WERF

Water Environment Research Foundation

Collaboration. Innovation. Results.

CASA

Biosolids Co-Composting VOC and Ozone Formation Study

Biosolids Co-Composting VOC and Ozone Formation Study

Final Report – June 1, 2011

Produced Under Contract by:

Peter G Green

University of California, Davis

Department of Civil & Environmental Engineering

CASA

WERF

Water Environment Research Foundation

Collaboration. Innovation. Results.

The Water Environment Research Foundation, a not-for-profit organization, funds and manages water quality research for its subscribers through a diverse public-private partnership between municipal utilities, corporations, academia, industry, and the federal government. WERF subscribers include municipal and regional water and wastewater utilities, industrial corporations, environmental engineering firms, and others that share a commitment to cost-effective water quality solutions. WERF is dedicated to advancing science and technology addressing water quality issues as they impact water resources, the atmosphere, the lands, and quality of life.

© Copyright 2011 by the Water Environment Research Foundation and the California Association of Sanitation Agencies. All rights reserved. Permission to copy must be obtained from the Water Environment Research Foundation or the California Association of Sanitation Agencies.
Library of Congress Catalog Card Number: 2011932564
Printed in the United States of America

This report was prepared by the organization(s) named below as an account of work sponsored by the Water Environment Research Foundation (WERF) and California Association of Sanitation Agencies (CASA). Neither CASA or WERF, members of CASA or WERF, the organization(s) named below, nor any person acting on their behalf: (a) makes any warranty, express or implied, with respect to the use of any information, apparatus, method, or process disclosed in this report or that such use may not infringe on privately owned rights; or (b) assumes any liabilities with respect to the use of, or for damages resulting from the use of, any information, apparatus, method, or process disclosed in this report.

UC Davis Dept. of Civil & Environmental Engineering

This document was reviewed by a panel of independent experts selected by CASA and WERF. Mention of trade names or commercial products or services does not constitute endorsement or recommendations for use. Similarly, omission of products or trade names indicates nothing concerning CASA's or WERF's positions regarding product effectiveness or applicability.

For more information, contact:
Water Environment Research Foundation
635 Slaters Lane, Suite G-110
Alexandria, VA 22314-1177
Tel: (571) 384-2100
Fax: (703) 299-0742
www.werf.org
werf@werf.org

California Association of Sanitation Agencies
1215 K Street, Suite 2290
Sacramento, CA 95814
Tel: (916) 446-0388
Fax: (916) 231-2141
www.casaweb.org

Table of Contents

Acknowledgments 2

Executive Summary 4

Introduction 7

- Background 7
- Project Goals and Objectives 8
- Sampling Strategy 8
- Sampling Protocols 8
- Mobile Ozone Chamber 10
- Sample Analysis Protocols 11
- Data Analysis 11
- Interpretation and Discussion 13
- Conclusions 14

Abbreviations, Acronyms, and Glossary 15

Appendix A: Compost Emission VOCs and Reactivity 17

Appendix B: Source Reference Notes and Bibliography 20

Appendix C: Commercial Compost Analysis 22

Acknowledgments

WERF would like to acknowledge the California Association of Sanitation Agencies (CASA) for initiating the process for executing this research. CASA secured financial contributions from some of its membership as listed below, as well as the Bay Area Clean Water Agencies (BACWA) because they recognized the value of this project for California and other parts of the country where ozone impacts air quality. WERF then was able to join the effort and contribute the remaining funds needed to fulfill the contract. CASA executed the contract with UC Davis and we are pleased to jointly publish this important research. Contributors included:

The City of Fresno
The City of Los Angeles, Bureau of Sanitation
The Sanitation Districts of Los Angeles County
Napa Sanitation District
Orange County Sanitation District
The City of Santa Rosa, Utilities Department
Synagro West Technologies

Bay Area Clean Water Agencies (BACWA)

The Water Environment Research Foundation

Lead Author

Peter G. Green, Ph.D., UC Davis Dept. of Civil & Environmental Engineering

Project Subcommittee

Greg Kester; Chair, California Association of Sanitation Agencies
Stanly Tong, Air Division, U.S. EPA Region 9
Jim Swaney, San Joaquin Valley Air Pollution Control District
Sally Brown, University of Washington
Geoffrey Kuter, Agresource
Peggy Leonard, King County Wastewater Treatment Division
Dan Woltering, Water Environment Research Foundation

Special Thanks

Central Valley Composting Facility, Dos Palos
City of Santa Rosa Composing Facility
Isabel Faria, Ph.D., UC Davis Department of Civil & Environmental Engineering
Walter Ham, Ph.D., UC Davis Department of Civil & Environmental Engineering
Zach Kay, City of Santa Rosa
Anuj Kumar, Ph.D., UC Davis Department of Civil & Environmental Engineering
Lorrie Loder, Synagro
City of Fresno
City of Los Angeles
Sanitation Districts of Los Angeles County
Orange County Sanitation District
Napa Sanitation District

City of Santa Rosa
Synagro
Bay Area Clean Water Agencies
Water Environment Research Foundation
California Association of Sanitation Agencies

Additional Thanks To:

Chris Alaimo, UC Davis Dept. of Civil & Environmental Engineering
Prof. Mike Kleeman, UC Davis Department of Civil & Environmental Engineering
Prof. Frank Mitloehner, UC Davis Department of Animal Science
Prof. Ruihong Zhang, UC Davis Department. of Biological & Agricultural Engineering

Executive Summary

Ground-level ozone is a serious problem in many of California's inland valleys, where mountain ranges trap polluted air.

