Characterization Of Odorous Compounds at a Composting Facility

Jeanette Campbell, Columbia Analytical Services, Inc. and Jeff Gage, Compost Design Services; Olympia, WA

Air sampling was conducted both at, and adjacent to, a facility that composts green waste (yard debris), blood and fat from chicken processing, fish carcasses, wood waste, gypsum and other wastes to identify the odorous airborne contaminants. The composting method was an outdoor turned windrow modified in a block configuration. The compounds of interest were those that are odorous at low levels and included amines, carboxylic acids (volatile organic/fatty acids), reduced sulfur compounds and odorous volatile organic compounds (VOCs). Carboxylic acids and amines were evaluated using two novel methods developed and validated by Columbia Analytical Services, Inc.'s Air Quality Laboratory.

Samples were collected using several types of media including solid sorbent tubes, glass-lined Silco canisters and Tedlar bags. Carboxylic acids and VOCs were analyzed by gas chromatography/mass spectrometry (GC/MS), while reduced sulfur compounds and amines were determined using gas chromatography/sulfur chemiluminescence detection and gas chromatography/nitrogen phosphorus detection, respectively.

Approximately 350 different compounds were identified during the study, including many of the reduced sulfur compounds, carboxylic acids and amines on the target compound lists as well as a diverse mixture of VOCs. The preponderance of carboxylic acids present at levels above their odor thresholds was consistent with the sweaty/fecal/sour odor detected at the fence line.

The majority of the compounds (89%) identified were VOCs. However, when only those compounds present above the odor threshold are considered, the VOCs become less important and carboxylic acids increasingly so. The results suggest that even a broad screening method, such as NIOSH 2549 does not effectively capture the full range of compounds that may be contributing to a complex contaminant matrix. The odorous source was better characterized with the use of four different methods than a single one.

For more information, please contact: Michael Tuday at our Simi Valley Laboratory, 2655 Park Center Drive, Suite A, Simi Valley, CA 93065, 805.526.7161; mtuday@caslab.com.

Columbia Analytical Services INC

Introduction

The characterization of complex odors such as those associated with composting, biosolid and agricultural activities may present challenges because of the variety of compounds present and the low odor thresholds of the contributing substances. Often an odor panel is used to evaluate odors from these facilities. However, in some situations the identification of the specific compounds contributing to the odor may be useful. This field trial utilized four different methodologies in an attempt to determine the odorous constituents at a composting facility.

Methodology

Samples were collected at the property's fence line, on top of compost piles and on the SCAT used to turn the compost piles. Sampling media, flow rates and analytical methodologies utilized are summarized in Table 1. Calibrated personal sampling pumps were used to collect the solid sorbent samples. Due to the wide range of compounds anticipated and the fact that there was some overlap among the methods, this sampling event was also used to compare sampling and analytical methods and sampling media. Therefore, collocated samples were collected using more than one media type for several of the target groups (e.g., VOCs, reduced sulfur).

Results were compared to the lowest available odor thresholds reported in the literature (see references).

Table 1. Sampling Strategy at a Composting Facility

Compounds	Sampling Media	Flow Rate	Analytical Methodology	Method Reference
Amines	Specialty Sorbent	1.0 L/min	GC/NPD	CAS's AQL Amines
Carboxylic acids	NaOH treated silica gel (SKC 226-55)	1.0 L/min	GC/MS	CAS's AQL Carboxylic Acids
Reduced sulfurs	Tedlar bags, Silco canisters	n/a	GC/SCD	ASTM D5504-01
Volatile Organic Compounds (VOCs)	Silco canisters	n/a	GC/MS	US EPA TO-15
	Tenax tubes, Mixed sorbent tubes	0.1 L/min	TD/GC/MS	NIOSH 2549

n/a – not applicable

ASTM – ASTM International (formerly American Society for Testing and Materials)

US EPA – United States Environmental Protection Agency

NIOSH – National Institute for Occupational Safety and Health (US)

GC/MS - Gas chromatograph/mass spectrometer

GC/NPD - Gas chromatograph/nitrogen phosphorus detector

GC/SCD - Gas chromatograph/sulfur chemiluminescence detector

TD - Thermal desorption

Results

A single method did not characterize the full range of compounds present throughout the facility (Figure 1). Volatile organic compounds represented the greatest number of compounds present in the perimeter samples (Figure 2). Dumping of blood and fat from chicken processing (chicken waste) was associated with the greatest number of odorous compounds (Figure 3).

