California Integrated Waste Management Board

Contractor's Report to the Board

October 31, 2007

Emissions Testing of Volatile Organic Compounds from Greenwaste Composting at the Modesto Compost Facility in the San Joaquin Valley

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Table of Contents

Table of Figures

Table of Tables

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Executive Summary

Field emission measurements of volatile organic compounds (VOCs) from greenwaste composting were conducted at the Modesto Compost Facility located in Modesto, California for the California Integrated Waste Management Board (CIWMB). This project had several purposes including:

- Evaluate baseline VOC emissions during greenwaste composting.
- Evaluate baseline VOC emissions during composting of greenwaste that includes food waste.
- Assess the VOC emission reduction potential of two Best Management Practices (BMP):
    - Application of a finished compost blanket to the top of a greenwaste windrow.
    - Application of two chemical additives to a greenwaste windrow.

The results will provide various regulatory agencies, such as the San Joaquin Valley Air Pollution Control District (SJVAPCD), with information that may be helpful in their decision making and the composting industry with BMP alternatives that could help reduce VOC emissions.

The Modesto Compost Facility is owned and operated by the City of Modesto and typically processes about 250 to 300 tons of greenwaste materials per day. These materials could include some paper and small amounts of residential food waste. The facility operates on a 30-acre site with a maximum permitted capacity of 500 tons per day. Greenwaste materials come from residential collection, landscape businesses, and large municipal prunings done on a monthly basis. The facility composts the source-separated greenwaste materials in static composting windrows. Greenwaste materials are tipped on a concrete pad and processed in a grinder before being shaped into windrows. The windrows are turned with a Scarab type windrow turner approximately once a week, and as required to meet Processes to Further Reduce Pathogens (PFRP) mandates.

The project consisted of constructing four test windrows in a fashion similar to standard, full-scale windrow operation. The test windrows included: a greenwaste windrow, a greenwaste windrow that contained 15% by weight food waste, a greenwaste windrow capped with a finished compost blanket, and a greenwaste windrow with two chemical additives. Over 100 field samples were collected during nine field-test days over a 57-day period in order to provide empirical data for estimating VOC emissions from each windrow.

Source emission samples were collected with the USEPA surface emission isolation flux chamber and VOCs were analyzed by the South Coast Air Quality Management District (SCAQMD) Method 25.3. The emission testing results were used to predict emission factors, or pounds of VOCs emitted per ton of compostable materials The emission results were used to compare VOC emissions from the greenwaste test windrow versus the greenwaste/food waste windrow, and to estimate potential emission reductions from the two BMPs.

Results and Conclusions

Composting of greenwaste generated from 0.8 to 0.9 lbs VOC per ton of greenwaste while the greenwaste mixed with food waste generated from 1.3 to 2.6 lbs/ton. When compared with the greenwaste windrow (control), the application of the finished compost blanket resulted in an 84% reduction in VOC emissions for the first seven days, and a 75% reduction for the first fourteen days of composting. The application of additives resulted in a 42% reduction in VOC emissions during the first week prior to the first turning. The effectiveness of the additives was diminished following the turning event, with VOC emissions reduced by only 14% by the end of the second week, indicating the need for additive application following turning events (see Tables 1 and 2).

Table 1. Life Cycle* VOC Emissions Factors (lb VOC per ton – wet basis, 57 days)

Windrow	Emission Factor
Food waste (FW)	1.3 - 2.6
Greenwaste (GW)	0.8 - 0.9

* VOC reported as non-methane non-ethane organic compounds (NMNEOC). Emission Factor range is dependent on methodology used for venting versus non-venting data – see tables 12 - 16 for details.

Table 2. Initial 2-Week VOC Emissions Factors (lb VOC per ton – wet basis)

Windrow	Emission Factor
Food waste (FW)	0.9 - 1.8
Greenwaste (GW)	0.6 - 0.7
Additive (A)	0.5 - 0.6
Biofilter (BF)	0.1 - 0.4

For a facility processing 200,000 tons of greenwaste per year, the cost estimates to implement these BMP practices are $300,000 or $1.50 per ton for the additive BMP and $120,000 or $0.60 per ton for the compost blanket BMP.

Consistent with prior studies, the majority of VOC emissions occurred during early stages of composting. About 80% of the VOCs from the greenwaste and 70 % of the VOCs from the food waste were emitted during the first two weeks of composting.

Additionally, the surface emission survey suggested that close to 85% of the emissions occurred from the windrow tops as compared to the sides.

A complete list of conclusions and recommendations is provided on page 50 of this report.

Introduction

This report describes a full-scale field investigation to determine life-cycle emissions of volatile organic compounds (VOC) resulting from windrow composting of greenwaste. It also examined the efficacy of two Best Management Practices (BMP) in reducing emissions. One BMP was the application of a finished compost blanket to the top of a greenwaste windrow; the other was the application of two chemicals to a different greenwaste windrow.

The study was conducted for the California Integrated Waste Management Board (CIWMB). The windrows were constructed and field testing was performed at the Modesto Composting Facility operated by the City of Modesto, California located in the San Joaquin Valley Air Pollution Control District (SJVAPCD).

In order to meet air quality standards, the SJVUAPCD is implementing stricter regulations on VOC emission sources including composting facilities.

The District adopted Rule 4565 (Managing Biosolids, Animal Manure, and Poultry Litter Operations) on March 15, 2007. Among other things, Rule 4565 regulates VOC emissions from co-composting facilities, i.e. facilities that include biosolids in their compost feedstocks. Rule 4565 requires an 80% reduction in VOC emissions for co-composting facilities with throughputs greater than 100,000 tons per year.

In addition, in April 2007 SJVUAPCD Board adopted the 2007 8-Hour Ozone Plan. This plan projects that SJVUAPCD Board will adopt Control Measure S-GOV-5, Composting Green Waste in the first quarter of 2009. SJVUAPCD staff estimates rulemaking for S-GOV-5 will commence around first quarter 2008.

Testing Protocol

A testing protocol was developed to describe the sampling strategy, sampling procedures, and analytical test methods. Prior to commencing field tests, the protocol was reviewed with SJVUAPCD in meetings with CIWMB, San Diego State University researcher Dr. Fatih Buyuksonmez, and field chemist Dr. Chuck Schmidt.

Sampling strategy

The four test windrows were formed on Day 0 (October 18, 2006). The sampling started on Day 1 and continued throughout the life-span of the windrows with more frequent sampling at the beginning. Fourteen samples were taken per sampling event as follows:

- Three flux samples collected from each composting windrow
- One extra ridgetop flux sample from one of the windrows (either greenwaste or food waste windrow)
- One media blank sample (a test for contaminants in the media used to trap the emissions. This media includes the reagent water and ultra-high-purity air.)

The greenwaste and food waste windrows were sampled for the full test period, while the two BMP windrows were sampled for only the first two weeks due to financial considerations. Each sample was analyzed in triplicate (sometimes in duplicate due to time constraints) for statistical analysis. Sample location zones included ridgetop, middle-side, and bottom-zone to evaluate the variable fluxes from the "chimney effect" caused by the temperature profile within the composting windrows. An initial screening of the ridgetops was conducted with a portable gas analyzer (TVA-1000) prior to each sampling event, to determine venting and non-venting locations. This data was then used to determine the exact sampling location within the ridgetop sample zone. See Tables 3 and 4 for the sampling scheme and project test schedule.

Figure 1 is a cross-sectional representation of a typical windrow divided into three sections: bottom, middle and ridgetop. Each bottom and middle section is approximately one eighth of the total width (W/8) and the ridgetop comprises the remainder.

For a given windrow, up to four emission samples were collected. These included:

1. High level of emissions on the ridgetop, i.e., venting (R1)
2. Low level of emissions on the ridgetop, i.e., non- venting (R2)
3. Middle section emissions
4. Bottom section emissions

In the event that all four samples were collected, the total ridgetop emissions were estimated based on the ratio of the venting versus non-venting surface of the ridgetop, and the emissions from the middle and bottom sections were assumed to be constant. Since most of the emissions resulted from the ridgetop, the middle and bottom section emissions would not significantly affect the total. In the event only one ridgetop sample was collected, an average of the previous and the following R2 (non-venting) emission values was used. (R1 (venting) samples were collected each sampling event for all windrows. R2 (non-venting) samples were collected on a rotating schedule between the greenwaste and the food waste windrows. There were a total of 109 emission samples collected, of which 9 were media blanks for quality control. Emission samples were collected in evacuated stainless steel Summa canisters and analyzed according to the AQMD Method 25.3 for VOC emissions.

The on-site field laboratory provided an opportunity to collect additional samples with a syringe using the isolation flux chambers. These were then injected directly into the on-site gas chromatograph and analyzed using SCAQMD Method 25.3. These samples were used to determine the variation in VOC emissions versus time of day for the same sample location and also to elucidate the emission differences along the cross-sectional profile of a windrow. The sampling procedure difference between the samples analyzed on-site and the source emission samples that were shipped to Almega Laboratories is that the samples analyzed on-site were withdrawn into a 30-ml sampling syringe instead of passing through a condensate trap and collected in canisters. For the on-site sampling protocol, condensation was not deemed to be a concern since the samples were injected into the gas chromatography immediately following their collection and the ambient temperature was sufficient to prevent condensation.

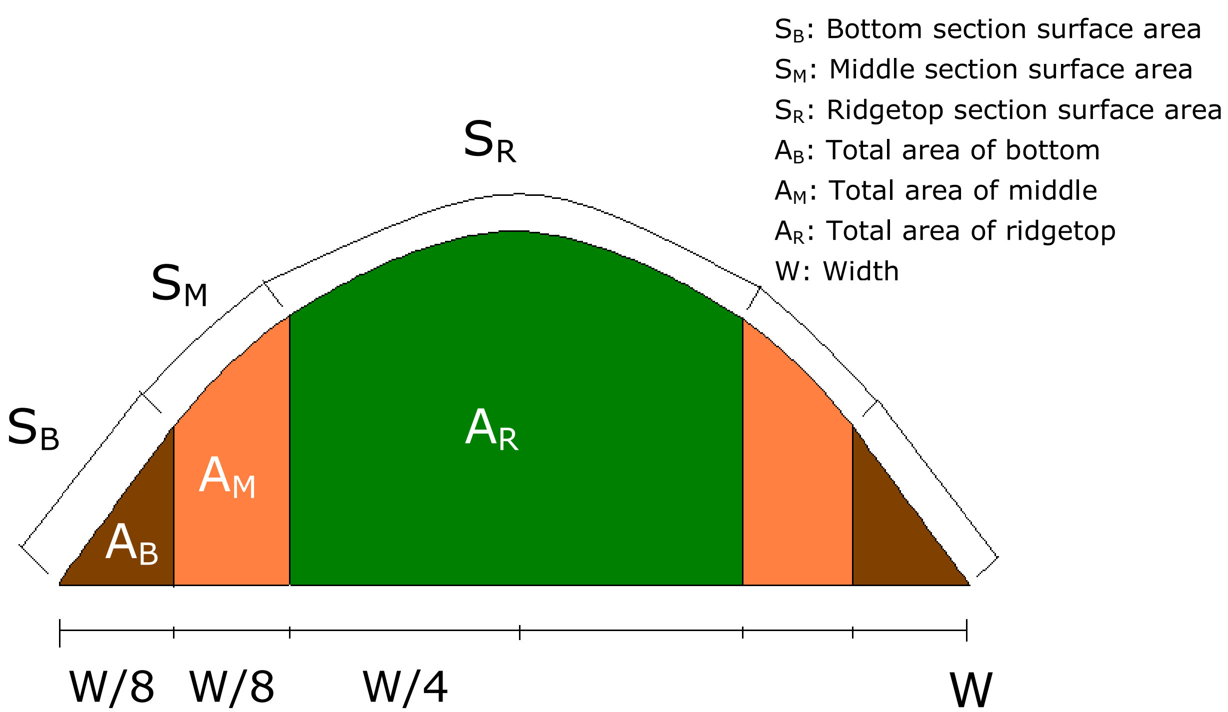


Figure 1. Sampling Segments of Windrows

Table 3. Sampling Scheme

Test Windrow	**Sample Location**	**Day 1**	**Day 2**	**Day 3**	**Day 6**	**Day 8**	**Day 14**	**Day 21**	**Day 30**	**Day 44**	**Day 57**
	Turning	**Before**	**Before**	**Before**	**Before**	**After**	**Before**	**Before**	**Before**	**Before**	**Before**
	Date	**Oct.19**	**Oct. 20**	**Oct. 21**	**Oct. 24**	**Oct. 26**	**Nov.1**	**Nov. 8**	**Nov. 17**	**Dec. 1**	**Dec. 14**
Greenwaste	Ridge high (R1)	1	1	1	1	1	1	1	1	1	1
	Middle (M)	1		1	1	1	1	1	1	1	1
	Bottom (B)	1		1	1	1	1	1	1	1	1
	Ridge low (R2)	1	1	1			1	1	1	1	1
Food waste	Ridge high (R1)	1		1	1	1	1	1	1	1	1
	Middle (M)	1		1	1	1	1	1	1	1	1
	Bottom (B)	1		1	1	1	1				
	Ridge low (R2)				1	1		1	1	1	1
Biofilter	Ridge high (R1)	1		1	1	1	1		1	1	
	Middle (M)	1		1	1	1	1				
	Bottom (B)	1		1	1	1	1				
	Ridge low (R2)	1							1	1	
Additive	Ridge high (R1)	1		1	1	1	1				
	Middle (M)	1		1	1	1	1				
	Bottom (B)	1		1	1	1	1				
	Ridge low (R2)										
QA/QC	Media Blank	1		1	1	1	1	1	1	1	1
Total Samples		**15**	**2**	**14**	**14**	**14**	**14**	**8**	**10**	**10**	**8**

Table 4. Project Test Schedule

Day	Date		Day	Activity	
0	October	18	Wednesday	Pile formation	
1	October	19	Thursday		Sampling
2	October	20	Friday		
3	October	21	Saturday		Sampling
4	October	22	Sunday		
5	October	23	Monday		
6	October	24	Tuesday		Sampling
7	October	25	Wednesday	Turn	
8	October	26	Thursday		Sampling
9	October	27	Friday		
10	October	28	Saturday		
11	October	29	Sunday		
12	October	30	Monday		
13	October	31	Tuesday		
14	November	1	Wednesday		Sampling
15	November	2	Thursday	Turn	
16	November	3	Friday		
17	November	4	Saturday		
18	November	5	Sunday		
19	November	6	Monday		
20	November	7	Tuesday		
21	November	8	Wednesday		Sampling
22	November	9	Thursday	Turn	
23	November	10	Friday		
24	November	11	Saturday		
25	November	12	Sunday		
26	November	13	Monday	Turn	
27	November	14	Tuesday		
28	November	15	Wednesday		
29	November	16	Thursday		
30	November	17	Friday		Sampling
31	November	18	Saturday		
32	November	19	Sunday		
33	November	20	Monday	Turn	
34	November	21	Tuesday		
35	November	22	Wednesday		
36	November	23	Thursday		
37	November	24	Friday		
38	November	25	Saturday		
39	November	26	Sunday		
40	November	27	Monday	Turn	
41	November	28	Tuesday		
42	November	29	Wednesday		
43	November	30	Thursday		
44	December	1	Friday		Sampling
45	December	2	Saturday		
46	December	3	Sunday		
47	December	4	Monday	Turn	

Day	Date		Day	Activity	
48	December	5	Tuesday		
49	December	6	Wednesday		
50	December	7	Thursday	Turn	
51	December	8	Friday		
52	December	9	Saturday		
53	December	10	Sunday		
54	December	11	Monday	Turn	
55	December	12	Tuesday		
56	December	13	Wednesday		
57	December	14	Thursday		Sampling
58	December	15	Friday	Turn	
59	December	16	Saturday		
60	December	17	Sunday		
61	December	18	Monday	Turn	

Emission Sampling Methods

Source emission samples were collected using the USEPA's Surface Isolation Flux Chamber (USEPA, 1986) and evacuated sample canisters with condensate traps. The emission samples were collected in evacuated canisters after passing the air stream through a cold trap to capture condensable organics as illustrated in Figure 2. The details of the cold-trap and canister setup are presented in Figure 3.

The sampling train was assembled and leak tested prior to the beginning of a sampling event. The leak test was performed by plugging the sample inlet and opening the canister's valve to apply vacuum, then, the valve was closed and the pressure drop over one minute was observed. A pressure drop of less than 10-inches of mercury was considered satisfactory. The sweep air, which is ultra high purity air with carbon monoxide added as the tracer, was uniformly introduced from the inner perimeter of the flux chamber at a rate of 5.0 liters per minute using a rotameter or digital mass flow controllers. In order to reach steady-state conditions within the isolation flux chamber, the sweep air was introduced for 30 minutes prior to the beginning of sampling.

Upon reaching the steady-state conditions, pertinent data was recorded (temperature, carbon monoxide and total volatile hydrocarbon readings) and sample collection was initiated. At the end of 30 minutes of sample collection, deionized water was introduced to the sample inlet to collect any condensable VOC left in the sampling tubing. The condensate traps were removed from the sampling train, capped, and shipped to the laboratory in an ice-chest. The remaining portion of the sampling assembly was removed, and the sample canister was capped for transportation to the laboratory with a chain of custody.

In addition to the source emission samples collected, there were several samples collected and analyzed on site. In this case, the sampling train shown in Figure 4 was utilized. Isolation flux chambers were equilibrated, and the sample was directly withdrawn into a syringe from the flux chamber for immediate analysis according to SCAQMD Method 25.3

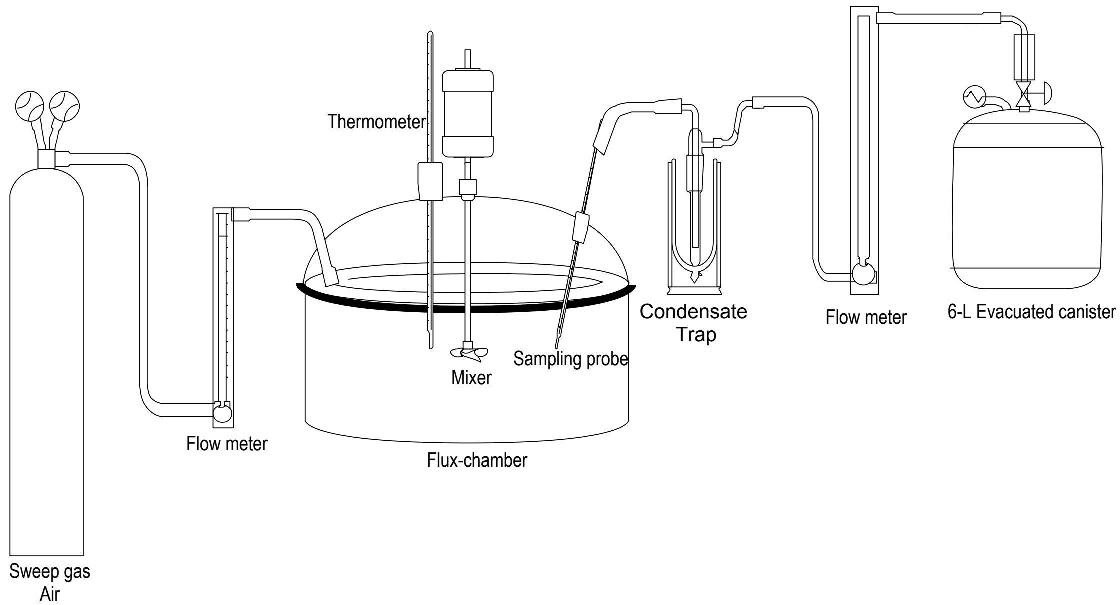


Figure 2. Sampling Train Utilizing Evacuated Canisters and Cold-Trap (Condensate Trap)

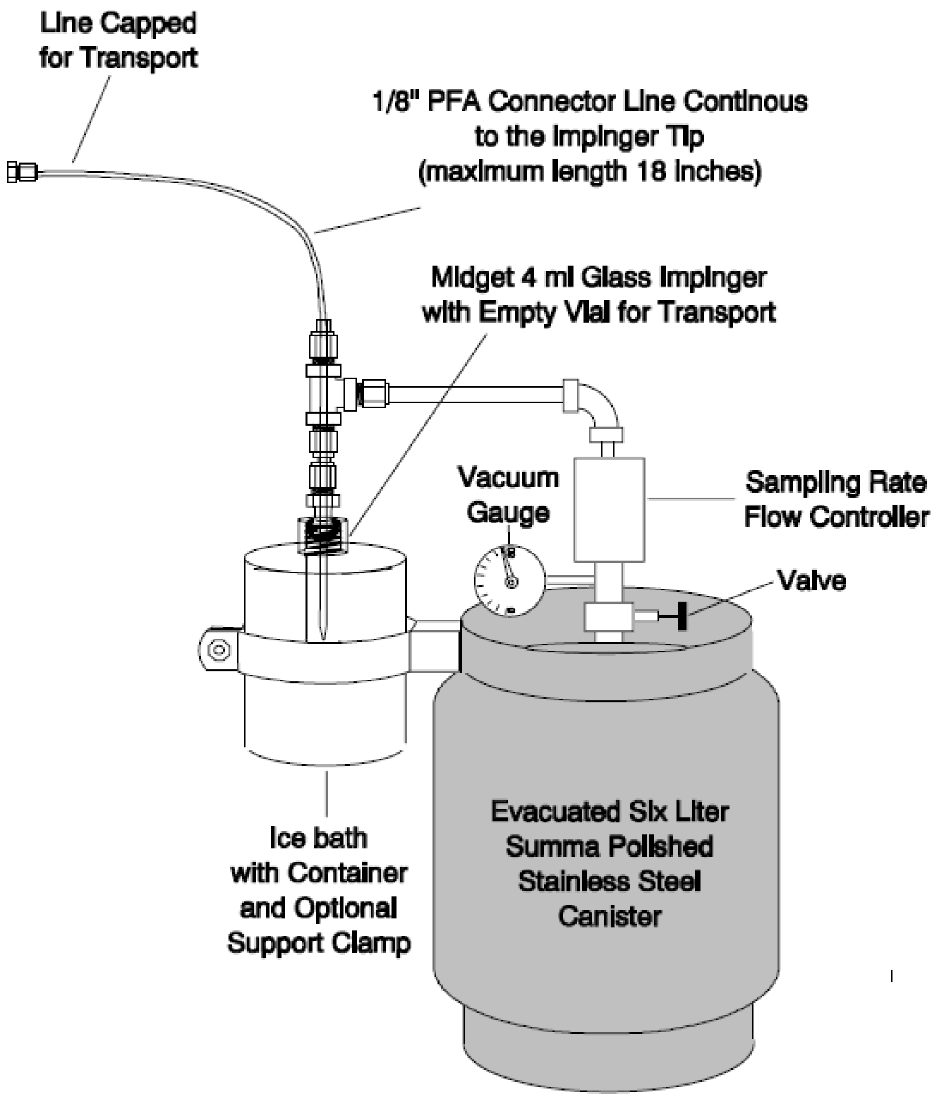


Figure 3. Evacuated Canisters and Cold-Trap (Ice Bath)

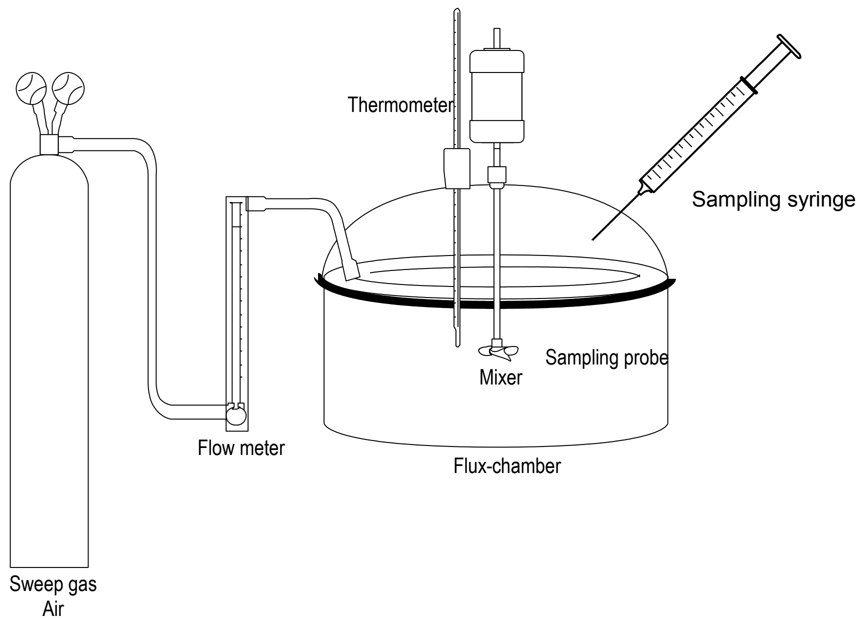


Figure 4. Sampling Train Utilizing a Sampling Syringe

Compost Sampling Methods

Composite samples of compost were collected in zip-lock bags by combining grab samples at four different locations approximately one foot below the surface in the same windrow. Composite samples were collected at the beginning of the composting cycle on Day 1 and at the end of the cycle on Day 57. The samples were transported to the laboratory in an ice-chest for determination of selected compost characteristics.