The federal Clean Air Act directs regional air quality control districts to reduce ozone levels below federal thresholds, under penalty of lost federal transportation funds. These districts generally attempt to lower ozone levels by controlling the precursors, volatile organic compounds (VOCs) and nitrogen oxides (NO_x). Air district officials in two of California's most challenged air basins, covering the San Joaquin Valley and the greater Los Angeles area, have identified biosolids composting facilities and their raw materials as a source of precursors, and adopted restrictive rules to reduce VOC emissions from the composting facilities.

The steady stream of raw materials flowing to composting facilities is a direct result of California's Integrated Waste Management Act, which requires municipal governments to divert half of all wastes away from landfill disposal. Composting can be a cost-effective and environmentally sustainable means to convert large volumes of treated biosolids into valuable products for agriculture. However, landfilling costs are very competitive with composting, and new regulations which increase composting costs can be expected to drive organic materials back to the landfill, decreasing solid waste diversion rates and depriving agriculture of a low-cost organic soil amendment.

Earlier research initiated by CalRecycle and sponsored by several composters and public agencies found that green waste composting emissions are more than 80% light alcohols, which are low-reactivity compounds. The ozone-formation potential of the total composting VOC mix is low, and it is similar to the potential from other biogenic sources, and lower than some natural VOC sources such as isoprene and terpenes from plants.

This report concerns assessment of biosolids co-composting which is the combined composting of 25% to 50% biosolids with 50% to 75% green waste. Because of the low overall ozone formation potential of the VOC emissions profile from green waste composting operations, it is expected that reducing biosolids co-composting pile emissions would be similar. Further reducing biosolids co-composting pile emissions is unlikely to have a detectable impact on regional tropospheric ozone levels.

Study Design

In this project, the research team evaluated emissions from sources at two biosolids composting facilities. At the City of Santa Rosa, emissions were evaluated from the lava rock biofilter through which the ventilation of the indoor active composting operation is output. The material at Santa Rosa was roughly one third biosolids, all of which has been previously processed through anaerobic digestion, with two thirds consisting of yard waste, recycled overs from compost screening and may include saw dust, grape pomace and wood chips. Santa Rosa used agitated beds, enclosed in a building which was vented through a lava rock biofilter. VOCs from a finished compost pile were also studied. At Central Valley Composting (CVC) Dos Palos, emissions were characterized from open windrows of various ages. The material at Dos Palos was 25% biosolids, some of which has been previously processed through either anaerobic or aerobic digestion.

As in the previous studies, sampling focused on identifying the greatest possible range of VOCs emanating from composting operations, including highly reactive compounds which may not be captured using typical total-mass-VOC measurement techniques. Samples are taken using a dilution tunnel device, and routed into stainless steel canisters and sorbent tubes for holding and transport to a lab, where they

are analyzed on a gas chromatograph/mass spectrometer. Once the individual compounds and concentrations were measured, the emissions mix was run through a computer model to predict how much ozone will be formed in the atmosphere based on the addition of the source emissions. (These calculations are detailed in the section on Data Analysis.)

The test protocol employs a mobile ozone chamber (abbreviated MOChA), which is towed to the composting sites behind a pickup truck. The research team measures actual ozone formation from the composting emissions within the chamber in real time. The next step is to compare MOChA chamber measurements with the ozone formation calculated by the model based on the identified VOCs within the emissions sample. If the model and the measured emissions are relatively close (within around 20 ppb), then it is highly likely that all of the reactive, ozone-forming compounds within the source emissions have been properly identified.

Results and Conclusions

There is one key overall conclusion from both phases of this work:

> VOCs from biosolids co-composting are a diverse mixture, but are comprised of primarily low-reactivity alcohols. The ozone formation potential (OFP) of the total composting VOC mix is considered low, and is similar to the OFP from other biogenic sources.

The research team identified all VOCs which were detectable in any sample. More than 50 VOCs were identified in some samples. The three main alcohols, ethanol, wood alcohol (methanol) and isopropyl, comprised greater than 90% of the total emissions by volume in all samples. Naturally occurring terpenes like alpha-pinene and limonene were found in many samples, and are moderately reactive compounds; they were occasionally found in low ppb range. Other compounds were generally found in fractions of a part per billion.

The Maximum Incremental Reactivity (MIR) scale is the most common scale used to compare the OFP of various compounds. Any compound or mixture with an MIR of less than 2 is considered to have low reactivity. The average (un-weighted) MIR of all samples taken in this study was close to 1. The MIR of a typical urban VOC mixture is 3.7. The volume weighted range of MIRs for VOC samples collected at the Santa Rosa facility was 0.9 to 1.2, and for CVC Dos Palos, 0.8 to 1.1. The mass weighted range of MIRs for VOC samples collected at the Santa Rosa facility was 1.0 to 1.4, and for CVC Dos Palos, 1.0 to 1.2. See table on the following page, and details of the calculation in Data Analysis.

A unique aspect to the MOChA approach to studying the formation of ozone from VOC sources is the ability to compare observed (measured) ozone formation in the MOChA chamber with the ozone predicted from the detailed VOC mixture measurements. Past projects have generally shown a difference between the model and MOChA of about 10 to 20 ppb. Overall ozone formation can be from 100ppb to 200ppb. For a highly variable source whose VOCs are both low in concentration and low in reactivity, such as biosolids composting pile emissions, this comparison can be more difficult. This means that the influence of biosolids is difficult to discern; it is weak.

