SW 1736

ODORS AND VOC EMISSIONS CONTROL METHODS

Chemical scrubbers and biofilters are effective at controlling odors. Data indicate that the same systems are removing volatile organic compounds as well.

Todd O. Williams

ODOR control at composting facilities has become one of the major issues affecting the efficacy of large and small operations alike. A more recent issue that is emerging is the control of Volatile Organic Compound emissions (VOCs). The 1990 Clean Air Act Amendments (CAAA) have targeted VOCs for control and treatment due to their reactivity as precursors to ozone. The generation of these compounds in nonattainment areas for the pollutant ozone (generally the more urban areas of our country) will become more strictly controlled as regulations continue to be developed. Ultimately, these regulations will impact sewage treatment plants, accompanying solids processing units, and solid waste processing facilities. Although not clearly defined as yet, it is likely that composting operations may come under the purview of these regulations. Therefore, control of VOCs at composting facilities, particularly larger biosolids and solid waste composting operations, may become necessary.

This paper presents information regarding the current state of the art in odor and VOC control at composting facilities. Control of particulate emissions and bioaerosols, while important, will not be addressed. A detailed description of odor and VOC regulations are available elsewhere (Card 1994; Lopez *et al.* 1994).

EMISSIONS CHARACTERISTICS

Odor emissions from composting facilities can be measured in dilution to threshold values in the exhaust gas. Levels have been reported between 70 and 1,700 D/T, depending upon the facility type/process used, and exhaust gas collection methodology (Williams 1994; Ostojic *et al.* 1994). Usually a D/T value of several hundred is not uncommon for biosolids or municipal solid waste composting facilities. Data for yard trimmings composting operations is not as readily available due to the lack of analytical work performed at these sites. Many different groups of compounds are present in compost exhaust gases at varying concentrations. The mixture of these compounds can result in odors which have greater intensity or a higher D/T value than the summation of the individual compound characteristics. The most significant groups of odorous compounds identified at composting facilities include reduced sulfur compounds, ammonia and amine compounds, fatty acids, terpenes, acetone, phenol, and toluene (Bohn 1977; Hentz *et al.* 1992; Miller 1992; Van Durme *et al.* 1992). The most common sulfur based compounds contributing to odors at composting facilities include hydrogen sulfide, dimethyl sulfide, dimethyl disulfide, dimethyl trisulfide, carbon disulfide, and methanethiol (Derikz *et al.* 1990; Miller 1993). Table 1 shows compounds either specifically identified or implicated in composting odors.

Only a handful of the compounds shown in Table 1 are listed as hazardous air pollutants (HAPs) in the CAAA. However, virtually all of the compounds shown (with the exception of hydrogen sulfide and ammonia) are volatile organics or hydrocarbons which are designated criteria pollutants. The quantity of these compounds emitted from composting facilities varies depending upon feedstocks, process type and quantities processed.

EMISSIONS REQUIREMENTS

The primary reason for emissions control at composting facilities in the past has been to control odors. This reason will continue to remain in the forefront of the minds of planners, designers, and operators — basically because neighbors close to composting facilities simply do not want to be impacted by malodors from the plant. Most states have some form of regulation governing the release of odorous emissions. The majority employ a nuisance approach which relies on citizen complaints to initiate enforcement of the regulation. Once odor problems have increased to this level, it is a major uphill battle for composting facility operators to develop acceptable solutions. A handful of states have emission or ambient standards for odors. Such rules provide more clear cut standards against which a facility must perform.

With the passage of the CAAA in 1990, standards for VOCs and HAPs are being developed for numerous sources of these air pollutants. Emissions from solid waste

Table 1. Compounds either specifically identified or implicated in composting odors. Physical data is taken from Weast (1971), odor descriptions and high and low threshold values from Ruth (1986) and the ADL threshold values are derived from Leonardos et al. (1969).