SJVUAPCD and CIWMB Considerations

The testing protocol was reviewed in meetings with SJVUAPCD and CIWMB staff, and with project researchers. Major points of interest to SJVUAPCD regarding the test protocol included:

- Timing of samples in relation to turning events
- Analysis of samples within 48 hours
- Spatial location of sample points both vertically and horizontally
- Analysis methods

Considerations that were important to CIWMB included:

- Defining VOC emissions for the full life cycle of the composting process
- Evaluating emissions for a mixture of greenwaste and food waste
- Determining the efficacy of BMP alternatives to reduce VOC emissions.

Timing of Samples in Relation to Turning Events

In order to evaluate the VOC emissions that occur during a turning event, the testing protocol called for sampling to occur within 24 hours before and after a turning event. As shown in Table 4, a turning event occurred on Day 7 and the sampling was done on Days 6 and 8. All other samples were gathered before the turning events so that emission data was not skewed. Turning events are noted on the test schedule (Table 4).

Analysis of Samples

When analyzing for VOC emissions by SCAQMD Method 25.3, there are two emission sample fractions of concern, the liquid fraction and the gas fraction. To minimize sample loss and underestimation of the VOC emissions during sampling, condensable gases or the liquid fraction of the VOC emissions were captured in condensate traps as liquids, kept on ice in the field, and refrigerated until analyzed.

The original plan for analysis of the gas fraction of the VOC emissions was to analyze all of the Summa canisters on-site in a trailer laboratory provided by Dr. Buyuksonmez and equipped with a gas chromatograph and TOC analyzer. However, due to unforeseen difficulties in setting up the on-site laboratory and the large volume of samples requiring analysis in a short period of time (including QA/QC samples), a field decision was made to shift analysis of all gas fractions to the Almega Laboratories. The on-site field laboratory was used to conduct additional field studies that were not part of the original test plan but provided useful insight on the characteristics of compost emissions.

Following the decision to not use the on-site laboratory, the gas fractions of the VOC emissions was captured in stainless steel Summa canisters and shipped overnight with chain of custodies to Almega Laboratories in Huntington Beach for analysis. Upon receipt, Almega Laboratories processed the gas fractions according to SCAQMD Method 25.3 protocol for sampling handling, analysis, and retention times. In all cases, the gas fractions were analyzed within the acceptable storage and retention time protocols for SCAQMD Method 25.3. This did not, in all cases, result in the analysis of the gas fractions within the 48 hours requested by SJVUAPCD; however, extreme care was taken to ensure the samples were analyzed within protocol to minimize sample loss and underestimation of VOC emissions.

Spatial Location of Sample Points, Vertically and Horizontally

To characterize the variable emission fluxes of the “chimney-breathing” pattern of a windrow, three vertical sampling points (bottom, middle, and ridgetop) were taken for most sample sets. In some sample sets an extra ridgetop sample was occasionally gathered instead of the daily field blank sample to provide additional emission data from both venting and non-venting locations along the horizontal length of the windrow ridgetops. Extra ridgetop samples were used since typically most of the emissions occur along the ridgetop of a windrow.

Note: a daily field blank sample is a more comprehensive sample than a blank media sample taken during each sampling event. It includes all potential sources of contamination such as any canister, impinger, or line the sample will touch in addition to the media water and ultra high purity air.

Analysis Methods

The VOC emission samples were analyzed using the SCAQMD Method 25.3. The feedstock materials and product samples were also analyzed for total carbon, total nitrogen and moisture contents as follows:

- Total carbon content was determined by loss-on-ignition method.
- Total nitrogen content was determined using a Perkin Elmer 2410 total nitrogen analyzer.
- Moisture content was determined gravimetrically after drying at 70° C.

The stability of the final products was determined by the respirometric method as described at Test Methods for Evaluation of Composting and Compost (TMECC).

VOC Emissions for the Full Life Cycle of the Composting Process

A primary CIWMB goal was to measure the full life cycle of VOC emissions during greenwaste composting. The life cycle is characterized by higher emissions during the active phase of composting, typically followed by significantly declining emission rates during the remaining life cycle. This life cycle characterization of the emission profile is important in order to estimate the total impact to the environment of the VOC emissions.

Emission samples were taken throughout a 60-day composting life cycle with a total of ten sampling events on Days 1, 2, 3, 6, 8, 14, 21, 30, 44, and 57; i.e. six sampling events during the more active initial two weeks and four sampling events during the remaining less active period. Every effort was made to observe the original sampling schedule. However, due to scheduling or operational considerations, some sampling days were added and a few of the sampling days were slightly shifted.

Evaluating Emissions for a Mixture of Greenwaste and Food waste

To evaluate baseline VOC emissions for food waste, one of the test windrows was constructed as a mixture of greenwaste and food waste materials. The windrow contained roughly 15% food processing waste, comprised of peppers, tomatoes, peaches and syrup, which was then mixed with the source-separated and ground greenwaste. For the food waste windrow, bottom location samples were sacrificed in favor of ridgetop samples for the tail-end of the composting cycle since there is little data on food waste composting and minimal emissions were anticipated from the bottom.

Determining the Efficacy of BMP Alternatives to Reduce VOC Emissions

Two test windrows were constructed to evaluate the effectiveness of two BMPs in reducing VOC emissions. Both of the BMP windrows were constructed with source-separated and ground greenwaste materials. One of the BMP windrows was capped with finished compost that served as a pseudo-biofilter layer. Chemical additives were applied to the other BMP windrow.

The pseudo-biofilter BMP was tested because, in another CIWMB-sponsored research project, a lab-scale setup showed that a blanket of finished compost (i.e. a pseudo-biofilter) applied on top of composting materials resulted in substantially lower emissions and odors. It should be noted that this blanket of finished compost becomes integrated into the windrow following a turning event and thus inoculates the windrow with beneficial microbes. Following a turning event, the pseudo-biofilter cap was re-applied using additional finished compost.

The other test windrow was constructed to evaluate the performance of two chemical additives provided by GOC Technologies. GOC Technologies submitted field test data from other test sites to CIWMB prior to the Modesto Composting Facility field tests. These additives were chosen because their previous performance indicated a reduction in VOC emissions. GOC Technologies provided two types of chemical additives: an inoculation type that was incorporated with the greenwaste during the formation of the windrow and a topical type that was sprayed on the surface of the windrow. GOC Technologies provided field assistance to ensure that the additives were applied to the windrow according to their application instructions.

For the two BMP windrows, the collected samples were analyzed only in duplicate or less, due to funding limitations and time constraints. Also the two BMP windrows were tested only for the first two weeks which approximated the active phase of composting.

Description of Test Windrows

On October 18, 2006, four test composting windrows were formed for emission testing of VOCs. The windrows were constructed as follows:

- **Greenwaste Windrow** containing approximately 103 tons of source-separated, ground green waste**.**
- **Food waste Windrow** containing roughly 15% food waste; comprised of approximately 113 tons of source-separated ground greenwaste with approximately 20 tons of food processing waste from the local food processing plants (peppers, tomatoes, peaches and syrup).
- **Pseudo-biofilter Windrow** containing approximately 120 tons of source-separated, ground greenwaste and capped with roughly 20 tons of screened finished compost applied topically with a bucket loader. (Unscreened finished compost was utilized as the pseudo-biofilter in the subsequent applications after windrow turnings.).
- **Additive Windrow** containing approximately 116 tons of source-separated, ground greenwaste, to which two GOC Technologies commercial chemicals were added. The first additive, ASC2600, was incorporated by turning the windrow following its application. The second additive, ASC 2500, was applied topically.

To form these four composting windrows, the Modesto Composting Facility followed their standard operating procedures (with additional requirements for the two BMP windrows). The windrows were then managed according to the regular facility schedule, i.e. the turning frequency, moisture addition, and composting duration.

The cross-sectional shape of the windrows was assumed to be trapezoidal. The equations for each windrow were determined based on their base widths and heights. The surface areas and subsurface volumes were calculated by integrating equations along the width of the windrows. The measured dimensions, the estimated equation constants, and total surface areas and volumes are presented in Tables 5 (metric units) and 6 (British units).

Table 5. Windrow Dimensions in Metric Units

Windrow	Dimensions (m)				Surface Area (m^2)		
	L	W_B	W_T	H	Bottom	Middle	Ridge Top
Food waste	35.14	4.72	2.44	1.77	73.91	73.91	85.69
Greenwaste	31.09	4.39	1.70	2.07	76.76	76.76	52.88
Additive	31.15	5.00	1.83	1.77	79.57	79.57	84.50
Biofilter	33.77	4.63	2.71	2.13	71.03	71.03	61.76

Table 6. Windrow Dimensions in British Units

Windrow	Dimensions (ft)				Surface Area (ft^2)		
	L	W_B	W_T	H	Bottom	Middle	Ridge Top
Food waste	115.3	15.5	8.0	5.8	795.57	795.57	922.40
Greenwaste	102.0	14.4	5.6	6.8	826.20	826.20	569.16
Additive	102.2	15.2	6.0	7.0	856.44	856.44	909.58
Biofilter	110.8	16.4	8.9	5.8	764.52	764.52	664.80

Analytical Methods

Analysis of Compost Samples

Compost samples were analyzed for moisture, organic matter, organic carbon, ash, total nitrogen contents, and bulk density. The finished compost samples were also analyzed for their stability. The analyses were carried out according to the protocols described in the Test Methods for the Examination of Composting and Compost.

Analysis of Condensate Traps

The contents of condensate traps were analyzed with a total organic carbon (TOC) analyzer. The results were converted to parts per million by volume (ppmv) and added to the non-methane non-ethane organic compound (NMNEOC) measurements for the respective canisters.

Analysis of Sample Canisters

The emission samples collected in evacuated canisters were analyzed according to the SCAQMD Method 25.3. Method 25.3 provides both NMNEOC and methane content for samples through a custom manufactured gas chromatograph. Method 25.3 first oxidizes the contents to carbon dioxide and subsequently reduces them to methane for detection by a flame ionization detector. Figure 5 is a schematic of the gas chromatograph.

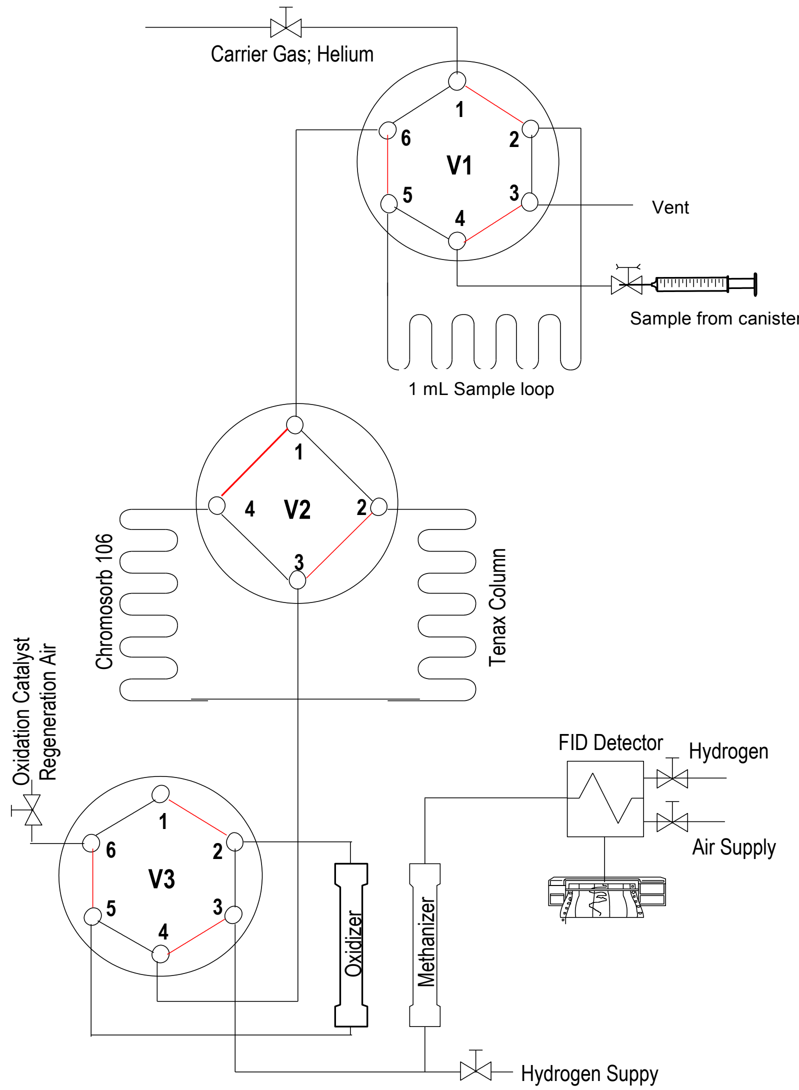


Figure 5. Schematic of Gas Chromatograph for SCAQMD Method 25.3

Results and Discussion

Table 7 provides the characteristics of the initial feedstock blends, the final products, and the screened and unscreened finished compost used for the pseudo-biofilter compost blanket application. For the pseudo-biofilter windrow, application of the compost blanket caused the bulk density to increase noticeably in the final product (29.8% compared to the greenwaste windrow); nevertheless, no adverse effects were observed as a result of the bulk density increase.

Table 7. Selected Properties of the Initial and Final Materials

Windrow/Product	Moisture (%)	Organic Matter (%)	Carbon (%)	Nitrogen (%)	C:N	Wet Bulk Density (kg/m^3)
Initial Feedstock Blends						
Food waste	48.7	54.9	29.6	1.78	16.6	401.5
Greenwaste	46.3	56.2	30.3	1.74	17.4	360.0
Additive	46.2	56.8	30.7	1.51	20.3	395.6
Biofilter	61.6	60.5	32.7	1.55	21.1	431.8
Final Products						
Food waste	28.1	45.1	24.4	2.29	10.6	485.6
Greenwaste	36.2	34.5	18.6	1.63	11.4	502.5
Additive	34.9	33.9	18.3	1.41	13.0	468.1
Biofilter	32.6	43.7	23.6	1.72	13.7	652.5
Unscreened	26.7	27.5	14.9	1.40	10.6	705.2
Screened	25.5	26.5	14.3	1.49	9.6	878.7

Product Stability

In addition to the characteristics presented above, the stability of the final products was analyzed to determine if the BMPs affected the quality of the final product. Compost stability was analyzed using test method TMECC 05.08B, (Test Methods for the Examination of Composting and Compost), which is based on carbon dioxide evolution over time. Stable materials have a low, stable carbon dioxide release as a large portion of the biodegradable carbon has already been consumed. The results of the stability test are presented in Figure 6 and Table 8.

Used as a benchmark or control, the stability results of the greenwaste windrow were 1.91 mg CO_2-C/g TS. In all cases, the results for the other windrows indicate that the stability of the finished compost was similar to the greenwaste windrow. In fact, the food waste windrow resulted in a more stable product (1.31 mg CO_2-C/g TS) than the greenwaste windrow, while the pseudo-biofilter windrow was the most stable (0.95 mg CO_2-C/g TS). The stability results for the additive windrow were essentially the same as for the greenwaste windrow. The stability results of the screened and unscreened finished compost are shown for reference purposes (0.64 mg CO_2-C/g TS and 0.57 mg CO_2-C/g TS respectively). Since finished compost was used as a cap on the pseudo-biofilter windrow which was then incorporated into the windrow upon turning, it is not surprising that the pseudo-biofilter windrow shows the most stable compost of the four test windrows. It is also likely that the incorporation of finished compost into the pseudo-biofilter windrow provided a diverse microbial community at the beginning of the composting process resulting in more stable compost in the final product.

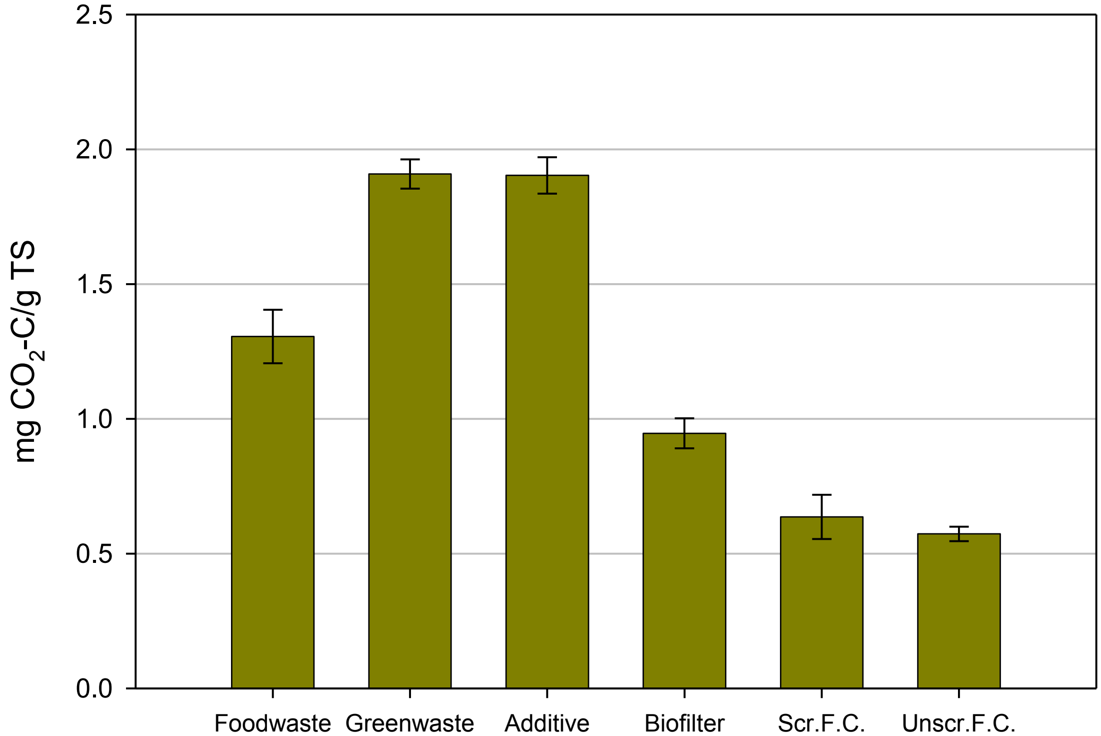


Figure 6. Stability of Finished Composts

Table 8. Stability of Finished Composts

Windrow	Stability Measure (mg CO^2-C/g TS)	Standard Deviation
Food waste	1.31	0.10
Greenwaste	1.91	0.05
Additive	1.90	0.07
Biofilter	0.94	0.06
Screened	0.64	0.08
Unscreened	0.57	0.03

Sample Screening Data – Venting versus Non-venting Locations

Sampling locations were determined based on the pre-screening of the windrow ridgetops for venting and non-venting locations (i.e., high and low readings) with a handheld toxic vapor analyzer (TVA) employing flame ionization detection (FID) technology. The results of TVA readings and other pertinent data including chamber and windrow temperatures are presented in Table 9.

