen separate field "readings" are collected and the standard deviations for each chemical's data set is determined. Three times the standard deviation of these calculated concentrations are defined as MDLs.

conclusions could be provided. Appendix A provides a preliminary public health evaluation of exposures to the screening level OPFTIR data from ambient air monitoring at locations near the IESI landfill.

It is important to keep in mind that trying to characterize and quantify odorous compounds in ambient air near landfills is highly complex (and for some chemicals not technologically feasible). Variable conditions make it very difficult to capture and quantify peak transient air events. Therefore, PADOH and ATSDR support prudent public health actions to reduce sources of identified odorous air emissions.

Residential well water sampling

PADEP provided the summary results of water samples collected (02/08/2010 – 02/09/2016) from two private residential wells (RW1 and RW2) located down gradient (towards north) of the IESI landfill. The wells are approximately 1/3 mile from the IESI landfill boundary.

Discussion

ATSDR/PADOH evaluation of residential well water samples

To identify the contaminants that require further evaluation for potential public health implications, chemical concentrations in drinking water are compared to health-based CVs. For initial screening of chemicals in private drinking water wells, PADOH used a number of sources of comparison values (CV), including ATSDR health-based comparison values (HCV), EPA's Maximum Contaminant Levels (MCL), EPA's Life Time Health Advisory (LTHA), and Secondary Drinking Water Regulations (SDWR). If detected levels of chemicals in water exceed their respective CVs, it does not necessarily indicate a problem but rather triggers a more in-depth review.

ATSDR and PADOH reviewed and evaluated the results of the water samples collected from two residential wells. No volatile organic compounds (VOC) were detected in any of the residential well (RW) water samples above the laboratory detection limits (0.5 micrograms per liter, or µg/L). Inorganic contaminants, including iron and manganese, were above EPA's SDWR in RW1. Since no VOCs were detected in the two private water wells assessed, only ingestion is considered as an exposure route for the contaminants detected.

Iron

Iron exceeded the SDWR of 300 µg/L on two occasions in residential well RW1, including 3,575 µg/L on December 16, 2012 and 375 µg/L on February 13, 2013. Iron concentrations ranged from 5 – 27 µg/L on all other sampling dates.

Iron levels above the SDWR cause water to have an unpleasant taste and color (rusty color; sediment; metallic taste; reddish or orange staining). Iron is an essential nutrient. Iron concentrations in groundwater are typically in the range of 10-250 µg/L [USGS 1995]. The recommended acceptable daily intakes for iron are 8,000 µg/day for men and post-menopausal women, 18,000 µg/day for pre-menopausal women, 10,000 µg/day for adolescents, 27,000 µg/day for pregnant women, and 3,000 µg/day for children (1-3 years old). The upper acceptable daily intake is 45,000 µg/day [IOM 2001].

The consumption of water from RW1 at the highest level of iron (3,575 µg/L) would contribute about 7,150 µg of iron to an adult's daily diet (2 liters of water consumed per day) and approximately 3,570 µg of iron to a child's daily diet (1 liter of water/day). Although exposure to iron at the levels detected in RW1 are not expected to be harmful to healthy individuals, a rare genetic disease called hemochromatosis is associated with iron overload in a small percentage of persons**.** It is recommended that anyone with hemochromatosis consult their health care professionals to discuss the potential for additional iron exposures from consuming their well water.

Manganese

Manganese was detected at a maximum concentration of 88 µg/L in RW1, which exceeds the EPA SDWR of 50 µg/L, but is below the concentration where further public health evaluation is recommended (i.e., EPA LTHA of 300 µg/L). The SDWR was set for aesthetic reasons (black to brown color; black staining; bitter metallic taste) and is not based on health effects [EPA 2016]. The World Health Organization (WHO) has established the average dietary intake of manganese to range from approximately 2,000 – 8,800 µg/day. Manganese is an essential dietary nutrient. Exposure to manganese at the levels detected is not expected to be harmful.

Limitations

Water

PADEP provided summarized data tables for the water sample results and not laboratory data sheets. Therefore, our conclusion and recommendation were based on the summarized data tables. Data were only available for two private residential wells located nearby the landfill, which limits our conclusions about impacts to the groundwater in the IESI landfill area.

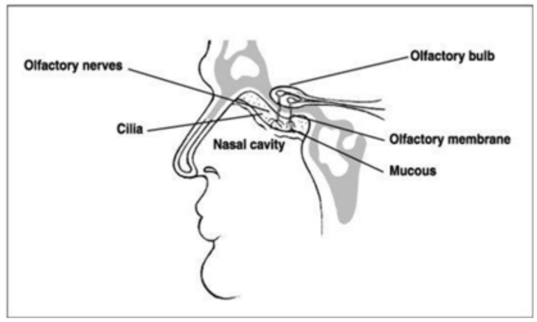
Air

Monitoring with an OPFTIR device identifies the presence of chemicals from a known library along a narrow, linear path in ambient air between a transmitter and its reflector. It provides an instantaneous average reading along the entire path of an infrared beam. Often because of environmental variables this method produces minimum detection limits well above health-based CVs or odor thresholds. Because the results are obtained from an instantaneous reading along a linear path and not from a specific exposure point over an extended time period, the OPFTIR data does not represent exposure point concentrations (i.e., representativeness), and can only be used to screen for potential acute health effects, as well as for odor-related events.

On each day of community monitoring, the monitor was not located downwind of the landfill; therefore, monitoring results were not optimal for assessing potential emissions from the landfill (or the wastewater treatment plant). A number of common landfill chemical pollutants were not detected during OPFTIR monitoring, including hydrogen sulfide, aldehydes such as formaldehyde and acetaldehyde, and styrene. Because of the high minimum detection limits of the OPFTIR technology, it is not known whether these chemicals were present at levels of health or nuisance odor concern. Other common chemicals (e.g., esters, phenols, chlorinated solvents, carbon tetrachloride) were not monitored by OPFTIR because they are not included in the OPFTIR compound library. In summary, PADOH and ATSDR cannot determine if a number of chemicals were present at levels of health or nuisance odor concern because of (1) the limited OPFTIR instrument sensitivity (i.e., high minimum detection limits), (2) the limited OPFTIR compound library, and (3) the representativeness of the data.