Name	Formula	Odor	Odor Threshold ug/m³ low	Odor Threshold ug/m³ high	Odor Threshold ug/m³ ADL[a]	Refs[b]
Sulfur Compounds						
*Hydrogen sulfide	H_2S	Rotten egg	0.7	14	6.7	A,B
Carbon oxysulfide	COS	Pungent	c	c	–	A
*Carbon disulfide	CS_2	Disagree, sweet	24.3	23,000	665	A,C
Dimethyl sulfide	$(CH_3)_2S$	Rotten cabbage	2.5	50.8	2.5	A,C
Dimethyl disulfide	$(CH_3)_2S_2$	Sulfide	0.1	346	–	A,C,E
Dimethyl trisulfide	$(CH_3)_2S_3$	Sulfide	6.2	6.2	–	A,C,E
Methanethiol	CH_3SH	Sulfide, pungent	0.04	82	4.2	A
Ethanethiol	CH_3CH_2SH	Sulfide, earthy	0.032	92	2.6	
Ammonia and nitrogen containing compounds						
Ammonia	NH_3	Pungent, sharp	26.6	39,600	33,100	A,B
Aminomethane	$(CH_3)NH_2$	Fishy, pungent	25.2	12,000	–	
Dimethylamine	$(CH_3)_2NH$	Fishy, amine	84.6	84.6	88.1	
Trimethylamine	$(CH_3)_3N$	Fishy, pungent	0.8	0.8	0.52	
3-methylindole (skatole)	$C_6H_5C(CH_3)CHNH$	Feces, chocolate	$4.0*10^{-5}$	268	–	
Volatile fatty acids[d]						
Methanoic (formic)	HCOOH	Biting	45.0	37,800	–	
Ethanoic (acetic)	CH_3COOH	Vinegar	2,500	250,000	2,500	D,G
Propanoic (propionic)	CH_3CH_2COOH	Rancid, pungent	84.0	60,000	–	D
Butanoic (butyric)	$CH_3(CH_2)_2COOH$	Rancid	1.0	9,000	3.7	D,G
Pantanoic (valeric)	$CH_3(CH_2)_3COOH$	Unpleasant	2.6	2.6	–	D
3-methylbutanoic (isovaleric)	$CH_3CH_2CH(CH_3)COOH$	Rancid cheese	52.8	52.8	–	
Ketones						
Propanone (acetone)	CH_3COOH_3	Sweet, minty	47,500	1,610,000	241,000	A
*Butanone (MEK)	$CH_3COOH_2CH_3$	Sweet, acetone	737	147,000	30,000	A
2-pentanone (MPK)	$CH_3COOH_2CH_2CH_3$	Sweet	28,000	45,000	–	A
Other compounds						
Benzothiozole	C_6H_4SCHN	Penetrating	442	2,210	–	C
*Ethanol (acetaldehyde)	CH_3CHO	Green sweet	0.2	4,140	385	
*Phenol	C_6H_5OH	Medicinal	178	2,240	184	E

[a] Values recalculated from volume/volume data assuming 20°C and 1 atmosphere
[b] References: A. Identified by Derikx et al. (1990); B. Identified by Miller et al. (1991); C. Identified by Fisher et al. (1986); D. Identified by Chanysak et al. (1982); E. Identified by Koe and Ng (1987) in decaying refuse, not strictly composting
[c] No odor threshold values for carbon oxysulfide are to be found in the literature
[d] Identified by class by Manios et al. (1989) in compost extracts and by Miller (1991) using Draeger tubes for organic acids in an open composting yard
* Listed as hazardous air pollutant in 1990 Clean Air Act amendments
Reference: Adapted from Miller, 1993

Although composting facilities are not specifically listed in the source category hazardous air pollutant list, they may be considered a point source under the POTW or TSDF categories.

treatment, storage, and disposal facilities (TSDF), as well as publicly owned treatment works (POTW), are listed categories of major and area sources of HAPs. According to Title III of the CAAA regulation, major HAP sources must install a maximum achievable control technology (MACT) device in accordance with EPA schedules. To be considered a major source, the facility must have the potential to emit over 10 tons per year of a single listed compound or 25 tons per year of the aggregate of the listed compounds on the HAP list. MACT is defined as being equal to the average of the top 12 percent best performing sources in the same source category. Although composting facilities are not specifically listed in the source category list, they may be considered a point source under the POTW category (for biosolids) or the TSDF category (for MSW or yard trimmings). Because the regulations are in the early development stage, it is not known how they will ultimately impact composting operations.

MACT standards for TSDFs were due in November, 1994; standards for POTWs are due in November, 1995. MACT installation is required within 18 months of rule promulgation. The November, 1994 promulgation date was not met and it isn't expected that the POTW one will be met either. Despite the delays, it is incumbent upon composting facility owners and operators to determine if their operation would be considered a major source through emission inventory estimation of actual and potential pollutants.

Title I of the CAAA, which covers criteria pollutants, will perhaps play a bigger role in impacting composting facilities, depending upon the operation's location. Unlike air toxics (HAPs), which have local impact, criteria pollutants (such as VOCs) have regional impact. In other words, if the composting facility is located in a designated nonattainment area, regulations will be more stringent. For example, a regional nonattainment designation of "extreme" would require less than 10 tons per year of aggregate VOC emissions from a POTW to prevent its classification as a major source. Because it is still unclear how composting operations will fit into these categories, it is prudent to either measure or estimate HAP and VOC emissions to determine if a facility is in any of these category levels (Card 1994; Lopez *et al.* 1994).

