Environ. Sci. Technol. **1998**, *32,* 3713−3718

Effect of Process Management on the Emission of Organosulfur Compounds and Gaseous Antecedents from Composting Processes

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Pilot-scale studies were performed to assess the effects of aeration rate and initial moisture content on the emissions of odorous organosulfur compounds and nonodorous gaseous antecedents from synthetic food waste (SFW) and biosolids composting processes. In the SFW studies peak organosulfur emissions occurred at an airflow rate of 0.16 L/min-kg VS. Emission rates (mol/time) and total aerobic biological activity (cumulative mass of O_2 consumed) were lower at 0.07 L/min-kg VS, possibly because the slightly higher temperatures encountered at this rate suppressed microbial activity. Emission rates were progressively lower at 0.32 and 0.65 L/min-kg VS, likely because of higher oxygen levels. As moisture content increased from 45 to 55% (H_2O/g wet weight), peak emission rates generally increased. In the biosolids studies organosulfur emissions decreased as aeration rate increased. In both the SFW and biosolids studies CO was emitted prior to the detection of organosulfur compounds. Additionally, average correlation coefficients relating the emission rate of CO with the emission rate of organosulfur odors were 0.67 for the SFW trials and 0.75 for the biosolids trials. These results suggest that CO may be a good antecedent compound for the early warning of odors from composting processes.

Introduction

As solid-waste disposal costs have escalated, composting has become a popular option for the treatment of organic solid wastes. Compost has been shown to suppress plant pathogens (*1*) and has been used successfully as a medium for biofiltration and bioremediation (*2*−*6*). Although these recent applications offer promise for the continued use of compost, the composting process itself continues to face problems such as odor emission and poor product stability and quality. The uncontrolled production of odors, which leads to complaints from neighbors, is widely accepted as one of the most difficult problems facing the composting industry (*7*); thus, increasing amounts of money are being allocated to odor control efforts.

Odors can be managed by treating gases leaving the system and by manipulating the composting process to prevent their emission. Treatment methods include chemical scrubbing, combustion, and biofiltration of exhaust gases. Chemical scrubbing methods have been successful in treating composting emissions; however, these methods can require as much as $1 million to install and $200 000 per year to operate for a site composting 200 wet tons of sludge per day (*7, 8*). Combustion methods can also be effective in treating odors, but extremely high fuel requirements hinder their use (*9*). Although biofiltration may be a less-expensive alternative to chemical scrubbing, biofilter performance varies with microbial ecology, and nutrient and moisture contents—and in some cases has not been adequate for the treatment of odors (*10*).

Several studies have observed odor removal within the composting process itself. For example, H_2S oxidation can occur rapidly upon contact with aerobic zones in composting systems so that elemental sulfur precipitates (*11*). The decomposition of odors in the outer zones of composting leaves has also been suggested to be an important aspect of odor prevention (*12*). Thus, with an increased understanding of odor formation and removal mechanisms, the prevention of odor emissions through process manipulation may be a feasible alternative to treatment.

Studies have shown that variables such as temperature (*13*−*15*), oxygen concentration (*11, 15*), and substrate (*14*) play a role in odor emissions from composting operations. However, most of these studies were either performed in very small systems that may not have adequately represented full-scale processes or in systems where the rates of odor emission and the effect of dilution were impossible to evaluate. Additionally, many studies were performed under conditions where it was difficult to distinguish the effects of temperature and aeration rate on the emission of odors. Better-controlled and monitored composting studies are imperative both for understanding the effect of process variables on the emission of odors and for developing process management strategies for odor prevention.

One strategy that has been shown repeatedly to lessen odor emissions is adequate oxygen supply (*9, 12, 14*). This can be achieved by maintaining porosity and free air space through material bulking and moisture management and by supplying air. Although a high-rate, continuous supply of air may prevent odors, an excess supply of air may have detrimental effects on the process, including overcooling and water loss, which may further result in poor product stability. Clearly there is a need to evaluate aeration and moisture management strategies which prevent odors while minimizing the coupled side effects such as rapid drying, high processing costs, and excessive cooling.