City of Santa Rosa Composting Facility, 14-20 July 2010

	Biofilter PM 7/14/2010	Biofilter AM 7/15/2010	Biofilter PM 7/15/2010	finished compost AM 7/16/2010	finished compost PM 7/16/2010	Biofilter AM 7/19/2010	Biofilter AM 7/20/2010
MIR-weighted reactivity:	1.21	1.04	1.17	1.11	1.45	1.32	1.24
Assumed equal MIR	3.7	3.7	3.7	3.7	3.7	3.7	3.7
EBIR-weighted reactivity:	0.43	0.33	0.53	0.35	0.46	0.36	0.33
Assumed equal EBIR	0.81	0.81	0.81	0.81	0.81	0.81	0.81

Dos Palos, Synagro Composting Facility, 20-30 September 2010

	8.5 week compost PM 9/20/2010	8.5 week compost PM 9/20/2010	8.5 week compost AM 9/21/2010	8.5 week compost PM 9/21/2010	2 week compost AM 9/22/2010	2 week compost PM 9/22/2010	3 week compost PM 9/27/2010	9.5 week compost AM 9/28/2010	finished compost PM 9/29/2010	finished compost AM 9/30/2010
MIR-weighted reactivity:	1.07	1.08	1.19	1.15	1.17	1.10	1.05	1.13	1.08	1.17
Assumed equal MIR	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7
EBIR-weighted reactivity:	0.39	0.40	0.42	0.41	0.42	0.38	0.39	0.41	0.40	0.40
Assumed equal EBIR	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81	0.81

Introduction

Background

Volatile Organic Compounds (VOCs) are a class of more than one thousand gaseous compounds which vary tremendously in terms of their odor, toxicity, and reactivity with other atmospheric constituents. Many VOCs react with Oxides of Nitrogen (NO_x) in the presence of sunlight to form ground-level or tropospheric ozone, a Clean Air Act criteria pollutant with significant negative impacts on human health and on plants, including agricultural crops.

The reactivity of any given VOC influences its ozone formation potential. Researchers have classified most common VOCs using a reactivity index, and the US Environmental Protection Agency has exempted certain very low reactivity compounds from Clean Air Act regulations.

Biosolid co-composters have come under scrutiny from air quality officials because of the emission of VOCs during the natural decomposition processes of composting piles of feedstocks.

Up until 2009, there had been no study with the specific intent of analyzing emissions from composting piles to capture and identify every VOC being emitted, and to determine whether these compounds were likely to react with NO_x to form ozone. Therefore, the contribution of composting facilities to regional ozone problems was not proven.

A preceding pair of projects, conducted in 2009 and 2010, and funded by two municipal agencies, four composters, and CalRecycle, isolated the full range of VOCs emanating from green waste composting piles, including the highly reactive ones which are not distinguished using total mass VOC measurement techniques. To accomplish this, VOCs were captured using sampling instruments such as a flux chambers and wind tunnels, and routed to stainless steel canisters where the gases are held until they can be taken to a laboratory for analysis with a gas chromatograph and mass spectrometer (GC/MS). Other containment methods for captured gases, such as sorbent tubes, are better suited for highly reactive gases such as aldehydes, and are used in addition to the steel canisters. The previous fall sampling indicated that a wind tunnel was a preferred method for sampling emissions, because the emissions captured by the flux chamber, even when routed through an ice trap to reduce water, were still too wet to be properly measured in the mobile ozone formation chamber (MOChA). Therefore, in this study, sampling was conducted with a wind tunnel; standard (un-diluted) flux chamber sampling would have produced excessive humidity.

The contractor's approach to understanding formation of ozone from complex VOC sources follows that used in previous efforts with dairies and field spraying in orchards. The approach includes the use of the MOChA to make real-time field measurements of ozone formation from composting emissions. The MOChA is a rectangular wood box approximately 4' x 8' in dimensions which is mounted on a 12' metal trailer and is pulled behind a pickup truck to research sites. The box is described in greater detail in another section of this report.

Gas species and proportions eluted from the GC/MS, based on the samples from the canisters and sorbent tubes, are run through the state-of-the-art photochemical model for atmospheric simulations of both ozone formation and aerosols. The model, known as SAPRC (Statewide Air Pollution Research Center), was developed and documented from 1990 through 2010 by Dr. William Carter at the University of California, Riverside. Briefly, SAPRC accounts for all the major and minor gases-- both organic and non-organic (e.g. NO_x, H_2O) -- in a sample of gas mixture (as in the atmosphere), and includes temperature and sun angle as parameters. With a progression of time steps, it calculates how much ozone is formed, as well as how VOCs are converted progressively to CO_2. One can then compare with the MOChA measurement of actual ozone formation in the field – with a small correction for chamber wall losses.

The values obtained from the MOChA are compared to the modeled ozone concentrations that would be expected to be formed based on the identified VOC species and their indexed reactivity. If the amount of ozone formed in the MOChA matches the modeled ozone amounts, within reasonable parameters, then that confirms all of the VOCs being emitted have been measured and identified.

Project Goals and Objectives

The primary goals of this project were to investigate speciated VOC emissions and ozone formation potential from biosolids co-composting, assessing their similarity to those from green waste composting. The data show that the VOC emissions are generally similar, being dominated by small alcohols (primarily ethanol and wood alcohol 'methanol') which have low ozone formation potential.

Sampling Strategy

This research contract funded two field projects of one to two weeks duration each at the two facilities. Sites were chosen for both projects based on (1) willingness to host, (2) being sizable and therefore inherently representative of this diverse industry, (3) being successful and therefore inherently 'good practitioners' in the current industry.

The two facilities selected were:

- City of Santa Rosa, Santa Rosa, CA
- Central Valley Composting, Dos Palos, in Merced County, CA

At Santa Rosa, emissions samples were collected from the biofilter which receives the entire ventilated emissions from the enclosed facility. This included 5 different samplings on 3 different days. In addition, emissions from a large pile of finished compost (which had cured for one month) were also tested twice.

At Dos Palos, 3 samplings were conducted on 2-3 week old compost, 5 samplings of older compost (8.5 to 9.5 weeks) and 2 of finished compost (which had cured for one month beyond the >2 months completion of composting).