Other potential odor-causing sources exist near the landfill, including a wastewater treatment plant, a nearby mulching operation, and nearby railroad activities. The presence of these other facilities makes it difficult to determine the source of the chemicals detected in the OPFTIR data set.

General health effects associated with environmental odors



People are capable of smelling chemicals at very low concentrations. When humans breathe in air, it travels through nasal passages, which are lined with mucus membranes (as shown in the figure). These mucus membranes help to filter out unwanted particles from the inhaled air and secrete a mucus layer that lines the nasal passages [Krough 2005]. The olfactory epithelium in the specific area of mucus membrane that houses the olfactory nerve cells is located at the top of the nasal cavity [Axel 2006]. Olfactory nerve cells, also referred to as receptor cells, transmit olfactory information to the brain upon being triggered by an odorant molecule (environmental substances) in the inhaled air. The concentration of odorant may be perceived in many different ways depending on the concentration. A change in concentration will change the receptor codes and a change in the perceived smell will occur [Malnic et al. 1999]. Furthermore, some odorants can be detected at lower concentrations than other odorants. In addition, air temperature and relative humidity affect the perception of odors [Little 1965]. Axel and Buck [1991] have provided understanding on how the nose is able to distinguish more than 10,000 distinct smells. The researchers discovered a gene pool of more than 1,000 different genes that encode olfactory receptors in the nose.

Mixtures of different chemicals that have odors have received limited investigation. A mixture of chemicals present in the air may possibly produce additive, antagonistic or synergistic odor effects.

A strong body of literature shows that offensive odors can cause health symptoms [ATSDR 2015; Schiffman and Williams 2005]. These symptoms may result from protective inborn or learned aversions to offensive odors, which may signal danger or threats to health [Schiffman et al. 2000; Schiffman and Williams 2005; Bulsing et al. 2009]. The presence of offensive odors in a community can also lead to a diminished sense of well-being or quality of life for community members [Shusterman 2002]. Health complaints reported from exposure to offensive odors (such as emanating from animal processing facilities, wastewater treatment plants, or landfills) include eye, nose, and throat irritation; headache; nausea; diarrhea; hoarseness; sore throat; cough; chest tightness; nasal congestion; palpitations; shortness of breath; stress; drowsiness; and alterations in mood [Schiffman et al. 2000]. Usually the symptoms occur at the same time as the odor and resolve when the odor goes away. But in sensitive people, such as those with asthma, the very young, or the very old, odors can cause symptoms that last longer and may aggravate existing medical conditions [Bulsing et al. 2009]. Children may be more sensitive to the effects of environmental odors. Young children have a faster breathing rate than adults, so they breathe in more of the odors. Some chemicals producing the environmental odors can be heavier than air and stay closer to the ground where children play. Because children are small and play or crawl on the ground, they can have higher exposure to these odors-producing chemicals. Odors can make asthma worse for people with asthma (including children)[2]. In addition, previous exposure to high levels of an irritating substance has been shown to make some people acutely sensitive to the substance in the future. If these people smell even very low levels of the substance, they might experience symptoms ranging from headaches and nausea to effects associated with panic attacks, such as lightheadedness or shortness of breath [Schiffman et al. 2000].

As mentioned earlier, most of the OPFTIR measurements around the IESI landfill were below the instrument's minimum detection limit. The estimation of odor production and dispersion from sites is a very complicated task because of the different chemical species that exist in biogas. Monitoring the odor annoyance generated by a site is difficult, because it is a multi-area-sources problem, with a discontinuous odor emission. Appendix A includes an evaluation of the five chemicals (dimethyl sulfide, methylamine, methyl mercaptan, nitrogen dioxide, and ozone) detected at community monitoring locations that exceeded their odor threshold levels. Also, the three common odor-causing chemicals found in landfills (i.e., hydrogen sulfide, acetaldehyde, and carbon disulfide) that were not detected during the OPFTIR monitoring are further discussed in Appendix A. ATSDR provides a website that contains additional information on effects of odors on health as well as resources for residents who are concerned about odors in their community (http://www.atsdr.cdc.gov/odors/index.html).

[2] Source: ATSDR's Environmental Odors FAQs available from: https://www.atsdr.cdc.gov/odors/faqs.html

Conclusions

PADOH and ATSDR reached three important conclusions based on the limited environmental data available.

Air

PADOH and ATSDR cannot currently conclude whether airborne chemicals in the Lower Saucon Township areas adjacent to the IESI landfill could harm people's health, because of the limited monitoring information.

Open Path Fourier Transform Infrared (OPFTIR) spectrometry was used to monitor the air in this community. This method can be helpful to relatively rapidly identify the presence of chemicals in the air in different locations of a community. However, this method has limited utility for public health exposure assessment because its detection limits are too high and its instantaneous readings cannot be converted into appropriate exposure values for the evaluation of health effects. Using the OPFTIR method, certain chemicals were identified in the air of this community. Five of these detected chemicals (benzene, methylamine, methyl mercaptan, nitrogen dioxide, and ozone) may be of potential health concern if exposures occurred at concentrations high enough and long enough, because the detected concentrations exceeded acute health-based comparison values. Further, for many chemicals (including common odor-causing chemicals like hydrogen sulfide), the OPFTIR detection limits were above health-based comparison values. Therefore, we do not know if additional chemicals were present but at concentrations lower than can be detected by this monitoring method.

PADOH and ATSDR conclude that chemicals detected in the air at community monitoring locations at this site could cause odor-related symptoms but could not specifically associate them with the landfill or the waste water treatment plant. Odor-related symptoms usually resolve when the odor goes away. These odor-related symptoms could include eye, nose, and throat irritation; headache; nausea; diarrhea; hoarseness; sore throat; cough; chest tightness; nasal congestion; palpitations; shortness of breath; stress; drowsiness; and alterations in mood.