The emission of reduced sulfur compounds is a major concern for composting facilities because of the pervasiveness of these compounds. Although organosulfur compounds have been observed to be emitted under aerobic conditions, their emission has been greater under anaerobic conditions

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10.1021/es980156n CCC: $15.00

than under aerobic conditions (*16*). In part, this may be because microbial production of organosulfurs is enhanced under anaerobic conditions; however, a contributing factor is that a decreased aerobic condition diminishes the likelihood of the oxidative degradation of organosulfurs, however formed. For example, the emission rates of methanethiol (MeSH) and hydrogen sulfide (H_2S) from mushroom composts were 3 orders of magnitude greater under anaerobic conditions than under aerobic conditions (*15*). Additionally, the emissions of carbonyl sulfide (COS) and dimethyl sulfide (DMS) were approximately an order of magnitude greater under anaerobic conditions. Since organosulfur emissions have been linked to the extent of anaerobiosis in composting, identification of nonodorous gaseous compounds associated with anaerobic activity and detected prior to odor detection (termed "antecedent gases") may provide an early warning for the emission of odors and thus a means of controlling the process to prevent odors.

Potential antecedent gases investigated as part of this study include H_2, CO, and CH_4. Molecular hydrogen is a common product of fermentative catabolism, but one that can be used by a variety of hydrogenotrophic microorganisms (including methanogens and sulfate reducers) (*17*). It is formed to a very significant extent during active fermentation of carbohydrates and fatty acids but potentially "turns over" rapidly through subsequent use; thus, it may or may not accumulate to significant levels. Carbon monoxide is an intermediate in the acetyl-CoA pathway for CO_2 fixation by many autotrophic obligate aerobes (*18*). Being a process intermediate, like H_2, it may not accumulate to high levels. However, both H_2 and CO can be measured at very low concentrations (5 and 1 ppb, respectively—well below the levels in ambient air); thus, they are reasonable candidate antecedents because their low detection thresholds make it possible to observe changes in their concentrations before odors would be detectable. Methane is a common, terminal product of organic-matter degradation under anaerobic conditions. Under aerobic conditions, CH_4 can be readily oxidized by methanotrophic bacteria. Though odorless, CH_4 in many ways would be expected to behave like a surrogate for organosulfurs; CH_4 is formed under similar reducing conditions and oxidized under aerobic conditions. However, the potential quantity of carbon flow to CH_4 is so great that increased CH_4 in compost gases may be detectable before odors.

The objectives of this study were to observe the effects of aeration rate and initial moisture content on the emission of odors from synthetic food waste (SFW) and biosolids composting processes and to evaluate gaseous antecedents such as CO, CH_4, and H_2 as indicators of future odor emissions. These antecedents were selected based on previous bench-scale composting trials (*19, 20*). Although odors such as ammonia, amines, volatile fatty acids, and aromatics have been detected from composting operations (*12*), the main focus in this study was on reduced sulfur compounds including hydrogen sulfide (H_2S), methanethiol or methylmercaptan (MeSH), dimethyl sulfide (DMS), and dimethyl disulfide (DMDS). These compounds were chosen because of their extreme pervasiveness and because they are often cited as the most problematic odors at composting facilities (*9, 10*). In the interest of understanding odor emission rates under known conditions of temperature, oxygen level, and moisture content with minimal effects of scale-up, composting experiments were performed using well-controlled and monitored pilot-scale bioreactors and extensive gas chromatography analysis.

Materials and Methods

Pilot-Scale Reactors. Composting experiments were performed using 770-L bioreactors. These reactors are described in detail elsewhere (*21*). The reactors accommodated several stainless steel bars containing thermocouples and gas-sampling tubes which allowed measurement of temperature and gas composition. Gas sensors were also mounted in the reactor for hourly measurement of oxygen (*22*). Air was supplied to the reactors continuously at a constant rate. It was heated and humidified at 25 °C to ensure constant inlet conditions. The reactors were sealed so gas flow entering and leaving the system could be controlled and monitored.