COMPONENTS OF CONTROL

The four basic elements of odor control which must be adequately addressed at a composting facility to ensure effective control of odor and VOC emissions are: Reduction through process control; containment and transport; treatment; and dispersal of residual odors. Control of the feedstock quality and quantity has a direct bearing on odor generation. While the quantity of material may not be a viable variable to be controlled by operators, the quality or stability of the feedstock is. For example, Wilbur and Murray (1990) reported that the odor producing potential of WWTP biosolids during composting decreased depending on the type, with secondary biosolids generating the least.

Proper moisture and nutrient content of the mixtures of biosolids, solid wastes, yard trimmings, or other materials is a crucial first step. For example, an improper nutrient balance can lead to excessive ammonia production during composting. Adequate mixing of feedstocks to insure homogeneity, adequate porosity and the elimination of large clumps (greater than three inches) will help to reduce odor production. At the Montgomery County, Maryland biosolids composting facility, a 40 percent reduction in odorous compound generation during composting was noted after the mobile windrow mixing equipment was replaced with an automated continuous feed mixer (Murray *et al.* 1991).

Proper aeration of the composting mass as well as temperature control also are necessary to minimize odor generation. Differences in composting technologies are significant in this regard. For example, a simple turned windrow process is not likely to provide adequate oxygen to maintain a fully aerobic environment during the most active phase of composting. The anaerobic conditions that may result can generate more reduced sulfur-type compounds, which are very pervasive, than a fully aerobic process. With forced aerated piles, Wilbur and Murray (1990) also showed that as compost pile temperatures were lowered with higher aeration rates, significantly more odors were released during composting. They theorized that as pile temperatures increased, degradation rates were slowed. While this may be true at higher temperatures (above 60°C), it is also likely that too great of an aeration rate actually will strip odors and VOCs out of the composting mass before they can be absorbed and degraded in subsequent zones of the pile.

Containment and transport of odors is imperative if odor treatment and dispersion are to be employed. Because most of the odorous compounds generated are water soluble, they tend to be transported with wa-

A regional nonattainment designation of extreme would require less than 10 tons/year of aggregate VOC emissions from a POTW to prevent its classification as a major source.

> Dilution can be effective if enough distance is available between the composting operation and receptors.

ter droplets in steam plumes. Treatment systems which have been used to reduce emissions from composting facilities include multi-stage wet chemical scrubbers; biofilters; bioscrubbers; carbon adsorption; chemical counteractants; and masking agents.

The two basic types of chemical scrubbers used are mist and packed towers. Mist scrubbers rely on reactive chemicals to oxidize odors quickly in the vapor phase by misting the scrubbant countercurrent to the odorous gases being treated in a large chamber. Packed tower scrubbers rely on plastic media with a high surface to volume ratio over which scrubbant is cascaded while the exhaust gases pass through. Both types are usually operated in stages (two to four) to allow different chemistry to affect the removal of different groups of compounds. Typically, an acid is used in the first stage to remove ammonia prior to the second stage where bleach is used to oxidize reduced sulfur compounds. Variations exist in this basic system, such as the addition of surfactants for enhanced VOCs removal, acid for pH adjustment, and peroxide addition for removal of any chemical residual odors. This type of odor treatment system is used at numerous enclosed composting facilities. A significant benefit is that residual odors can be discharged through a stack at elevated levels, thereby increasing dispersion/dilution of the odors prior to impacting off-site receptors.

Biofiltration has been gaining increased acceptance as a treatment technology for composting facilities as better designed operations are built and removal data is generated. Biofilters rely on adsorption of odors and VOCs onto a moist media followed by biological oxidation of these compounds. Typically, gases are forced through a three- to four-foot deep layer of media (consisting of mixtures of compost, soil, wood chips, bark, sand, etc.) where adsorption and degradation take place. Biofilters require a significant land area due to the low loading rates which are required.

Bioscrubbing uses the same principle as biofiltration, only in a liquid-phase rather than a gas/liquid/solid-phase system. Odorous air is bubbled through activated sludge or a biological "broth" type system where odors are absorbed and broken down biologically. Only a few composting facilities use this practice and it is generally predicated on the location of the facility in the vicinity of an activated sludge system.

Activated carbon has been utilized with poor performance, primarily because dust and moisture in compost facility exhaust fill carbon adsorption sites, thereby reducing its effectiveness. Chemical counteractants have shown some success in odor treatment but are not as widely used as other chemical scrubbing technologies. A highly reactive stream of counteractant is sprayed in a very fine mist into compost exhaust gases. Reactions occur instantaneously and alter odor intensity and concentration. They generally are not as effective as wet chemical scrubbers or biofilters.

