Methodology

A test protocol and sampling strategy were developed to describe the test plan, methodology, sampling procedure, and analytical test methods for source testing VOC emissions at the City of Modesto Compost Facility. Prior to commencing field tests, the test plan was reviewed with the SJVUAPCD in meetings with CIWMB, San Diego State University researcher Dr. Fatih Buyuksonmez, and field chemist Dr. Chuck Schmidt. Major points of interest to the 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, and analysis methods. Additional considerations that were important to the CIWMB included defining VOC emissions for the full life cycle of the composting process, evaluating emissions for a mixture of greenwaste and food waste, and 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 test protocol included provisions for sampling within 24 hours before a turning event (Day 6) and within 24 hours after a turning event (Day 8) – turning event to be conducted on Day 7. Additionally, all other samples were gathered before the turning events so that turning events did not skew emission data. Facility turning events are noted on the test schedule.

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. It is important to take precautions to minimize sample loss and underestimation of 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 to minimize sample loss and underestimation of the VOC emissions.

The gas fraction of the VOC emissions were 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. 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 equipped with a gas chromatograph and TOC analyzer. However, due to unforeseen difficulties in the field in setting up the on-site laboratory and the large volume of samples that needed to be analyzed 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 as described above. This did not, in all cases, result in the analysis of the gas fractions within 48 hours; however, extreme care was taken to ensure the samples were analyzed within protocol to minimize sample loss and underestimation of VOC emissions. 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.

Spatial Location of Sample Points, Vertically and Horizontally

Three vertical sampling points on the test windrows (bottom, middle, and ridgetop) were taken for most sample sets to characterize the variable emission fluxes of the "chimney-breathing" pattern of a windrow. Additionally, in some sample sets an extra ridgetop sample was occasionally gathered instead of the daily field blank sample to provide emission data from both venting and non-venting locations along the horizontal length of the windrow ridgetops. The extra ridgetop samples were primarily used to gather additional data on the greenwaste windrow since typically most of the emissions occur along the ridgetop of a windrow.

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. The total carbon content was determined by loss-on-ignition method; the total nitrogen content was determined a Perkin Elmer 2410 total nitrogen analyzer; moisture content was determined by gravimetrically after drying at 70°C. The stability of the final products were 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 goal of the CIWMB for this project was to measure the full life cycle of VOC emissions from greenwaste composting that characterizes the emissions during the active phase of composting followed by typically 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 from greenwaste composting. Emission samples were taken throughout a 60-day 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 on the more active initial two weeks of composting and four sampling events on the less active portion of the compost life cycle. Although every effort was made to observe the original sampling schedule, some sampling days were added and a few of the sampling days were slightly shifted due to scheduling or operational considerations.

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 were mixed with 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 location during the latter phase of composting.

Determining the Efficacy of BMP Alternatives to Reduce VOC Emissions

Two test windrows were constructed to evaluate the effectiveness of two BMP alternatives 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 to reduce VOC emissions. Chemical additives were applied to the other BMP windrow to reduce VOC emissions.

The pseudo-biofilter BMP alternative 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 the finished compost, used to cap the test windrow as a pseudo-biofilter, becomes integrated into the windrow following a turning event which serves to inoculate the windrow with beneficial microbes. Following a turning event, the pseudo-biofilter cap is re-applied using additional finished compost.

The other BMP 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 field tests conducted at the Modesto Composting Facility. These additives were chosen because in prior field tests, their performance indicated a reduction in VOC emissions. GOC Technologies provided two types of chemical additives: an inoculation type of additive that was incorporated with the greenwaste during the formation of the windrow and a topical additive that was sprayed on the surface of the windrow to reduce emissions and odors. 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 for the first two weeks of the field tests only which approximated the active phase of composting.

Sampling strategy

The sampling started on Day 1 after the formation of windrows on Day 0 and continued throughout the life-span of the windrows with more frequent sampling at the beginning. There were 3 flux samples collected from each composting windrow, one extra ridgetop flux sample from one of the windrows (either greenwaste or food waste windrow), and one media blank sample, making a total of 14 samples per sampling event. The two BMP windrows were sampled for the first two weeks of testing only while the greenwaste and food waste windrows were sampled for the full test period. Each sample was analyzed in triplicate (or duplicate as time allowed) for statistical analysis. Sample location zones included ridgetop, middle-side, and bottom-zone to evaluate the variable fluxes from the "chimney effect" due to the temperature profile within the composting windrows. To determine the exact location within the ridgetop sample zone, an initial screening of the windrows was conducted on the ridgetops with a portable gas analyzer (TVA-1000) to determine venting and non-venting sampling locations. The sampling scheme and project test schedule are presented in Table 1 and Table 2

For a given windrow, up to four emission samples were collected, that were (i) high level of emissions on the ridgetop, i.e., the venting (R1); (ii) low level of emissions on the ridge—non-venting (R2); (iii) middle section emissions; and (iv) bottom section emissions (Figure 1). In the case 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. Considering the fact that most of the emissions result from the ridgetop, the total emissions would not be affected significantly by the emissions resulting from the middle and bottom sections. In the cases where only one ridgetop sample was collected during a sampling event for a given windrow, an average of the previous and the following R2 (non-venting) emission values were used. (R1 (venting) was collected each sampling event for all windrows; R2 (non-venting) was collected on a rotating schedule between the greenwaste and the food waste windrows). There were 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 which were then analyzed by direct injection into the on-site gas chromatograph. The samples were 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 protocol 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