Monitoring identified five chemicals contaminants (dimethyl sulfide, methylamine, methyl mercaptan, nitrogen dioxide, and ozone) above their odor threshold levels at community sampling locations. Note, not all of these chemicals were detected at the landfill or wastewater treatment plant monitoring locations. Monitoring did not detect three odor-causing chemicals commonly associated with landfills (i.e., hydrogen sulfide, acetaldehyde, and carbon disulfide) at any of the six monitoring locations during the June 2015 monitoring event; however, the instrument's minimum detection limits were higher than odor threshold values for these chemicals.

Residential well water samples

PADOH and ATSDR conclude that consuming chemicals detected in two residential drinking water wells near the IESI landfill is not expected to harm people's health, except possibly for individuals who are on a reduced-iron diet for medical reasons. Based on multiple rounds of sampling from two residential wells downgradient of the landfill, the maximum levels of chemicals detected in the private well water did not exceed ATSDR health-based comparison values or state or federal primary drinking water standards established for municipal drinking water supplies. Manganese and iron exceeded secondary drinking water standards indicating poor water quality (e.g., color, taste, and smell) at this location. Water from this well may have a rusty color that can stain clothes and dishes after washing and may also have a metallic taste that can make it unsuitable for drinking.

For persons with a rare genetic disease called hemochromatosis, the consumption of the water may cause a potential risk from iron overload. It is recommended that anyone with hemochromatosis using this well water consult their health care professionals to discuss the additional iron exposures from consuming their well water.

Recommendations

To reduce the potential for unhealthy air exposures and nuisance odor events in this community, PADOH and ATSDR recommends that PADEP:

1. Work with local air emission sources (e.g., landfill, wastewater treatment plant) to implement robust engineering controls to reduce air emissions. If additional engineering controls are not taken to better control these sources of air emissions/odors, PADOH recommends more rigorous environmental sampling and analytical methods to identify and quantify specific chemical emissions and to better characterize exposures to these chemicals in the surrounding community's ambient air.

2. Continue oversight, permit enforcement, and timely nuisance odor response, including maintaining an odor complaint log (e.g., frequency, intensity, duration, odor characteristics, and weather conditions such as wind direction).

3. Continue groundwater monitoring for landfill contaminant migration, including sampling of nearby residential water wells near the landfill.

PADOH and ATSDR will review and evaluate any future environmental data for this site as requested and share the findings with the community.

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Report Preparation

This public health consultation prepared by the PADOH and ATSDR complies with the approved agency methods, policies, and procedures existing at the date of the publication. Editorial review was completed by the cooperative agreement partner. ATSDR has reviewed this document and concurs with its findings based on the information presented.

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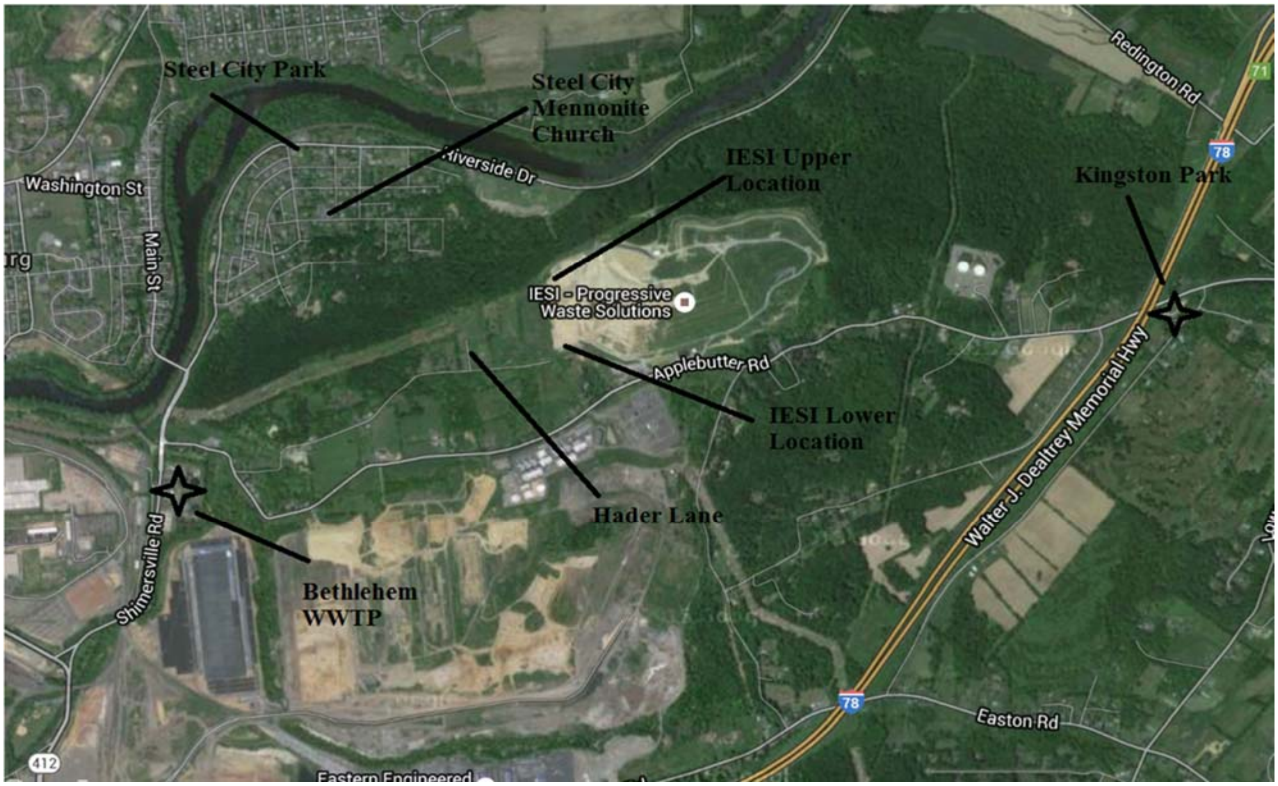
Figures

Figure 1: IESI Landfill

Figure 2: IESI Landfill air monitoring and residential well locations located downgradient towards north from the landfill



Appendix A

Based on OPFTIR monitoring data limitations as discussed in the main document, PADOH and ATSDR cannot make a public health determination about the detected chemicals in the air. However, in this appendix we provide a discussion of potential acute health effects and odor related symptoms. As discussed in the data limitations section in the main document, instantaneous OPFTIR data do not sufficiently represent exposure point concentrations, therefore public health conclusions about OPFTIR data are uncertain and considered preliminary and potential health outcomes from exposures.