Masking agents are basically perfumes designed to cover up compost or other odors with a more pleasant odor. In other words, the hedonic tone and the character of the odor may be changed but the intensity and concentration is not diminished. They are not recognized as effective means of treatment.

Dispersion of residual odors after treatment is a component of any composting facility which should not be ignored. Dilution can be effective if enough distance is available between the composting operation and receptors. Unfortunately, encroachment around existing facilities has created troubles for numerous operations. Basic dispersion of residual odors through a building roof upblast fan rather than across ground level can drastically reduce odor problems if enough other odor control measures are in place. Stacks have the advantage of discharging high enough in the air to allow mixing odors with ambient air prior to the plume of gases reaching ground level where receptors might notice them. Area sources (such as compost piles or biofilters) have discharges at ground level which do not allow for dispersion prior to off-site transport, es-

Table 2. Odor removal data from several wet scrubber installations at composting facilities

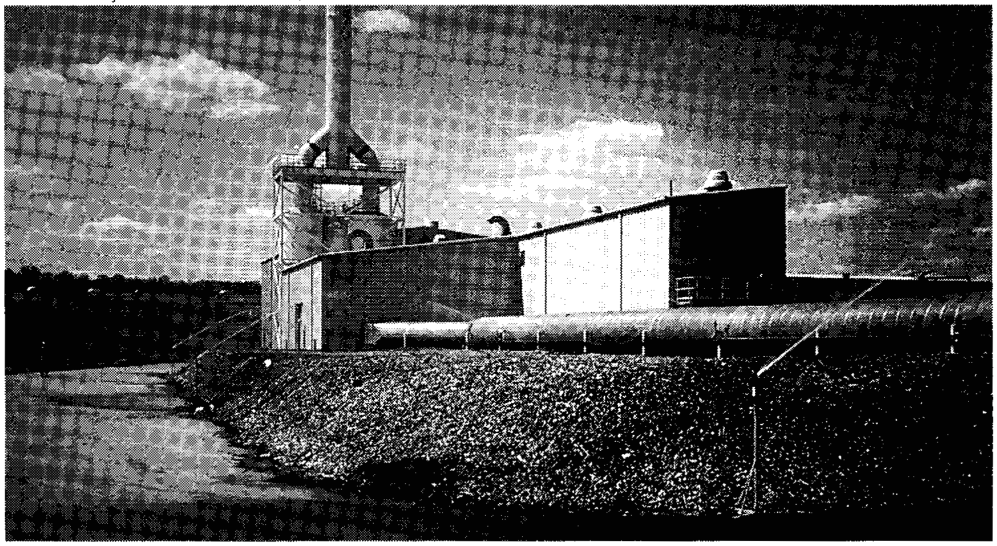
Facility	Date of Test	D/T Inlet		D/T Outlet		Odor Removal		TRS Removal %	VOC Removal %
		Range	Average	Range	Average	Range	Average		
Akron, OH[1]	3/93 & 8/93	53-338	180	12-85	47	55-85	74	–	–
Hamilton, OH[1]	9/91	158-289	223	84-158	127	0-47	31	–	–
Hampton Roads, VA[2]	6/90	–	1700	–	200	–	88	–	–
Lancaster, PA[1]	9/88	130-380	–	60-140	–	55-67	–	–	–
Montgomery Co., MD[1]	1/92	175-315	230	52-94	63	67-76	72	–	–
Montgomery Co., MD[3]	n/a	–	–	–	–	80-90	–	–	–
Montgomery Co., MD[4]	10/93-1/94	–	–	–	–	–	–	87	90
Schenectady, NY[1]	7/90	480-860	660	110-200	150	70-83	77	–	–
Schenectady, NY[5]	9/90	–	558	–	21	–	96	–	–

D/T = Dilutions to Threshold or ED50.
n/a = not available
References: 1. Ostojic, et al. 1994; 2. Van Durme, et al. 1992; 3. Hentz, et al. 1992; 4. Thompson, et al. 1995; 5. Muirhead, et al. 1993

pecially during stable air conditions. Modeling of residual odors is recommended for most facilities being built or expanded to insure off-site odor problems do not occur.

Treatment systems are generally not used at composting facilities unless exhaust gases are contained (in a structure or through ducting) and directed to an odor treatment device. The majority of composting systems in the U.S., that have some means of odor treatment system, utilize multistage chemical scrubbers or biofiltration. Other technologies listed previously have been utilized at only a handful of facilities. In addition, operating data on their performance is not readily available. Because multistage chemical scrubbing and biofiltration are the most common systems used for compost facility emissions treatment, information about these technologies is presented.

Photos courtesy of PWT Waste Solutions, Inc.



