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ODOUR FROM A COMPOST FACILITY

Odour from a compost facility

Primary inquiry: A citizen's group reported that putrid smells were occurring daily from a local commercial compost facility located in a suburban area of the city. The local public health agency was contacted to provide information to answer the following questions:

1) What types of contaminants are potentially emitted in air from commercial composting facilities?

2) What causes odours associated with the composting process?

3) Are there health impacts to nearby residents from exposure to compost emissions?

4) How can the odour from compost facilities be minimized?

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Background

Composting involves the collection and processing of the organic fractions of municipal solid waste including plant materials such as leaf and yard waste, and fish and food waste.[1] In Canada, as of 2013, 41% of households had access to curbside composting programs to collect household food and yard organic waste for commercial composting.[2] Residential composting not only reduces the amount of waste shipped to a landfill, it can also reduce greenhouse gas emissions formed from organic material decomposing in landfills.[2]

Composting is a method of waste management involving biological degradation and stabilization of organic matter under aerobic conditions.[3] Use of high temperatures and oxygen encourages optimal growth of thermophilic microflora to breakdown organic materials. Traditional open composting involves the periodic turning of windrows (piles of biodegradable waste in long rows), typically by front-end loaders. An alternative method of static aerated piles may use a network of pipes to deliver air into or draw air out of a pile. The newer, more sophisticated in-vessel composting is a closed container system which feeds organic materials into a vessel, such as a large drum or silo, and confines open-air processes to the final maturation process, when biological activity slows.[4]

Commercial compost facilities are located in every province and territory in Canada. As of 2016, there were approximately 350 composting facilities across the country.[5] Complaints from citizens about odours from a composting facility are not uncommon. As stated in an industry-based newsletter,[5] "The

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thorn in the side of the industry does continue to be odour." Examples of municipalities where residents have complained about odours arising from commercial composting facilities include Ladysmith, Vancouver Island, British Columbia; Richmond, British Columbia; Strathmore, Alberta; Winnipeg, Manitoba; South London, Ontario; and Sydney, Nova Scotia.

Methods

A rapid academic literature search was undertaken for articles related to potential health effects, perception and annoyance, and measurement of compost-type odour and contaminants from an organic composting facility. Articles were identified using EBSCOhost (to access MEDLINE, CINAHL, PsycINFO, Biomedical Reference Collection, and Academic Search Complete), Ovid (to access Elsevier Science Direct, Evidence Based Medicine, SAGE journals online, and Cochrane Database of Systematic Reviews), and Google Scholar (to access books, book chapters, older articles, and articles from journals not indexed through major database platforms).

The search terms included: (odor OR odour OR smell) AND (compost OR organics or anaerobic digest*) AND (health OR illness OR annoy* OR irritat* OR somatic OR sensory).

Inclusion criteria were publication date (from 2000), English language, and human subjects. Excluded were occupational health studies of compost workers. Internet searches were done using Google to access relevant pre-2000 articles and informative documents, including Canadian public health documents concerning compost facility requirements.

Results

1) WHAT TYPES OF CONTAMINANTS ARE EMITTED IN AIR FROM COMMERCIAL COMPOSTING FACILITIES?

During the process of aerobic decomposition, air emissions of bioaerosols and microbial volatile organic compounds (VOCs) are produced, particularly when agitation activities are used to break up clumps of compost material.[4]

Bioaerosols refer to microorganisms (e.g., bacteria including gram-positive actinomycetes; fungi such as moulds; viruses; algae; and pollen) and to biomolecules (e.g., endotoxins from the outer membrane of gram-negative bacteria; beta glucans from fungi cell walls).[4] The concentration and composition of bioaerosols originating from a composting site depend on the characteristics of the microorganisms, the size and technology of the facility, and the prevailing winds.[3] Bioaerosols released into the air from compost facilities returned to background levels (measured upwind) at distances anywhere from 100 to 1400 m away from the facility.[3] For example, thermophilic actinomycetes (gram-positive bacteria) were not detected upwind of a composting site, but were detected at noticeable concentrations as far as 550 m downwind.[6] Compared to 100 m upwind from a green-waste facility (equivalent to background levels), measurements of gram-negative bacteria in the air were higher up to 400 m downwind, while endotoxin levels remained higher up to 100 m downwind from the facility.[7]