ATSDR/PADOH evaluation process for air monitoring data set

Because OPFTIR data are from instantaneous ambient air measurements, chemical concentrations are compared only with acute (short-term) health-based CVs. PADOH and ATSDR compared OPFTIR data to ATSDR acute health-based CVs or Minimal Risk Levels (MRL) in parts per billion (ppb) or micro grams per cubic meter (µg/m3). If ATSDR has not established a CV for a certain chemical, then alternative CVs derived by other relevant agencies were used for comparison, including EPA National Ambient Air Quality Standards (NAAQS) and Air Quality Index (AQI), California Air Resources Board acute reference exposure levels (CARB-REL) [CARB 2009], Texas Commission on Environmental Quality short-term Effects Screening Levels (TCEQ-ESL) [TCEQ 2009], National Institute for Occupational Safety and Health Reference Exposure Levels (NIOSH-REL), and American Conference of Governmental Industrial Hygienists (ACGIH) threshold limit values (TLV).

NAAQS are standards established by EPA under the Clean Air Act 40 CFR part 50 for pollutants considered harmful to public health and the environment. The AQI is an index for reporting daily air quality. It tells you how clean or polluted your air is, and what associated health effects might be a concern for you. The AQI focuses on health affects you may experience within a few hours or days after breathing polluted air. An AQI value of 100 generally corresponds to the national air quality standard for the pollutant, which is the level EPA has set to protect public health [EPA 2016a]. AQI values below 100 are generally thought of as satisfactory. “Good” AQI is 0 to 50. Good air quality is considered satisfactory, and air pollution poses little or no risk. “Moderate” AQI is 51 to 100. Moderate air quality is considered acceptable; however, for some pollutants there may be a moderate health concern for a very small number of people. For example, people who are unusually sensitive to ozone may experience respiratory symptoms. When AQI values are above 100, air quality is considered to be unhealthy –at first for certain sensitive groups of people, then for everyone as AQI values get higher (AQI>150).

The CARB-REL is an exposure level that is unlikely to cause adverse effects in a human population, including sensitive subgroups (such as infants and children), exposed to that concentration for up to 1 hour. The CARB has established acute (1-hour) inhalation RELs for toxic air contaminants. Short-term TCEQ-ESLs are used to evaluate the potential for non-cancer health effects or nuisance odor impacts to occur as a result of exposure to concentrations of constituents in the air for 1-hour averaging period. TCEQ-ESLs are based on data concerning health effects, the potential for odors to be a nuisance, effects on vegetation, and corrosive effects. TCEQ-ESLs are not ambient air standards. If predicted airborne levels of a chemical do not exceed the TCEQ-ESL, adverse health or welfare effects are not expected. NIOSH-RELs are for occupational exposures (8-10 hour workdays) designed for a healthy population that has been informed of the workplace hazards and trained to be aware of how to protect themselves from unhealthy exposures, while ATSDR screening values (24 hour exposures) are designed to protect all of the population, including subpopulations (infants, children, immune compromised and the elderly). Using NIOSH and ACGIH comparison values for non-occupational and non-industrial exposure is not recommended, but, in this case, were used for data screening because no other health screening levels were available for screening the detected chemicals. If ambient air chemical concentrations exceed these CVs, it does not necessarily indicate a problem but rather triggers a review in more depth.

Overall, five chemical contaminants were detected using OPFTIR spectroscopy offsite at community monitoring locations that exceed acute health comparison values (benzene, methylamine, methyl mercaptan, nitrogen dioxide, and ozone) or odor threshold values (dimethyl sulfide, methylamine, methyl mercaptan, nitrogen dioxide, and ozone).

Discussion of potential acute health effects from exposure to chemicals in air

The OPFTIR data show that some gases are present in the community near the landfill (e.g., methyl mercaptan, methylamine, and carbon monoxide). Some of these chemicals are not exclusively related to landfill emissions and are commonly detected in ambient air (e.g., benzene and ozone). Detection limits during these monitoring events were variable but often were well above health-based CVs. The procedures and equipment used during this monitoring event provide instantaneous peak concentrations and are, at best, suited for evaluating short-term airborne chemical exposures. ATSDR and PADOH did not compare these results to chronic (long-term) exposure guidelines since OPFTIR monitors provide only instantaneous concentrations of chemicals along the linear path being monitored.

A number of compounds were tested and detected during these monitoring events (Tables 1 and 2). Eleven (11) chemicals were detected at one of the community monitoring locations *and* at the landfill or the wastewater treatment plant. Fourteen (14) chemicals were detected in the community but not at either of the potential source locations (landfill or wastewater treatment plant) (Table 3). Five chemical compounds were detected above acute health comparison values at community monitoring locations, including benzene, methyl mercaptan, methylamine, nitrogen dioxide, and ozone (Table 4). These chemicals were selected for further evaluation for potential acute health effects as well as odor related health effects.

Table 1: All chemical contaminants tested for using OPFTIR at or near IESI Landfill, Bethlehem, PA and their minimum detection limit range.

Compound	Minimum Detection Limit Range (ppb)	Compound	Minimum Detection Limit Range (ppb)
1,2,4-Trimethylbenzene	200 – 313	Methyl mercaptan	168 – 580
2-Methyl butane	23 – 144	Methyl tert-butyl ether	10 – 168
2-Methyl pentane	43 – 326	Methylamine	123 – 169
3-Methyl pentane	28 – 339	Naphthalene	20 – 35
Acetaldehyde	110 – 368	n-butane	31 – 120
Ammonia	5 – 9	n-hexane	56 – 344
Benzene	139 – 198	n-heptane	218 – 1,293
Carbon disulfide	86 – 492	Nitric acid	14 – 23
Carbon monoxide	19 – 86	Nitric oxide	384 – 1,559
Carbonyl sulfide	5 – 24	Nitrogen dioxide	106 – 556
Chloroform	6 – 36	Nitrous oxide	6 – 370
Chloromethane	251 – 367	Nitrous acid	4 – 7
Dimethyl sulfide	83 – 207	n-octane	185 – 2,358
Ethane	88 – 768	n-pentane	36 – 397
Ethanol	19 – 72	Ozone	20 – 32
Ethyl benzene	84 – 462	Propane	32 – 445
Ethylene	11 – 42	Styrene	23 – 32
Formaldehyde	17 – 37	Sulfur dioxide	121 – 188
Hydrogen chloride	22 – 46	Toluene	83 – 366
Hydrogen sulfide	6,995 – 14,124	Triethylamine	13 – 44
Iso-butane	2 – 270	m-xylene	58 – 112
Methane	68 – 291	o-xylene	32 – 360
Methanol	11 – 15	p-xylene	98 – 224