Three to four different aeration rates were chosen for the study. These were chosen to capture the range of aeration rates employed in composting and study the impact of aeration level on organosulfur emission and rates of decomposition. The lowest aeration rate was chosen to simulate conditions that might exist when the system had some air supply, but was still starved for oxygen—somewhat like conditions observed in a windrow or passive system. On the other hand, the highest aeration rate was chosen to simulate conditions that might exist when the system had an excessive level of air supply. Although temperature-feedback-controlled aeration is common for aerated composting systems, employing this method of aeration control was not appropriate to the goals of the study.

Two substrates were used in the studies. One was synthetic food waste (SFW) which consisted of dry dog food (Big Red Puppy Food, Pro-Pet Inc., Syracuse, NY), and the other was anaerobically digested, polymer-dewatered biosolids obtained from the Ithaca Wastewater Treatment Plant (Ithaca, NY). The dry dog food was chosen as a SFW because it had a fat, fiber, and protein content similar to cafeteria waste and because it offered a means of controlling the variability of substrate characteristics (*23, 24*). Digested biosolids (biosolids) were chosen because they were part of a successful forced-aeration composting program and could be obtained locally. Hard maple wood chips (Coastal Lumber, Cayuta, NY) were added to both substrates as a bulking agent and as a means of moisture content reduction for the biosolids which had a moisture content of 81−86% (g H_2O/g wet weight). The carbon to nitrogen dry mass ratios (C:N) of the SFW and biosolids were 8.4 and 7.2, respectively. With the addition of the wood chips (C:N = 228), the C:N of the SFW and biosolids composts increased to 18:1 and 43:1, respectively. The SFW studies were performed at 45 and 55% (g H_2O/g wet weight) initial moisture and the biosolids studies at 50 and 60% initial moisture.

Oxygen and temperature were monitored continuously using a data acquisition system. Samples of 10-mL volume were taken daily and analyzed for gas composition. To minimize the effects of water on the gas analysis system, the sample was first pulled through a condenser at 10 °C prior to injection into the gas chromatographs (GCs). After sample injection, the condenser was purged with N_2 gas for 5 min.

Moisture content was determined by oven drying of samples at 103 °C for 24 h. Volatile solids content was determined by combustion of samples at 560 °C for at least 8 h.

Gas Analysis. The analytical system consisted of two GCs (Autosystems, Perkin-Elmer) that were controlled by a Turbochrom data acquisition system (PE-Nelson). The GCs and the data acquisition system are described in detail elsewhere (*19, 20*). Briefly, the first GC consisted of two separate channels. The detector for one channel was an electron capture detector (ECD), used to detect CO_2 and N_2O. The column used for this channel was a 12-foot Porapak Q (80/100 mesh) in 1/8" stainless steel, and the carrier gas was N_2. The second channel was equipped with a flame photometric detector (FPD) to detect low levels of the sulfur gases including dimethyl disulfide (DMDS), dimethyl sulfide (DMS), methanethiol (MeSH), carbonyl sulfide (COS), and hydrogen sulfide (H_2S). The carrier gas for this channel was

TABLE 1. Cumulative O_2 Consumed; Minimum O_2 Concentration; Peak Methanethiol (MeSH), Dimethyl Sulfide (DMS), and Dimethyl Disulfide (DMDS) Emission Rates; and Peak Temperature Observed during the First 200 h of SFW Composting

	45% initial moisture						55% initial moisture					
			emission rates (nmol/min-kg VS)						emission rates (nmol/min-kg VS)			
aeration (L/min-kg VS)	O_2 consumed (g/kg VS)	min. O_2 (%)	peak MeSH	peak DMDS	peak DMS	peak temp (°C)	O_2 consumed (g/kg VS)	min. O_2 (%)	peak MeSH	peak DMDS	peak DMS	peak temp (°C)
0.07	99	3	19.7	3.9	3.0	63	84	2	15.3	17.2	13.4	69
0.16	131	7	26.1	5.2	2.3	60	129	5	31.0	25.5	8.0	67
0.32	152	16	1.2	0	0	61	140	14	12.5	7.0	4.9	58
0.65	117	18	0	0	0	58	150	18	4.9	0	4.0	57