Sampling Protocols

The sampling team used a wind tunnel to pull samples off the composting windrow. The wind tunnel is a rectangular stainless steel enclosure with half of the bottom open to receive the source emissions. The model in use has a 0.32 m^2 area and a volume of 0.08 m^3. The wind tunnel is placed 0.5" into the selected composting pile location to fix the tunnel surface. The wind tunnel is equipped with a chemisorbant-and-activated-carbon filter at the intake to clean the air being pulled into the chamber. That filter is replaced after each week of sampling.

The use of the wind tunnel instead of the flux chamber provides a larger surface area, a defined flow direction, and air exchange rates or air speed in the tunnel which may be more representative of natural conditions. Moreover, higher air flow provides dilution of emissions that helps to counter the high humidity interference with the photo-acoustic measuring device used in tandem with the ozone chamber, as well as water aerosol (fog) formation in the ozone chamber – which precludes ozone formation.

The first sampling port in the wind tunnel allows the sampling of inlet air. The second port allows the sampling of post-filter air and the third port is used for source sampling at the tunnel outlet. A perforated stainless steel tube in the tunnel is connected to each sampling port. This perforated sampling tube ensures mixing so that representative samples are collected. The outlet baffle of the tunnel helps avoid back pressure which might be caused by ambient wind during sampling. A fan is used to push the filtered air through the tunnel. The fan mixes the inlet air with the emissions and draws them toward the tunnel

outlet. The bulk speed in the wind tunnel, which is measured using a pressure gauge installed on the tunnel, can be adjusted between 0.13 and 0.47 meters per second, with the resulting air exchanges of 10 to 35 per minute respectively. The velocity profile in the tunnel is fairly uniform and consistent (Schmidt and Bicudo, 2002). After each experiment, the tunnel is wiped and cleaned with dry paper towels and flushed on a clean surface with zero air. All the Teflon tubes are purged with zero air after every experiment.

Samples from the outlet port of the wind tunnel are pulled into a sampling train using Teflon tubing. Flow in each sampling medium is regulated either with a flow regulator (canister) or low flow pumps (sorbent tubes) and excess flow is passed aside to avoid any back pressure.

We used six-liter passivated stainless canisters to collect VOC samples for laboratory analysis using U.S. EPA method TO-15. Charcoal sorbent tubes containing 400 mg and 200 mg of activated carbon in two successive sections were used to collect less volatile/semi volatile organic compounds. Carbonyl compounds (aldehydes and acetone), which may either be present in the sample or may be an oxidation product, were captured using sorbent tubes comprising 300 and 150 mg silica gel impregnated with 2,4-dinitrophenylhydrazine (DNPH) in the front and backup section of the tube (U.S. EPA TO-11A, 1999, ASTM D 5197).

Sampled tubes and field blanks were capped, labeled and placed in polypropylene bags immediately after collection and stored in an ice chest with ice packs. After delivery to the laboratory at the Department of Civil and Environmental Engineering at UC Davis, they were refrigerated until analysis.

In view of the complex nature of composting emissions, multiple sampling techniques are applied to collect the widest possible range of VOCs. Six-liter passivated stainless canisters are used to collect VOC samples to be analyzed in the laboratory using U.S. EPA method TO-15. The charcoal sorbent tubes containing 400 mg and 200 mg of activated carbon in two successive sections are used to collect less volatile/semi volatile organic compounds at the sampling rate of 1.5 L/min for 2 – 3 hrs. Charcoal tubes supplement canister samples to ensure that a full range of hydrocarbons are measured in the sample, but are not typically analyzed unless there is a large disagreement between the model and the MOChA chamber results. (None were analyzed in this study.) Carbonyl compounds (aldehydes and acetone), which may either be present in the sample or may be an oxidation product, are captured using sorbent tubes comprising 300 and 150 mg silica gel impregnated with 2,4-dinitrophenylhydrazine (DNPH) in the front and backup section of the tube (U.S. EPA TO-11A, 1999, ASTM D 5197). Samples would be collected at the sampling flow rate of 200 - 500 mL per min^{-1} for 2-3 hrs. Backup sorbent sections of charcoal and DNPH silica tubes are analyzed to determine the breakthrough of sample collection.

All the sorbent tube samples were collected in duplicate, while more than half of the canisters were also collected in duplicate depending on the availability of canisters and experimental set up. Sampled tubes and field blanks are capped, labeled and placed in polypropylene bags immediately after collection and stored in an ice chest with ice packs as per protocol. Once delivered to the laboratory at the Department of Civil and Environmental Engineering at UC Davis, they are refrigerated until analysis. Canisters were capped and stored at ambient temperature with their filled chain of custody form. One month storage time is the maximum recommended for canister samples (U.S. EPA TO-15). All the experimental details, including location and sample collection information, are maintained in the data sheet. All the samples (sorbent tubes, canisters) were analyzed within 2-3 weeks after sampling.

We measured alcohols, which constitute a major fraction of composting emissions, using an INNOVA photo-acoustic multi-gas monitor. This INNOVA is configured for methanol, ethanol, 2-propanol, and water vapor through the use of respective optical filters, and is calibrated by the instrument manufacturer. This analyzer is capable of monitoring these compounds at one-minute intervals.

Physico-chemical properties of the sampled composting pile were studied along with the VOC measurements. We measured internal pile temperature at 1’ and 4’ deep below the wind tunnel using

commercial-style compost temperature probe. Additional properties of the compost being tested were measured on site using the following protocols:

- Porosity (volumetric addition of water)
- Density (gravimetric and volumetric measurements)
- Moisture saturation (qualitative, with a soil moisture meter), and
- pH (by addition of water to make a paste; USDA Agricultural Handbook 60

Representative samples of each compost source were shipped to the commercial Soil Control Lab (Watsonville, CA) laboratory for analysis of detailed composition in the following categories: nutrients, metals, stability, maturity, pathogens, inerts as well as size and volume distribution. These results are detailed in Appendix C.