Offgases from the tunnel reactor system in Hamilton, Ohio can be routed to either a multistage mist scrubber or a biofilter.

MULTISTAGE SCRUBBERS

Data on the effectiveness of chemical scrubbers to remove odors at full-scale composting operations is shown in Table 2. Several other facilities utilize chemical scrubbers for odor treatment but data on effectiveness was not available. The primary data available is in the form of odor removal D/T data. A brief description of each facility follows.

Akron, Ohio operates a 70-dry ton per day Paygro biosolids composting system. Offgas from the headspace above the compost reactors is collected and treated through a two-stage packed tower system consisting of acid addition in the first stage and sodium hypochlorite in the second stage. Full-scale performance resulted in 55 to 85 percent odor removal efficiency.

Hamilton, Ohio operates a 17-dry ton per day Waste Solutions tunnel reactor to process biosolids. Offgases from this reactor can be routed to either a multistage mist scrubber or a biofilter. Full-scale tests included various combinations of acid, sodium hypochlorite, and sodium hydroxide. Because odor removal efficiencies never exceeded 50 percent, the scrubber system was shut down in 1991 and the biofilter (discussed later) was utilized.

Hampton Roads Sanitation District (HRSD) operates a 12-dry ton per day aerated static pile biosolids composting facility in Newport News, Virginia. Although this facility has been in operation since 1980, it has no odor treatment system. Plans to expand the operation to 17.5-dry tons per day at a different location included pilot testing of odor treatment options (Van Durme, *et al.* 1992). The most promising pilot test resulted in 88 percent odor reduction through a two-stage packed tower consisting of sulfuric acid in the first stage, followed by a mixture of sodium hypochlorite and sodium hydroxide in the second stage. HRSD is planning on doing additional pilot testing this summer to optimize scrubber design parameters.

Lancaster, Pennsylvania operates a 30-dry ton per day Davis (formerly Taulman) biosolids composting facility. Offgas from the vertical top-down flow reactor was processed through a single-stage sodium hypochlorite mist scrubber. At the time when odor testing was performed in 1988, an odor removal efficiency of 55 to 67 percent was achieved. However, odor problems continued. Modifications in the wet scrubbing system to an acid stage followed by a hypochlorite stage yielded significant improvement. However, subsequent odor testing was not performed to verify removal results. The State of Pennsylvania did its own stack test on the scrubber and determined that an 89 percent removal rate was being achieved on total reduced sulfur compounds.

Montgomery County, Maryland operates a 70-dry ton per day aerated static pile biosolids composting facility which is totally enclosed. Process offgases from the active compost piles are treated through a three-stage mist system which includes acid, surfactant and hypochlorite, followed by hydrogen peroxide. Test data in 1992 showed that a 72 percent odor reduction was achieved with this high tech scrubbing system (Ostojic, *et al.* 1992). However, Hentz, *et al.* (1992) reported that between 80 and 90 percent of odors were removed from this process exhaust by the scrubbing system. In October, 1993, a new scrubber was placed in service which utilizes the same basic process flow and chemistry, but subtle mechanical modifications were made. This scrubber reportedly achieves nearly 90 percent VOC reduction compared to only 40 percent reduction in the original scrubber (Thompson, *et al.* 1995).

Schenectady, New York operates a 15-dry ton per day American Biotech air lance biosolids composting facility. Process offgas is treated through a multistage packed tower scrubber that was modified several times. The present sulfuric acid (first stage) followed by sodium hypochlorite/sodium hydroxide two-stage system reportedly achieves 96 percent odor reduction (Muirhead, 1993).

With the exception of the latest system in Schenectady, all wet scrubber systems re-

Presumably, if much of the organic compounds responsible for odors are removed, then VOC reduction also is occurring.

One of the key phenomena of biofilter performance is the consistent results of D/T values in the exhaust being below 25 regardless of inlet D/T values.