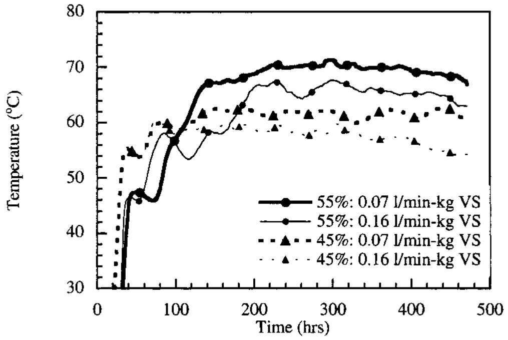

FIGURE 1. Temperature profiles for SFW studies with aeration rates of 0.07 and 0.16 L/min-kg VS. The profiles represent the location where the maximum temperature was observed in each study.

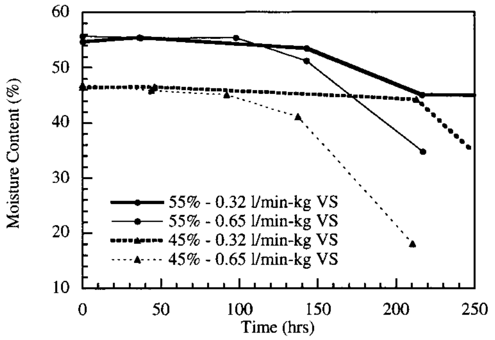

FIGURE 2. Moisture content profiles for SFW studies with aeration rates of 0.32 and 0.65 L/min-kg VS. Measurements were taken 135 cm above the air inlet.

He, and the column was a 4.6-foot Carbopak-B HT 100 (40/60 mesh) in 1/8” FEP Teflon tubing.

The second GC was configured with one channel leading to two detectors in series and a third in parallel. The flow was split with a stainless steel tee. The first detector in the series was a thermal conductivity detector (TCD) used to measure O_2 and high levels of H_2. The second detector was a flame ionization detector (FID) used to measure CH_4. The parallel detector was a reduction gas detector (RGD, Trace Analytical, Inc.) sensitive to trace levels of H_2 and CO. The flow from the column was split with 40% to the RGD and 60% to the TCD/FID.

Results

SFW Results. Trends in peak MeSH, DMDS, and DMS emission rates, peak temperatures, minimum O_2 concentrations, and cumulative oxygen consumed in the SFW experiments are summarized in Table 1. Selected temperature profiles for the SFW studies are illustrated in Figure 1. MeSH, DMDS, and DMS emission rates were generally higher in the studies at 55% initial moisture than in those at 45%. At the lower aeration rates of 0.07 and 0.16 L/min-kg VS, DMDS emission was 4−5 times greater, and DMS emission was 3−4 times greater in the trials at 55% moisture than in those at 45%. Peak temperatures were also somewhat higher in the 55% initial moisture studies than in the 45% studies. At the lower aeration rates peak temperatures were 6−9 °C higher at 55% than at 45% initial moisture. As illustrated in Figure 1, temperatures in the 55% initial moisture study with an aeration rate of 0.07 L/min-kg VS exceeded 65 °C for over 340 h, while in the 0.16 L/min-kg VS-study they exceeded 65 °C for approximately 240 h of the composting process. Temperatures in the studies completed at 45% initial moisture content never exceeded 65 °C; however, temperatures in the 0.07 L/min-kg VS-study were greater than 60 °C for over 390 h of the composting process.

Total O_2 consumption was generally higher at 45% initial moisture than at 55%, with the exception of the studies with an aeration rate of 0.65 L/min-kg VS. This highest of aeration rates resulted in the greatest drying, as evident from the moisture-content profiles shown in Figure 2. Moisture content in the 0.65 L/min-kg VS-study with an initial moisture content of 45% dropped below 18% within the first 220 h of composting, likely limiting microbial activity. Other studies have demonstrated that microbial activity is adversely impacted in composting studies when moisture levels drop below about 25−30% (*21, 25, 26*).