Organic acids and aldehydes were the principal compounds detected at levels above the odor thresholds in the perimeter samples (Figure 4). Microbial volatile organic compounds were identified in several of the samples. Based on comparisons with reported odor thresholds, butyric acid, valeric acid, isovaleric acid, acetic acid, propionic acid, isobutyric acid, dimethyl disulfide, acetaldehyde, decanal, nonanal, benzaldehyde and, p-cresol were likely contributors to the odor detected at the edge of the property (Table 2). Of these, butyric acid was present at levels above the odor threshold in all of the perimeter samples.

Figure 1.

Types of compounds identified broken down by group. Data reported represent samples collected on top of piles, during turning and at perimeter of facility.

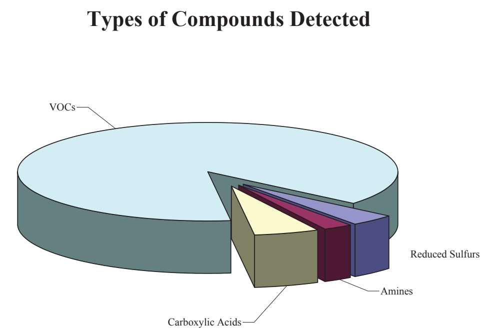


Figure 2.

Perimeter sampling results. Types of compounds detected while chicken waste was dispensed from tanker, near the storage area for the finished product and near the raw material.

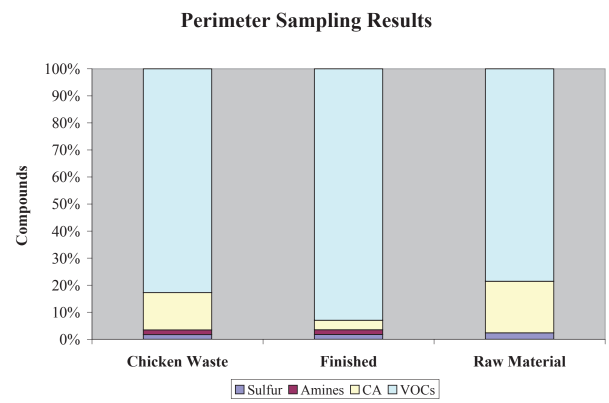


Figure 3.

Odorous compounds detected in the perimeter samples. Number of compounds that were present at levels above and below the lowest reported odor threshold are presented. The number of compounds identified without odor thresholds is also provided.