Mobile Ozone Chamber

Mobile Ozone Chamber Assays (MOChA) were used for direct on-site measurement of ozone formation from composting emissions. MOChA chambers were characterized and used successfully in our previous studies, which have been published in peer-reviewed journals (Howard, et al., 2008, Kumar et al., 2008, Howard et al., 2010, in press, Kumar et al., 2010 in press).

The MOChA chamber is a rectangular wood box approximately 4' by 8' in dimensions which is mounted on a 12' metal trailer and is pulled behind a pickup truck to research sites. The box is equipped on the inside with 26, 4-foot long UV lights installed on one inner side of the chamber, capable of generating 50 W m^{-2} of UV radiation. These particular types of light bulbs are selected because they give off light in the near ultraviolet portion of the light spectrum, the one which tends to form ozone in the atmosphere, which represents a "worst case" scenario. The MOChA is equipped with two 12" fans to prevent heating of the box above normal summer (ozone season) temperatures of 25-40°C.

A 1,000-liter Teflon bag inside the MOChA chamber is filled with the air sample drawn from the sampling port of the wind tunnel using Teflon-coated diaphragm pumps at a flow rate of approximately 50 L min^{-1} until the bag is full, which takes approximately 20 minutes. A Teflon membrane filter is used at the sampling inlet point of bag to remove particulate matter from the sample.

Nitrogen oxide (NO_x) in the concentration range of 45-55 ppb is introduced into the bag using a gas cylinder (10.1± 0.5 ppm as NO_2 in air) to simulate the typical NO_x level of rural/agricultural areas of the San Joaquin Valley (SJV) during summer ozone episodes. The background reactive organic gases (or minisurrogate) consists of a 55 ± 1 ethylene, 33 ± 1% hexane, and 12 ± 1% xylene mixture by volume, and are also introduced in the bag. The purpose of the minisurrogate is to take the source emissions and mix them with a representative, well-defined atmosphere acting as the receiving air with which emissions from any source will mix. Then we assess how much more ozone is formed than would be formed by the receiving air itself. 6-liter "grab" canister samples of VOC concentration are also collected from the bag at the start of each MOChA experiment, in order to verify that the VOC mixture reaching the bag (through tubing and pump) is identical to that measured directly at the source.

Once the Teflon bag is full with the combined sample and the introduced gas mixtures, the lights are turned on, exposing the bag within the MOChA chamber to 50 W m^{-2} of UV radiation for 180 minutes. Probes measure temperature and relative humidity, while dedicated instruments measure concentrations of oxides of nitrogen (as NO, NO_2 & NO_x) and ozone from sample removed from the Teflon bag at 0-5, 20-30, 55-65, 85-90, 115-120, 145-150, and 175-180 minutes. Ambient air is measured in between bag measurements so that the ozone and NO_x instruments remain active and flowing. The intermittent sampling schedule allows 180-minute experiments to be conducted while ensuring that the final Teflon bag sample volume does not drop below 60-70% of initial bag sample volume – at which point the effects

of increased surface-to-volume ratio would begin to bias the measurements. After each experiment the Teflon bag is emptied and flushed (re-filled and emptied again) with clean air produced by a Zero-Air generator. A new Teflon bag was used for each week in the field. Moreover, each bag is checked for contamination at regular intervals and is replaced with the spare bag whenever required.

Sample Analysis Protocols

Besides the Ozone Chamber measurement, VOC measurements were conducted using three techniques:

1. Photo-acoustic infrared absorption monitored the small alcohols and major non-VOCs: H_2O, CO_2 and NH_3. This occured at the start of the field experiment while the source sample was being filled into the ozone chamber.

2. Canister sampling followed by cryo-focused GC-MS (gas chromatography-mass spectrometer) analysis (for highly volatile and non-polar or semi-polar VOCs) using the established EPA TO-15 protocol.

3. DNPH-impregnated sorbent tubes followed by HPLC (high-performance liquid chromatograph), for highly reactive aldehydes and ketones, using the established EPA TO-11 protocol.

A fourth method, charcoal sorbent tube-sampling followed by solvent elution and GC-MS, was aimed to quantify a broader range of moderately volatile VOCs. This method was used for worker safety through NIOSH (method 1500 for hydrocarbons, method 1501 for aromatic hydrocarbons, and method 1552 for terpenes) and has been described and validated in various publications. These samples have not yet been needed in any study to find ozone-forming VOCs which are not otherwise accounted for. Since they were easy to sample and stable during storage, we collected them 'just in case' there is a mismatch of 50 or 100 ppb in the ozone formation predicted by model versus what was observed in the MOChA.

To determine mass-weighted reactivities, the volume fractions measured on the VOC samples (nL/L or 'ppb') are converted to mole fraction with the ideal gas law: $n = (p * V) / (R * T)$. Then moles are converted to mass with molecular weight: $m = n * MW$. Finally, these are multiplied by the appropriate reactivity (MIR or EBIR) and summed.

Data Analysis

Hundreds of compounds fall under the definition of volatile organic compounds. Some of these compounds contribute significantly to ozone formation in the atmosphere, and others do not. There is no single approach to measure the full range of compounds. We employed multiple techniques in order to obtain the widest possible profile of VOC emissions from the composting source. We combined compounds analyzed by several techniques to make a complete emission profile from the source samples. Results from canister samples gave a wide range of compounds and were supplemented with the carbonyls trapped in the DNPH silica tubes. Alcohols (methanol, ethanol, 2-propanol) were measured with the INNOVA analyzer.

Quality control processes included using field blanks on greater than 10% of all samples, field duplicates, laboratory calibration standards, and laboratory blanks. These processes ensured that canisters and sorbent materials were being kept clean through transport to and from the field, and that field samples were reproducible.

