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Identification and quantification of nuisance odors at a trash transfer station

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ABSTRACT

The objective of this study was to evaluate the effectiveness of a modified Odor Profile Method (OPM) at a trash transfer station (TTS). An updated Landfill Odor Wheel was used to define odor character and distinguish among odor sources. The Flavor Profile Analysis (FPA) intensity scale was used to rank the relative intensity of the various odor characters defined by the odor wheel and to understand how each odor profile changed off site. Finally, the odor wheel was used to select the appropriate chemical analysis to identify the odorants causing the odors identified by the human panelists. The OPM was demonstrated as an effective tool for characterizing and distinguishing odor sources at a TTS. Municipal solid waste (MSW) odors were characterized as rancid, sulfur, and fragrant; rancid odors were dominant in the odor profile on-site, while sulfur odors dominated off-site. Targeted chemical analysis was used to identify odorants potentially responsible for odors at the site. Methyl mercaptan (rotten vegetable) and hydrogen sulfide (rotten egg) were identified as the odorants most likely to be responsible for the sulfur odors at the site. Acetaldehyde (sweet, fruity), acetic acid (vinegar), and butyric acid (rancid) were identified as the odorants mostly likely to be causing the rancid and sour odors. Terpenes/pine odors were observed near the greenwaste pile. Results confirm that the OPM, together with properly selected chemical analyses, can be a useful tool for identifying and quantifying the sources of odors.

1. Introduction

Odors have been investigated previously in a variety of operational settings, including wastewater treatment, dairy farms, and composting (Blanes-Vidal et al., 2009; Filipy et al., 2006; Gostelow et al., 2001; Tsai et al., 2008). Odors can be described by their character, intensity, and duration. The character of an odor provides an indicator as to its cause. One or more operations at a facility may be the source of distinct odors with different odor characters. The intensity of each odor character is a measure of odor strength. Knowledge of odor intensity can help define the relative importance of each odor character and evaluate the effectiveness of odor control strategies. The duration of odor events, along with their frequency, can also help inspectors and facility operators identify odor sources based on operation schedules and weather patterns.

Burlingame (1999) initially developed the Odor Profile Method (OPM) to prioritize odor sources for purposes of odor control at a wastewater treatment plant based on the character, intensity, and duration of the odors. Character was defined using a Wastewater Odor Wheel. Intensity was defined using a scale anchored to word descriptors. Duration was defined as the fraction of time that odors caused by a specific process were detected at the fence line of the wastewater treatment plant.

Odor wheels consist of three rings: an inner ring segmented into general odor categories (e.g., rancid); a middle ring listing specific odor descriptors within each odor category (e.g., vinegar and rancid); and an outer virtual ring identifying chemical compounds associated with the categories and descriptors on the inner and middle rings (e.g., acetic acid and butyric acid) (Suffet et al., 2009). Odor wheels have been used to characterize and

Abbreviations: FPA, Flavor Profile Analysis; GC–MS, gas chromatograph–mass spectrometer; GW, green waste; OD, observation deck; OPM, Odor Profile Method; MDL, method detection limit; MRL, method reporting limit; MSW, municipal solid waste; ND, non-detect; OTC, odor threshold concentration; TF, tipping floor; TTS, trash transfer station.

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troubleshoot odor problems at many types of facilities. Decottignies et al. (2009) and Suffet et al. (2009) have used odor wheels to identify major odor characters at a landfill and compost facility, respectively. The Drinking Water Taste and Odor Wheel has been incorporated into decision matrices to help facility operators investigate odor problems and identify potential treatment options (McGuire et al., 2005). Identifying odor character can guide nuisance odor resolution.

Odor intensity can be evaluated with word descriptors, the butanol scale, or by using the Flavor Profile Analysis (FPA) scale as proposed by Curren et al. (2014). The FPA method uses a 7-point intensity scale to measure the intensity of individual flavor and odor characters. Perceived intensity varies with the concentration of sugar (sucrose) dissolved in drinking water (APHA, 2012). On the FPA odor intensity scale, 4 is defined as weak, 8 as moderate, and 12 as very strong.

The results of the OPM can be used to select the types of chemical analyses, which can be used to identify which odorants are causing odors. Odorants are the individual chemical compounds associated with odors (e.g., dimethyl sulfide is an odorant associated with a rotten vegetable odor). Odorants have been identified from chemical analysis by using statistical correlations between the odorant and the odor concentrations, ratios of odorant concentrations to odor threshold concentrations, and characterization of the odor produced by an odorant using gas chromatography (GC) with a sniff port at the end of the GC column (known as GC-Sniff, GC sensory analysis, or GC-Olfactometry) (Khiari et al., 1992). Using GC-Sniff methodology, the odor character of each odorous compound eluting from the GC is detected using the human nose and recorded. Samples are typically run through a GC-Mass Spectrometer (MS) to determine which chemicals are causing the odors.