VOCs are chemicals emitted from plant debris and microorganisms such as fungi and bacteria in the process of aerobic degradation. There is very little correlation found between concentrations of bioaerosols and microbial VOCs.[8] Emissions from composting facilities typically belong to any of the following chemical classes of VOCs: aromatics, sulphur compounds (mercaptans, and organic sulphides), aldehydes, alcohols, amines (ammonia), volatile fatty acids, terpenes, ketones, benzene, toluene and ethylbenzene.[9,10] The most common VOCs characterized in samples from one compost facility were acetic acid, acetone, limonene, benzene derivatives, hexane, pinenes, toluene, napthalene, and xylene. Another study identified 74 compounds in the ambient air of a composting plant, with ethyl alcohol detected at the highest concentration of all compounds.[9] Measurements of microbial VOCs at set distances away from two commercial composting facilities identified terpenes (pinene, limonene, and camphene) at levels over 100 ng/m^3, 800 m downwind from the facilities.[11]

In addition to the composition of feedstock, the type of composting will affect the concentration of compounds emitted. Use of an aerated static pile resulted in lower concentrations of ammonia (72%), and formic acid (57%), and acetic acid (11%) when compared to values obtained from a nearby windrow.[12]

2) WHAT CAUSES ODOURS ASSOCIATED WITH THE COMPOSTING PROCESS?

Detecting odours is a physiological process whereby inhaled odourant molecules are detected by one or more of the thousand types of odour receptor cells in the olfactory epithelium of the nasal cavity. The neurons of the olfactory epithelium "translate" the chemical message into nerve impulse emissions which are sent to the piriform cortex in the cerebellum (which is involved in determining odour intensity) and then projected to various brain areas, including the amygdala (which distinguishes pleasant from unpleasant odour). Conscious perception of smell takes place in the orbitofrontal cortex.[13]

Odours are distinguished by their detection threshold (i.e., the level at which the odour is first detectable), intensity, hedonic

tone (pleasantness or offensiveness), discrimination threshold (level to discriminate between two odours), quality of the odour (i.e., the type of smell, such as floral or woody), and recognition threshold (i.e., the level at which the odour quality can be identified).[14] How odour is perceived is also influenced by personal experience, attitude, expectation, and adaptions of the individual.[11]

Perception of odour can result in "annoyance"; a feeling of displeasure associated with any agent or condition, known or believed by an individual or group to adversely affect them.[15] A survey of residents near waste treatment facilities found annoyance to be related to the frequency and intensity of waste odours as well as by the hedonic tone of odour, with neutral and unpleasant odours more likely to cause annoyance.[16] Odour annoyance was reported by 80% of residents living within 500 m downwind of a composting plant in Germany. Ten percent characterised it as "disgusting."[17]

The usual odour sources considered in compost facilities are from the main processing activities that involve fugitive emissions from vessels and aeration systems, or active composting piles (if not enclosed). Other odour sources are from truck transport of waste materials, loading or mixing of material, and storage until processing, material handling, screening and storage.[18]

Microbial VOCs are considered to be the main source of odour from compost facilities as many of these compounds can be smelled at extremely small concentrations, below what is known to be harmful to human health.[16] Odours associated with specific types of VOCs include the rotten egg or rotten cabbage smell of reduced sulphur compounds, the vinegar smell of volatile fatty acids, the fishy smell of ammonia, the smell like nail polish remover of ketones, and the sharp unpleasant odour of aldehydes.[18] Major emissions of odours and VOCs occur during the process of turning over the compost piles for aerobic biological treatment, and vary with time and type of handling, as well as temperature and humidity.[19] For example, when organic matter is being degraded, microbial activity increases the composting temperature, which corresponds to the release of large amounts of odourous compounds.