Net ozone formation from MOChA was calculated using the following equation (Carter et al., 1995) because an increase in NO represents a net production of ozone from NO_2 photolysis – independent of VOC reaction:

$$\text{Net } O_3 \text{ formation } (\Delta O_3) = (O_3^{final} - O_3^{initial}) - (NO^{final} - NO^{initial}) \quad (1)$$

We calculate the net ozone formation from the VOCs in the source by subtracting the expected ozone formation from the defined background gas mixture (known as the mini-surrogate) that we added to each MOChA experiment. In some of our earlier studies, the amount of ozone formed from the source VOCs was so high that a small variation in mini-surrogate VOC concentration was insignificant. In this study; however, the amount of ozone formed from the source VOCs was relatively small, so greater precision regarding the mini-surrogate contribution to ozone formation in the chamber was needed. To increase the precision of the ozone modeling from the mini-surrogate, we collected canister samples from the Teflon bag at the start of each MOChA experiment. In this way, we knew the actual concentrations of the mini-surrogate gases in the chamber for each MOChA run.

We measured ozone concentrations inside the MOChA chamber using an ozone analyzer (Model 450, Advanced Pollution Instrumentation, Inc., San Diego, CA). This device uses the ultraviolet absorption method and is accurate to 1 ppb. Concentrations of NO_x (NO and NO_2) were measured inside the ozone chamber using a chemiluminescence analyzer (Model #ML9841A, Teledyne Monitor Labs, Englewood, CO). We subtracted out any production of nitric oxide (NO) because production of NO represents ozone which was formed by the light itself and without the contribution of VOCs.

We ran photo-chemical model calculations for the VOCs obtained from the combined laboratory analysis of the composting emissions to calculate modeled ozone formation. We validated the model in our two previously published papers (Howard et al., *Atmospheric Environment* 42 (2008) 5267–5277 and Kumar et al, *Journal of ASTM International*, Vol. 5, No. 7). When modeled values of ozone formation matched the on-site MOChA values for measured ozone, this confirmed the capture of the complete ozone precursor VOC profile.

Briefly: In order to compare the measurements with our current understanding of atmospheric chemical reactions, calculations were carried out using a modified form of the Caltech Atmospheric Chemistry Mechanism (CACM) (Griffin et al., 2002). Modifications were made to the standard CACM inputs to simulate the light intensity and the UV spectrum produced by the UV lamp assembly used with MOChA. The CACM reactions describing EtOH chemistry were expanded
to accurately account for ethanol chemistry in the Teflon reaction chamber. Ethanol reacts with the hydroxyl radical according to the following equation:

ETOH + OH -> 0.11HOCH2CH2O2 + 0.89CH3CHO + 0.89HO2 (2)

However, in the base case version of CACM, the acetylaldehyde produced by this reaction is lumped into a general aldehyde species with the properties of n-pentanal (C5 molecule). CACM also lumps the peroxy radical as a C4 species. These approximations are made because EtOH chemistry is not usually dominant in large urban systems and so it makes sense to increase computational efficiency by combining species. These lumping approximations have unintended consequences when modeling simple systems dominated by EtOH, because the lumped products lead to unrealistically high amounts of ozone formation. In particular, the lumped C5 aldehyde species creates a five-carbon PAN molecule that produces ozone. The CACM lumping for EtOH was modified by explicitly representing several EtOH reactions as described by the Master Chemical Mechanism (University of Leeds, 2004). Eq. (2) above was retained in the new version of CACM. The mechanism now includes the reactions of acetaldehyde (Eqs. (3–5), the peroxy radical (Eq. (6)), and a few of the subspecies (Eqs. (7–12))). These reactions are shown on the following page:

(Note that species present in excess, such as H_2O and O_2, are omitted, so that some of these equations are not written to depict chemical balance.)

$CH_3CHO + OH \rightarrow CH_3CO_3$ (3)

$CH_3CHO + hv \rightarrow CH_3O_2 + HO_2 + CO$ (4)

$CH_3CHO + NO_3 \rightarrow HNO_3 + CH_3CO_3$ (5)

$HOCH_2CH2O_2 + NO \rightarrow NO_2 + HO_2 + 1.44\ HCHO + 0.28\ HOCH_2CHO$ (6)

$HOCH_2CHO + OH \rightarrow HOCH_2CO_3 + GLYOX + HO_2$ (7)

$HOCH_2CHO + hv \rightarrow HO_2 + HCHO + HO_2 + CO$ (8)

$HOCH_2CHO + NO_3 \rightarrow HOCH_2CO_3 + HNO_3$ (9)

$GLYOX + hv \rightarrow 3CO + HCHO$ (10)

$GLYOX + OH \rightarrow 1.2CO + 0.6HO_2 + 0.4HCOCO_3$ (11)

$GLYOX + NO_3 \rightarrow 1.2CO + 0.6HO_2 + HNO_3 + 0.4HCOCO_3$ (12)

The products of these reactions are defined explicitly in CACM, except for two species, HOCH2CO3 and HCOCO3, which were easily lumped back into the original mechanism. Note that lumped chemical mechanisms that seek to efficiently represent ozone formation do not always conserve carbon mass for the parent VOCs or their products. This treatment is used in many state of the art chemical mechanisms including MCM, RADM, RACM, SAPRC and CACM. The chemical equations used in the current study were taken directly from the MCM and/or CACM parent mechanisms.

Interpretation and Discussion

This research study immediately followed a project using similar methods to report the full range of VOCs emitting from green waste composting, as well as the ozone formation potential (OFP) for those emissions. Testing was initially conducted at the early and intermediate-early stages of the composting process, because emissions from green waste composting are known to be more abundant then.