Table 9. Data Pertaining to Sampling

Time	Source	Sample ID	FID ppmv	Surf. Temp.°F	Cham. Temp. °F
		Day 1			
9:42	15% Food Waste- Ridge High	D1-FW-R1-001	280	94	96
9:46	15% Food Waste- Middle	D1-FW-M-002	170	145	93
10:11	15% Food Waste- Bottom	D1-FW-B-003	56	127	102
10:15	Biofilter- Ridge High	D1-BF-R1-004	460	75	95
15:52	Biofilter- Ridge Low	D1-BF-R2-014	13		
11:31	Biofilter- Middle	D1-BF-M-005	64	93	93
11:43	Biofilter- Bottom	D1-BF-B-006	9.3	88	89
12:07	Greenwaste- Ridge High	D1-GW-R1-007	230	119	116
12:07	Greenwaste- Ridge Low	D1-GW-R2-008	240	116	110
13:25	Greenwaste- Middle	D1-GW-M-009	58	102	97
13:35	Greenwaste- Bottom	D1-GW-B-010	65	98	94
15:07	Additive Windrow- Ridge High	D1-ADD-R1-011	100	115	100
15:12	Additive Windrow- Middle	D1-ADD-M-012	260	112	106
15:39	Additive Windrow- Bottom	D1-ADD-B-013	26	129	115
13:29	QC Media Blank Sample	D1-MB-Q-015	NA	NA	NA
		Day 2			
16:57	Greenwaste- Ridge High	D2-GW-R1-016	140	138	109
16:58	Greenwaste- Ridge Low	D2-GW-R2-017	190	139	120
		Day 3			
9:05	15% Food Waste- Ridge High	D3-FW-R1-018	840	101	77
9:07	15% Food Waste- Middle	D3-FW-M-019	58	78	79
9:10	15% Food Waste- Bottom	D3-FW-B-020	14	113	75
9:11	Biofilter- Ridge High	D3-BF-R1-021	350	132	87
11:25	Biofilter- Middle	D3-BF-M-022	6.4	110	100
11:22	Biofilter- Bottom	D3-BF-B-023	4	106	93
12:27	Greenwaste- Ridge High	D3-GW-R1-028	270	123	110
11:52	Greenwaste- Ridge Low	D3-GW-R2-025	270	122	119
13:13	Greenwaste- Middle	D3-GW-M-026	3.7	113	101
13:12	Greenwaste- Bottom	D3-GW-B-027	13	109	94
13:38	Additive Windrow- Ridge High	D3-ADD-R1-029	51	110	109
15:00	Additive Windrow- Middle	D3-ADD-M-030	62	105	105
14:46	Additive Windrow- Bottom	D3-ADD-B-031	4.9	112	93
13:45	QC Media Blank Sample	D3-MB2-Q-032	NA	NA	NA
		Day 6			
9:30	15% Food Waste- Ridge High	D6-FW-R1-033	1,700	107	102
9:30	15% Food Waste- Ridge Low	D6-FW-R2-034	110	109	97
9:40	15% Food Waste- Middle	D6-FW-M-035	19	72	85
9:39	15% Food Waste- Bottom	D6-FW-B-036	4.7	76	73
11:14	Biofilter- Ridge High	D6-BF-R1-037	490	101	108

Time	Source	Sample ID	FID ppmv	Surf. Temp.°F	Cham. Temp. °F
11:18	Biofilter- Middle	D6-BF-M-038	NA	98	90
11:23	Biofilter- Bottom	D6-BF-B-039	NA	87	85
11:14	Greenwaste- Ridge High	D6-GW-R1-040	210	106	99
13:03	Greenwaste- Middle	D6-GW-M-041	3	99	91
12:58	Greenwaste- Bottom	D6-GW-B-042	5	93	91
12:54	Additive Windrow- Ridge High	D6-ADD-R1-043	44	96	93
14:33	Additive Windrow- Middle	D6-ADD-M-044	56	102	103
14:35	Additive Windrow- Bottom	D6-ADD-B-045	3	100	92
12:41	QC Media Blank Sample	D6-MB3-Q-046	NA	NA	NA
Day 8					
10:06	15% Food Waste- Ridge High	D8-FW-R1-047	250	78	74
9:59	15% Food Waste- Ridge Low	D8-FW-R2-048	41	56	60
10:17	15% Food Waste- Middle	D8-FW-M-049	380	139	101
10:12	15% Food Waste- Bottom	D8-FW-B-050	130	88	91
11:39	Biofilter- Ridge High	D8-BF-R1-001	35	87	77
11:56	Biofilter- Middle	D8-BF-M-002	670	147	120
11:55	Biofilter- Bottom	D8-BF-B-003	88	131	107
11:51	Greenwaste- Ridge High	D8-GW-R1-004	74	127	77
13:41	Greenwaste- Middle	D8-GW-M-005	12	103	100
13:43	Greenwaste- Bottom	D8-GW-B-006	4	96	88
13:50	Additive Windrow- Ridge High	D8-ADD-R1-007	25	94	88
15:28	Additive Windrow- Middle	D8-ADD-M-008	160	134	105
15:29	Additive Windrow- Bottom	D8-ADD-B-009	9	103	97
13:30	QC Media Blank Sample	D8-MB4-Q-010	NA	NA	NA
Day 14					
7:45	15% Food Waste- Ridge High	D14-FW-R1-011	1,500	113	98
8:48	15% Food Waste- Middle	D14-FW-M-012	45	84	81
8:55	15% Food Waste- Bottom	D14-FW-B-013	95	69	67
9:22	Biofilter- Ridge High	D14-BF-R1-014	46	73	70
10:37	Biofilter- Middle	D14-BF-M-015	310	135	104
10:46	Biofilter- Bottom	D14-BF-B-016	16	94	85
10:54	Greenwaste- Ridge High	D14-GW-R1-017	1,000	101	94
10:55	Greenwaste- Ridge Low	D14-GW-R2-018	130	101	82
12:10	Greenwaste- Middle	D14-GW-M-019	NA	87	86
11:22	Greenwaste- Bottom	D14-GW-B-020	NA	87	90
12:45	Additive Windrow- Ridge High	D14-ADD-R1-021	890	117	101
14:18	Additive Windrow- Middle	D14-ADD-M-022	12	134	89
14:10	Additive Windrow- Bottom	D14-ADD-B-023	5	89	83
11:47	QC Media Blank Sample	D14-MB5-Q-024	NA	NA	NA
Day 21					
11:11	15% Food Waste- Ridge High	D21-FW-R1-025	48	66	71
11:07	15% Food Waste- Middle	D21-FW-M-026	350	113	60
12:07	15% Food Waste- Ridge Low	D21-FW-R2-027	14	74	66
13:14	Greenwaste- Ridge High	D21-GW-R1-028	1,300	94	77
13:51	Greenwaste- Ridge Low	D21-GW-R2-029	1,700	91	82
13:20	Greenwaste- Middle	D21-GW-M-030	530	93	82
13:19	Greenwaste- Bottom	D21-GW-B-031	210	78	71
12:30	QC Media Blank Sample	D21-MB7-Q-032	NA	NA	NA
Day 30					
10:35	15% Food Waste- Ridge High	D30-FW-R1-033	2,600	105	92
10:35	15% Food Waste- Ridge Low	D30-FW-R2-034	810	74	68

Time	Source	Sample ID	FID ppmv	Surf. Temp.°F	Cham. Temp. °F
10:37	15% Food Waste- Middle	D30-FW-M-035	59	74	69
10:45	15% Food Waste- Bottom	D30-GW-B-036	5	68	64
12:35	Greenwaste- Ridge Low	D30-GW-R2-038	4,400	99	79
12:35	Greenwaste- Ridge High	D30-GW-R1-037	4,700	110	92
12:36	Greenwaste- Middle	D30-GW-M-039	54	80	68
14:10	Biofilter- Compost Layer	D30-BF-RC-040	4,300	72	69
14:33	Biofilter- No New Compost	D30-BF-RCN-041	4,300	95	79
14:29	QC Media Blank Sample	D30-MB8-Q-042	NA	NA	NA
Day 44					
10:35	15% Food Waste- Ridge High	D44-FW-R1-043	4,400	154	110
10:35	15% Food Waste- Middle	D44-FW-M-045	77	58	64
10:35	15% Food Waste- Ridge Low	D44-FW-R2-044	210	93	74
12:29	Greenwaste- Ridge High	D44-GW-R1-047	1,700	156	109
12:33	Greenwaste- Ridge Low	D44-GW-R2-048	140	68	67
12:21	Greenwaste- Middle	D44-GW-M-049	170	89	80
10:34	Greenwaste- Bottom	D44-GW-B-046	46	76	74
14:22	Biofilter- Compost Layer	D44-BF-RC-050	3,200	87	69
14:22	Biofilter- No New Compost	D44-BF-RCN-051	8,000	158	104
13:43	QC Media Blank Sample	D44-MB9-Q-052	NA	NA	NA
Day 57					
10:59	15% Food Waste- Ridge High	D57-FW-R1-053	1,700	92	84
10:59	15% Food Waste- Ridge Low	D57-FW-R2-054	340	69	66
10:59	15% Food Waste- Middle	D57-FW-M-055	2,000	76	57
13:52	Greenwaste- Ridge High	D57-GW-R1-056	7	102	88
13:54	Greenwaste- Ridge Low	D57-GW-R2-057	640	78	74
13:54	Greenwaste- Bottom	D57-GW-B-058	18	77	73
13:53	Greenwaste- Middle	D57-GW-M-059	2	84	74
14:18	QC Media Blank Sample	D57-MB-10-060	NA	NA	NA

- The windrows were surveyed to establish a ratio of venting versus non-venting. First, a visual inspection was conducted by researchers and field technicians. Based on the visual inspection, the biofilter windrow surface appeared to be venting on roughly 1% of the total surface area of the windrow. The other three test windrows appeared to be venting on roughly 10% of the total surface area of the windrows. The venting versus non-venting sections were clearly visible by the naked eye in the early morning due to the temperature differences between the windrows and the ambient air. Photos of the venting areas of the windrows are presented in Figures 7 through 10.

Figure 7. Food Waste Windrow

Figure 8. Greenwaste Windrow

Figure 9. Additive Windrow

Figure 10. Biofilter Windrow

The analysis of venting versus non-venting locations is critical when determining placement of the isolation flux chamber, and when calculating the emission factors using the laboratory results of the flux chamber samples. Therefore, a systematic measurement approach was used in the field to further evaluate the percent of venting versus non-venting locations.

A section on the ridgetops of the pseudo-biofilter and the food waste windrows was marked off in a six-inch by six-inch grid and surveyed with the TVA. The survey of the food waste windrow was assumed to be representative of the greenwaste windrow and the additive windrow since their venting/non-venting patterns were similar. For this survey, 44 data points were taken for the pseudo-biofilter windrow and 51 data points were taken for the food waste windrow. Figures 11 and 12 show the FID readings from the food waste windrow in 3-D and planar view, respectively. The pseudo-biofilter windrow was surveyed in the same manner (Figures 13 and 14).

During the survey of the pseudo-biofilter windrow, a settling crack in the finished compost cap was observed, located between two sampling points. To determine if the crack resulted in a higher level of emissions, a micro-survey with one-inch intervals was conducted on this segment (Figure 15). The emissions in close vicinity to the crack were observed to be substantially higher, approximately five times higher compared to the rest of the windrow surface. This indicates the importance of proper application of the finished compost cap as a pseudo-biofilter blanket.

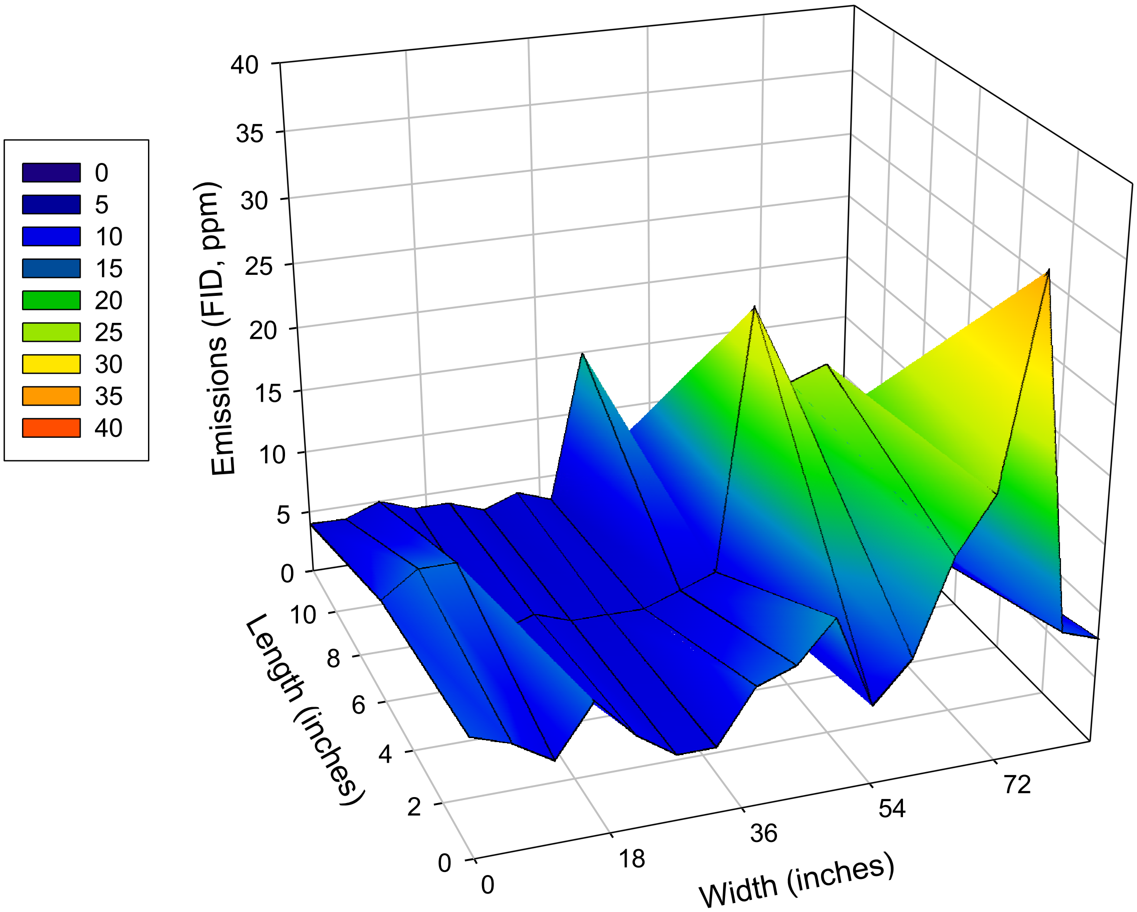


Figure 11. Emission Survey of Food Waste Windrow Ridge (3D Presentation)

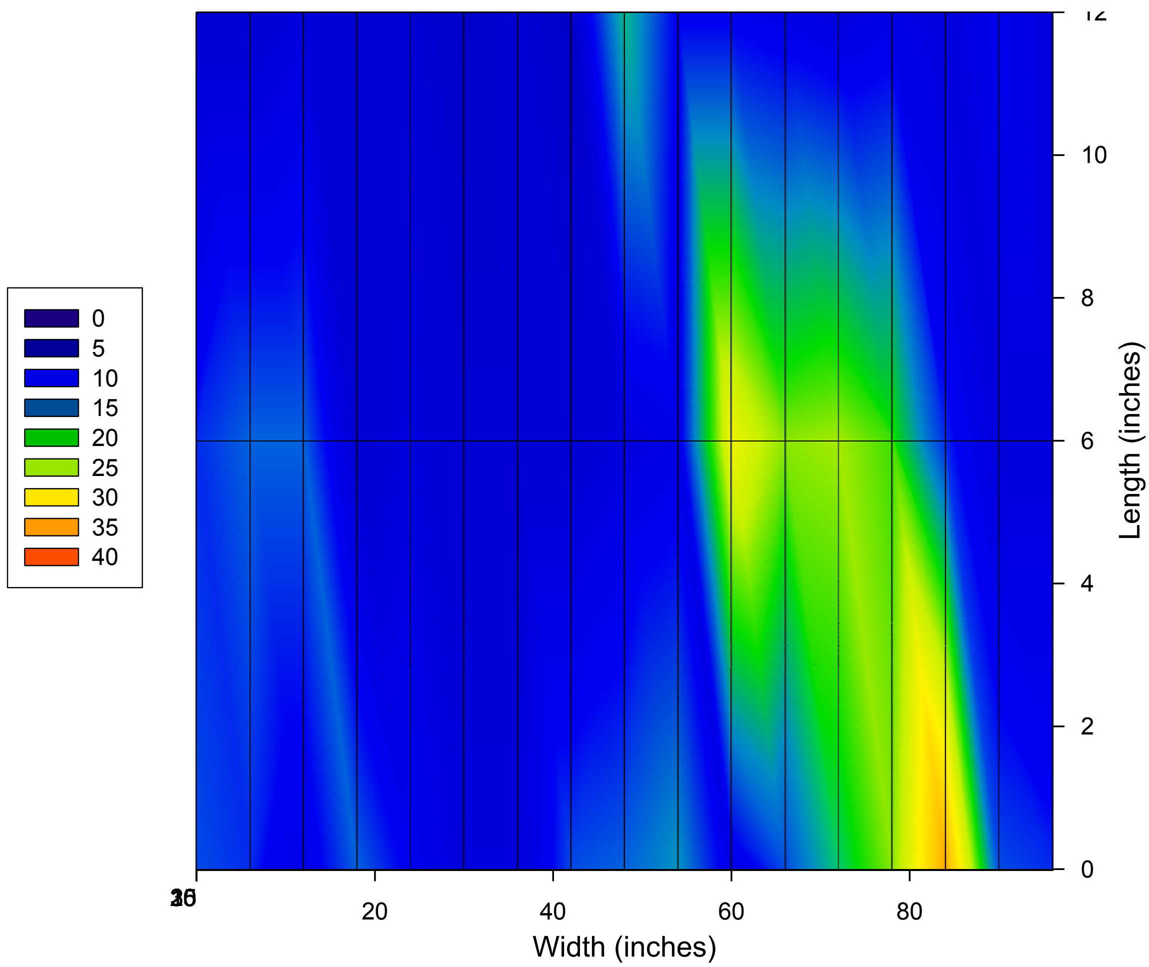


Figure 12. Emission Survey of Food Waste Windrow Ridge (2D Presentation)

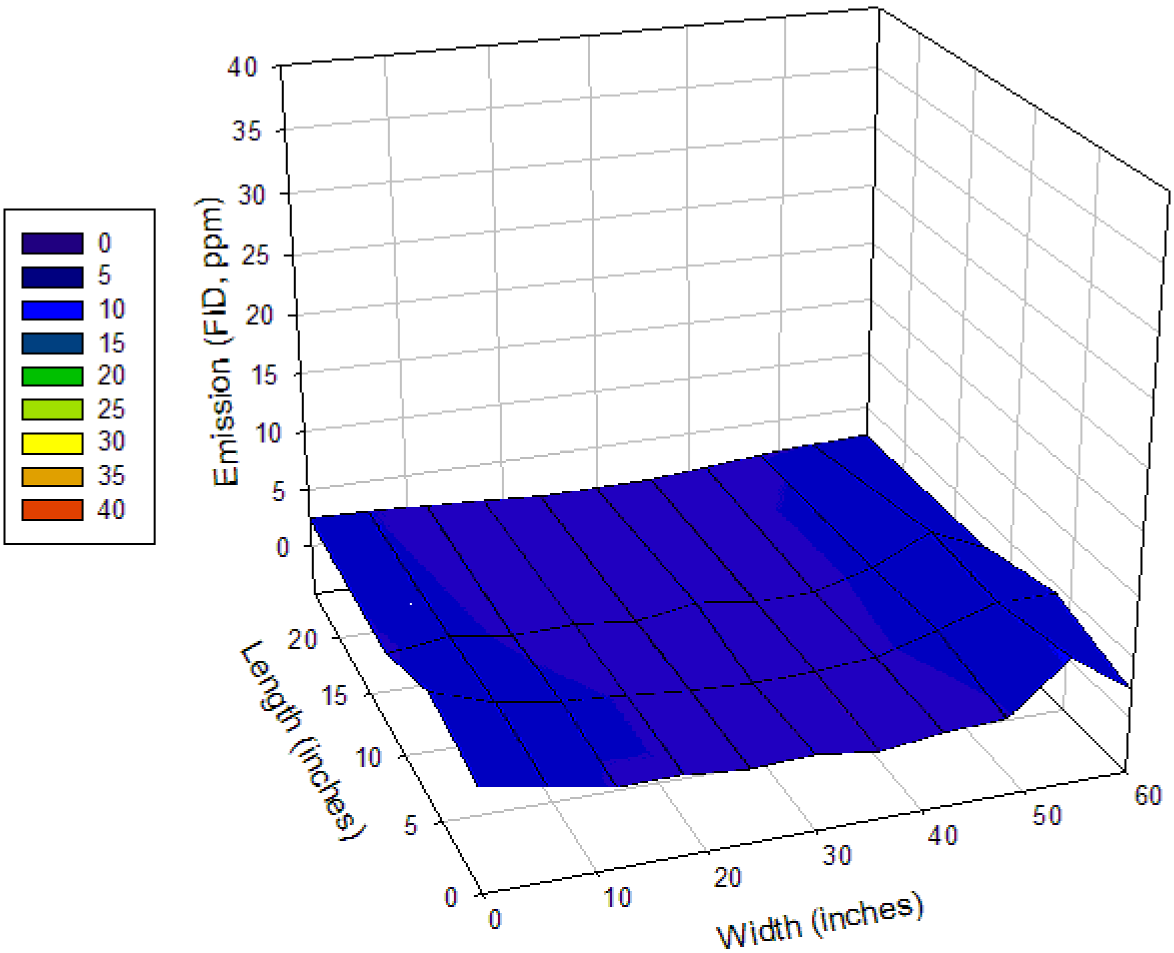


Figure 13. Emission Survey of Biofilter Windrow Ridge (3D Presentation)

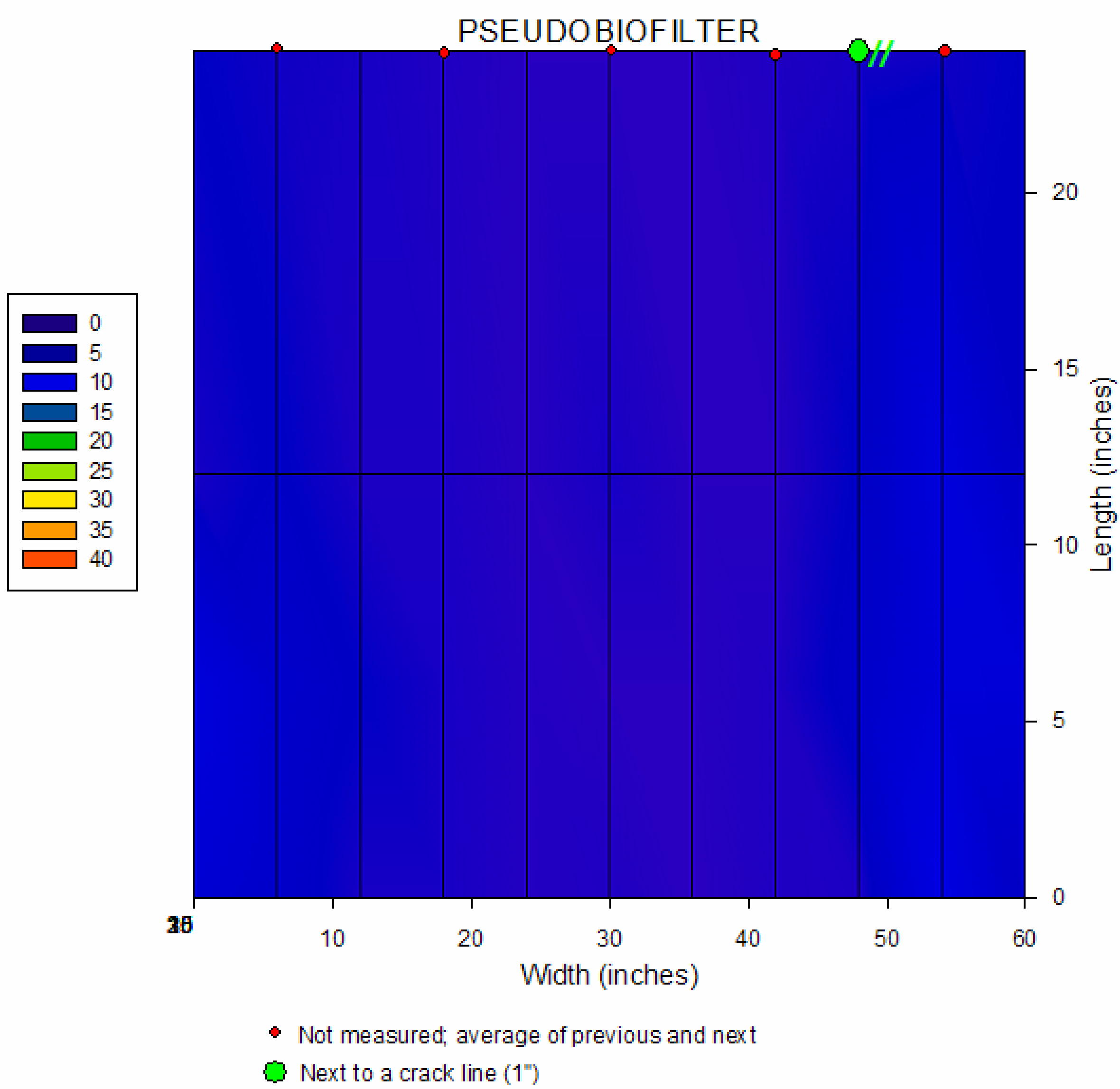


Figure 14. Emission Survey of Food Waste Windrow Ridge (2D Presentation)