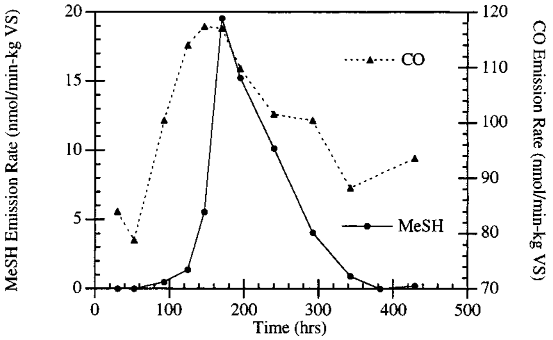

FIGURE 3. MeSH and CO emission rates from a SFW composting trial with an initial moisture content of 45% and an aeration rate of 0.07 L/min-kg VS.

In all SFW studies peak MeSH and DMDS emissions occurred at an airflow rate of 0.16 L/min-kg VS, while peak DMS emissions occurred at 0.07 L/min-kg VS. Aerobic activity, measured by cumulative oxygen consumed, was also lower at 0.07 than at 0.16 L/min-kg VS and generally increased with increasing aeration rate. The highest peak temperatures occurred at 0.07 L/min-kg VS. Organosulfur emissions and peak temperatures were progressively lower at 0.32 and 0.65 L/min-kg VS.

MeSH and CO emission rates from SFW composting trials with an aeration rate of 0.07 L/min-kg VS are illustrated in Figures 3 and 4. MeSH profiles are shown because MeSH was the organosulfur compound emitted at the highest rate from the SFW trials and because MeSH was generally emitted

TABLE 2. Cumulative O_2 Consumed; Minimum O_2 Concentration; Peak Methanethiol (MeSH), Dimethyl Sulfide (DMS), and Dimethyl Disulfide (DMDS) Emission Rates; and Peak Temperature Observed during the First 200 h of Biosolids Composting

	50% initial moisture						60% initial moisture					
			emission rates (nmol/min-kg VS)						emission rates (nmol/min-kg VS)			
aeration (L/min-kg VS)	O_2 consumed (g/kg VS)	min. O_2 (%)	peak MeSH	peak DMDS	peak DMS	peak temp (°C)	O_2 consumed (g/kg VS)	min. O_2 (%)	peak MeSH	peak DMDS	peak DMS	peak temp (°C)
0.08							97	11	0	13.3	4.0	60
0.22	102	16	0	50	1.0	58	91	17	0	12.7	2.4	56
0.45	62	19	0	33	0	54	57	19	0	9.8	0	50
0.83							57	ND	0	0	4.2	43
0.94	65	20	0	26	0	45						

before DMDS and DMS. CO emission rates are illustrated in Figures 3 and 4 rather than H_2 because CO was found to be a potential antecedent for both biosolids and SFW composting. CO and H_2 were both detected prior to the organosulfurs, while CH_4 was detected at concentrations not substantially greater than in ambient air (data not shown). This suggests that CO and H_2 may be potential antecedents for organosulfur compounds emitted from SFW composting processes.

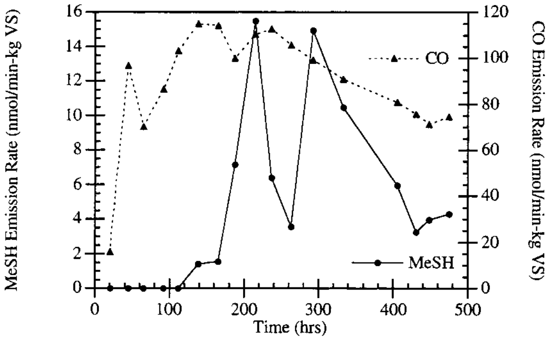

FIGURE 4. MeSH and CO emission rates from a SFW composting trial with an initial moisture content of 55% and an aeration rate of 0.07 L/min-kg VS.

CO was emitted at rates greater than 80 nmol/min-kg VS prior to the detection of MeSH. In the SFW trial where MeSH, DMDS, and DMS were not detected, emission of CO was less than 11 nmol/min-kg VS (data not shown). Also, as organosulfur emission rates decreased, CO emission rates decreased.