Since the earlier project was our first effort to conduct complete VOC speciation from composting windrow emissions, different sampling approaches—a flux chamber at the first site and a wind tunnel at the second--were used before adequate overall success was achieved with real-time ozone monitoring in the MOChA chamber. The results from the predecessor study were documented in a peer-reviewed journal article (Kumar et al., *Atmospheric Environment* 45 (2011) 1841-1848.)

In the prior study, VOCs from green waste composting, more than 100 VOCs were detected and quantified in the study, including aliphatic alkanes, alkenes, aromatic hydrocarbons, biogenic organics, aldehydes, ketones, alcohols, furans, acids, esters, ether, halogenated hydrocarbons and dimethyl disulfide (DMDS). Alcohols were found to be the dominating VOCs in the emissions from a composting pile regardless of age, making up from 80-95% of the total emissions in every age pile.

Ozone formation was instigated using the MOChA chamber, measured using an ultra-violet absorption device, compared with photochemical model calculations, and determined to be low. The VOCs making up the great majority of the composting source were considered to be low reactivity; that is, they had a maximum incremental reactivity (MIR) of less than 2, and the overall reactivity of the mix was also very

low. The reactivity of a typical urban VOC mix is moderate, with an average MIR of around 3.6 (http://www.engr.ucr.edu/~carter/SAPRC). Common plant-based biogenic VOCs – such as pinene and limonene – have an MIR around 4.5.

In the current study, we assessed the VOCs and OFP from biosolids co-composting for emissions vented through a rock biofilter, as well as from open windrows with materials of differing ages. Generally, the results were similar to that seen from green waste composting.

This study compared ozone measured in the MOChA chamber with ozone which we would expect to see in the chamber based on the gas concentrations captured in the canisters and tubes and analyzed on the GC-MS. Variations can be explained by several factors, including the limitations of the real-time measurement equipment, the inherent high variability of composting feedstocks, and the inherent variations in microbially driven composting process. But variations must also be taken in the context of a very weak ozone-forming source. Because the net ozone formation numbers were low, small variations look larger. However, the overall picture remains of a VOC source dominated by low-reactivity alcohols and unlikely to play a major role in regional tropospheric ozone formation.

Conclusions

We characterized the VOC emissions coming from biosolids co-composting for emissions vented through a rock biofilter, as well as from open windrows with materials of differing ages. Generally, the results are similar to that seen from green waste composting.

We characterized the emissions from each of these sources, and found that their overall reactivity was low – around 1 on a scale (MIR) where anthropogenic emissions average 3.6.

Three light weight, low reactivity alcohols—ethanol, methanol and isopropyl, made up more than 90 percent of the emissions from all sources tested in this experiment. This is consistent with earlier studies on green waste composting. A wide variety of other compounds were found, including biogenic terpenes and aldehydes, but other compounds almost never comprise more than 1% of the total emissions mix, and most often comprise fractions of a percent.

Using the Maximum Incremental Reactivity (MIR) Scale, the most commonly used method of comparing the relative reactivity of compounds, the range of total volume weighted reactivity of all piles was around 1. The MIR of a typical urban VOC mixture is 3.6. On the Equal Benefit Incremental Reactivity (EBIR) scale, which may be more appropriate for the San Joaquin Valley because of its relatively high levels of natural and man-made VOCs, the volume weighted range of average reactivity ranged from 0.3 to 0.5. The EBIR of a typical urban VOC mixture is 0.81.

The accompanying spreadsheets show all the data obtained: ranked VOC emissions aggregated from all measurement methods, specific VOC results from the separate methods (INNOVA, canister, DNPH) as well as physico-chemical measurements of the source, plus the observations during the ozone chamber runs: temperature, relative humidity, NO_x and ozone. Notably, NO_x was rather high during sampling from the Santa Rosa biofilter, but this was tracked back to emissions from the loading and unloading vehicles operating inside the source building – which have diesel engines. So, regardless of the observed formation of ozone from these samples, the cause was not reactive VOCs, rather it was due to NO_x from high temperature combustion.

Abbreviations, Acronyms, and Glossary

EBIR: Equal Benefit Incremental Reactivity: an ozone yield scale derived by adjusting the NO_x emissions in a base case scenario so VOC and NO_X reductions are equally effective in reducing ozone.

INNOVA: Danish manufacturer of air quality monitoring instruments.

MIR: Maximum Incremental Reactivity, an ozone yield scale derived by adjusting the NO_x emissions in a base case to yield the highest incremental reactivity of the base reactive organic gas mixture.

MOChA: Mobile Ozone Chamber Assay, a portable ozone chamber devised at UC Davis and towed to sampling sites.

NO_x: Oxides of Nitrogen, in air pollution terminology, generally refers to the combustion byproducts of nitric oxide (NO) and nitrogen dioxide (NO_2). It may also refer to nitrous oxide (N_2O).

OFP: Ozone Formation Potential, the reactivity or propensity of a volatile organic compound to form ozone when mixed with NOx.

SJVUAPCD: San Joaquin Valley Unified Air Pollution Control District.

VOC: Volatile Organic Compounds, organic chemical compounds that have high enough vapor pressures under normal conditions to significantly vaporize and enter the atmosphere. A wide range of carbon-based molecules, such as aldehydes, ketones and other light hydrocarbons, are classified as VOCs.

Appendix A

Composting Emission VOCs and Reactivity

There are several accepted scales for measuring the reactivity of organic compounds. MIR stands for the Maximum Incremental Reactivity scale. This tool was developed by William Carter at the University of California, Riverside. MIR was designed for use in air pollution basins where additional hydrocarbons have been determined to have the predominant impact on ozone formation – that is, where NO_x is present in excess. MIR has become the default standard for measuring reactivity. EBIR stands for Equal Benefit Incremental Reactivity. This scale, also developed by William Carter, was optimized for use in air basins where reduction of VOCs and NO_x are equally beneficial (rather than having NO_x in excess), and is appropriate for air basins which are not densely urbanized – such as the San Joaquin Valley. The molecular weight of each VOC is listed as grams per mole (g/mole) which is needed to convert from field & laboratory measurements, which are calibrated to volume dilutions (proportional to number) rather than mass. These leading VOCs found in biosolids co-composting emissions, ranked in descending order of (non-weighted) per cent emissions from the two sites, are led by ethanol and methanol; their reactivities, by both scales, are lower than most other VOCs.