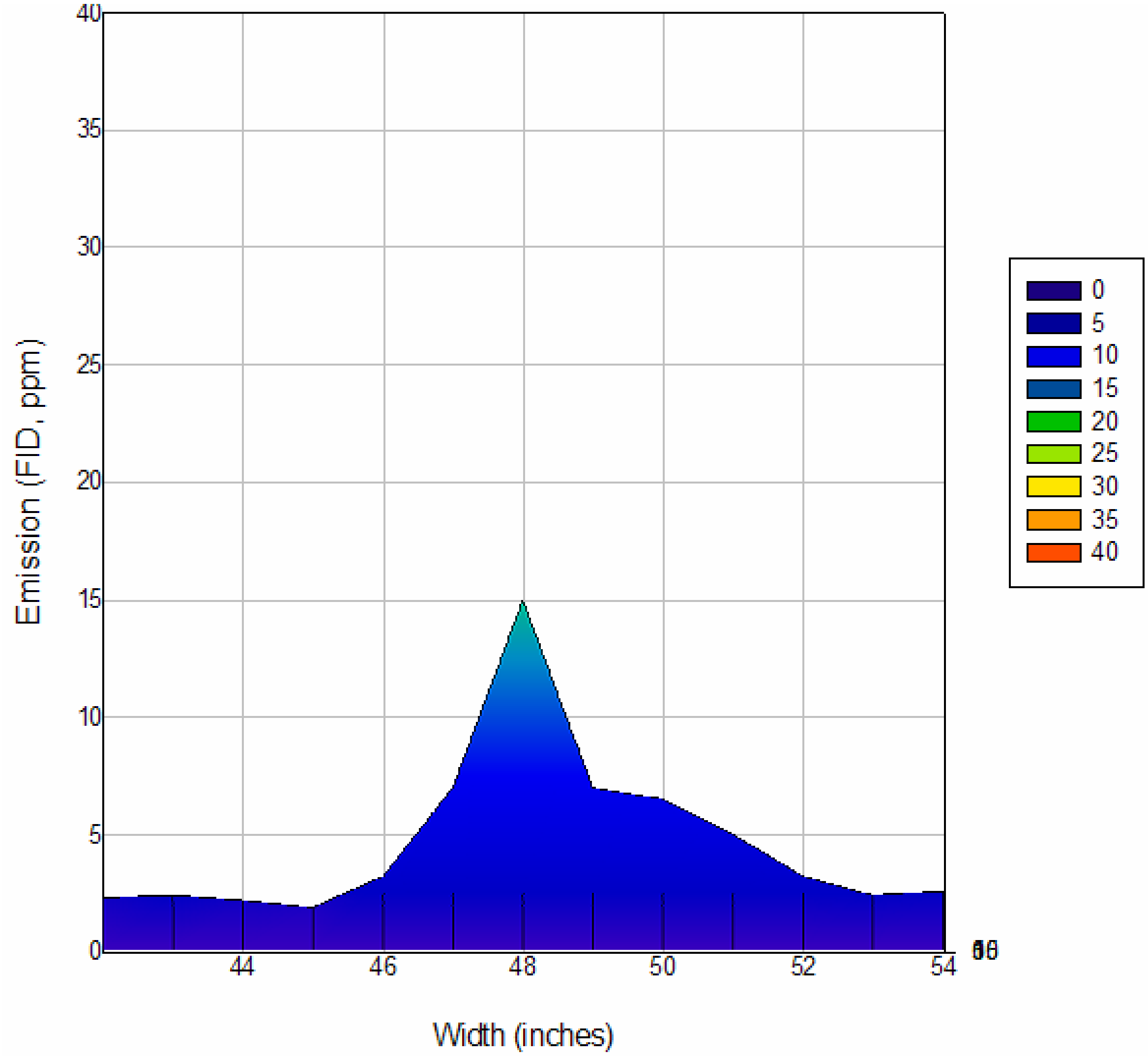


Figure 15. Survey of Biofilter Windrow Ridge at the Vicinity of a Crack-Line

A summary of the visual inspection and the grid survey approach to determine the fraction of the windrow surface areas that were venting versus non-venting is presented in Table 10. Using the statistical mean of the data points from the grid survey for the pseudo-biofilter and food waste windrows, the percent of data points above the mean would indicate the percent of the total locations that are venting, while the percent of data points below the mean would indicate the percent of the total locations that are non-venting. If the entire data set is used in calculations, the resulting analysis indicates that the pseudo-biofilter windrow was venting from 5% of the total surface area and the food waste windrow was venting from 49% of the total surface area. These ratios were 20% and 25% when individual data sets were used for biofilter and food waste windrows, respectively. The emission factors were calculated based on the venting/non-venting ratios determined using the entire data set. Additionally, a sensitivity analysis was performed with all three respective venting/non-venting values to provide a comparison to the readers.

Table 10. Surface Survey Analysis: Venting versus Non-Venting

	Pseudo-biofilter Windrow		Food waste Windrow	
	# of occurrence	% Venting	# of occurrence	% Venting
On-site Visual Inspection		1		10
Average FID, ppmv	2.4		8.7	
Readings ≥ 3.3 ppm	9	20		
Readings ≥ 5 ppm	1	2.56	41	80.4
Readings ≥ 9.1 ppm			13	25
Readings ≥ 10 ppm	0 (1*)	0 (0.2*)	13	25.5
Readings ≥ 20 ppm	0	0	5	9.8
Readings ≥ 30 ppm	0	0	1	2
Number of Readings	44		51	
Mean	3.3		9.1	
Statistical approach: % venting = % above the Mean (Entire data set)		**5**		**49**
Statistical Approach: % venting = % above the Mean (Individual data sets)		**20**		**25**

Source Emission Test Results and Lifecycle Emission Factors

Tables 11 through 14 summarize the results of the source emission testing for VOCs measured as non-methane non-ethane organic compounds (NMNEOC) in terms of the total flux and the emission factors in both unit systems. Note that the sampling protocol called for a total of 14 flux samples per sampling event as follows:

- Three flux samples collected from each composting windrow (ridgetop, middle, and bottom zones)
- One extra ridgetop flux sample from one of the windrows (either greenwaste or food waste windrow)
- One media blank sample.

Therefore, for each sampling event, some of the windrows have two ridgetop flux measurements (venting and non-venting) while the remaining windrows only have one ridgetop flux measurement (venting). Since the analysis of source emission test results relies on evaluating venting and non-venting ridgetop fluxes, it is important to reconcile the data so that it reflects venting and non-venting values for each data set. The shaded cells in Tables 11 through 14 represent the data points where samples were not collected and the data points were estimated by extrapolating from existing data sets. The emission values for the estimated data points were calculated as follows:

- Venting ridgetop samples (R1) were collected in every sampling event; and non-venting ridgetop samples (R2) were collected for some sampling events according to the sampling protocol. In the cases where R2 samples were not collected, an analysis was performed on all of the sampling sets that included both R1 and R2. The average ratio of R1 to R2 was determined to be 3.75. It was used to estimate the missing R2 data points based on the existing R1 data point for that sampling event.

- Since the total number of flux samples was limited per sampling event, in some cases the middle or bottom section samples were not taken on a given windrow in order to take both R1 and R2 ridgetop samples on that windrow. In these cases, to estimate the missing middle or bottom data points, a logical approach similar to that used to estimate the missing R2 data points was used. An analysis was performed on all of the sampling points that included 4 data points per windrow, i.e. 2 ridgetop, 1 middle, and 1 bottom. The overall average relative percentages of the sampling locations was used to estimate the missing middle or bottom data points based on existing data points for that sampling event.

The total VOCs measured as NMNEOC flux values were calculated according to the following equation. The equation is based on the ideal gas law, by assuming that the samples were analyzed under normal conditions, i.e. 1 atmosphere pressure and 25°C.

$$C = \frac{C_{ppmv} \times M}{R \times T}$$

Where:

C = the VOC concentration in g/m^3

C_{ppmv} = the VOC concentration in ppmv

M = molecular weight (16 g/mole for methane)

R = the ideal gas constant (8.21×10^{-5} m^3-atm/mole-°K)

T = temperature (°K)

A carbon monoxide tracer gas was used during the flux chamber emission testing. The tracer accounts for the dilution of the flux of emissions coming from the windrow by the addition of sweep gas and provides a method for calculating sample capture efficiency. The VOC flux values were normalized based on the tracer gas results. The normalized VOC flux values, presented as lb/ft^2hr^{-1}, were calculated from the flux data based on the total flux chamber flow rate determined by the carbon monoxide recovery. The results of the emission fluxes are presented in Tables 11 through 14 for each windrow.

Emission rates were calculated based on three venting and non-venting surface distribution methods:

1. Visual observation
2. The entire data set
3. The individual subsets (Tables 15 through 18).

Daily emission rates for each windrow are calculated by determining the weighted emission rate as follows: multiply the flux for each section by the surface area for each section and then add the results for all sections together. Emission rates are presented in lb VOC/day.

Note: Shaded cells in Tables 11-14 denote that a sample was not collected; data was estimated using methods described above. Details are provided in Appendix A. Emission rates were calculated using the entire data set for venting versus non-venting distribution method.

Table 11. Emission Fluxes and Rates from Food Waste Windrow*

	VOC Flux (mg/m^2-min)				Emission Rates		VOC Flux (lb/1000 ft^2-hr)				Emission Rates	
Day	**Ridge–R1**	**Ridge-R2**	**Middle**	**Bottom**	**mg/min**	**kg/day**	**Ridge-R1**	**Ridge-R2**	**Middle**	**Bottom**	**lb/hr**	**lb/day**
1	42.532	11.342	11.385	7.819	3677.493	5.296	0.5189	0.1384	0.1389	0.0954	0.486	11.664
3	28.569	7.618	11.024	0.827	2393.188	3.446	0.3485	0.0929	0.1345	0.0101	0.316	7.591
6	53.917	31.451	0.828	1.143	3760.135	5.415	0.6578	0.3837	0.0101	0.0139	0.497	11.926
8	196.056	13.211	21.387	5.003	10691.90	15.396	2.3919	0.1612	0.2609	0.0610	1.413	33.913
14	77.009	20.536	0.221	0.212	4136.716	5.957	0.9395	0.2505	0.0027	0.0026	0.547	13.121
21	0.200	0.053	0.280	0.091	37.883	0.055	0.0024	0.0007	0.0034	0.0011	0.005	0.120
30	4.124	0.421	0.141	0.105	208.480	0.300	0.0503	0.0051	0.0017	0.0013	0.028	0.661
44	24.591	0.781	0.093	0.105	1074.528	1.547	0.3000	0.0095	0.0011	0.0013	0.142	3.408
57	2.797	0.736	0.168	0.105	168.750	0.243	0.0341	0.0090	0.0020	0.0013	0.022	0.535

Table 12. Emission Fluxes and Rates from Greenwaste Windrow*

	VOC Flux (mg/m^2-min)				Emission Rates		VOC Flux (lb/1000 ft^2-hr)				Emission Rates	
Day	**Ridge-R1**	**Ridge-R2**	**Middle**	**Bottom**	**mg/min**	**kg/day**	**Ridge -R1**	**Ridge-R2**	**Middle**	**Bottom**	**lb/hr**	**lb/day**
1	20.823	38.012	2.957	40.359	4858.33	6.996	0.254	0.464	0.036	0.492	0.642	15.410
2	32.959	42.568	2.141	20.911	3747.28	5.396	0.402	0.519	0.026	0.255	0.495	11.886
3	37.640	45.443	1.324	1.463	2399.26	3.455	0.459	0.554	0.016	0.018	0.317	7.610
6	27.103	7.227	0.449	0.500	963.831	1.388	0.331	0.088	0.005	0.006	0.127	3.057
8	22.639	6.037	7.183	3.421	1553.36	2.237	0.276	0.074	0.088	0.042	0.205	4.927
14	14.831	3.859	0.424	0.369	545.721	0.786	0.181	0.047	0.005	0.005	0.072	1.731
21	1.549	1.403	0.104	0.283	106.964	0.154	0.019	0.017	0.001	0.003	0.014	0.339
30	1.765	2.367	0.093	0.212	132.153	0.190	0.022	0.029	0.001	0.003	0.017	0.419
44	1.905	0.524	0.304	0.141	97.059	0.140	0.023	0.006	0.004	0.002	0.013	0.308
57	0.425	1.492	0.172	0.172	77.166	0.111	0.005	0.018	0.002	0.002	0.010	0.245

Table 13. Emission Fluxes and Rates from Additive Windrow*

	VOC Flux (mg/m^2-min)				Emission Rates		VOC Flux (lb/1000 ft^2-hr)				Emission Rates	
Day	Ridge-R1	Ridge-R2	Middle	Bottom	mg/min	kg/day	Ridge -R1	Ridge-R2	Middle	Bottom	lb/hr	lb/day
1	49.029	13.074	10.532	1.917	3561.378	5.128	0.598	0.160	0.128	0.023	0.471	11.296
3	12.871	3.432	2.669	0.880	957.132	1.378	0.157	0.042	0.033	0.011	0.126	3.036
6	10.799	2.880	0.589	0.429	648.146	0.933	0.132	0.035	0.007	0.005	0.086	2.056
8	5.088	1.357	22.671	2.232	2236.258	3.220	0.062	0.017	0.277	0.027	0.296	7.093
14	21.771	5.806	4.788	0.255	1543.007	2.222	0.266	0.071	0.058	0.003	0.204	4.894

Table 14. Emission Fluxes and Rates from Biofilter Windrow*

	VOC Flux (mg/m^2-min)				Emission Rates		VOC Flux (lb/1000 ft^2-hr)				Emission Rates	
Day	Ridge-R1	Ridge-R2	Middle	Bottom	mg/min	kg/day	Ridge-R1	Ridge-R2	Middle	Bottom	lb/hr	lb/day
1	92.687	0.872	0.320	0.348	382.392	0.551	1.131	0.011	0.004	0.004	0.051	1.213
3	112.020	1.120	0.219	0.229	440.660	0.635	1.367	0.014	0.003	0.003	0.058	1.398
6	193.709	1.937	0.249	0.095	731.610	1.054	2.363	0.024	0.003	0.001	0.097	2.321
8	3.972	0.040	0.628	8.968	696.164	0.996	0.048	0.000	0.077	0.109	0.091	2.194
14	0.524	0.005	1.724	0.643	168.942	0.243	0.006	0.000	0.021	0.008	0.022	0.536

Table 15. Food waste Windrow Emission Rates (lb VOC/day)

	Venting versus Non-venting Methodology			
Day	Visual	Individual Data	Total Data Set	Average
1	8.433	9.704	11.664	9.934
3	5.418	6.273	7.591	6.427
6	9.621	10.537	11.926	10.695
8	14.747	22.202	33.913	23.621
14	7.218	9.521	13.121	9.953
21	0.105	0.111	0.120	0.112
30	0.273	0.424	0.661	0.453
44	0.906	1.877	3.408	2.064
57	0.320	0.404	0.535	0.420

Table 16. Greenwaste Windrow Emission Rates (lb VOC/day)

	Venting versus Non-venting Methodology			
Day	Visual	Individual Data	Total Data Set	Average
1	16.632	16.200	15.410	16.081
2	12.590	12.348	11.886	12.275
3	8.169	7.973	7.610	7.917
6	1.777	2.277	3.057	2.370
8	3.873	4.290	4.927	4.363
14	1.024	1.300	1.731	1.352
21	0.332	0.336	0.339	0.336
30	0.461	0.446	0.419	0.442
44	0.219	0.254	0.308	0.260
57	0.316	0.289	0.245	0.283

Table 17. Additive Windrow Emission Rates (lb VOC/day)

	Venting versus Non-venting Methodology			
Day	Visual	Individual Data	Total Data Set	Average
1	7.610	9.055	11.296	9.320
3	2.069	2.448	3.036	2.518
6	1.241	1.560	2.056	1.619
8	6.748	6.898	7.093	6.913
14	3.257	3.898	4.894	4.016

Table 18. Biofilter Windrow Emission Rates (lb VOC/day)

	Venting versus Non-venting Methodology			
Day	Visual	Individual Data	Total Data Set	Average
1	0.501	3.919	1.213	1.878
3	0.538	4.665	1.398	2.200
6	0.833	7.970	2.321	3.708
8	2.177	2.324	2.194	2.232
14	0.535	0.555	0.536	0.542

As an example, a plot of the emission rates over time for the food waste windrow is shown in Figure 16. This plot shows a lifecycle emission curve that represents the amount of VOC released over the composting cycle. By calculating the area under the emission line, the total pounds of VOC or the total VOCs for the composting cycle were determined for each treatment. Table 19 shows estimated Emission Factors (EF's) expressed in lb VOC/ton wet material based on all three venting and non-venting assumptions for each test windrow. The starting feedstock tonnage is as follows: FW 133 tons, GW 103 tons, BF 120 tons, and A 116 tons.

Previous source emission studies presented total emissions on a wet weight basis. Therefore, in order to make the results comparable to previous studies, the total emission factors are also calculated based on wet weight. The total VOC emission value determined for greenwaste composting in this study is lower than the range of previously reported values. The SCAQMD reported total VOC values of 3.4 lb/wet-ton for active greenwaste composting in a status report presented to their Board on April 5, 2002, Agenda No. 34. This study reports approximately .6-.7 lb per wet ton for the active greenwaste composting phase.

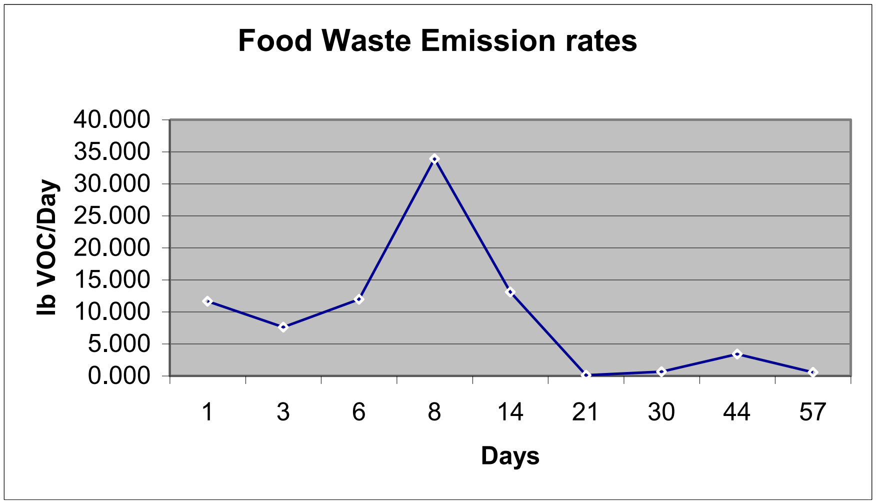


Figure 16. Emissions Rates (Food Waste)

Table 19. Total* NMNEOC Emission Factors (lb VOC/ton compost)

Windrow	Visual	Individual Data Sets	Total Data Set	Average
Food waste	1.312	1.812	2.596	1.907
Greenwaste	0.826	0.863	0.916	0.868
Additive	0.487	0.542	0.627	0.552
Biofilter	0.121	0.404	0.179	0.235

*For food waste and greenwaste 57 days; for additive and biofilter 14 days.

About 70% of the emissions from food waste and 80% from the greenwaste were generated in the first two weeks. These results are summarized in Table 20. Similar patterns for emissions of ammonia, methane, NMNEOC and other VOCs have been observed in prior studies (Chou and Buyuksonmez, 2006; Buyuksonmez and Evans, 2007). These results reiterate the importance of process controls during the first two weeks of the composting process since most VOC emissions are generated in this period.

Table 20. Percent of Total Emissions Occurring During the First 14 Days of Composting

Windrow	(% of Total VOCs)
Food waste	70
Greenwaste	80
Average	75

Sensitivity Analysis on Emission Factors Based on Venting Versus Non-venting Assumptions

The placement of the isolation flux chamber is critical in conducting representative sampling of the diverse nature of composting windrows, especially in characterizing the emissions from the windrow ridge tops. Therefore, a sensitivity analysis was completed to determine the effect that venting versus non-venting assumptions had on the final emission factors. Table 19 shows the final emission factors based on three different assumptions for the venting versus non-venting evaluation:

1. Visual observations of venting versus non-venting (Figures 7 through 10), assume 1% venting for pseudo-biofilter and 10% venting for other windrows.
2. Separation of venting versus non-venting data points based on the statistical mean for individual windrows assumes 20% for pseudo-filter and 25% venting for other windrows.
3. Separation of venting versus non-venting data points based on the statistical mean for the overall grid survey data points assumes 5% venting for pseudo-filter and 49% venting for other windrows.

A recommendation for future tests is to complete a more comprehensive survey of venting versus non-venting surface areas.

Emissions in Relation to Turning Event

Emission tests were conducted on Day 6 and Day 8, before and after the turning event on Day 7, to evaluate the effect of windrow turning on the amount of VOCs emissions. As expected, there was a spike of emissions caused by the turning event. The turning event, on average, doubled the emissions for food waste, greenwaste and additive windrows. The biofilter windrow emitted slightly lower on Day 8 than Day 6 (5% reduction). This was expected since a new layer of biofilter was applied immediately following the turning event.

In the future, additional samples in a tighter time sequence following a turning event would provide a more accurate estimate of the impacts of turning on overall lifecycle emissions. A BMP that might be considered to minimize turning event emission spikes would be to refrain from turning the windrows during the initial two weeks of composting, or the active phase, until the emissions profile has declined. This alternative might be feasible as long as the temperature profiles in the windrow can be maintained, the windrow has adequate oxygen for effective aerobic composting, and the pathogen reduction (PFRP) requirements for time, temperature, and turnings can still be met after the first two weeks of composting.

Emissions from Food waste

The results show that the emissions were higher from the windrow containing greenwaste mixed with food waste than from any other windrow. The total emission from the greenwaste mixed with food waste was 1.3 to 2.6 lb per wet ton of blend, compared to 0.8 to 0.9 lb/wet ton for greenwaste alone. Thus, the inclusion of food waste resulted in two-to-three times higher emissions. Since the food waste contains a larger fraction of easily biodegradable and volatile materials, a higher emission value is expected.