Levels of certain VOCs near compost facilities were found to correspond to odours perceived by trained observers, doing "sniffing" evaluations.[11] In this commonly used method for odour detection, prequalified odour panelists sniff decreasingly diluted air samples until an odour can be detected. Compost odour was recognizable at a distance 800 m downwind from the compost facilities. At that distance, terpenes (pinene, limonene, camphene) were the highest VOCs measured.[11] Other known VOC odourants, such as 2-methyl-1-butanol, 2-heptanone and dimethyl-disulphide, were suggested to also have a role in creating this characteristic compost odour, even when not measured in detectable concentrations.

3) ARE THERE HEALTH IMPACTS TO NEARBY RESIDENTS FROM EXPOSURE TO COMPOST EMISSIONS?

Exposure to VOCs has the potential to induce acute toxicological effects such as inflammatory and immune effects, as well as sensory irritation in the eye, nose, or throat.[16] However, measured concentrations of microbial VOCs nearby composting facilities are below levels thought to be capable of causing symptoms of intoxication or sensory irritation. While some VOCs are odourous, even at very low concentrations, they are not considered to be the primary cause of health symptoms for residents near to composting facilities.[11] There may be interactions between different types of VOCs with non-odourous co-pollutants, such as particulates, which can contribute to health symptoms.[20]

Chronic exposure to elevated levels of bioaerosols is known to affect respiratory health. Potential health effects to bioaerosols include allergic asthma, rhinitis, hypersensitivity pneumonitis, chronic obstructive pulmonary disease, and organic dust toxic syndrome, as well as eye and skin irritation.[4] An experimental study of airborne endotoxins around composting sites found an association between endotoxin levels and cytokine induction in human cells, suggesting a mechanism for health effects resulting from infection, immune responses, or inflammation.[21]

There is some epidemiological evidence relating exposure to compost emissions to symptomatic complaints by residents, although findings are inconsistent, as shown in Table 1 below.

Table 1. Studies on health impacts to residents from compost emissions.

Location and Study	Odour Measure	Increased Risk of Symptoms
Finland – waste treatment centres with composting plants.[16]	Residents <1.5 km vs. 3 or 5 km	cough/phlegm, nose irritation/stuffy nose, hoarseness/dry cough, fever/shivering
	Perceived Odour vs. none	hoarseness/dry cough, headache, diarrhoea
	Odour Annoyance vs. none	unusual shortness of breath, eye irritation, dry throat, toothache, unusual tiredness, fever/shivering, joint pain, muscular pain
Germany – large-scale composting site.[6]	<200 m from site, highest (to >105 CFU/m^3) bioaerosols vs. near background levels	shortness of breath (following exertion and while at rest), bronchitis, coughing (waking up or on rising/during the day), sore eyes, diarrhoea, excessive tiredness, shivering
	Odour annoyance vs. none	Smarting eyes, itchy eyes, joint trouble, muscular complaints

A recent cross-sectional study in Finland[16] found that residents who lived <1.5 km from waste treatment centres (with composting plants) have increased risks of specific symptoms. However, since almost all residents lived more than 600 m away from the facility, it was unlikely that exposure to bioaerosols were related to the symptoms, given that previous measurements of bioaerosols returned to near-background levels less than 600 m from the facilities. The authors concluded that physical symptoms were mainly associated with odour annoyance rather than odour perception, for residents living near composting plants.[16] A cross-sectional questionnaire-based study of residents in a German town living much closer to a large-scale composting site (within 500 m) improved upon exposure assessment by measuring outdoor bioaerosol pollution (thermophilic actinomycetes, fungi, moulds, and total bacteria/m^3 in air).[6] The airborne microorganisms measured in residential air at 150 to 320 m from the composting site were 100-1000 times higher than background concentrations. Perceived odour annoyance was related to a few general symptoms, but with the large number of complainants (80%) it was difficult to compute reliable odds ratios.