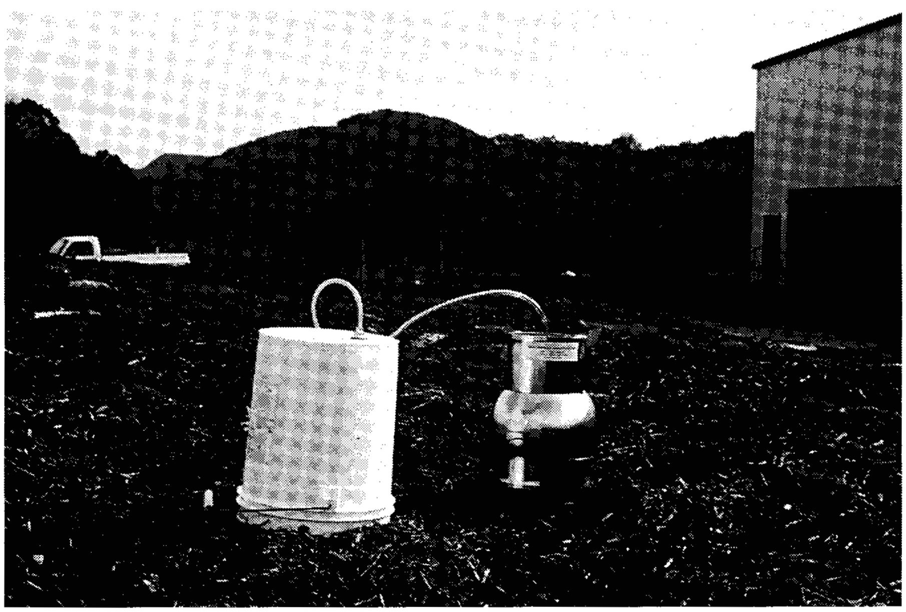
Table 3. Odor and VOC removal data from several biofilter installations at composting facilities

Facility	Date of Test	D/T Inlet Range	D/T Inlet Average	D/T Outlet Range	D/T Outlet Average	Odor Removal % Range	Odor Removal % Average	TRS Removal %	VOC Removal %
Dartmouth, MA [1]	5/93, 12/93	–	–	–	–	76-97	86	81	–
Hamilton, OH [2]	9/91-3/92	180-1,200	635	5-25	19	–	97	99	99
Hoosac, MA [3]	9/93	–	–	–	–	–	95	99	52
Lewiston-Auburn, ME [4,5]	9/93	71-158	115	7-11	8	90-94	93	–	–
Plymouth, NH [6]	4/92	170-318	227	< 10-35	23	79-96	90	–	–
Sevier, TN [7]	11/93	–	1,020	–	22	–	99	93	82
Yarmouth, MA [4]	4/93	143-262	214	4-26	12	88-98	95	>90	–

D/T = Dilutions to Threshold or ED50
TRS = Total Reduced Sulfur
VOC = Total Volatile Organic Compounds
References: 1. Amirhor, et al.,1994; 2. Wheeler, 1992; 3. E&A Environmental Consultants, Inc., 1993; 4. Giggey, et al., 1994; 5. Ostojic, et al., 1994; 6; Kuter, et al., 1993; 7; E&A Environmental Consultants, Inc., 1994.

viewed had difficulty in consistently achieving stack discharge gas detectability below 50 D/T. These systems, however, typically have had little difficulty in achieving high (greater than 90 percent) removal efficiency of specific compounds such as ammonia and total reduced sulfur compounds. Removal of other compounds, such as terpenes, has been less effective. Data which compares or correlates odor removal efficiency with VOC removal efficiency for wet scrubbers is not readily available. One advantage of the wet scrubber systems is that discharge stacks are used to disperse any residual odors from the treatment process even further before being detected by a receptor. However, presumably, if much of the organic compounds responsible for odors are removed, then VOC reduction is also occurring. One author found that when greater than 99 percent removal of six target odorous compounds was achieved, only 88 percent odor reduction occurred (Van Durme, *et al.* 1992). Additional research and in-field data gathering is needed in order to better establish the relationship between odor removal and VOC removal in wet scrubbers.

Biofilters at the mixed waste/biosolids cocomposting plant in Sevierville, Tennessee treat air from the tipping floor, the digester, and the active composting building.



BIOFILTER PERFORMANCE

Biofilters are gaining popularity as an odor control treatment technology for composting facilities due to their simple operation, low cost, and ability to treat multiple compounds simultaneously. Currently, over two dozen biosolids and MSW composting facilities in the U.S. rely on biofilters for their primary odor treatment device. Much work has been accomplished in the past three to five years to improve problem areas of biofilters, primarily air distribution and moisture control. Most of the poor performance case studies of the past are due to poor moisture control or overloading. Typical biofilters in use today at composting facilities are uncovered and consist of an air distribution piping network embedded in gravel beneath a three to four-foot deep biofilter media consisting of mixtures of wood chips, bark, compost, soil, etc. When loading rates are kept below 5 cfm/sf and nominal gas detention times greater than 45 seconds are maintained, very good (greater than 90 percent) odor removal efficiencies are obtained. Table 3 shows odor and VOC removal efficiencies for seven different biofilter installations.