The Weber-Fechner law states that the log of the concentration of an odorant is proportional to the odor intensity it produces and that the constant of proportionality varies by compound. Ratios of concentrations of odorants in ambient air to their odor thresholds have been used to identify which odorants are most likely to be significant contributors to nuisance odors (Decottignies et al., 2009). The higher the ratio the more likely an odorant is contributing to perceived nuisance odors. Linear regression has been used to relate the odor concentration to the chemical concentration of the odorant (Noble et al., 2001).

While chemical analyses can identify odorants and their concentrations in ambient air, Gostelow et al. (2001) and others have noted that chemical analyses often do not directly relate to human sensory experience. Odor samples often contain multiple odorants and/or components, which can have synergistic or antagonistic effects upon the way in which these odorants are perceived. In other words, there may not always be a one-to-one correspondence between the odorant(s) in a sample and the odor(s) perceived. Further, the human nose is often more sensitive than analytical equipment to odor-causing compounds at very low concentrations. Despite these limitations, chemical analysis can be an effective tool for characterizing odor problems when used in conjunction with OPM.

Studies examining odors at trash transfer stations, landfills, and composting facilities have employed a variety of methods, including measurement of specific compounds such as hydrogen sulfide, measurement of groups of compounds such as sulfides, broad spectrum techniques such as USEPA method TO-15, dynamic olfactory, triangle bag odor methods, odor profile method, and others (Chunping et al., 2008; Palmiotto et al., 2014; Suffet et al., 2009; Yong et al., 2008; Yue et al., 2014). Over the course of five years, Chunping et al. (2008) evaluated total odor (using a triangle bag method), ammonia concentrations, hydrogen sulfide concentrations, and variety of other parameters at several trash transfer stations in China. Compounds detected from trash transfer stations, landfills, and greenwaste composting ranged from sulfide compounds (such as dimethyl sulfide) to terpenes (such as α-pinene), to volatile organic compounds (such as xylene) (Chunping et al., 2008; Yong et al., 2008; Yue et al., 2014). Additionally, Palmiotto et al. (2014) evaluated a landfill using dynamic olfactometry and found that there might be an odor impact for downwind residents.

Few TTS studies have included odor panels (i.e., the Odor Profile Method) and targeted chemical analysis. Odor panels offer the human perspective, which can be useful in understanding the potential for odor complaints. Targeted chemical analysis provides an idea of odorants present, where broad-spectrum methods such as USEPA TO-15 may miss groups of odorous compounds including reduced sulfides and carboxylic acids; further, odorants in waste streams may vary as a function of cultural factors.

The objective of the present study was to use a modified version of the OPM to demonstrate the usefulness of an updated version of the Landfill Odor Wheel (originally developed by Decottignies et al., 2009) for defining odor character, and of a scaling method for defining odor intensity, at a trash transfer station (Snyder et al., 2013). The updated Landfill Odor Wheel is shown in Fig. 2. The FPA intensity scale was evaluated for its usefulness in ranking the importance of each individual odor character detected. The odor wheel was evaluated for its utility in defining and distinguishing odors as well as linking them to specific odorants through appropriate chemical analyses. This methodology was used to evaluate odors at a trash transfer station in order to evaluate its potential value.

2. Materials and methods

2.1. Site

A trash transfer station (TTS) previously alleged by complainants as the source of nuisance odors was selected as the site for this study. The waste received by the facility is characterized as one of four types: greenwaste, recycling materials (plastics, glass, metals, and paper), construction and demolition waste, or municipal (household) waste. Most complaints alleging the facility as the source of odors were reported by residents located east of the facility, primarily during afternoon hours. The prevailing wind direction is from the west/southwest. An initial facility visit was conducted to identify the best on- and off-site locations for odor panel observations based on facility activities and odor intensities observed. Seven sites were selected for OPM analysis. Three off-site locations (Sites 1 through 3) were selected to evaluate how odors changed as they moved off site. The majority of odor complaints originated near Site 2, and additional complaints sometimes originated near Site 3. Four on-site locations (Sites 4 through 7) were selected based on their relative proximity to three potential odor sources: a greenwaste pile, the tipping floor where municipal and construction and demolition wastes are deposited, and a clarifier that processes facility wastewater (see Fig. 1). Samples from three sites closest to the odor sources (Site 5 – tipping floor, Site 6 – observation deck, and Site 7 – greenwaste) were gathered for chemical analysis studies to ensure that sufficient concentrations of odorants would be present for detection.

Weather data were collected by the facility using a weather station on the roof of the facility (see Table 1).

2.2. Odor profile analysis

A modified version of the OPM was applied at the TTS to characterize the odors and to help select the appropriate chemical analyses. Odor character was evaluated using the updated Landfill Odor Wheel (Fig. 2) as this was anticipated to be the best match for