Effectiveness of Alternative BMPs

One BMP evaluated the performance of two chemical additives where one additive was incorporated into the windrow when it was constructed and another additive was sprayed on the surface of the windrow. The other BMP evaluated the performance of capping the outer surface of the windrow with finished compost to provide a pseudo-biofilter.

Chemical Additives

GOC Technologies provided the additives used for this BMP.

- One additive is called 2600. It is a bioaugmentation treatment intended to serve as an inoculant by providing a nutrient package that increased facultative microbes. The additive was incorporated into the windrow during construction by spraying it on and then turning the windrow.
- The other additive is called 2500. It is a topical agent; it served as a chemical biofilter that interacted with gases coming off the windrow.

The performance of the windrow with chemical additives indicates a 42% reduction in VOCs when compared to emissions from the greenwaste windrow during the first week. However, after the first turning event, which occurred on Day 7, the effectiveness of the chemical additives diminished.

For the first two week period the additive windrow generated 14% less VOC's compared to emissions from the greenwaste windrow. The percent reduction values during the first and second week are presented in Table 21. After the turning event, the emissions spiked upward on Day 8 and then declined closer to pre-turn levels.

The effectiveness of the additives appeared to diminish over time. Although additive 2500 (topical additive) was reapplied after turning, additive 2600 was not re-applied. Future consideration should be given to re-applying both additives following turning events.

Pseudo-Biofilter

Capping the outer surface of the windrow with finished compost that served as a pseudo-biofilter proved to be very effective in reducing VOC emissions throughout the lifecycle of the composting process compared to the other three test windrows.

Approximately 19 tons of screened finished compost were applied after construction of the initial windrow. The finished compost was applied using a front loader to deposit the compost on the ridgetop of the windrow. The finished compost was then gently tapped with the bottom of the bucket and allowed to drape down the side surfaces of the windrow. (Figure 17).

Figure 17. Application of Pseudo-Biofilter Using Front-loader

During a turning event, the finished compost cap was turned along with the other windrow materials and incorporated into the blend. This process served to inoculate the windrow with beneficial microbes present in the finished compost. Following turning, an unscreened finished compost cap was applied to the windrow. Unscreened finished compost is less dense than screened compost, and might make an effective pseudo-biofilter without the added expense of screening.

As mentioned, the initial application of the pseudo-biofilter compost cap used roughly 19 tons of screened finished compost while subsequent applications following turning events used roughly 11 tons of unscreened finished compost.

For the first two week period the pseudo-biofilter windrow generated 75% less VOCs compared to emissions from the greenwaste windrow. The percent reduction values are presented in Table 21.

Table 21. VOC Emission Reductions of BMPs Relative to Greenwaste

Period	Additive	Pseudo-Biofilter
7 days (Week 1)	42%	82%
14 days (First 2 weeks)	14%	75%

Depending on facility operations and financial parameters, application of a pseudo-biofilter layer may be a financially feasible alternative compared to other more costly emission reduction technologies such as enclosure, aerated static piles, and standard biofilters.

Cost Estimate Data and Assumptions

Cost Estimate Data and Assumptions

Chemical Additives

The application cost of additives is estimated to be $170.00 per 100-ft windrow. Note that product 2600 is applied only at pile formation and mixed with the windrow by turning over. The second additive is then applied topically after each turning event. The cost estimate is based on the following assumptions:

- $99.00 material cost of product 2600 for a 100-ft long windrow
- 15 minute application time for product 2600 (labor)
- $90.00/hr windrow turner cost and 15 minutes to turn
- $11.95 material cost for product 2500 for a 100-ft long windrow
- 15 minute application time for product 2500 (labor)
- $60,000 yearly salary for the operator
- 50% overhead rate
- 50 week/yr and 40 hr/week work schedule

Pseudo-biofilter

The use of finished compost as a BMP is a practical application since the finished compost is readily available on site. Furthermore, it is important to note that, while the finished compost is initially recycled back into the process by using it to cap new windrows, it is not consumed in the process. Rather, it cycles back through to finished compost at the end of the compost process.

Therefore, the only cost of using the pseudo-biofilter BMP alternative is the time and fuel spent during the application of the finished compost on new windrows.

The cost figures depend on the compost facility layout and the proximity of the cured compost storage to the newly constructed windrows. At the Modesto Compost Facility, given the proximity of the cured compost to the newly constructed windrows, it took approximately 15 minutes to apply the pseudo-biofilter cap to the 110-foot windrow. The total cost for each application is calculated to be $35.00 per 100-ft windrow. This calculation is based on the following assumptions:

- 15 minutes application time (labor)
- $90.00/hr front loader operation cost
- $60,000 yearly salary for the operator
- 50% overhead rate
- 50 week/yr and 40 hr/week work schedule

Note that the finished compost was in very close proximity to the test windrow. The total distance traveled was less than one mile. If the finished compost pile is considerably farther from the windrows, the fuel cost of the front loader might be a significant cost. In this case, the fuel cost should be considered and added to the front loader operating cost.

An additional benefit from both the chemical additives and the pseudo-biofilter BMPs was not quantified. This is the potential positive impact of pile inoculation by these BMPs which may slightly decrease the overall life cycle for composting by early activation of the compost process.

Table 22. Cost Analysis for BMP Treatments

BMP Treatment	Cost per 100 ft Windrow	Cost per Ton	Facility Yearly Cost*
Additive	$170	$1.50	$300,000
Pseudo Biofilter	$35	$0.60	$120,000

* Facility processing 200,000 tons of greenwaste a year

Temperature Profiles on Sunny versus Shady Sides of Windrows

On October 19th, the longitudinal temperature profiles of the windrows were determined on both sides of the windrows (i.e., the shady and the sunny sides). Figures 18 through 21 provide data for each windrow. Figure 22 provides data for all four windrows. Even though not statistically significant, the results seem to suggest that the sunny sides are warmer, as would be expected. The one exception to this conclusion is the food waste windrow.

Figure 18. Temperature Profile along the Food Waste Windrow

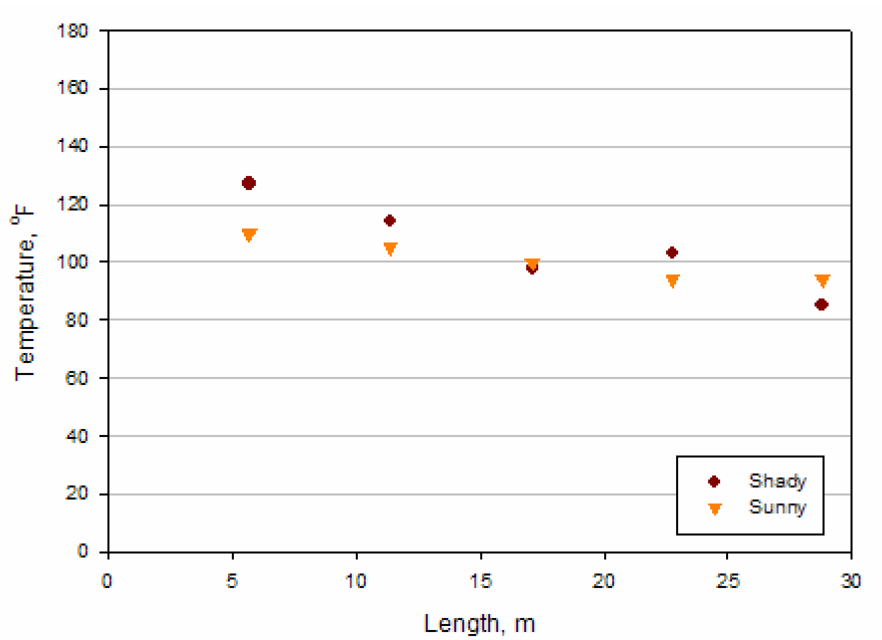


Figure 19. Temperature Profile along the Greenwaste Windrow

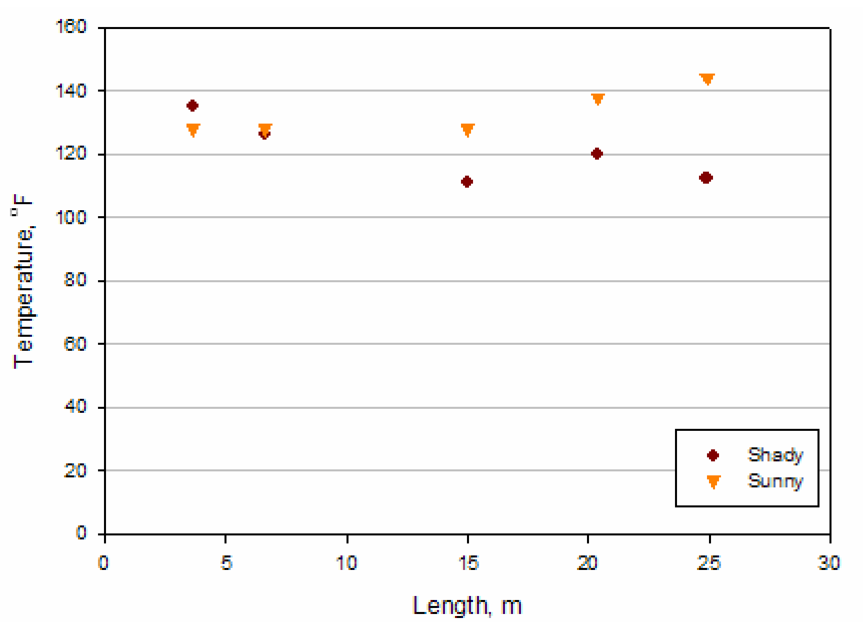


Figure 20. Temperature Profile along the Additive Windrow

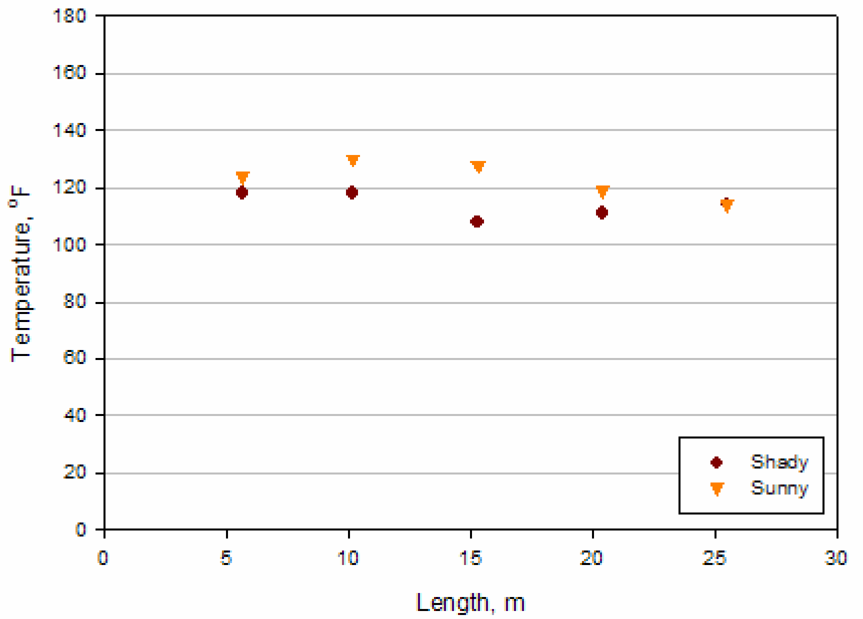


Figure 21. Temperature Profile along the Biofilter Windrow

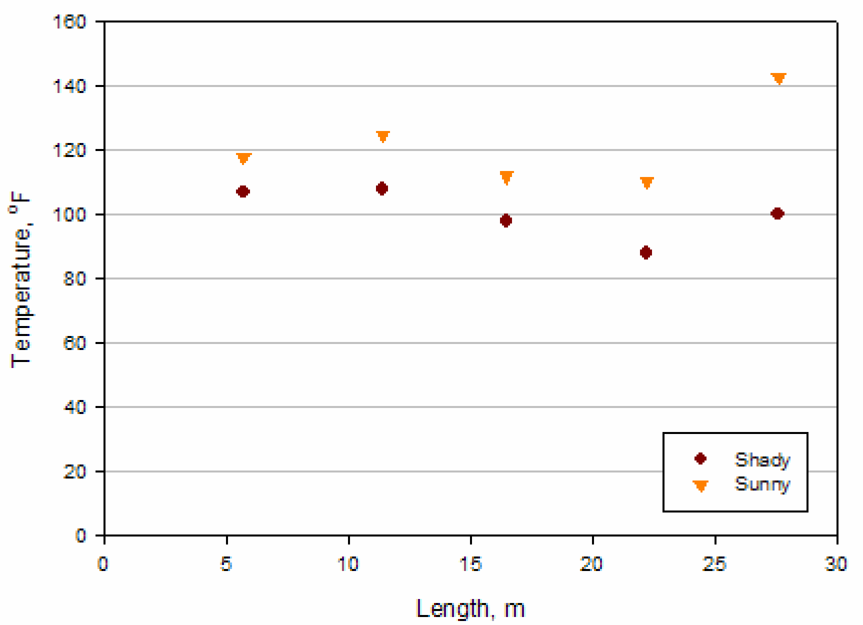
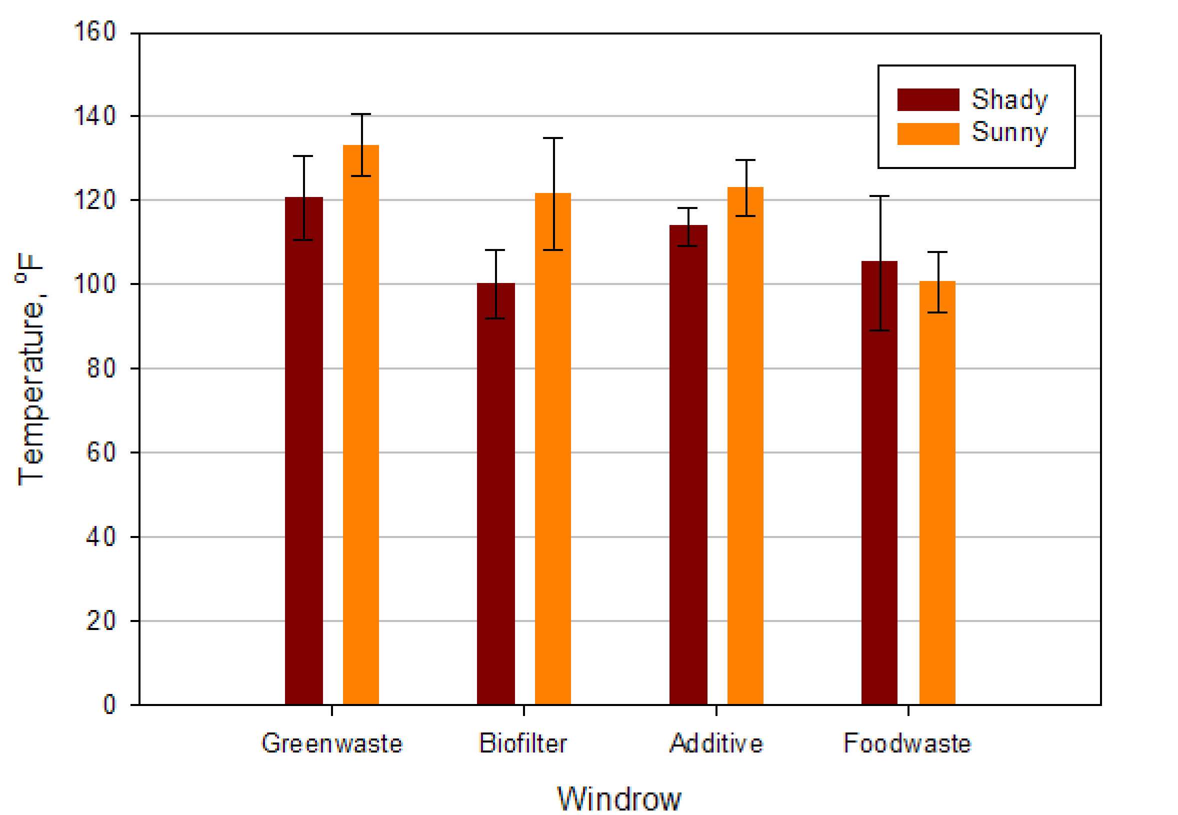


Figure 22. Comparison of Temperature Profiles Along all Windrows



Emissions from Bottom, Middle, and Ridgetop Windrow Zones

An analysis of emissions relative to vertical spatial location in the windrows was completed.

Typical windrow construction facilitates a natural convective flow of air into the windrow from the bottom and sides and out of the windrow through the ridgetop. This "chimney-breathing" pattern of a windrow can be analyzed by vertical spatial placement of the flux chamber when conducting emission testing (see Figure 1). Flux chamber results were used to determine if VOC emissions from a windrow follow the "chimney-breathing" pattern and whether most VOC emissions occur from the ridgetop of windrows.

To evaluate this phenomenon, three vertical sampling points (bottom, middle, and ridgetop) were taken for sample sets from each test windrow. This was intended to characterize the variable emission fluxes from the different zones.

Table 23 shows the ratios of the emissions from the three windrow zones. In general, the food waste, greenwaste, and additive windrows displayed a similar pattern; the ridge versus sides (R1/S) average ratio was 48.74. On the other hand, with an R1/S ration of 486.83, this ratio was about 10 times higher for the biofilter windrow.

Table 23. Analysis of Ridge versus Side Emissions

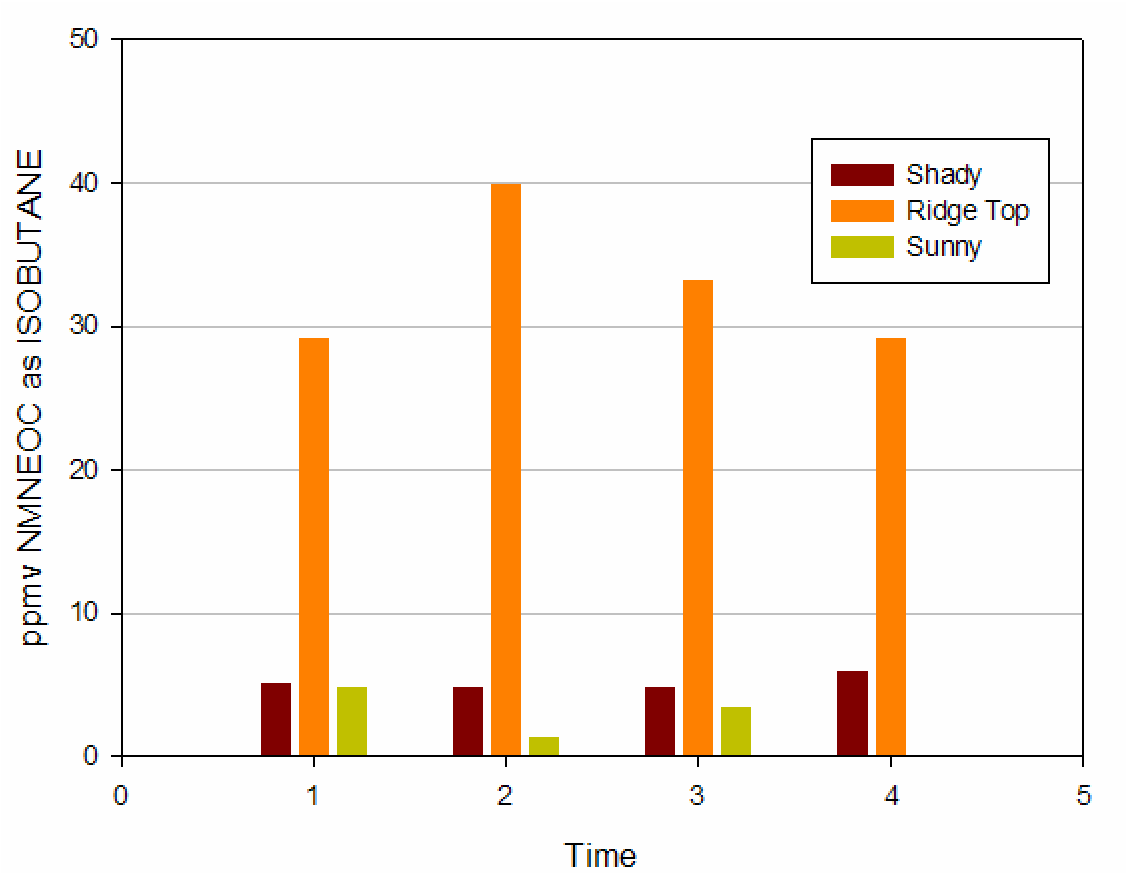
Windrow	R1/M	R1/B	R1/S*
Food waste	82.06	75.85	79.35
Greenwaste	38.67	36.55	37.67
Additive	6.51	30.62	18.57
AVERAGE	48.66	48.82	48.74
Biofilter	394.79	560.46	486.83

*S: Side (includes middle and bottom zones)

Also, the greenwaste windrow was investigated to characterize its emissions from the ridge top versus sides. Three additional isolation flux chambers were randomly placed on the same cross-section: one on the ridge top and one on each side equally spaced from the ridge.

The source emissions were analyzed throughout the day. The results are presented in Figure 23 and clearly demonstrate that the emissions are substantially and statistically different from the ridgetop and the sides.