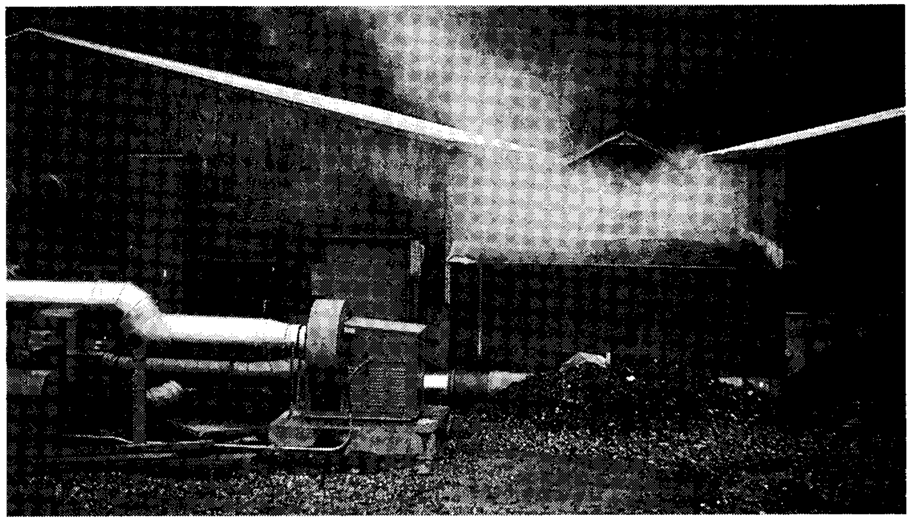
Four of these installations: *Dartmouth, New Hampshire; Lewiston-Auburn, Maine; Plymouth, Massachusetts, and Yarmouth, Massachusetts*, utilize the agitated bed composting technology to process biosolids. A large headspace above the compost bins results in significant dilution of offgases prior to treatment.

Hamilton, Ohio was described Concentrated offgas from the horizontal tunnel system is cooled with a water spray system prior to treatment in the biofilter.

Sevierville, Tennessee is a solid waste/biosolids cocomposting plant which utilizes a drum composter and an aerated static pile technology. Data reported here is for the most odorous gases being treated from the initial digester drum.

Hoosac, Massachusetts is an aerated static pile biosolids composting facility. Biofilters consisting of yard trimmings compost and wood chips are used to treat compost offgases with a high degree of effectiveness. The filter media has been in use for three years with no deterioration in performance.

As this data shows, odor removal at all of these facilities is very good, ranging from 86 to 99 percent. Removal of total reduced sulfur (TRS) compounds showed nearly equal performance of 78 to 99 percent. VOC removal data was less available, but between 52 and 99 percent was reported at three facilities. From the limited amount of data available, it appears that biofilters which achieve high (greater than 90 percent) odor removal efficiency will also achieve nearly as high VOC removal. One of the key phenomena of biofilter performance is the consistent results of D/T values in the exhaust being below 25 regardless of inlet D/T values. This is very important since residual odors are not diluted well from open biofilters due to their large ground level area source characteristics. Continued development of adsorptive media which resists air channeling over time will help improve biofilter performance. Data on biofilter design and operating criteria is published elsewhere (Williams, 1994; Leson *et al.* 1991).



Hoosac, Massachusetts operates an aerated static pile biosolids composting plant. The biofilter consists of yard trimmings compost and wood chips.

PROACTIVE MANAGEMENT

Odor and VOC emissions control at composting facilities needs to be managed more proactively than has been done historically. Because odors generated at these facilities tend to be very pervasive, odor problems can occur miles from a facility. Nuisance odor conditions can create ill will between operators and neighbors, and can trigger enforcement action from state regulatory agencies. With the enactment of the 1990 Clean Air Act Amendments, regulations regarding VOC control are being developed. Facility owners and operators should determine actual or calculated inventory emission data from their facilities to determine potential for impact by these regulations and/or the need for additional treatment systems.

Based on case study reviews, multistage

The majority of composting systems in the U.S. that have some means of odor treatment utilize multistage chemical scrubbers or biofiltration.

chemical scrubbers and biofilters are the two treatment technologies most commonly used and have the most promising results. Each has the capability to remove high percentages of odors and VOCs. However, limited data is available which compares odor reduction with VOC reduction achieved by either of these treatment technologies at composting facilities. Continued proactive research and development of these and other technologies will help ensure the successful continued growth of composting as a preferred waste management option. ■

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REFERENCES

Amirhor, P. and G.A. Kuter. 1994. Performance evaluation of biofilter at Dartmouth, Massachusetts, biosolids composting facility. Presented at the New England Water Environment Association Annual Meeting, February 1994, Boston, Massachusetts.

Bohn, H.L. 1977. Soil treatment of organic waste gases. *In:* Soils for Management of Organic Wastes and Waste Waters. Published by Soil Science Society of America, Madison, Wisconsin. pp. 607-618.