OPFTIR – open path Fourier transform infrared spectrometer; ppb – parts per billion

Table 2: Chemical contaminants (maximum) detected at or near IESI Landfill, Bethlehem, PA, using OPFTIR (ppb)

Compounds	Acute CV (ppb)	CV Source	Minimum Detection limit range (ppb)	Monitoring Locations					
				06/02/2015		06/03/2015		06/04/2015	
				Landfill		Community locations			Wastewater plant
				IESI LUL (ppb)	IESI LLL (ppb)	SCC* (ppb)	Hader* (ppb)	SCP* (ppb)	BWWTP (ppb)
2-methyl butane	NA	NA	23 – 144	ND	ND	44	ND	ND	ND
Ammonia	1,700	a.MRL	5 – 9	ND	7	12	ND	ND	22
Benzene	9	a.MRL	139 – 198	ND	ND	212	ND	147	ND
Carbon monoxide	35,000	NAAQS	19 – 86	216	128	141	91	208	166
Chloroform	100	a.MRL	6 – 36	ND	ND	ND	ND	8	ND
Dimethyl sulfide	500	ACGIH	83 – 207	ND	205	ND	191	ND	ND
Ethane	NA	NA	88 – 768	ND	ND	ND	ND	174	ND
Ethanol	1,000	TCEQ	19 – 72	84	95	177	103	39	118
Ethyl benzene	NA	NA	84 – 462	ND	ND	155	85	ND	ND
Hydrogen Chloride	1,400	CARB-REL	22 – 46	ND	ND	ND	ND	28	ND
Methane	NA	NA	68 – 291	3,895	12,656	ND	1,198	808	4,584
Methanol	200	TCEQ Short-ESL	11 – 15	ND	15	18	ND	14	ND
Methyl mercaptan	500	NIOSH- REL 15 min	168 – 580	564	657	ND	ND	566	1,289
Methyl tertiary butyl ether (MTBE)	2,000	a.MRL	10 – 168	ND	19	24	ND	ND	ND
n-butane	NA	NA	31 – 120	ND	314	ND	ND	ND	ND
Methylamine	35	TCEQ Short-ESL	123 – 169	ND	ND	ND	ND	177	ND
Xylenes									
m-xylene	2,000	a.MRL	58 – 112	ND	ND	95	ND	ND	ND
o-xylene	2,000	a.MRL	32 – 360	ND	ND	64	ND	189	ND
p-xylene	2,000	a.MRL	98 – 224	ND	ND	163	ND	130	ND
Ozone	70	NAAQS	20 – 32	ND	27	ND	103	29	64
Naphthalene	90	TCEQ	20 – 35	54	ND	27	ND	ND	ND
Nitric Acid	30	CARB-REL	14 – 23	ND	ND	7	27	ND	ND
Nitrogen dioxide	100	NAAQS	106 – 556	ND	ND	ND	373	ND	ND
Nitrous acid	NA	NA	1 – -23	ND	ND	ND	ND	5	ND
Nitrous oxide	2,500	TCEQ	6 – 370	220	135	ND	ND	107	232
Propane	NA	NA	32 – 445	40	ND	ND	ND	ND	ND
Sulphur dioxide	10	a.MRL	121 – 188	58	147	ND	ND	ND	ND
Toluene	2,000	a.MRL	83 – 366	ND	ND	ND	200	ND	ND
Triethylamine	676	CARB-REL	13 – 44	ND	56	ND	ND	ND	53

Notes: *highlighted columns are community monitoring locations; CV- Comparison Values; NA-Not Available; ND- Not Detected; IESI LUL – Landfill Upper Location; IESI LLL – IESI Lower Location; SCC – Steel City Mennonite Church; SCP – Steel City Park; BWWTP – Bethlehem Waste Water Treatment Plant; NA- Not Available; a.MRL- acute Minimum Risk Level; NIOSH- REL- National Institute for Occupational Safety and Health- Reference Exposure Levels; NAAQS= 8-hour National Ambient Air Quality Standards; CARB-REL-California Air Resources Board acute-Reference Exposure Levels; ACGIH – American Conference of Governmental Industrial Hygienists; TCEQ-ESL-Texas Commission on Environmental Quality- Effects Screening Levels; OPFTIR – open path Fourier transform infrared spectrometer; ppb – parts per billion.

Table 3: Summary of locations of chemicals detected

Landfill and nearby community	Landfill, wastewater treatment plant, and nearby community	Offsite/Nearby community only	Landfill or wastewater treatment plant only
Dimethyl sulfide Methanol Methyl-tert-butyl ether (MTBE) Naphthalene	Ammonia Carbon monoxide Ethanol Methane Methyl mercaptan Nitrous oxide Ozone	2-Methyl butane Benzene Chloroform Ethane Ethyl benzene Hydrogen chloride Methylamine Nitric acid Nitrogen dioxide Nitrous acid Toluene Xylenes (m-, o-, p-)	n-Butane Propane Sulphur dioxide Triethylamine

Table 4: Chemicals detected at offsite, community locations near IESI Landfill, Bethlehem, PA that exceed health-based comparison values (ppb)

Compounds	Acute health effect CV (ppb)	CV Source	Minimum detection limit range (ppb)	Community Monitoring Locations		
				SCC (ppb)	Hader (ppb)	SCP (ppb)
Benzene	9	a.MRL	139 – 198	212	ND	147
Methyl mercaptan	500	NIOSH REL 15min	168 – 580	ND	ND	566
Methylamine	50	TCEQ Short-ESL	123 – 169	ND	ND	177
Nitrogen dioxide	100	NAAQS 1-hour	106 – 556	ND	373	ND
Ozone	70	NAAQS 8-hour	20 – 32	ND	103	29

Notes: CV- Comparison Values; ND- Not Detected; SCC – Steel City Mennonite Church; SCP – Steel City Park; a.MRL- Acute Minimum Risk Level; NIOSH-REL- National Institute for Occupational Safety and Health-Reference Exposure Levels; NAAQS= 1-hour National Ambient Air Quality Standards; TCEQ Short-ESL- Texas Commission on Environmental Quality Short Effects Screening Levels.