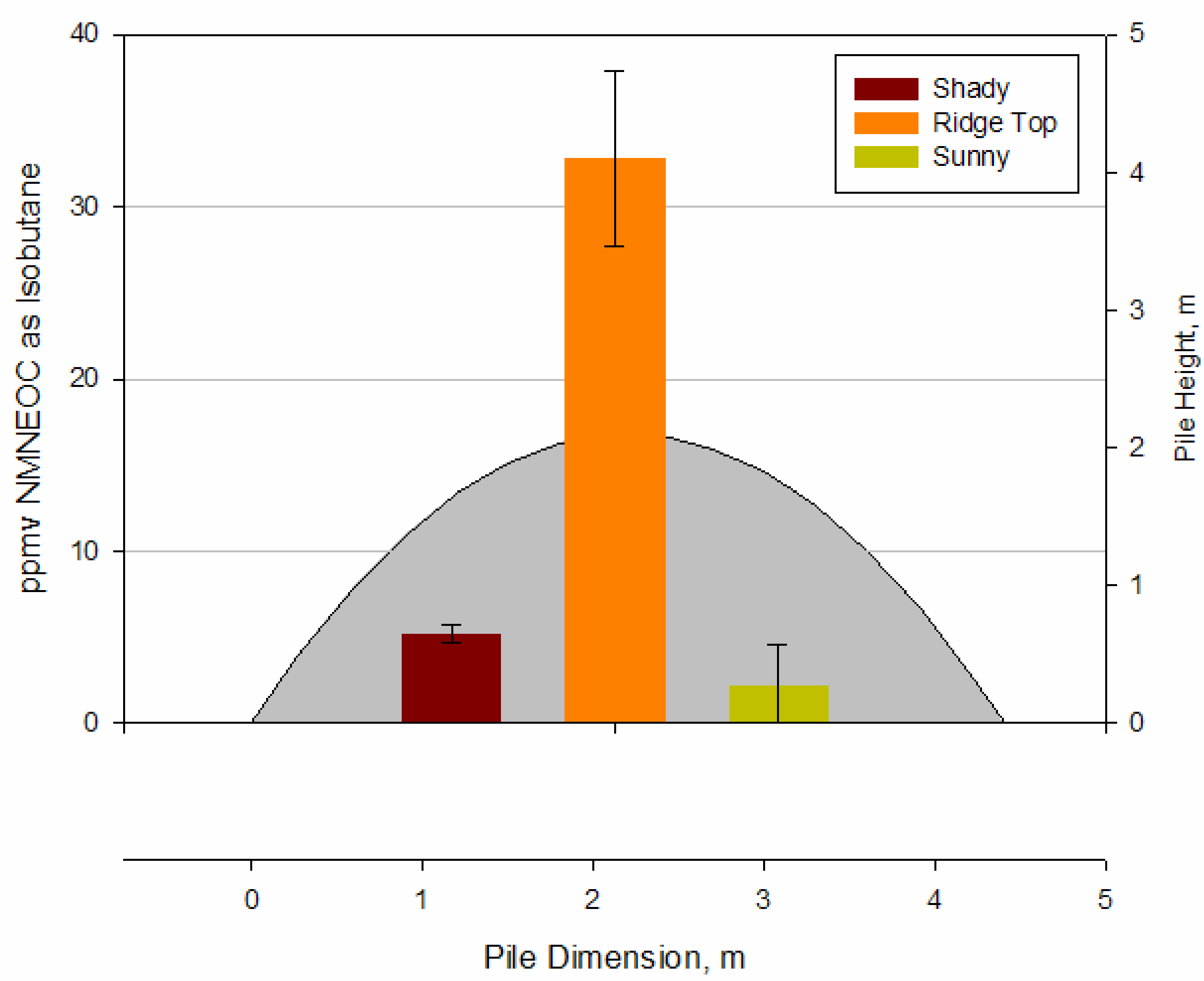
Figure 23. Emission Comparison at a Cross-Section for Greenwaste



There are two possible reasons for this effect. First, there is a larger amount of material under the ridgetop. Second, and perhaps more importantly, the increased ridgetop emissions are due to the chimney effect created by the temperature profile within the cross-section of the windrow.

Another observation from the results is that the sunny side seems to emit less. Perhaps, this can be attributed to an inversion phenomenon occurring at the outer layer of the windrow. Since the windrow surface is warmer than ambient temperature, the intrusion of ambient air into the windrow from the sunny side is hindered and therefore emissions of VOCs out of the windrow may be hindered. This also supports the hypothesis that the emissions are higher from the ridge top due to the temperature profile and subsequent chimney effect.

Figure 24. Emission Comparison at a Cross-Section for Greenwaste



Conclusions and Recommendations

The conclusions of this study are outlined below:

- The life-cycle VOC emissions (measured as NMNEOC) were estimated to be in the range of 1.3 to 2.6 lb/wet-ton for food waste and 0.8 to 0.9 lb/wet-ton for greenwaste during the 57 days of the active composting period.
- The addition of 15% food waste to the greenwaste compost window resulted in roughly two times higher VOC emissions for the life cycle (57 days).
- The total emissions for the two-week testing period of the mitigation alternatives were 0.5 to 0.6 lb/wet-ton for the additive BMP and 0.1 to 0.4 lb/wet ton for the pseudo-biofilter BMP.
- Application of finished compost as a pseudo-biofilter appears to be an effective VOC mitigation alternative. The reduction of emissions was 75% for the first two weeks of the composting period compared to greenwaste emissions.
- Application of additives resulted in a 14% emission reduction for the first two weeks of the composting period compared to greenwaste emissions.
- The majority of VOC emissions (70-85%) occur from the ridge top.
- The majority of VOC emissions (70-80%) occur during the first two weeks.
- Additional ridge top flux samples and a more comprehensive survey to characterize venting versus non-venting areas can improve the accuracy of emission factor estimates.
- The application of finished compost and additives should be studied in conjunction with turning frequency and pathogen-reduction requirements.
- The cost estimates to implement these BMP practices, for a facility processing 200,000 tons of greenwaste a year are $300,000 or $1.50 per ton for the additive BMP and $120,000 or $0.60 per ton for the pseudo-biofilter BMP.

Appendix A: Technical Memorandum

TECHNICAL MEMORANDUM

Reporting of Total Non-Methane Non-Ethane Organic Compound (TNMNEO) Flux from Four Engineered Test Piles Using the USEPA Surface Emission Isolation Flux Chamber Technology, Modesto Compost Facility

Modesto, California

By

Dr. Chuck E. Schmidt

I. INTRODUCTION

This technical memorandum describes the field testing that was conducted in order to assess the TNMNEO compound emissions from engineered test piles of greenwaste materials at the Modesto Compost Facility, Modesto, California. Area source flux data were collected with the intention of using the flux data as input to an engineering assessment of the air emissions from four engineered test piles for the CIWMB. Testing was conducted by Dr. C.E. Schmidt and Mr. Harold Litwiler as subconsultants to Dr. Fatih Buyuksonmez, Principal Investigator with the San Diego State University, San Diego, California. The work was conducted for Ms. Brenda Smyth with the CIWMB. Ms. Smyth developed the testing objectives, planned the field tests, and arranged for the testing at the facility including providing site operational information and identifying representative materials for testing.

The objective of these studies was to provide unit process flux data for TNMNEO compounds representative of air emissions from the composting cycle of four engineered test piles. Surface flux data can be used, along with information about the engineering process of greenwaste operations, to assess the air emissions from these compost test piles.

This memorandum includes a discussion of the testing methodology, quality control procedures, results expressed as flux (mg/m2,min-1 and lb/1,000ft2,hr-1), discussion of the results, and summary statements.

II. TEST METHODOLOGY

Testing for surface flux was conducted using the USEPA recommended Surface Isolation Flux Chamber (USEPA. Radian Corporation, February 1986). Flux chamber sampling was performed on piles of greenwaste materials as found on the site for specific days of testing during the approx. 60 day test cycle.

The operation of the surface flux chamber is given below:

1) Flux chamber, sweep air, sample collection equipment, and field documents were located on-site. The modified chamber design (6” diameter exhaust port for high volume flow) was used on all pile ridge top locations; the standard chamber was used on all side-of-pile test locations.

2) The site information, location information, equipment information, date, and proposed time of testing were documented on the Emissions Measurement Field Data Sheet.

3) The exact test location was selected by screening using a flame ionization detector (FID) and the flux chamber placed about 1” into the compost surface sealing the chamber.

4) The sweep air flow rate (ultra high purity air with a carbon monoxide tracer gas additive) was initiated and the rotometer, which stabilizes the flow rate, was set at 5.0 liters per minute. A constant sweep air flow rate was maintained throughout the measurement for each sampling location.

5) Flux chamber data were recorded every residence interval (6 minutes) for five intervals, or 30 minutes.

6) At steady-state or five residence times, sample collection was performed by interfacing the sample container (impinger/evacuated canister) to the purged, sample line and filling the container with sample gas or collecting the impinger sample.

7) After data collection (temperature data and gas screening data- carbon monoxide and total hydrocarbon compounds) and sample collection (impinger /evacuated canister), all field data were documented on the data sheet.

8) After sampling, the flux measurement was discontinued by shutting off the sweep air, removing the chamber, and securing the equipment. The chamber was cleaned by dry wipe with a clean paper towel and the sample lines were purged with UHP air.

9) Sampling locations were recorded on the field data sheet. The equipment was then relocated to the next test location and steps 1) through 8) were repeated.

III. QUALITY CONTROL

Control procedures were used to assure that data of sufficient quality resulted from the flux chamber study. The application and frequency of these procedures were developed to meet the program data quality objectives as described in the project work plan (Dr. Fatih Buyuksonmez, 2006). Control procedures and QC data collected

Field Documentation – A field notebook containing data forms, including sample chain-of-custody (COC) forms, was maintained for the testing program. Attachment A contains the Emission Measurement Data Sheets.

Chain-of-Custody – COC forms were not used for field data collection. Field data were recorded on the Chain-of-Custody forms provided in Attachment B.

REAL TIME TVA-1000 FID AND PID FIELD QC

TVA-1000 field QC consisted of pre and mid-use instrument blank and single span QC checks. After initial calibration, the instrument performed within specifications and field data are provided below (100 ppmv CH_4 span gas used for the FID instrument, 100 ppmv span gas used for the PID instrument.) The instruments were used to generate field data comparing one location on a test pile to another (relative comparison); these data were not used quantitatively. The daily calibration data are provided in Attachment B along with the Chain of Custody documentation, and these data indicated acceptable instrument performance.

REAL TIME CO ANALYZER FIELD QC

The CO analyzer field QC consisted of pre-use and post-use blank (ambient air) QC check and span QC checks. These data were not used quantitatively, and provided for a back-up data set for CO data generated by Method 25.3. The instrument performed within specifications and field data are provided in Attachment B.

Total Non-Methane and Non-Ethane Organic Compound Analysis by SCAQMD Method 25.3

Method Quality Control – Method quality control included duplicate analysis of all samples, method blank determinations, and method response to four-point calibration curves. All method QC testing was found to be within method specifications, and these data indicate acceptable method performance. All analytical method QC data are provided in the full laboratory reports delivered to Dr. Fatih Buyuksonmez.

Laboratory Duplicate Sample Analysis – All samples were analyzed in duplicate, and these data showed acceptable method precision with all tank data, including carbon monoxide, methane, carbon dioxide, oxygen, ethane, and NMNEO from the tank less that 30% difference from the mean, with the exception of the listed 13 of 110 samples as reported below for the compounds exceeding criteria (30% difference). This amounts to less than 2% of the tank compounds for the sample set exceeding the criteria or acceptable method performance for the tank analyses. The coefficient of variation (COV) for all 110 replicate trap analyses were less than criteria of 10 COV (0% of the trap compounds exceeding criteria) or acceptable method performance of the trap analyses. These data, for both the tank and trap analysis, indicate acceptable method performance, and no corrective action is recommended.

Lab ID	Sample ID	Tank	Tank	Tank	Tank
		CO	CH4	CO2	NMNEO
A173-111	D8-GW-B-006	-39.58	--	--	
A178-061	D14-BF-B-016	--	--	--	37.70
A178-091	D14-GW-M-019	--	--	--	30.70
A178-121	D14-ADD-M-022	40.19	--	--	--
A178-141	D14-MB3-Q-046	--	--	-65.42	--
A178-061	D14-BF-B-016	--	--	--	37.70
A185-011	D21-FW-R1-025	--	--	--	34.99
A191-081	D30-MB8-Q-042	--	--	-45.41	--
A197-011	D44-GW-B-046	--	--	--	-30.33
A197-071	D44-GW-R2-048	--	--	--	-66.82
A209-021	D57-FW-R2-054	31.64	--	--	--
A209-081	D57-MB-10-060	--	--	47.23	--
A169-221	D3-BF-M-022	--	--	--	-42.10

Field System Blank – Nine media (field) blank samples were analyzed as field samples (blind QC samples). Methane was non-detect as was NMNEO compounds in the tank, there were no detections above 2 ppmv for all samples. The values below the method detection limit reported were calculated as flux data and reported in the data tables for completeness. These data indicate acceptable method performance.

Carbon Monoxide Analysis by SCAQMD Method 25.3

Recovery of Trace Gas – Carbon monoxide, at around 100 ppmv, was added to the sweep air used in the measurement of TNMNO flux. A total of nine carbon monoxide recovery tests were performed ranging in response from 47% to 84% (one recovery of nine exceeding criteria) with an average recovery of 67%. Acceptable recovery for the test is ±50%, and these recovery data indicate acceptable method performance. However, a bias correction may be performed using these tracer recovery data. Such a correction should be conducted on a batch basis or on a per test day basis using the method blank recovery data for that test day. Note that these field data have not been corrected using the tracer recovery data.

IV. RESULTS AND DISCUSSIONS

Sample collection information is provided in Table 1. Emission factor data for program are presented in Table 2 per greenwaste material tested in flux units, mg/m2,min-1. These data are also presented in Table 2 in emission factor units as lb/1,000ft2,hr-1. The conversion factor includes conversion from milligrams to pounds, square meters to square feet, and minutes to hour; the correction factor from mg/m2,min-1 to lb/1,000ft2,hr-1 is 0.0122. These data can then be compared to data produced by the SCAQMD. An effort has been made to present results with equivalent data processing considerations so that data comparisons can be made on the same basis. To calculate pile emissions, or facility emissions in mass flow terms (lb/hr), the flux measurements must be multiplied by the corresponding surface area and facility operating factors related to number of piles and age/disposition of the piles. Although this technical memorandum does not extend the flux data to mass flow calculations, it should be noted that the surface roughness factor used by SCAQMD to complete such a calculation would not be advised. Translating flux measurements to mass flow calculations is more dependent on the planar surface area as compared to the interstitial surface area of the compost pile and would not include such a surface roughness factor. Also note that exempt compounds have not been subtracted from the emissions results. In order to calculate emissions of concern to the SCAQMD, exempt VOCs would need to be estimated from other studies (percentage of exempt compounds found in the TNMNEO value) and subtracted from the total measured emissions.

Meteorological data collected from the Modesto wastewater treatment facility on site are reported in Table 3.

Surface flux data for a surface area source are calculated using measured target compound concentrations and flux chamber operating parameter data (sweep air flow rate of 5.0 liters per minute [L/min], surface area of 0.13 square meters [m^2]). The site emissions can be calculated by multiplying the flux by the surface area of the source. The flux is calculated from the sweep air flow rate Q (cubic meters per minute [m^3/min]), the species concentration Yi (micrograms per cubic meter [mg/m^3)], and exposure to the chamber surface area A (square meters [m^2]), as follows:

$$Fi = (Q) (Yi) / (A)$$

Emission rate from a given greenwaste surface can be calculated by multiplying unit flux data per compound by surface area. Emission profiles can be generated by knowing the engineering considerations of the greenwaste compost production and the target compound flux.

A summary of the field sample collection for the biofilter testing is shown in Table 1. All field data for the on site surface flux chamber testing (screening) for ammonia, carbon monoxide (advective flow tracer compound), FID compound response, PID compound response, are presented in Table 1 in concentration units (ppmv). Quality control data are presented in Table 2. These data represent blank values that can be used to estimate flux levels at the method detection limits. Reduced Method 25.3 data and ammonia data are provided in Table 3. These flux data include measured advective flow rate in the flux calculation. Surface flux data are shown in flux units (mg/m2,min-1 as methane, ppmvC). Note that ammonia was not detected by the laboratory to a method detection limit of 0.02 ppmv; method detection limit flux levels were reported for each test location.

Surface flux data for a surface area source are calculated using measured target compound concentrations and flux chamber operating parameter data (sweep air flow rate of 5.0 liters per minute [or 0.005 m3/min] plus advective flow [m3/min], surface area of 0.13 square meters [m^2]). The site emissions can be calculated by multiplying the flux by the surface area of the source. The flux is calculated from the sweep air flow rate Q (cubic meters per minute [m^3/min]), the species concentration Yi (micrograms per cubic meter [mg/m^3)], and exposure to the chamber surface area A (square meters [m^2]), as follows:

$$Fi = (Q)\ (Yi) / (A)$$

Emission rate of from the test pile can be calculated by multiplying unit or average flux data per compound by surface area and reported as a function of area source.

Advective filter flow into the flux chamber per location was measured by using a calibrated carbon monoxide (CO) analyzer in the field, and CO as determined by the laboratory (SCAQMD 25.3). Recovery of known tracer by the SCAQMD Method 25.3 was an average of 67%, indicating that a bias correction is not required given that the average recovery, and most of individual recovery tests, were within method criteria ($\pm$50%). However, the data are reported for each data set (samples corrected per day), and the bias in the CO tracer analysis can be corrected for each days-worth of data if necessary.

A significant consideration of the emissions calculation is the surface areas of the representative test areas, especially the surface area of vented sources on the top of the test piles. The dimensions of the test piles are recorded elsewhere, and the percentage of vented area per type of test pile were estimated based on field observations of steaming vents and on FID screening data collected on grids applied to the pile tops. Screening data used to estimate the surface area of vented pile-top are provided in Attachment A, and a summary of these estimates is provided below. Note that these estimates are both qualitative (visual observation) and semi-quantitative (field FID screening).

TEST PILE	PERCENT OF PILE TOP	PERCENT OF PILE TOP
	VISUAL OBSERVATION	FID SCREENING SURVEY
Biofilter Test Pile	0%	1%-2%
Food Waste Test Pile	10%	10%
Additive Test Pile	10%	10%
Greenwaste (Control) Test Pile	10%	10%

Note that the recommended SCAQMD method bias factor correction of 1.086 was not applied to these data. There is no scientific justification for applying a specific bias correction factor generated from one laboratory to another laboratory, since a given analytical method bias is unique to that laboratory and not intrinsic to the method.

V. SUMMARY

Emission measurements were performed on four test piles for the CIWMB with the intent of collecting data to address specific project goals, including: the emissions that are resultant from co-composting of food waste with greenwaste; the effectiveness of emission mitigation by using a layer of finished compost on greenwaste during the compost cycle; and the effectiveness of a commercial inoculant on emission mitigation during the compost cycle. The following is a summary of activities and results associated with this objective:

- Surface flux measurements of study compounds were measured at four, representative test locations on the four test piles using the USEPA recommended surface flux chamber technology with modification (6" exhaust port for advective flow sources). This technology quantitatively measures flux of study compounds at the test surface.
- Field quality control data indicate acceptable data quality for the field analyzers. Field and laboratory quality control data indicate acceptable data quality for SCAQMD Method SCAQMD Method 25.3. Method blank levels were acceptable showing non-detection at method detection limits for all samples.
- Screening measurements conducted each day on the test piles prior to quantitative testing provided useful information for decision-making regarding representative test location selection. Test areas were screened using a FID instrument and a vent area (high FID detection) and a typical or low non-vent area (low FID) were selected for testing on the top of the test piles.
- The results of the quantitative analysis using the dilution of the tracer gas added to the flux chamber sweep air (CO at about 100 ppmv) indicated advective flows into the chamber from the test piles that was used in the determination of flux for each test location.
- The results of the quantitative analysis of selected study compounds (CO, CH4, tank NMNEO, trap NMNEO, and TNMNEO) are reported for each flux measurement. The TNMNEO flux is reported in mg/m2,min-1 units and lb/1,000ft2,hr-1 units.
- The estimated surface area of the vented source on all of the test piles is 10%, with the exception of the biofilter test pile, which was determined by FID screening to be about 1% to 2% vented source. The vented area estimate is significant in the determination of pile emissions.
- The recommended SCAQMD method bias factor correction of 1.086 was not applied to these data. There is no scientific justification for applying a specific bias correction factor generated from one laboratory to another laboratory, since a given analytical method bias is unique to that laboratory and not intrinsic to the method.
- The flux data can be used to estimate TNMNEO emissions from the test piles by knowing the surface are of the test piles and the area flux.

REFERENCES

US EPA. 1986. "Measurement of Gaseous Emission Rates From Land Surfaces Using an Emission Isolation Flux Chamber, Users Guide." EPA Environmental Monitoring Systems Laboratory, Las Vegas, Nevada, EPA Contract No. 68-02-3889, Work Assignment No. 18, Radian Corporation, February 1986. NTIS # PB 86-223161.

South Coast Air Quality Management District, March 2000. Method 25.3 *Determination of Low Combustion Non-Methane Non-Ethane Organic Compound Emissions From Clean Fuel Combustion Sources,* Monitoring and Engineering Branch, Monitoring and Analysis.

Buyuksonmez, Fatih, May 2006. Test Protocol. *Life-Cycle Emissions Source Test at a San Joaquin Composting Site.* Prepared for the California Integrated Waste Management Board, Organic Division.