Brown, D., J. Smith, J. Donovan, J. Johnston and A. Pincence. 1989. Summary Report: In-Vessel Composting of Municipal Wastewater Sludge. EPA/625/8-89/016.

Card, T.R. 1994. How air quality regulations are impacting POTWs. Presented at the Water Environment Federation Specialty Conference Series: Odor and Volatile Organic Compound Emission Control for Municipal and Industrial Wastewater Treatment Facilities, Pre-Conference Workshop, April 1994, Jacksonville, Florida.

Derikx, P.J.L., G.A.H. de Jong, H.J.M. Opden Camp, C. Van der Drift, L.J.L.D. Van Griensven and G.D. Vogels. 1989. Isolation and characterization of thermophilic methanogenic bacteria from mushroom compost. *FEMS Microbiology Ecology* 62:251-258.

E&A Environmental Consultants, Inc. 1993. Report Submitted to the Town of Hoosac, Massachusetts.

E&A Environmental Consultants, Inc. 1994. Air sampling report for Sevier compost facility. Report Submitted to Bedminster Bioconversion Corporation. Cherry Hill, New Jersey.

Giggey, M.D., C.A. Dwinal, J.R. Pinnette and M.A. O'Brien. 1994. Performance testing of biofilters in a cold climate. Presented at the Water Environment Federation Specialty Conference Series: Odor and Volatile Organic Compound Emission Control for Municipal and Industrial Wastewater Treatment Facilities, April 1994, Jacksonville, Florida. pp. 4/29-39.

Goldstein, N.G. and R. Steuteville. 1993. Biosolids composting makes healthy progress. *BioCycle* 34(12):48-57.

Hentz, L.H., C.M. Murray, J.L. Thompson, L.L. Gasner and J.B. Dunson, Jr. 1992. Odor control research at the Montgomery County regional composting facility. *Water Environment Research* 64(1):13-18.

Kuter, G.A., J.E. Harper, L.M. Naylor and P.J. Gormsen. 1993. Design, construction and operation of biofilters for controlling odors at composting facilities. Presented at the 86th Annual Meeting and Exhibition of the Air and Waste Management Association, June 1993, Denver, Colorado.

Leson, G. and A.M. Winer. 1991. Biofiltration: an innovative air pollution control technology for volatile organic compound emissions. *Air & Waste Management Association* 41(8):1045-1054.

Lopez, T.M. and M. Turner. 1994. The new wave of odor and VOC air quality regulations for wastewater treatment plants. Presented at the Water Environment Federation Specialty Conference Series: Odor and Volatile Organic Compound Emission Control for Municipal and Industrial Wastewater Treatment Facilities, April 1994, Jacksonville, Florida. pp. 9/13-24.

Miller, F.C. 1993. Minimizing odor generation. *In:* Science and Engineering of Composting: Design, Environmental, Microbiological and Utilization Aspects. Eds. H.A.J. Hoitink and H.M. Keener. Renaissance Publications: Worthington, Ohio. pp. 219-241.

Muirhead, T., P. LaFond and D. Dennis. 1993. Air handling and scrubber retrofits optimize odor control. *BioCycle* 34(3):68-75.

Murray, C.M., J.L. Thompson and J.S. Ireland. 1991. Process control improvements at composting sites. *BioCycle* 32(12):54-58.

Ostojic, N. and M. O'Brien. 1994. Control of odors from sludge composting using wet scrubbing biofiltration and activated sludge treatment. Presented at the Water Environment Federation Specialty Conference Series: Odor and Volatile Organic Compound Emission Control for Municipal and Industrial Wastewater Treatment Facilities, April 1994, Jacksonville, Florida. pp. 5/9-20.

Thompson, J.L., C.M. Murray and D.K. Grimes. 1995. Improving compost odor scrubbing performance. *BioCycle* 36(2):80-86.

VanDurme, G.P., B.F. McNamara and McGinley. 1992. Bench-scale removal of odor and volatile organic compounds at a composting facility. *Water Environment Research* 64(1):19-27.

Wheeler, M.L. 1992. Proactive odor management: the evolution of odor control strategies at the Hamilton, Ohio wastewater treatment and sludge composting facility. Presented at the BioCycle National Conference, May 1992, St. Louis, Missouri.

Wilbur, C., and C. Murray. 1990. Odor source evaluation. *BioCycle* 31(3):68-72.

Williams, T.O. 1994. Biofiltration for control of odorous emissions and volatile organic compounds (VOCs) from wastewater and sludge processing facilities. Presented at the Water Environment Federation Specialty Conference Series: Odor and Volatile Organic Compound Emission Control for Municipal and Industrial Wastewater Treatment Facilities, April 1994, Jacksonville, Florida. pp. 4/1-13.