Biosolids Results. Trends in peak MeSH, DMDS, and DMS emission rates, peak temperatures, minimum O_2 concentrations, and cumulative oxygen consumed in the biosolids experiments are summarized in Table 2. MeSH was not detected in any of the biosolids composting trials. DMDS was generally emitted at higher levels in the biosolids studies than in the SFW studies, and emission rates decreased as aeration rate increased. In contrast to the SFW experiments, cumulative oxygen consumed decreased as aeration rate increased, and DMDS emission rates generally decreased as initial moisture content increased. DMDS emissions were significantly higher in the 50% than in the 60% initial moisture studies. At airflow rates of 0.22 and 0.45 L/min-kg VS emissions of DMDS were 3–4 times greater in the 50% initial moisture studies than in the 60% studies.

CO and CH_4 were detected very early in the biosolids studies. Table 3 lists CO and CH_4 emission rates measured within the first 25 h of composting. Values for the studies with an aeration rate of 0.22 and 0.45 L/min-kg VS represent averages of two samples taken during the first 25 h of composting. Early emission rates for the 0.22 and 0.45 L/min-kg VS studies were 21–42% higher at 50% than at 60% initial moisture. CH_4 emission rates early in the study were 44–62% higher at 50% than at 60%. These results suggest possible differences in the microbial ecology and substrate composition of the biosolids used for the 50% and 60% initial moisture studies.

TABLE 3. CO and CH_4 Emission Rates from the Biosolids Studies during the First 25 h of Composting

	emission rates (nmol/min-kg VS)			
	50% initial moisture		60% initial moisture	
aeration (L/min-kg VS)	CO	CH_4	CO	CH_4
0.08			136	335
0.22	263[a]	246[a]	208	94
0.45	293[a]	135[a]	169	75
0.83			140	38
0.94	130	52		

[a] Average value over 25 h.

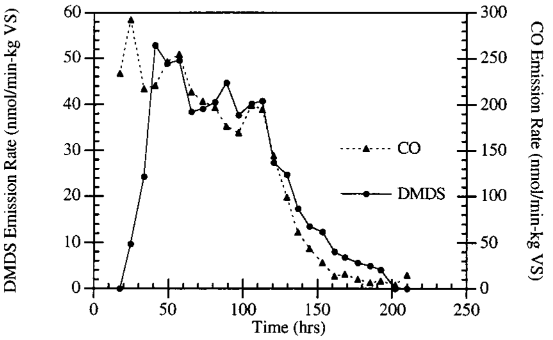

FIGURE 5. DMDS and CO emission rates from a biosolids composting trial with an initial moisture content of 50% and an aeration rate of 0.22 L/min-kg VS.

DMDS and CO emission rates from biosolids composting trials are illustrated in Figures 5 and 6. DMDS profiles are shown because DMDS was the organosulfur compound emitted at the highest rate from the biosolids trials. CO emission rates followed trends of DMDS emission rates very well for all of the biosolids studies.

DMDS was detected 40–70 h earlier in the biosolids composting experiments than in the SFW experiments. CO emission also occurred earlier in the biosolids experiments than in the SFW experiments and tended to occur prior to DMDS detection. Additionally, initial CO emission rates which varied from 130 to 325 nmol/min-kg VS in the biosolids studies were higher than rates emitted from the SFW experiments which varied from 2 to 100 nmol/min-kg VS.

CH_4 was also found to be produced prior to organosulfur detection and may be a good antecedent for biosolids composting. In contrast to the SFW studies, H_2 was emitted at levels as low or lower than levels observed in ambient air during the biosolids studies.