ATTACHMENT A

DATE	TIME	SOURCE	SCAQMD 25.3 ID	FID	CO	SURF TEMP	CHAM TEMP	COMMENT
DAY 1				(ppmv)	(ppmv)	Deg F	Deg F	
10/19/2006	942	Food Waste- Ridge High	D1-FW-R1-001	280	42	94	96	Piles constructed by noon on 10/18/06, Day 0
10/19/2006	946	Food Waste- Middle	D1-FW-M-002	170	87	145	93	
10/19/2006	1011	Food Waste- Bottom	D1-FW-B-003	56	140	127	102	
10/19/2006	1015	Mitigation Biofilter- Ridge High	D1-BF-R1-004	460	33	75	95	
10/19/2006	1552	Mitigation Biofilter- Ridge Low	D1-BF-R2-014	13	9			
10/19/2006	1131	Mitigation Biofilter- Middle	D1-BF-M-005	64	120	93	93	
10/19/2006	1143	Mitigation Biofilter- Bottom	D1-BF-B-006	9.3	120	88	89	
10/19/2006	1207	Greenwaste- Ridge High	D1-GW-R1-007	230	150	119	116	
10/19/2006	1207	Greenwaste- Ridge Low	D1-GW-R2-008	240	95	116	110	
10/19/2006	1325	Greenwaste- Middle	D1-GW-M-009	58	110	102	97	
10/19/2006	1335	Greenwaste- Bottom	D1-GW-B-010	65	59	98	94	
10/19/2006	1507	Additive Pile- Ridge High	D1-ADD-R1-011	100	15	115	100	
10/19/2006	1512	Additive Pile- Middle	D1-ADD-M-012	260	200	112	106	
10/19/2006	1539	Additive Pile- Bottom	D1-ADD-B-013	26	64	129	115	
10/19/2006	1329	QC Media Blank Sample	D1-MB-Q-015	NA	NA	NA	NA	
DAY 2								
10/20/2006	1657	Greenwaste- Ridge High	D2-GW-R1-016	140	32	138	109	
10/20/2006	1658	Greenwaste- Ridge Low	D2-GW-R2-017	190	42	139	120	
DAY 3								
10/21/2006	905	Food Waste- Ridge High	D3-FW-R1-018	840	43	101	77	
10/21/2006	907	Food Waste- Middle	D3-FW-M-019	58	72	78	79	
10/21/2006	910	Food Waste- Bottom	D3-FW-B-020	14	84	113	75	
10/21/2006	911	Mitigation Biofilter- Ridge High	D3-BF-R1-021	350	70	132	87	
10/21/2006	1125	Mitigation Biofilter- Middle	D3-BF-M-022	6.4	102	110	100	

DATE	TIME	SOURCE	SCAQMD 25.3 ID	FID	CO	SURF TEMP	CHAM TEMP	COMMENT
10/21/2006	1122	Mitigation Biofilter- Bottom	D3-BF-B-023	4	106	106	93	
10/21/2006	1227	Greenwaste- Ridge High	D3-GW-R1-028	270	49	123	110	D3-GW-R1-024 ran for 10 min, replaced with -028
10/21/2006	1152	Greenwaste- Ridge Low	D3-GW-R2-025	270	43	122	119	
10/21/2006	1313	Greenwaste- Middle	D3-GW-M-026	3.7	53	113	101	
10/21/2006	1312	Greenwaste- Bottom	D3-GW-B-027	13	64	109	94	
10/21/2006	1338	Additive Pile- Ridge High	D3-ADD-R1-029	51	43	110	109	
10/21/2006	1500	Additive Pile- Middle	D3-ADD-M-030	62	76	105	105	
10/21/2006	1446	Additive Pile- Bottom	D3-ADD-B-031	4.9	62	112	93	
10/21/2006	1345	QC Media Blank Sample	D3-MB2-Q-032	NA	NA	NA	NA	
DAY 6								
10/24/2006	930	Food Waste- Ridge High	D6-FW-R1-033	1,700	17	107	102	
10/24/2006	930	Food Waste- Ridge Low	D6-FW-R2-034	110	8	109	97	
10/24/2006	940	Food Waste- Middle	D6-FW-M-035	19	54	72	85	
10/24/2006	939	Food Waste- Bottom	D6-FW-B-036	4.7	72	76	73	
10/24/2006	1114	Mitigation Biofilter- Ridge High	D6-BF-R1-037	490	40	101	108	
10/24/2006	1118	Mitigation Biofilter- Middle	D6-BF-M-038	NA	73	98	90	
10/24/2006	1123	Mitigation Biofilter- Bottom	D6-BF-B-039	NA	77	87	85	
10/24/2006	1114	Greenwaste- Ridge High	D6-GW-R1-040	210	17	106	99	
10/24/2006	1303	Greenwaste- Middle	D6-GW-M-041	3	38	99	91	
10/24/2006	1258	Greenwaste- Bottom	D6-GW-B-042	5	23	93	91	
10/24/2006	1254	Additive Pile- Ridge High	D6-ADD-R1-043	44	18	96	93	
10/24/2006	1433	Additive Pile- Middle	D6-ADD-M-044	56	48	102	103	
10/24/2006	1435	Additive Pile- Bottom	D6-ADD-B-045	3	48	100	92	
10/24/2006	1241	QC Media Blank Sample	D6-MB3-Q-046	NA	NA	NA	NA	
DAY 8								
10/26/2006	1006	Food Waste- Ridge High	D8-FW-R1-047	250	31	78	74	
10/26/2006	959	Food Waste- Ridge Low	D8-FW-R2-048	41	27	56	60	
10/26/2006	1017	Food Waste- Middle	D8-FW-M-049	380	71	139	101	

DATE	TIME	SOURCE	SCAQMD 25.3 ID	FID	CO	SURF TEMP	CHAM TEMP	COMMENT
10/26/2006	1012	Food Waste- Bottom	D8-FW-B-050	130	64	88	91	
10/26/2006	1139	Mitigation Biofilter- Ridge High	D8-BF-R1-001	35	15	87	77	
10/26/2006	1156	Mitigation Biofilter- Middle	D8-BF-M-002	670	150	147	120	
10/26/2006	1155	Mitigation Biofilter- Bottom	D8-BF-B-003	88	37	131	107	
10/26/2006	1151	Greenwaste- Ridge High	D8-GW-R1-004	74	15	127	77	
10/26/2006	1341	Greenwaste- Middle	D8-GW-M-005	12	53	103	100	
10/26/2006	1343	Greenwaste- Bottom	D8-GW-B-006	4	47	96	88	
10/26/2006	1350	Additive Pile- Ridge High	D8-ADD-R1-007	25	24	94	88	
10/26/2006	1528	Additive Pile- Middle	D8-ADD-M-008	160	79	134	105	
10/26/2006	1529	Additive Pile- Bottom	D8-ADD-B-009	9	51	103	97	
10/26/2006	1330	QC Media Blank Sample	D8-MB4-Q-010	NA	NA	NA	NA	
DAY 14								
11/1/2006	745	Food Waste- Ridge High	D14-FW-R1-011	1,500	24	113	98	
11/1/2006	848	Food Waste- Middle	D14-FW-M-012	45	68	84	81	
11/1/2006	855	Food Waste- Bottom	D14-FW-B-013	95	58	69	67	
11/1/2006	922	Mitigation Biofilter- Ridge High	D14-BF-R1-014	46	25	73	70	
11/1/2006	1037	Mitigation Biofilter- Middle	D14-BF-M-015	310	43	135	104	
11/1/2006	1046	Mitigation Biofilter- Bottom	D14-BF-B-016	16	58	94	85	
11/1/2006	1054	Greenwaste- Ridge High	D14-GW-R1-017	1,000	22	101	94	
11/1/2006	1055	Greenwaste- Ridge Low	D14-GW-R2-018	130	18	101	82	
11/1/2006	1210	Greenwaste- Middle	D14-GW-M-019	NA	43	87	86	
11/1/2006	1122	Greenwaste- Bottom	D14-GW-B-020	NA	33	87	90	
11/1/2006	1245	Additive Pile- Ridge High	D14-ADD-R1-021	890	24	117	101	
11/1/2006	1418	Additive Pile- Middle	D14-ADD-M-022	12	52	134	89	
11/1/2006	1410	Additive Pile- Bottom	D14-ADD-B-023	5	41	89	83	
11/1/2006	1147	QC Media Blank Sample	D14-MB5-Q-024	NA	NA	NA	NA	
DAY 21								
11/8/2006	1111	Food Waste- Ridge High	D21-FW-R1-025	48	24	66	71	Piles very wet; watered

DATE	TIME	SOURCE	SCAQMD 25.3 ID	FID	CO	SURF TEMP	CHAM TEMP	COMMENT
								11/7/06. Rainfall.
11/8/2006	1107	Food Waste- Middle	D21-FW-M-026	350	33	113	60	High temps and mega condensation
11/8/2006	1207	Food Waste- Ridge Low	D21-FW-R2-027	14	NA	74	66	
11/8/2006	1314	Greenwaste- Ridge High	D21-GW-R1-028	1,300	15	94	77	
11/8/2006	1351	Greenwaste- Ridge Low	D21-GW-R2-029	1,700	16	91	82	
11/8/2006	1320	Greenwaste- Middle	D21-GW-M-030	530	55	93	82	
11/8/2006	1319	Greenwaste- Bottom	D21-GW-B-031	210	50	78	71	
11/8/2006	1230	QC Media Blank Sample	D21-MB7-Q-032	NA	NA	NA	NA	
DAY 30								
11/17/2006	1035	Food Waste- Ridge High	D30-FW-R1-033	2,600	33	105	92	Wet piles- watered the day prior
11/17/2006	1035	Food Waste- Ridge Low	D30-FW-R2-034	810	22	74	68	
11/17/2006	1037	Food Waste- Middle	D30-FW-M-035	59	54	74	69	
11/17/2006	1045	Food Waste- Bottom	D30-GW-B-036	5	68	68	64	
11/17/2006	1235	Greenwaste- Ridge Low	D30-GW-R2-038	4,400	9	99	79	
11/17/2006	1235	Greenwaste- Ridge High	D30-GW-R1-037	4,700	12	110	92	
11/17/2006	1236	Greenwaste- Middle	D30-GW-M-039	54	40	80	68	
11/17/2006	1410	Mit Biofilter- Compost Layer	D30-BF-RC-040	4,300	8	72	69	
11/17/2006	1433	Mit Biofilter- No New Compost	D30-BF-RCN-041	4,300	8	95	79	
11/17/2006	1429	QC Media Blank Sample	D30-MB8-Q-042	NA	NA	NA	NA	
DAY 44								
12/1/2006	1035	Food Waste- Ridge High	D44-FW-R1-043	4,400	12	154	110	
12/1/2006	1035	Food Waste- Middle	D44-FW-M-045	77	60	58	64	
12/1/2006	1035	Food Waste- Ridge Low	D44-FW-R2-044	210	10	93	74	
12/1/2006	1229	Greenwaste- Ridge High	D44-GW-R1-047	1,700	8	156	109	
12/1/2006	1233	Greenwaste- Ridge Low	D44-GW-R2-048	140	11	68	67	
12/1/2006	1221	Greenwaste- Middle	D44-GW-M-049	170	36	89	80	
12/1/2006	1034	Greenwaste- Bottom	D44-GW-B-046	46	21	76	74	

DATE	TIME	SOURCE	SCAQMD 25.3 ID	FID	CO	SURF TEMP	CHAM TEMP	COMMENT
12/1/2006	1422	Mit Biofilter- Compost Layer	D44-BF-RC-050	3,200	6	87	69	Added finish compost cover at 0800 12/1/06
12/1/2006	1422	Mit Biofilter- No New Compost	D44-BF-RCN-051	8,000	8	158	104	
12/1/2006	1343	QC Media Blank Sample	D44-MB9-Q-052	NA	NA	NA	NA	
DAY 57								
12/14/2006	1059	Food Waste- Ridge High	D57-FW-R1-053	1,700	10	92	84	
12/14/2006	1059	Food Waste- Ridge Low	D57-FW-R2-054	340	8	69	66	
12/14/2006	1059	Food Waste- Middle	D57-FW-M-055	2,000	43	76	57	
12/14/2006	1352	Greenwaste- Ridge High	D57-GW-R1-056	7	29	102	88	
12/14/2006	1354	Greenwaste- Ridge Low	D57-GW-R2-057	640	16	78	74	
12/14/2006	1354	Greenwaste- Bottom	D57-GW-B-058	18	7	77	73	
12/14/2006	1353	Greenwaste- Middle	D57-GW-M-059	2	38	84	74	
12/14/2006	1418	QC Media Blank Sample	D57-MB-10-060	NA	NA	NA	NA	

FID-Flame ionization detector data, real time data
CO-Carbon monoxide detector data, real time data
FW-Food waste
BF-Biofiltration
GW-Greenwaste
ADD-Additive
D-Day
R1-Ridge location #1 (highest FID screen)
R2-Ridge location #2 (lowest FID screen)
M-Middle location
B-Bottom location
MB-Method blank sample
Q-Quality control sample
NA-Not applicable
Surf Temp-Temperature of the compost surface in the flux chamber
Cham Temp-Temperature of the air inside the flux chamber

ATTACHMENT B

SOURCE	25.3 Sample ID	FID	TNMNEO	NMNEO Trap	NMNEO Tank	CO Added	CO	Total Flow	Total Flow	TNMNEO Flux	TNMNEO Flux	COMMENT
		(ppmv)	**(ppmv)**	(ppmv)	(ppmv)	(ppmv)	(ppmv)	(lpm)	(m3/min)	**mg/m2, min-1**	**lb/1,000ft2, hr-1**	
Media Blank Sample	D1-MB-Q-015	NA	**2.0**	2.0	2.0	101	80.7	NA	NA	ND	ND	CO Recovery= 80%
Media Blank Sample	D3-MB2-Q-032	NA	**2.0**	2.0	2.0	101	66.9	NA	NA	ND	ND	CO Recovery= 66%
Media Blank Sample	D6-MB3-Q-046	NA	**2.0**	2.0	2.0	101	62.1	NA	NA	ND	ND	CO Recovery= 61%
Media Blank Sample	D8-MB4-Q-010	NA	**2.0**	2.0	2.0	101	84.5	NA	NA	ND	ND	CO Recovery= 84%
Media Blank Sample	D14-MB5-Q-024	NA	**2.0**	2.0	2.0	101	61.0	NA	NA	ND	ND	CO Recovery= 60%
Media Blank Sample	D21-MB7-Q-032	NA	**2.0**	2.0	2.0	93	60.9	NA	NA	ND	ND	CO Recovery= 66%
Media Blank Sample	D30-MB8-Q-042	NA	**2.0**	2.0	2.0	93	74.6	NA	NA	ND	ND	CO Recovery= 81%
Media Blank Sample	D44-MB9-Q-052	NA	**2.0**	2.0	2.0	93	49.8	NA	NA	ND	ND	CO Recovery= 54%
Media Blank Sample	D57-MB-10-060	NA	**2.0**	2.0	2.0	93	43.8	NA	NA	ND	ND	CO Recovery= 47%
DAY 1		**FID**	**TNMNEO**	**NMNEO Trap**	**NMNEO Tank**	**CO Added**	**CO**	**Total Flow**	**Total Flow**	**TNMNEO Flux**	**TNMNEO Flux**	
Food Waste- Ridge High	D1-FW-R1-001	280	**527**	292	236	101	31.4	16	0.016	**39**	**0.47**	
Food Waste- Middle	D1-FW-M-002	170	**342**	106	236	101	76.9	6.6	0.0066	**10**	**0.13**	
Food Waste- Bottom	D1-FW-B-003	56	**250**	78	172	101	81.2	6.2	0.0062	**7.2**	**0.087**	
Mitigation Biofilter- Ridge High	D1-BF-R1-004	460	**1225**	734	490	101	33.3	15	0.015	**85**	**1.0**	
Mitigation Biofilter- Ridge Low	D1-BF-R2-014	13	**6.92**	4.52	2.39	101	20.6	25	0.025	**0.80**	**0.010**	
Mitigation Biofilter- Middle	D1-BF-M-005	64	**10.4**	6.08	4.30	101	83.2	6.1	0.0061	**0.29**	**0.0036**	
Mitigation Biofilter- Bottom	D1-BF-B-006	9.3	**10.6**	4.53	6.04	101	77.8	6.5	0.0065	**0.32**	**0.0039**	
Greenwaste- Ridge High	D1-GW-R1-007	230	**129**	81.4	47.9	101	15.6	32	0.032	**19**	**0.23**	
Greenwaste- Ridge Low	D1-GW-R2-008	240	**314**	200	114	101	21.3	24	0.024	**35**	**0.42**	
Greenwaste- Middle	D1-GW-M-009	58	**53.3**	34.9	18.6	101	46.6	11	0.011	**2.7**	**0.033**	
Greenwaste- Bottom	D1-GW-B-010	65	**89.9**	88.5	2.0	101	5.66	89	0.089	**37**	**0.45**	
Additive Pile- Ridge High	D1-ADD-R1-011	100	**360**	290	69.7	101	18.5	27	0.027	**45**	**0.55**	
Additive Pile- Middle	D1-ADD-M-012	260	**261**	87.0	174	101	63.3	8.0	0.0080	**9.6**	**0.12**	
Additive Pile- Bottom	D1-ADD-B-013	26	**39.6**	20.8	18.8	101	52.6	9.6	0.0096	**1.8**	**0.021**	

SOURCE	25.3 Sample ID	FID	TNMNEO	NMNEO Trap	NMNEO Tank	CO Added	CO	Total Flow	Total Flow	TNMNEO Flux	TNMNEO Flux	COMMENT
		(ppmv)	**(ppmv)**	(ppmv)	(ppmv)	(ppmv)	(ppmv)	(lpm)	(m3/min)	**mg/m2, min-1**	**lb/1,000ft2, hr-1**	
QC Media Blank Sample	D1-MB-Q-015	NA	**2.0**	2.0	2.0	101	80.7	6.3	0.0063	**0.058**	**0.00071**	MDL from the blank sample; non-detect or ND
DAY 2		**FID**	**TNMNEO**	**NMNEO Trap**	**NMNEO Tank**	**CO Added**	**CO**	**Total Flow**	**Total Flow**	**TNMNEO Flux**	**TNMNEO Flux**	
Greenwaste- Ridge High	D2-GW-R1-016	140	**198**	112	85.7	101	15.1	33	0.033	**30**	**0.37**	
Greenwaste- Ridge Low	D2-GW-R2-017	190	**291**	190	102	101	17.3	29	0.029	**39**	**0.48**	
DAY 3		**FID**	**TNMNEO**	**NMNEO Trap**	**NMNEO Tank**	**CO Added**	**CO**	**Total Flow**	**Total Flow**	**TNMNEO Flux**	**TNMNEO Flux**	
Food Waste- Ridge High	D3-FW-R1-018	840	**236**	41.6	194	101	21.1	24	0.024	**26**	**0.32**	
Food Waste- Middle	D3-FW-M-019	58	**235**	151	84.6	101	54.5	9.3	0.0093	**10**	**0.12**	
Food Waste- Bottom	D3-FW-B-020	14	**18.2**	8.86	9.30	101	55.9	9.0	0.0090	**0.76**	**0.0092**	
Mitigation Biofilter- Ridge High	D3-BF-R1-021	350	**1,388**	708	680	101	31.4	16	0.016	**102**	**1.3**	
Mitigation Biofilter- Middle	D3-BF-M-022	6.4	**4.92**	2.73	2.19	101	57.6	8.8	0.0088	**0.20**	**0.0024**	
Mitigation Biofilter- Bottom	D3-BF-B-023	4	**6.50**	4.77	2.0	101	71.8	7.0	0.0070	**0.21**	**0.0026**	
Greenwaste- Ridge High	D3-GW-R1-028	270	**287**	70.3	216	101	19.2	26	0.026	**34**	**0.42**	
Greenwaste- Ridge Low	D3-GW-R2-025	270	**429**	187	242	101	24.3	21	0.021	**42**	**0.51**	
Greenwaste- Middle	D3-GW-M-026	3.7	**16.4**	10.2	6.26	101	31.8	16	0.016	**1.2**	**0.015**	
Greenwaste- Bottom	D3-GW-B-027	13	**22.3**	18.8	3.49	101	39.2	13	0.013	**1.3**	**0.016**	
Additive Pile- Ridge High	D3-ADD-R1-029	51	**94.5**	29.5	65.0	101	18.9	27	0.027	**12**	**0.14**	
Additive Pile- Middle	D3-ADD-M-030	62	**48.1**	27.9	20.2	101	48.0	11	0.011	**2.4**	**0.030**	
Additive Pile- Bottom	D3-ADD-B-031	4.9	**10.9**	7.55	3.34	101	32.0	16	0.016	**0.80**	**0.010**	
QC Media Blank Sample	D3-MB2-Q-032	NA	**2.0**	2.0	2.0	101	66.9	7.5	0.0075	**0.069**	**0.00084**	MDL from the blank sample; non-detect or ND
DAY 6		**FID**	**TNMNEO**	**NMNEO Trap**	**NMNEO Tank**	**CO Added**	**CO**	**Total Flow**	**Total Flow**	**TNMNEO Flux**	**TNMNEO Flux**	
Food Waste- Ridge High	D6-FW-R1-033	1,700	**509**	195	314	101	23.9	21	0.021	**49**	**0.60**	
Food Waste- Ridge Low	D6-FW-R2-034	110	**215**	59.6	156	101	17.2	29	0.029	**29**	**0.35**	
Food Waste- Middle	D6-FW-M-035	19	**21.9**	15.6	6.35	101	67.7	7.5	0.0075	**0.76**	**0.0092**	
Food Waste- Bottom	D6-FW-B-036	4.7	**20.6**	3.06	17.5	101	44.4	11	0.011	**1.0**	**0.013**	

SOURCE	25.3 Sample ID	FID	TNMNEO	NMNEO Trap	NMNEO Tank	CO Added	CO	Total Flow	Total Flow	TNMNEO Flux	TNMNEO Flux	COMMENT
		(ppmv)	**(ppmv)**	(ppmv)	(ppmv)	(ppmv)	(ppmv)	(lpm)	(m3/min)	**mg/m2, min-1**	**lb/1,000ft2, hr-1**	
Mitigation Biofilter- Ridge High	D6-BF-R1-037	490	**2,259**	1,313	947	101	28.9	17	0.017	**177**	**2.16**	
Mitigation Biofilter- Middle	D6-BF-M-038	NA	**6.58**	4.51	2.07	101	67.4	7.5	0.0075	**0.23**	**0.0028**	
Mitigation Biofilter- Bottom	D6-BF-B-039	NA	**2.37**	2.37	2.0	101	63.6	7.9	0.0079	**0.086**	**0.0011**	
Greenwaste- Ridge High	D6-GW-R1-040	210	**199**	83.1	116	101	18.9	27	0.027	**25**	**0.30**	
Greenwaste- Middle	D6-GW-M-041	3	**5.93**	4.35	2.0	101	33.1	15	0.015	**0.41**	**0.0050**	
Greenwaste- Bottom	D6-GW-B-042	5	**6.20**	6.20	2.0	101	32.1	16	0.016	**0.46**	**0.0056**	
Additive Pile- Ridge High	D6-ADD-R1-043	44	**89.2**	19.1	70.2	101	21.3	24	0.024	**9.9**	**0.12**	
Additive Pile- Middle	D6-ADD-M-044	56	**8.98**	8.01	2.0	101	40.2	13	0.013	**0.54**	**0.0066**	
Additive Pile- Bottom	D6-ADD-B-045	3	**6.08**	4.88	2.0	101	35.1	14	0.014	**0.39**	**0.0048**	
QC Media Blank Sample	D6-MB3-Q-046	NA	**2.0**	2.0	2.0	101	62.1	8.1	0.0081	**0.075**	**0.00091**	MDL from the blank sample; non-detect or ND
DAY 8		**FID**	**TNMNEO**	**NMNEO Trap**	**NMNEO Tank**	**CO Added**	**CO**	**Total Flow**	**Total Flow**	**TNMNEO Flux**	**TNMNEO Flux**	
Food Waste- Ridge High	D8-FW-R1-047	250	**948**	789	159	101	12.2	41	0.041	**179**	**2.2**	
Food Waste- Ridge Low	D8-FW-R2-048	41	**58.2**	53.0	5.23	101	11.1	45	0.045	**12**	**0.15**	
Food Waste- Middle	D8-FW-M-049	380	**424**	372	52.0	101	48.7	10	0.010	**20**	**0.24**	
Food Waste- Bottom	D8-FW-B-050	130	**109**	98.5	10.9	101	55.7	9.1	0.0091	**4.6**	**0.056**	
Mitigation Biofilter- Ridge High	D8-BF-R1-001	35	**25.4**	9.67	15.7	101	16.2	31	0.031	**3.6**	**0.044**	
Mitigation Biofilter- Middle	D8-BF-M-002	670	**795**	644	151	101	14.9	34	0.034	**125**	**1.5**	
Mitigation Biofilter- Bottom	D8-BF-B-003	88	**127**	114	12.8	101	35.3	14	0.014	**8.2**	**0.10**	
Greenwaste- Ridge High	D8-GW-R1-004	74	**102**	91	11.5	101	11.5	44	0.044	**21**	**0.25**	
Greenwaste- Middle	D8-GW-M-005	12	**89**	75	13.8	101	31.2	16	0.016	**6.6**	**0.080**	
Greenwaste- Bottom	D8-GW-B-006	4	**39.9**	36.9	2.98	101	29.9	17	0.017	**3.1**	**0.038**	
Additive Pile- Ridge High	D8-ADD-R1-007	25	**24.6**	5.5	19.1	101	12.2	41	0.041	**4.7**	**0.057**	
Additive Pile- Middle	D8-ADD-M-008	160	**505**	394	111	101	56.6	8.9	0.0089	**21**	**0.25**	
Additive Pile- Bottom	D8-ADD-B-009	9	**31.6**	27.0	4.63	101	35.7	14	0.014	**2.0**	**0.025**	
QC Media Blank Sample	D8-MB4-Q-010	NA	**2.0**	2.0	2.0	101	84.5	6.0	0.0060	**0.055**	**0.00068**	MDL from the blank sample; non-detect or