Potential public health implications for chemicals that exceeded acute CVs

Benzene

Benzene was detected at a maximum concentration of 147 ppb and 212 ppb at two (SCC and SCP) out of three locations near the landfill exceeding ATSDR's acute MRL of 9 ppb. Benzene was not detected on the landfill or at the wastewater treatment plant.

Benzene, which has a sweet smell (odor threshold 1,500 ppb) [ATSDR 2001], can be present in outdoor urban air as a result of emissions from many sources, including the burning of coal and oil, benzene waste and storage operations, motor vehicle exhaust, and evaporation from gas stations. Everyone is exposed to a small amount of benzene every day. Benzene levels in urban areas are greater than those in rural areas. The concentration of benzene in urban areas is generally between 0.3 and 19 ppb, and in rural areas between 0.02 and 1 ppb [EPA 1987; Roberts 1985; ATSDR 2007]. People are exposed to benzene in the outdoor environment, in the workplace, and in the home.

Exposure of the general population to benzene mainly occurs through breathing air that contains benzene. The major sources of benzene exposure are tobacco smoke, automobile service stations, exhaust from motor vehicles, and industrial emissions [ATSDR 2007]. Vapors from products that contain benzene, such as glues, paints, furniture wax, and detergents, can also be a source of exposure. Automobile exhausts and industrial emissions account for about 20% of the total national exposure to benzene. About half of the benzene exposure in the United States comes from smoking tobacco or from exposure to tobacco smoke. The average smoker (32 cigarettes per day) takes in about 1.8 milligrams (mg) of benzene per day. This amount is about 10 times the average daily intake of benzene by nonsmokers [ATSDR 2007]. Auto exhaust and industrial emissions account for about 20% of the total national exposure to benzene. People may be exposed to higher levels of benzene in air by living near hazardous waste sites, petroleum refining operations, petrochemical manufacturing sites, or gas stations [ATSDR 2007].

Short-term exposure to benzene at a concentration below the acute MRL of 9 ppb is not likely to cause any non-cancerous health effect. The main target of benzene exposure is the blood forming cells in the bone marrow. Benzene can harm the bone marrow leading to decreased production of red blood cells, white blood cells, and/or platelets. In cases with lower levels of exposure, only one blood cell type might be affected, while higher exposures might result in all the blood cell types being affected. Changes in the blood cell counts have not been reported in people with long term exposure to benzene that was less than 492 ppb in the air. This effect level is much higher than those found by screening the ambient air with an OPFTIR monitor. There are also other health effects that can occur from breathing in benzene at high enough concentrations and durations. Health effects from exposure to high concentrations of benzene can include dizziness, headaches, confusion, and unconsciousness.

If the benzene concentrations detected by OPFTIR monitoring are present in the community's ambient air, then acute health effects are possible from exposure.

Methyl mercaptan

Methyl mercaptan was detected at a community monitoring location (Steel City Park - SCP) once during these monitoring events at a concentration of 566 ppb (Table 2). Methyl mercaptan was also detected at the landfill and the wastewater treatment plant.

The NIOSH-REL recommended airborne exposure limit for methyl mercaptan is 500 ppb, not to be exceeded during any 15-minute work period. Acute inhalation exposure to methyl mercaptan can irritate the mucous membranes of the respiratory tract. Also, restlessness, headache, staggering, and dizziness may develop, which might harm quality of life. Methyl mercaptan is a colorless gas that smells like rotten cabbage with a low odor detection level of 2 ppb [http://www.atsdr.cdc.gov/MHMI/mmg139.pdf]. Methyl mercaptan, a natural substance found in the blood, brain, and other tissues of people and animals, occurs naturally in certain foods, such as some nuts and cheese [ATSDR 1999a]. Methyl mercaptan is present in the natural gas of certain regions in the United States, in coal tar, in some crude oils, and is also released as a decay product of wood in pulp mills.

The level detected near the landfill exceeded the NIOSH-REL of 500 ppb [15-minute] and the odor threshold limit of 2 ppb. Therefore, methyl mercaptan, if confirmed to be present at the levels detected by OPFTIR monitoring, has the potential to cause acute health effects as well as odor related symptoms.

Methylamine

Methylamine was detected at a maximum concentration of 177 ppb at one (Steel City Park) location, exceeding the TCEQ-REL of 50 ppb and the odor threshold level of 35 ppb [Nagata 2003]. The minimum detection limit for methylamine (123 ppb) was above the acute health based comparison value and the odor threshold. Methylamine was not detected on the landfill or at the wastewater treatment plant during OPFTIR monitoring.

Methylamine is a colorless gas with a fish- or ammonia like odor. Methylamine is used in the production of insecticides, herbicides, fungicides, surfactants, rocket fuels, explosives, pharmaceuticals, photographic chemicals, dyes, textiles, dye assists, rubber and anticorrosive chemicals. Transient irritation of the eyes, nose, and throat has resulted from brief exposures to methylamine at concentrations of 20,000 to 100,000 ppb; the odor was considered intolerable at 100 to 500,000 ppb [Clayton and Clayton 1981]. Inhalation of methylamine vapors (at concentrations greater than 100,000 ppb) has caused irritation of the nose and throat, followed by violent sneezing, burning sensation of the throat, coughing, constriction of the larynx and difficulty in breathing, pulmonary congestion, and edema of the lungs [Deichmann and Gerarde 1969.