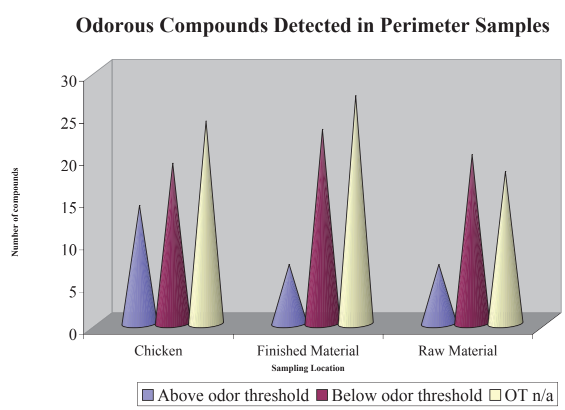
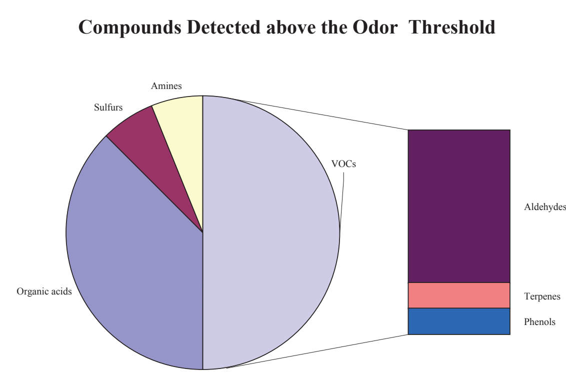
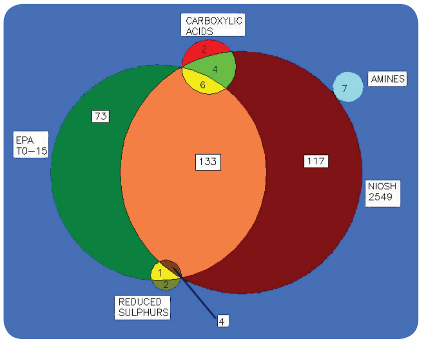


Figure 4.

Breakdown of compounds identified in the perimeter samples by group. Information about the types of VOCs detected is also provided.



Columbia Analytical Services INC



Conclusions

1. No single method identified all of the compounds detected above the odor threshold.
2. Organic acids and aldehydes were the principal compound groups that were detected at levels above the odor thresholds.

Table 2. Compounds detected above the odor threshold in the perimeter samples. The number and percentage of samples in which the compounds were identified is reported.

Compounds Detected Above the Odor Threshold		Samples	
Compounds	Descriptor	Number	%
Butyric Acid	Rancid, sour, sweaty	8	100
Isovaleric acid	Rancid, moldy cheese, fecal	7	88
Isobutyric acid	Sharp, berry sauce, fecal	6	75
Valeric acid	Fecal, unpleasant	6	75
Acetaldehyde	Green, sweet	6	75
Acetic Acid	Pungent	4	50
Propionic Acid	Sour, unpleasant, rancid, pungent, fecal	4	50
Benzaldehyde	Almond, pleasant, bitter	4	50
alpha-Pinene	Resin, coniferous, pine, turpentine	4	50
Dimethyl disulfide	Putrid, decayed vegetables, rotten cabbage	3	38
p-Cresol	Creosote, fecal	3	38
Decanal	Fatty, citrus, soapy, orange peels, tallowy	3	38
Nonanal	Unpleasant, tallowy/soapy	3	38
Trimethylamine	Fishy, pungent	2	25
Octanal	Soapy	1	13
Pentanal	Pungent, sickening/decayed/rancid	1	13

References

1. Jacobson et al., Generic Environmental Impact Statement on Animal Agriculture: A Summary of the Literature Related to Air Quality and Odor (Source: www.eqb.state.mn.us/geis/LC_AirQuality.pdf)
2. van Gemert, L.J., A.H. Nettenbreijer, 1977. Compilation of Odour Threshold Values in Air and Water, National Institute for Water Supply and Central Institute for Nutrition and Food Research TNO, Netherlands. Lowest reported detection threshold.
3. Odorous Compounds Associated with Wastewater Treatment (Source Malcolm Pirnie website)
4. O'Neill, Phillips, 1992. A Review of the Control of Odour from Livestock Buildings: Part 3, Properties of Odourous Substances, which have been Identified in Livestock Wastes or in the Air around them. J. Agric. Eng. Res. 53: 23-50
5. 5. Ruth, J.H. 1986. Odor thresholds and irritation levels of several chemical substances: A Review. AIHAJ 47:A142-A151.
6. Louhelaine, K., et al., 2001. Effect of In Situ Composting on Reducing Offensive Odors and Volatile Organic Compounds in Swineries. AIHAJ 62:159-167
7. AIHA, 1986. Odor Thresholds for Chemicals with Established Occupational Heath Standards