SOURCE	25.3 Sample ID	FID	TNMNEO	NMNEO Trap	NMNEO Tank	CO Added	CO	Total Flow	Total Flow	TNMNEO Flux	TNMNEO Flux	COMMENT
		(ppmv)	**(ppmv)**	(ppmv)	(ppmv)	(ppmv)	(ppmv)	(lpm)	(m3/min)	**mg/m2, min-1**	**lb/1,000ft2, hr-1**	
												ND
DAY 14		**FID**	**TNMNEO**	**NMNEO Trap**	**NMNEO Tank**	**CO Added**	**CO**	**Total Flow**	**Total Flow**	**TNMNEO Flux**	**TNMNEO Flux**	
Food Waste- Ridge High	D14-FW-R1-011	1,500	**727**	512	216	101	24.4	21	0.021	**70**	**0.86**	
Food Waste- Middle	D14-FW-M-012	45	**4.38**	4.38	2.0	101	48.7	10	0.010	**0.20**	**0.0025**	
Food Waste- Bottom	D14-FW-B-013	95	**3.01**	2.0	1.54	101	36.8	14	0.014	**0.19**	**0.0024**	
Mitigation Biofilter- Ridge High	D14-BF-R1-014	46	**2.97**	2.0	1.91	101	14.5	35	0.035	**0.48**	**0.0059**	
Mitigation Biofilter- Middle	D14-BF-M-015	310	**20.1**	10.6	9.52	101	29.2	17	0.017	**1.6**	**0.019**	
Mitigation Biofilter- Bottom	D14-BF-B-016	16	**9.10**	6.06	3.04	101	35.8	14	0.014	**0.59**	**0.0072**	
Greenwaste- Ridge High	D14-GW-R1-017	1,000	**89.1**	37.1	52.0	101	15.2	33	0.033	**14**	**0.17**	
Greenwaste- Ridge Low	D14-GW-R2-018	130	**22.5**	17.3	5.23	101	14.8	34	0.034	**3.5**	**0.043**	
Greenwaste- Middle	D14-GW-M-019	NA	**9.76**	8.36	1.40	101	58.9	8.6	0.0086	**0.39**	**0.0047**	
Greenwaste- Bottom	D14-GW-B-020	NA	**4.07**	2.0	2.26	101	27.5	18	0.018	**0.34**	**0.0041**	
Additive Pile- Ridge High	D14-ADD-R1-021	890	**166**	65.4	101	101	19.2	26	0.026	**20**	**0.24**	
Additive Pile- Middle	D14-ADD-M-022	12	**8.63**	6.15	2.48	101	4.58	110	0.11	**4.4**	**0.053**	
Additive Pile- Bottom	D14-ADD-B-023	5	**3.36**	3.36	2.0	101	34.1	15	0.015	**0.23**	**0.0028**	
QC Media Blank Sample	D14-MB5-Q-024	NA	**2.0**	2.0	2.0	101	61.0	8.3	0.0083	**0.077**	**0.00093**	MDL from the blank sample; non-detect or ND
DAY 21		**FID**	**TNMNEO**	**NMNEO Trap**	**NMNEO Tank**	**CO Added**	**CO**	**Total Flow**	**Total Flow**	**TNMNEO Flux**	**TNMNEO Flux**	
Food Waste- Ridge High	D21-FW-R1-025	48	**1.20**	2.0	2.0	93	14.2	33	0.033	**0.18**	**0.0022**	
Food Waste- Middle	D21-FW-M-026	350	**4.26**	2.0	2.65	101	38.4	13	0.013	**0.26**	**0.0031**	
Food Waste- Ridge Low	D21-FW-R2-027	14	**0.43**	2.0	2.0	93	11.1	42	0.042	**0.083**	**0.0010**	
Greenwaste- Ridge High	D21-GW-R1-028	1,300	**9.31**	2.60	6.72	93	14.1	33	0.033	**1.4**	**0.017**	
Greenwaste- Ridge Low	D21-GW-R2-029	1,700	**7.32**	2.0	6.80	93	12.3	38	0.038	**1.3**	**0.016**	
Greenwaste- Middle	D21-GW-M-030	530	**1.59**	2.0	2.0	101	40.0	13	0.013	**0.10**	**0.0012**	
Greenwaste- Bottom	D21-GW-B-031	210	**4.00**	2.45	2.0	101	36.6	14	0.014	**0.26**	**0.0032**	
QC Media Blank Sample	D21-MB7-Q-032	NA	**2.0**	2.0	2.0	93	60.9	7.6	0.0076	**0.070**	**0.00086**	MDL from the blank sample; non-detect or

SOURCE	25.3 Sample ID	FID	TNMNEO	NMNEO Trap	NMNEO Tank	CO Added	CO	Total Flow	Total Flow	TNMNEO Flux	TNMNEO Flux	COMMENT
		(ppmv)	**(ppmv)**	(ppmv)	(ppmv)	(ppmv)	(ppmv)	(lpm)	(m3/min)	**mg/m2, min-1**	**lb/1,000ft2, hr-1**	
												ND
DAY 30		**FID**	**TNMNEO**	**NMNEO Trap**	**NMNEO Tank**	**CO Added**	**CO**	**Total Flow**	**Total Flow**	**TNMNEO Flux**	**TNMNEO Flux**	
Food Waste- Ridge High	D30-FW-R1-033	2,600	**62.9**	26	36.8	101	37.5	13	0.013	**3.8**	**0.046**	
Food Waste- Ridge Low	D30-FW-R2-034	810	**4.39**	2.0	3.31	93	24.2	19	0.019	**0.38**	**0.0047**	
Food Waste- Middle	D30-FW-M-035	59	**3.25**	2.0	2.80	93	54.3	8.6	0.0086	**0.13**	**0.0016**	
Food Waste- Bottom	D30-GW-B-036	5	**2.20**	2.0	2.0	101	53.4	9.5	0.0095	**0.10**	**0.0012**	
Greenwaste- Ridge Low	D30-GW-R2-038	4,400	**20.4**	3.17	17.3	93	20.1	23	0.023	**2.2**	**0.026**	
Greenwaste- Ridge High	D30-GW-R1-037	4,700	**17.5**	2.96	14.6	93	23.0	20	0.020	**1.6**	**0.020**	
Greenwaste- Middle	D30-GW-M-039	54	**2.0**	2.0	2.0	101	54.3	9.3	0.0093	**0.086**	**0.0010**	
Mit Biofilter- Compost Layer	D30-BF-RC-040	4,300	**8.23**	2.0	6.78	93	18.4	25	0.025	**0.95**	**0.012**	
Mit Biofilter- No New Compost	D30-BF-RCN-041	4,300	**5.07**	2.0	4.03	93	12.5	37	0.037	**0.87**	**0.011**	
QC Media Blank Sample	D30-MB8-Q-042	NA	**2.0**	2.0	2.0	93	74.6	6.2	0.0062	**0.057**	**0.00070**	MDL from the blank sample; non-detect or ND
DAY 44		**FID**	**TNMNEO**	**NMNEO Trap**	**NMNEO Tank**	**CO Added**	**CO**	**Total Flow**	**Total Flow**	**TNMNEO Flux**	**TNMNEO Flux**	
Food Waste- Ridge High	D44-FW-R1-043	4,400	**125**	112	13.0	93	11.9	39	0.039	**23**	**0.27**	
Food Waste- Middle	D44-FW-M-045	77	**2.0**	2.0	2.0	93	49.9	9.3	0.0093	**0.086**	**0.0010**	
Food Waste- Ridge Low	D44-FW-R2-044	210	**2.87**	2.0	2.05	93	8.67	54	0.054	**0.72**	**0.0087**	
Greenwaste- Ridge High	D44-GW-R1-047	1,700	**7.87**	5.84	2.03	93	9.68	48	0.048	**1.7**	**0.021**	
Greenwaste- Ridge Low	D44-GW-R2-048	140	**2.0**	2.0	2.0	93	8.99	52	0.052	**0.48**	**0.0059**	
Greenwaste- Middle	D44-GW-M-049	170	**3.76**	2.01	2.0	93	28.7	16	0.016	**0.28**	**0.0034**	
Greenwaste- Bottom	D44-GW-B-046	46	**2.0**	2.0	2.0	101	37.2	14	0.014	**0.13**	**0.0016**	
Mit Biofilter- Compost Layer	D44-BF-RC-050	3,200	**13.6**	1.22	12.4	93	5.88	79	0.079	**5.0**	**0.060**	
Mit Biofilter- No New Compost	D44-BF-RCN-051	8,000	**70.0**	44.6	25.3	93	7.57	61	0.061	**20**	**0.24**	
QC Media Blank Sample	D44-MB9-Q-052	NA	**2.0**	2.0	2.0	93	49.8	9.3	0.0093	**0.09**	**0.0010**	MDL from the blank sample; non-detect or ND
DAY 57		**FID**	**TNMNEO**	**NMNEO Trap**	**NMNEO Tank**	**CO Added**	**CO**	**Total Flow**	**Total Flow**	**TNMNEO Flux**	**TNMNEO Flux**	

SOURCE	25.3 Sample ID	FID	TNMNEO	NMNEO Trap	NMNEO Tank	CO Added	CO	Total Flow	Total Flow	TNMNEO Flux	TNMNEO Flux	COMMENT
		(ppmv)	**(ppmv)**	(ppmv)	(ppmv)	(ppmv)	(ppmv)	(lpm)	(m3/min)	**mg/m2, min-1**	**lb/1,000ft2, hr-1**	
Food Waste- Ridge High	D57-FW-R1-053	1,700	**12.9**	3.08	9.77	93	10.9	43	0.043	**2.6**	**0.031**	
Food Waste- Ridge Low	D57-FW-R2-054	340	**2.28**	2.0	2.1	93	7.23	64	0.064	**0.67**	**0.0082**	
Food Waste- Middle	D57-FW-M-055	2,000	**2.38**	2.0	2.0	93	33.0	14	0.014	**0.15**	**0.0019**	
Greenwaste- Ridge High	D57-GW-R1-056	7	**2.01**	2.0	2.0	93	11.0	42	0.042	**0.39**	**0.0048**	
Greenwaste- Ridge Low	D57-GW-R2-057	640	**6.43**	2.0	5.07	93	10.1	46	0.046	**1.4**	**0.017**	
Greenwaste- Bottom	D57-GW-B-058	18	**2.0**	2.0	2.0	93	27.0	17	0.017	**0.16**	**0.0019**	
Greenwaste- Middle	D57-GW-M-059	2	**2.0**	2.0	2.0	93	26.6	17	0.017	**0.16**	**0.0019**	
QC Media Blank Sample	D57-MB-10-060	5	**2.0**	2.0	2.0	93	43.8	11	0.011	**0.10**	**0.0012**	MDL from the blank sample; non-detect or ND

U- Reported at or below method detection limit; non-detect (ND)
NA- Not applicable
Advective Flow (m3/min)= (ppmv CO Trace)(0.005 m3/min)/(ppmv CO Recovered)
Conversion: from mg/m2,min-1 to lb/1,000ft2,hr-1 is 0.0122 times mg/m2,min-1
Note 1: Average recovery of CO was 67%; field data not corrected

ATTACHMENT C

SOURCE	25.3 ID	DATE	TEMP.	WIND SPEED	WIND DIRECTION	BAR PRESSURE	COMMENT
		DAY 1	(deg F)	(mph)		(inches water)	
Food Waste- Ridge High	D1-FW-R1-001	10/19/2006					Sunny and warm; 80 deg F
Food Waste- Middle	D1-FW-M-002	10/19/2006					
Food Waste- Bottom	D1-FW-B-003	10/19/2006					
Mitigation Biofilter- Ridge High	D1-BF-R1-004	10/19/2006					
Mitigation Biofilter- Ridge Low	D1-BF-R2-014	10/19/2006					
Mitigation Biofilter- Middle	D1-BF-M-005	10/19/2006					
Mitigation Biofilter- Bottom	D1-BF-B-006	10/19/2006					
Greenwaste- Ridge High	D1-GW-R1-007	10/19/2006					
Greenwaste- Ridge Low	D1-GW-R2-008	10/19/2006					
Greenwaste- Middle	D1-GW-M-009	10/19/2006					
Greenwaste- Bottom	D1-GW-B-010	10/19/2006					
Additive Pile- Ridge High	D1-ADD-R1-011	10/19/2006					
Additive Pile- Middle	D1-ADD-M-012	10/19/2006					
Additive Pile- Bottom	D1-ADD-B-013	10/19/2006					
QC Media Blank Sample	D1-MB-Q-015	10/19/2006					
		DAY 2					Sunny and warm, 84 deg F
Greenwaste- Ridge High	D2-GW-R1-016	10/20/2006					
Greenwaste- Ridge Low	D2-GW-R2-017	10/20/2006					
		DAY 3					
Food Waste- Ridge High	D3-FW-R1-018	10/21/2006	81	0	S	32.6	Sunny and warm, 82 deg F
Food Waste- Middle	D3-FW-M-019	10/21/2006	81	0	S	32.6	
Food Waste- Bottom	D3-FW-B-020	10/21/2006	81	0	S	32.6	
Mitigation Biofilter- Ridge High	D3-BF-R1-021	10/21/2006	81	0	S	32.6	
Mitigation Biofilter- Middle	D3-BF-M-022	10/21/2006	81	0	S	32.6	
Mitigation Biofilter- Bottom	D3-BF-B-023	10/21/2006	81	0	S	32.6	
Greenwaste- Ridge High	D3-GW-R1-028	10/21/2006	81	0	S	32.6	

SOURCE	25.3 ID	DATE	TEMP.	WIND SPEED	WIND DIRECTION	BAR PRESSURE	COMMENT
		DAY 1	(deg F)	(mph)		(inches water)	
Greenwaste- Ridge Low	D3-GW-R2-025	10/21/2006	81	0	S	32.6	
Greenwaste- Middle	D3-GW-M-026	10/21/2006	81	0	S	32.6	
Greenwaste- Bottom	D3-GW-B-027	10/21/2006	81	0	S	32.6	
Additive Pile- Ridge High	D3-ADD-R1-029	10/21/2006	81	0	S	32.6	
Additive Pile- Middle	D3-ADD-M-030	10/21/2006	81	0	S	32.6	
Additive Pile- Bottom	D3-ADD-B-031	10/21/2006	81	0	S	32.6	
QC Media Blank Sample	D3-MB2-Q-032	10/21/2006	81	0	S	32.6	
		DAY 6					
Food Waste- Ridge High	D6-FW-R1-033	10/24/2006					Sunny and warm, 86 deg F
Food Waste- Ridge Low	D6-FW-R2-034	10/24/2006					
Food Waste- Middle	D6-FW-M-035	10/24/2006					
Food Waste- Bottom	D6-FW-B-036	10/24/2006					
Mitigation Biofilter- Ridge High	D6-BF-R1-037	10/24/2006					
Mitigation Biofilter- Middle	D6-BF-M-038	10/24/2006					
Mitigation Biofilter- Bottom	D6-BF-B-039	10/24/2006					
Greenwaste- Ridge High	D6-GW-R1-040	10/24/2006					
Greenwaste- Middle	D6-GW-M-041	10/24/2006					
Greenwaste- Bottom	D6-GW-B-042	10/24/2006					
Additive Pile- Ridge High	D6-ADD-R1-043	10/24/2006					
Additive Pile- Middle	D6-ADD-M-044	10/24/2006					
Additive Pile- Bottom	D6-ADD-B-045	10/24/2006					
QC Media Blank Sample	D6-MB3-Q-046	10/24/2006					
		DAY 8					
Food Waste- Ridge High	D8-FW-R1-047	10/26/2006					Sunny and warm, 81 deg F
Food Waste- Ridge Low	D8-FW-R2-048	10/26/2006					
Food Waste- Middle	D8-FW-M-049	10/26/2006					
Food Waste- Bottom	D8-FW-B-050	10/26/2006					
Mitigation Biofilter- Ridge High	D8-BF-R1-001	10/26/2006					

SOURCE	25.3 ID	DATE	TEMP.	WIND SPEED	WIND DIRECTION	BAR PRESSURE	COMMENT
		DAY 1	(deg F)	(mph)		(inches water)	
Mitigation Biofilter- Middle	D8-BF-M-002	10/26/2006					
Mitigation Biofilter- Bottom	D8-BF-B-003	10/26/2006					
Greenwaste- Ridge High	D8-GW-R1-004	10/26/2006					
Greenwaste- Middle	D8-GW-M-005	10/26/2006					
Greenwaste- Bottom	D8-GW-B-006	10/26/2006					
Additive Pile- Ridge High	D8-ADD-R1-007	10/26/2006					
Additive Pile- Middle	D8-ADD-M-008	10/26/2006					
Additive Pile- Bottom	D8-ADD-B-009	10/26/2006					
QC Media Blank Sample	D8-MB4-Q-010	10/26/2006					
		DAY 14					
Food Waste- Ridge High	D14-FW-R1-011	11/1/2006	69	0	S	32.11	Sunny and warm, 71 deg F
Food Waste- Middle	D14-FW-M-012	11/1/2006	69	0	S	32.11	
Food Waste- Bottom	D14-FW-B-013	11/1/2006	69	0	S	32.11	
Mitigation Biofilter- Ridge High	D14-BF-R1-014	11/1/2006	69	0	S	32.11	
Mitigation Biofilter- Middle	D14-BF-M-015	11/1/2006	69	0	S	32.11	
Mitigation Biofilter- Bottom	D14-BF-B-016	11/1/2006	69	0	S	32.11	
Greenwaste- Ridge High	D14-GW-R1-017	11/1/2006	69	0	S	32.11	
Greenwaste- Ridge Low	D14-GW-R2-018	11/1/2006	69	0	S	32.11	
Greenwaste- Middle	D14-GW-M-019	11/1/2006	69	0	S	32.11	
Greenwaste- Bottom	D14-GW-B-020	11/1/2006	69	0	S	32.11	
Additive Pile- Ridge High	D14-ADD-R1-021	11/1/2006	69	0	S	32.11	
Additive Pile- Middle	D14-ADD-M-022	11/1/2006	69	0	S	32.11	
Additive Pile- Bottom	D14-ADD-B-023	11/1/2006	69	0	S	32.11	
QC Media Blank Sample	D140MB5-Q-024	11/1/2006	69	0	S	32.11	
		DAY 21					
Food Waste- Ridge High	D21-FW-R1-025	11/8/2006	68	10	NW	29.96	Light rain 0800, cloudy, south wind 0-1 mph
Food Waste- Middle	D21-FW-M-026	11/8/2006	68	10	NW	29.96	Piles irrigated day prior; very wet

SOURCE	25.3 ID	DATE	TEMP.	WIND SPEED	WIND DIRECTION	BAR PRESSURE	COMMENT
		DAY 1	(deg F)	(mph)		(inches water)	
Food Waste- Ridge Low	D21-FW-R2-027	11/8/2006	68	10	NW	29.96	
Greenwaste- Ridge High	D21-GW-R1-028	11/8/2006	68	10	NW	29.96	
Greenwaste- Ridge Low	D21-GW-R2-029	11/8/2006	68	10	NW	29.96	
Greenwaste- Middle	D21-GW-M-030	11/8/2006	68	10	NW	29.96	
Greenwaste- Bottom	D21-GW-B-031	11/8/2006	68	10	NW	29.96	
QC Media Blank Sample	D21-MB7-Q-032	11/8/2006	68	10	NW	29.96	
		DAY 30					
Food Waste- Ridge High	D30-FW-R1-033	11/17/2006	65	4	NW	32.70	Cooler with fog
Food Waste- Ridge Low	D30-FW-R2-034	11/17/2006	65	4	NW	32.70	
Food Waste- Middle	D30-FW-M-035	11/17/2006	65	4	NW	32.70	
Food Waste- Bottom	D30-GW-B-036	11/17/2006	65	4	NW	32.70	
Greenwaste- Ridge Low	D30-GW-R2-038	11/17/2006	65	4	NW	32.70	
Greenwaste- Ridge High	D30-GW-R1-037	11/17/2006	65	4	NW	32.70	
Greenwaste- Middle	D30-GW-M-039	11/17/2006	65	4	NW	32.70	
Mit Biofilter- Compost Layer	D30-BF-RC-040	11/17/2006	65	4	NW	32.70	
Mit Biofilter- No New Compost	D30-BF-RCN-041	11/17/2006	65	4	NW	32.70	
QC Media Blank Sample	D30-MB8-Q-042	11/17/2006	65	4	NW	32.70	
		DAY 44					
Food Waste- Ridge High	D44-FW-R1-043	12/1/2006	59	10	WNW	31.97	Sunny and mild, pile have high surf temp
Food Waste- Middle	D44-FW-M-045	12/1/2006	59	10	WNW	31.97	
Food Waste- Ridge Low	D44-FW-R2-044	12/1/2006	59	10	WNW	31.97	
Greenwaste- Ridge High	D44-GW-R1-047	12/1/2006	59	10	WNW	31.97	
Greenwaste- Ridge Low	D44-GW-R2-048	12/1/2006	59	10	WNW	31.97	
Greenwaste- Middle	D44-GW-M-049	12/1/2006	59	10	WNW	31.97	
Greenwaste- Bottom	D44-GW-B-046	12/1/2006	59	10	WNW	31.97	
Mit Biofilter- Compost Layer	D44-BF-RC-050	12/1/2006	59	10	WNW	31.97	
Mit Biofilter- No New Compost	D44-BF-RCN-051	12/1/2006	59	10	WNW	31.97	

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SOURCE	25.3 ID	DATE	TEMP.	WIND SPEED	WIND DIRECTION	BAR PRESSURE	COMMENT
		DAY 1	(deg F)	(mph)		(inches water)	
QC Media Blank Sample	D44-MB9-Q-052	12/1/2006	59	10	WNW	31.97	
		DAY 57					
Food Waste- Ridge High	D57-FW-R1-053	12/14/2006	59	0	SE	32.68	Fog and partly cloudy, mild, 68 deg F
Food Waste- Ridge Low	D57-FW-R2-054	12/14/2006	59	0	SE	32.68	
Food Waste- Middle	D57-FW-M-055	12/14/2006	59	0	SE	32.68	
Greenwaste- Ridge High	D57-GW-R1-056	12/14/2006	59	0	SE	32.68	
Greenwaste- Ridge Low	D57-GW-R2-057	12/14/2006	59	0	SE	32.68	
Greenwaste- Bottom	D57-GW-B-058	12/14/2006	59	0	SE	32.68	
Greenwaste- Middle	D57-GW-M-059	12/14/2006	59	0	SE	32.68	
QC Media Blank Sample	D57-MB-10-060	12/14/2006	59	0	SE	32.68	

Note-: Met data collected from the WWT facility as real time readout data, end of the day.