If the methylamine concentrations detected by OPFTIR monitoring are present in ambient air in the community, then acute health effects are possible from exposure.

Nitrogen dioxide

Instantaneous nitrogen dioxide (NO_2) concentrations were detected up to a maximum concentration of 373 ppb at one (Hader Lane) location near the landfill; it was not detected on the landfill or at the wastewater treatment plant during OPFTIR monitoring. The detected concentration exceeds the CARB-REL of 250 ppb, as well as the NAAQS 1-hour daily maximum concentration of 100 ppb [EPA 2010a], which is a regulatory value determined by averaging concentrations over a 3 year period. The 1-hr average AQI for the observed maximum concentration (373 ppb) is 153 [EPA 2016b]. This AQI value is considered “unhealthy,” where everyone may begin to experience health effects, and members of sensitive groups (people with asthma or other respiratory diseases, the elderly, and children) may experience more serious health effects. Therefore, active children, the elderly, and people with lung disease, such as asthma, should avoid prolonged or heavy outdoor exertion; everyone else, especially children, should reduce prolonged or heavy outdoor exertion.

Nitrogen oxides are a mixture of gases that are composed of nitrogen and oxygen that creates a pungent, acrid odor. The observed concentration exceeded the NO_2 odor threshold level of 120 ppb [Nagata 2003]. Current scientific evidence links short-term NO_2 exposures, ranging from 30 minutes to 24 hours, with adverse respiratory effects, including airway inflammation in healthy people and increased respiratory symptoms in people with asthma. Studies have also shown a connection between breathing elevated short-term NO_2 concentrations, and increased visits to emergency departments and hospital admissions for respiratory issues, especially asthma. NO_2 concentrations in vehicles and near roadways are appreciably higher than those measured at the locations monitored around IESI by PADEP. Near-roadway (within about 50 meters) concentrations of NO_2 have been measured to be approximately 30 to 100% higher than concentrations away from roadways [ATSDR 2002]. The observed concentration may or may not be related to the IESI landfill given the potential for nearby roadways to have contributed to this. In addition, NO_2 can have many regional sources. NO_2, if confirmed to be present at the levels detected by OPFTIR monitoring, has the potential to cause acute health effects as well as odor related symptoms. Nitrogen dioxide was not detected on the landfill or at the wastewater treatment plant.

Ozone

The maximum instantaneous ozone concentration of 103 ppb detected by OPFTIR monitoring at one location (Hader Lane) exceeds the CARB-REL of 90 ppb and the NAAQS 8-hour standard of 70 ppb. Ozone was detected at two of the three community monitoring locations (70 ppb at Harder Lane and 29 ppb at Steel City Park) and at both the landfill (27 ppb) and the wastewater treatment plant (64 ppb) (Table 3).

The 8-hr AQI for the maximum detected concentration of ozone by OPFTIR (i.e., 108 ppb) is 195, a level considered to be "unhealthy." Specifically, children and people with asthma are considered the most at risk populations from exposure to ozone at the maximum concentration detected in the area (103 ppb), particularly for exposures that continue for 8 hours or more. There is also a greater likelihood of respiratory symptoms and breathing difficulties in active children and adults and people with respiratory disease, such as asthma; and there are possible respiratory effects in the general population when exposed for 8 hours or more to ozone at 103 ppb.

However, the OPFTIR data is an instantaneous reading and there is insufficient data to determine what the actual 8-hour maximum ozone average in ambient air may be for this community.

Ozone is a highly reactive form of oxygen, which has a strong pungent odor threshold level of 3 ppb [Nagata 2003]. The instantaneous concentrations detected at all four locations exceeded the odor threshold level of 3 ppb. EPA notes that acute health symptoms from exposure to ozone include cough, throat irritation, pain, burning, or discomfort in the chest when taking a deep breath, chest tightness, wheezing, or shortness of breath. Results from a National Institute of Environmental Health Sciences (NIEHS) funded study show that children who played three or more outdoor sports in areas with high ozone concentrations were more than three times as likely to develop asthma as children who did not engage in sports activities in these areas [NIEHS 2015]. In the upper atmosphere, ozone forms a protective layer that shields us from the sun's ultraviolet rays. At ground level, ozone is a harmful air pollutant and a primary constituent of urban smog. Ozone is produced when air pollutants from automobile emissions and manufacturing operations interact with sunlight. Long-term exposure to high concentrations of ozone can cause a significant reduction in lung function, inflammation of the airways, and respiratory distress. People with lung diseases are particularly vulnerable to the respiratory effects of ozone.

The instantaneous ozone levels detected in the IESI landfill area by OPFTIR monitoring are likely a combination of emissions from mobile and fixed industrial sources in the region and not emissions from a single source, such as the IESI landfill. However, there is insufficient data to determine the source of ozone in the ambient air.

Due to the limited data available for this community (e.g., few instantaneous readings from limited locations), PADOH and ATSDR cannot determine the source or the potential for health impacts from ozone exposures at the levels detected by OPFTIR monitoring.

Chemicals detected that pose potential odor effects

Five chemicals were detected in community monitoring locations above their respective odor threshold levels, including dimethyl sulfide, methylamine, methyl mercaptan, nitrogen dioxide, and ozone (Table 4). The potential health effects associated with exposure to methylamine, methyl mercaptan, nitrogen dioxide, and ozone odors are evaluated in the potential public health implications section above. The potential health effects associated with exposure to dimethyl sulfide is discussed below.