Note that the cross-sectional study design used in both studies is prone to reporting and selection biases when questionnaires are used, and is subject to limitations with interpreting causality (does the exposure precede the symptoms or are symptoms affecting odour perception or annoyance?).[4]

Rather than a questionnaire survey of symptoms, a recent study in England assessed hospital admissions for respiratory disease for residents living within 2,500 m of a compost facility, based on concerns about bioaerosol exposure.[22] For the population living closest to a facility, at 250 to 750 m, no increased risk was found for respiratory hospital admissions, respiratory infections, asthma, or chronic obstructive pulmonary respiratory disease. The authors noted study limitations, such as very few people living within 250 m of a compost facility, where concentration of bioaerosols are most likely to exceed the UK environmental agency guidelines. The design did not capture minor respiratory health problems, such as cough or bronchitis.[22]

The limited literature suggests that there may be respiratory and irritant symptoms associated with bioaerosol exposure, but only for residents living very close (around 250 m) away from certain compost facilities. The low levels of VOCs may contribute to odour, but not have a direct effect on symptoms. Rather, it is the psychosocial aspects of odour annoyance that may have a bearing on symptomatic complaints.

4) HOW CAN THE ODOUR FROM COMPOST FACILITIES BE MINIMIZED?

There are no federal regulations relating to odour emissions from industrial facilities, including compost facilities. Most provinces, and some municipalities, have established regulations and guidelines for waste management facilities, including composting. Siting of the facility is an important consideration. Minimum setback distances for compost facilities within Canada are typically 300 m from a permanent residence, hotel, restaurant, school, church, or public park.[1] An example of a provincial standard for composting facilities is from Alberta,[23] which includes an odour contingency response plan to minimize or remedy offensive odour. This may involve removing or disposing of the substance causing the offensive odour, containing or controlling the odourant, or by installing or modifying equipment or making

improvements to the structure of the compost facility. Further details regarding odour control in compost facilities are provided in a report for Metro Vancouver.[18] Best practices for odour management include siting considerations to maximize the distance of the facility away from public spaces, prohibiting certain types of waste and meat products being sent to compost facilities, restricting open composting to yard and garden waste, and otherwise ensuring that processing areas are enclosed.

From a policy point of view, a closed "vessel" system has the advantage of reducing odour emissions during the initial composting process, when odour emissions are highest.[24] Moreover, vessel systems can be equipped with a biofiltration system and scrubbers to minimize these emissions and are economical to install and maintain.[24] Properly designed and operated biofilters at composting facilities can routinely remove over 90% of incoming odours.[1] The effectiveness of biofiltration was illustrated by progressive reductions in measured VOC emissions in a compost facility after installation of a biofilter unit.[9] However, odour emissions are still possible despite use of biofilters. For instance, terpenes have been detected in the effluent air stream of compost facilities equipped with biofilters, and in one facility, the outlet of the biofilter contained dimethyl disulphide, which is known to be malodorous.[19]

Summary

Composting facilities are an essential part of sustainable waste management, performing the important function of diverting organic matter from landfills. However, residents living close to commercial composting facilities often complain about odours and may experience symptoms thought to be caused by exposure to compost emissions. Odours from the biodegradation process are attributed to low concentrations of volatile organic compounds that are considered to be too low to cause physical symptoms. However, some residents may be at risk of respiratory health symptoms from exposure to emissions of bioaerosols when living near to the facilities (typically a distance less than 250 m). Symptoms also may be attributed to annoyance to perceived odours. In addition to promoting large setback distances from composting facilities, closed vessel systems equipped with biofiltration systems can be effective at reducing odours associated with commercial composting facilities.

Further research is needed to determine what specific types and levels of odourants are emitted during the different processes involved in commercial composting according to the type of organic waste processed and engineering practice, and how best to mitigate the odours. Successful odour control in commercial compost facilities will involve development and enforcement of an odour management plan, odour-monitoring, and the opportunity for community engagement.

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