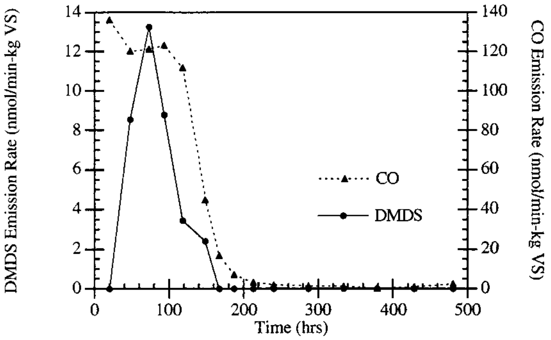

FIGURE 6. DMDS and CO emission rates from a biosolids composting trial with an initial moisture content of 60% and an aeration rate of 0.08 L/min-kg VS.

TABLE 4. Correlation Coefficients Relating the Emission of CO with Organosulfur Compounds Emitted during SFW Composting Trials

aeration rate (L/min-kg VS)	initial moisture (%)	$\rho_{MeSH/CO}$	$\rho_{DMDS/CO}$	$\rho_{DMS/CO}$
0.07	45			0.96
0.16	45	0.49		0.94
0.07	55	0.64	0.12	0.23
0.16	55	0.53	0.93	0.82
0.32	55	0.88		0.81

TABLE 5. Correlation Coefficients Relating the Emission of CO with Organosulfur Compounds Emitted during Biosolids Composting Trials

aeration rate (L/min-kg VS)	initial moisture (%)	$\rho_{DMDS/CO}$	$\rho_{DMS/CO}$
0.22	50	0.78	
0.45	50	0.78	
0.94	50	0.82	
0.08	60	0.69	0.74
0.22	60	0.67	

Correlation of CO Emission Rates with Organosulfur Emission Rates. One way to assess CO as an indicator of organosulfur emission is to correlate CO emission rates with organosulfur emission rates. Correlation coefficients were calculated using the following equation

$$\rho_{x/y} = \frac{\sum_{i=1}^{n}(x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_{i=1}^{n}(x_i - \bar{x})^2 \sum_{i=1}^{n}(y_i - \bar{y})^2}}$$

where $\rho_{x/y}$ is the coefficient correlating organosulfur emission rate to CO emission rate, x is the organosulfur emission rate, nmol/min-kg VS, $\bar{x}$ is the mean organosulfur emission rate, nmol/min-kg VS, y is the CO emission rate, nmol/min-kg VS, and $\bar{y}$ is the mean CO emission rate, nmol/min-kg VS.

Coefficients were calculated for studies in which organosulfur compounds were detected on more than two occasions and when CO concentrations were within detection limits. Only sampling points that resulted in nonzero values for both the organosulfur and CO were used in the statistical analysis.

Correlation coefficients for the SFW and biosolids composting trials are listed in Tables 4 and 5, respectively. For the SFW composting studies $\rho_{MeSH/CO}$ was generally greater than 0.5. Excluding the study with the lowest aeration rate, $\rho_{DMS/CO}$ was greater than 0.8. The poor correlation observed for the 0.07-L/min-kg VS study may have been due to the high temperatures and long exposure to high temperatures encountered in this study (see Table 1 and Figure 1). The biosolids results showed good correlation between DMDS and CO where $\rho_{DMDS/CO}$ was greater than 0.67.

Discussion

Degradation rates and organosulfur production are closely related to oxygen supply within the composting process. Theoretical models of the composting process have suggested that the initial stages of composting degradation are limited by oxygen transport (*27*). O_2 supply is influenced by aeration, O_2 concentration, and moisture content. In general, as aeration rate increases, the bulk supply of O_2 increases. This increase should reduce organosulfur emissions and increase aerobic biological activity. Too much aeration, however, may result in excessive cooling and rapid drying, while too little aeration may result in temperatures that inhibit both aerobic and anaerobic microbial growth and thus organosulfur production. In both the biosolids and SFW trials organosulfur emission generally decreased with increasing aeration. The exceptions were the 0.07 L/min-kg VS−SFW trials where high temperature, resulting from low aeration, likely inhibited microbial activity.

In the SFW trials cumulative O_2 consumption generally increased with increasing aeration rate. Moisture limitations resulting from excessive drying explain the lower cumulative O_2 consumed in the 0.65 L/min-kg VS-trial with an initial moisture of 45%. In the biosolids trials, cumulative O_2 decreased with increasing aeration likely because of cooling resulting from excessive aeration.