Table 5: Chemical contaminants (maximum) detected using OPFTIR in the community near IESI Landfill that exceed odor threshold levels (in ppb)

Compound	Odor description	Odor threshold (ppb)	Detection limit range (ppb)	Highest community concentration detected (ppb)	Acute health effect CV (ppb)
Dimethyl sulfide	strong garlic-like	3	83 – 207	191	10,000 – ACGIH TLV
Methylamine	fish or ammonia like	35	123 – 169	177	50 – TCEQ Short-ESL
Methyl mercaptan	rotten cabbage	2	168 – 580	566	500 – NIOSH REL 15min
Nitrogen dioxide	pungent, acrid	120	106 – 556	373	250 – CARB-REL 100 – NAAQS 1-hour
Ozone	sharp, reminiscent of chlorine	3	20 – 32	103	90 – CARB-REL 70 – NAAQS 8-hour

ACGIH TLV- American Conference of Governmental Industrial Hygienists threshold limit value; CARB-REL-California Air Resources Board acute Reference Exposure Levels; CV- Comparison Values; NIOSH-REL National Institute for Occupational Safety and Health- Reference Exposure Levels; ppb – parts per billion; TCEQ-ESL-Texas Commission on Environmental Quality- Effects Screening Levels

<u>Dimethyl sulfide</u>

Dimethyl sulfide was detected at a community monitoring location (Harder Lane) once during these monitoring events at a concentration of 191 ppb (Table 2). Dimethyl sulfide was detected once during this monitoring period at the IESI landfill (205 ppb) and was not detected at the wastewater treatment plant.

No acute exposure health-based screening values were identified for comparison to dimethyl sulfide. The lowest exposure comparison value identified was the occupational exposure threshold limit value (TLV) of 10,000 ppb (10 parts per million or ppm), as determined by ACGIH. The odor detection level for dimethyl sulfide is 3 ppb [Nagata 2003]. Dimethyl sulfide has a strong garlic-like smell, so, people can smell these compounds at low concentrations. Health factors identified by the Occupational Safety and Health Administration (OSHA) include irritation of eyes and skin, cough, sore throat, nausea, and weakness, with the affected organs including eyes, skin and the respiratory system. Due to the limited sensitivity of OPFTIR spectroscopy for this compound (i.e., high minimum detection limit), PADOH and ATSDR cannot determine the potential for health impacts from dimethyl sulfide exposures in this community.

Common chemicals not detected by OPFTIR that may be present at lower concentrations exceeding odor threshold values

Three common odor-causing chemicals that have very low odor thresholds (hydrogen sulfide, acetaldehyde, carbon disulfide) were not detected during the OPFTIR monitoring. However, because of the high minimum detection limits of the OPFTIR device for these chemicals, it is not known whether these chemicals are present in ambient air at levels of health or odor concern. Health effects from exposure to these odorous chemicals (see Table 5) are detailed below.

Table 6: Chemical contaminants that may cause odor related symptoms and were not detected by OPFTIR at or near IESI landfill, Bethlehem, PA

Landfill Gas	Odor description	Odor threshold (ppb)	Health-based comparison value (ppb)	Minimum detection limit range (ppb)	Highest concentration detected (ppb)
Acetaldehyde	pungent fruity	1.5	5 ppb (RfC)	110 – 368	ND
Carbon disulfide	sweet, pleasant, chloroform like	210	10 (short TCEQ-ESL) 230 (EPA RfC)	86 – 492	ND
Hydrogen sulfide	characteristic of rotten egg	0.5	69 (aEMEG)	6,995 – 14,124	ND

aEMEG – ATSDR acute environmental media evaluation guideline; CARB-REL-California Air Resources Board acute reference exposure levels; CV- Comparison Values; EPA RfC – U.S. Environmental Protection Agency reference concentration; MRL- Minimum Risk Level; NA-Not Available; ND- Not detected above the detection limit range; ppb – parts per billion; TCEQ-ESL Texas Commission on Environmental Quality Effects Screening level

Acetaldehyde

Acetaldehyde is a common landfill gas emission. Acetaldehyde was not detected by OPFTIR monitoring above 110-368 ppb (the minimum detection limit range) at any of the six monitoring locations.

The TCEQ ESL for acetaldehyde is 50 ppb; and, the EPA reference concentration (RfC) for acetaldehyde, a screening value for chronic, long term exposure assessment (no acute health-based values are available), is 5 ppb. The odor threshold level is 1.5 ppb [Nagata 2003]. The TCEQ ESL, EPA RfC, and the odor threshold are below the OPFTIR monitor's minimum detection limit range of 110-368 ppb. Acetaldehyde has a pungent suffocating odor, but at dilute concentrations the odor is fruity and pleasant. Acetaldehyde is an intermediate product of incomplete wood combustion in fireplaces and woodstoves, vehicle exhaust fumes, and waste processing.

The OPFTIR monitor is not sensitive enough to determine whether acetaldehyde is present in ambient air at concentrations that might result in health effects or nuisance odor events. It is also not known if offensive acetaldehyde odors (as opposed to more pleasant fruity odors at dilute levels) are present in the community.

Carbon disulfide

Carbon disulfide is a common landfill gas emission where municipal solid waste sludge is handled. Carbon disulfide is also emitted from wastewater treatment facilities. Carbon disulfide was not detected above the OPFTIR minimum detection limit range of 86 to 492 ppb.

Carbon disulfide has a strong, disagreeable odor. The odor threshold for carbon disulfide is 210 ppb [Nagata 2003]. The short-term TCEQ-ESL for carbon disulfide is 10 ppb; the EPA RfC (a chronic exposure screening value) is 230 ppb. Due to its strong disagreeable odor, the presence of carbon disulfide above the odor threshold could adversely affect the quality of life near the landfill.

The OPFTIR monitor is not sensitive enough to determine whether carbon disulfide is present in ambient air at concentrations that might result in health effects or nuisance odor events.

Hydrogen sulfide

Hydrogen sulfide (H_2S) is a common landfill and wastewater treatment plant gas considered to be a primary cause of offensive odors. H_2S was not detected above the OPFTIR monitors minimum detection limit range of 6,995 to 14,124 ppb at any of the six monitoring locations.

H_2S is a colorless, flammable gas with a distinctive rotten egg odor with typical odor threshold of 0.5 ppb [ATSDR 2001]. ATSDR’s acute health-based comparison value for H_2S is 69 ppb. H_2S is formed by anaerobic (oxygen-free) degradation of sulfur-containing compounds and is a major concern for odors and exposures from landfills, wastewater treatment facilities, and animal production operations. H_2S can be particularly dangerous because, at higher levels, the human nose becomes desensitized over time and may not detect the odor [ATSDR 2014].

The OPFTIR monitor is not sensitive enough to determine whether hydrogen sulfide is present in ambient air at concentrations that might result in health effects or nuisance odor events.

Appendix A References

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