As moisture content increases, O_2 diffusion limitations increase. These limitations likely lead to higher levels of anaerobic activity and organosulfur production, and lower levels of oxygen consumption. On the other hand, too little moisture may inhibit microbial activity. In the SFW studies higher organosulfur emissions were observed in the 55% moisture trials than in the 45% moisture trials. In general, higher levels of oxygen consumption were observed in the 45% moisture trials than in the 55% moisture trials. The exception was the 0.65 L/min-kg VS-trial with an initial moisture of 45% where moisture limitations likely reduced microbial activity.

In contrast to the SFW observations, greater organosulfur emission rates were observed at 50% initial moisture that at 60% in the biosolids studies. Higher emission rates at the lower moisture could be due to differences in initial biosolids composition and microbial ecology as well as to differences in initial moisture content. Unlike the SFW which had a fairly uniform composition guaranteed by the manufacturer of the dog food, the biosolids could have varied from batch to batch. Although biosolids experiments with similar initial moisture contents were performed using sludge that only varied in age by about a week, experiments with different initial moisture contents varied in age by approximately 7 weeks. Significant differences were observed in the initial emission rates of CH_4 and CO, thus it is likely that the microbial ecology of the initial biosolids varied between the biosolids used for the 50% and 60% initial moisture studies. These differences complicate any discussion of the effect of moisture content on the emission of organosulfur compounds from the biosolids composts.

MeSH was the most prevalent organosulfur emitted from the SFW studies followed by DMDS and DMS. In the biosolids studies DMDS was emitted at much higher rates than DMS and MeSH. The lower MeSH emission rates observed in the biosolids studies as compared to the SFW studies may have been due to a variety of factors such as surface chemistry and sorptive-characteristic differences between the substrates, since sulfur compounds have been shown to be extremely reactive and sorptive in nature (*16, 28*). The higher rates of MeSH emission observed in the SFW studies may have been a result of sulfur-containing amino acids present in the SFW (*16, 29*). These amino acids likely were lacking in the anaerobically digested biosolids. In addition the microbial ecology of the system may have played a role in the types of odors emitted. The biological production of DMDS and DMS from MeSH has been well documented (*12, 30, 31*). The anaerobically digested biosolids used in the studies probably contained organisms that had been exposed to high concentrations of sulfur during anaerobic digestion and thus organisms capable of utilizing MeSH. On the other hand, the SFW which consisted of dry dog food and wood chips probably did not initially contain such specialized organisms. If this was indeed the case, MeSH produced in the biosolids studies would have had a greater chance of being altered than the MeSH produced in the SFW studies.

DMDS emissions occurred earlier and were generally higher in the biosolids studies than in the SFW studies. Residual anaerobic activity and high population of the specialized organisms in the biosolids, as indicated by the higher and much earlier CH_4 and CO emissions in these trials, may explain the earlier emission of DMDS.

CO was emitted prior to the detection of organosulfur compounds in both the biosolids and SFW studies. Organosulfur emission rates were found to correlate fairly well with CO emission rates. Although in some cases correlation coefficients were not very high, visual inspection of time varying data showed reasonable capture of trends between CO and organosulfur emissions. These results suggest that CO may be a good antecedent compound for providing early warning of organosulfur emissions and that monitoring CO may offer a method for monitoring organosulfur emissions. Monitoring of CO, biological activity, temperature, and moisture with subsequent control of aeration and water levels may allow better management of the composting process by encouraging high rates of aerobic biological activity, while preventing odors.

Acknowledgments

This research was supported by Agreement 3027-ERER-MW-94 from the New York State Energy Research and Development Authority, by a fellowship from the U.S. Environmental Protection Agency, and by support from the New York State Center for Advanced Technology in Biotechnology at Cornell University. The authors are grateful to Timothy Nock, Carolyn Baker, and Josh Watson for their help with pilot-scale experimentation.

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Received for review February 17, 1998. Revised manuscript received August 13, 1998. Accepted August 24, 1998.

ES980156N