Overall biosolids co-composting VOCs				
ranked by ppbv	**MW**	**MIR**	**EBIR**	**%**
ethanol	46.07	1.53	0.59	44.74
methanol	32.04	0.67	0.19	37.81
2-propanol	60.10	0.61	0.25	12.56
camphor (trimethyl bicyclo heptan-2-one)	152.23	0.49	0.129	0.37
monoterpene	136.23	4.04	0.86	0.32
alpha-pinene	136.23	4.51	0.89	0.25
eucalyptol	152.23	0.49	0.129	0.18
2-methyl 1-propene	56.11	6.29	1.18	0.18
limonene	136.23	4.55	0.96	0.12
3-heptene	98.19	4.43	1.14	0.11
1-propoxy 2-propanol	118.17	2.68	0.92	0.10
naphthalenone octahydro methyl (C11H18O)	154.25	0.86	0.30	0.10
nonanal	142.24	3.16	0.77	0.10
trans decahydronaphthalene (C10H18)	138.25	1.09	0.30	0.10
3-decen-1-ol	152.23	0.49	0.129	0.09
3-ethyl hexane	114.23	1.07	0.35	0.09
3-methyl 1-hexene	98.19	4.41	1.15	0.09
octanal	128.21	3.16	0.77	0.09
heptanal	114.19	3.69	0.92	0.09
dimethylsulphide	62.13	0.25	0.121	0.08
hexanal	100.16	4.35	1.1	0.08
camphene	136.23	4.51	0.89	0.08
cis methyldecahydronaphthalene (C11H20)	152.28	0.91	0.24	0.08
carene	136.23	3.24	0.75	0.07
trans 4-methyldecahydro naphthalene (C11H20)	152.28	0.91	0.24	0.07
undecadiene (C11H20)	152.28	3.65	0.93	0.07
dichlorodifluoromethane	120.91	0	0	0.06
1,1-bicyclohexyl (C12H22)	166.30	0.81	0.19	0.06
methylbicyclo nonane (C10H18)	138.25	1.09	0.30	0.06
3-methyl hexane	100.20	1.61	0.57	0.06
2-octene	112.21	3.25	0.82	0.06
tetramethyl silane	88.22	-0.025	0.036	0.06
acetone	58.08	0.36	0.089	0.06
2,4-dimethyl hexane	114.23	1.73	0.54	0.05
naphthalene 2-ethyldecahydro (C12H22)	166.30	0.81	0.19	0.05

Appendix B

Source Reference Notes (bibliography)

Papers on ozone formation using the mobile chamber:

Cody J. Howard, Wenli Yang, Peter G. Green, Frank Mitloehner, Irina L. Malkina, Robert G. Flocchini, Michael J. Kleeman. *Direct Measurements of the Ozone Formation Potential from Dairy Cattle Emissions Using a Transportable Smog Chamber*, Atmospheric Environment 2008. Vol 42, issue 21, pp 5267-7.

Anuj Kumar, Wenli Yang, Cody J. Howard, MIchael J. Kleeman, Doniche Derrick, Peter G. Greeen, *Assessment of the Ozone Formation Potential from Pesticide Solvents Using a Mobile Ozone Chamber Approach*, Journal of ASTM International 2008 (5) 7.

Cody J. Howard, Anuj Kumar, Frank Mitloehner, Kimberly Stackhouse, Peter G. Green, Robert G. Flocchini, and Michael J. Kleeman, *Direct Measurements of the Ozone Formation Potential from Livestock and Poultry Waste Emissions*, Environmental Science and Technology 44, pp 2292-2298 (2010).

Cody J. Howard, Anuj Kumar, Irina Malkina, Frank Mitloehner, Peter G. Green, Robert G. Flocchini, and Michael J. Kleeman, *Reactive Organic Gas Emissions from Livestock Feed Contribute Significantly to Ozone Production in Central California*, Environmental Science and Technology 44, pp 2309-2314 (2010).

Anuj Kumar, Cody Howard, Doniche Derrick, Irina L. Malkina, Frank M. Mitloehner, Michael J. Kleeman, Wenli Yang, Robert G. Flocchini and Peter G. Green, *Determination of volatile organic compound emissions and ozone formation potential from spraying solvent-based pesticides*, Journal of Environmental Quality (in press). Special Issue on Pesticide Formulations (2011).

Irina L. Malkina, Anuj Kumar, Peter G. Green, and Frank M. Mitloehner, *Identification and quantifitation of volatile organic compounds emitted from dairy silages and other feedstuffs*, Journal of. Environmental. Quality 40, p28-36 (2011).

Anuj Kumar, Chris Alaimo, Robert Horowitz, Frank Mitloehner, Michael J. Kleeman, and Peter G. Green, *Volatile Organic Compound Emissions from Compost: Characterization and Ozone Formation*, Atmospheric .Environment 45 (2011) 1841-1848.

Report to CalRecycle: An Investigation of the Potential for Ground-Level Ozone Formation Resulting from Compost Facility Emissions, DRRR-2011-002, Peter G. Green, 2010 http://www.calrecycle.ca.gov/Publications/default.asp?pubid=1369.

Key papers by William Carter on ozone reactivity:

Author(s): Atkinson, R; Carter, WPL, *Kinetics and Mechanisms of the Gas-Phase Reactions of Ozone with Organic Compounds Under Atmospheric Conditions*, Chemical Reviews, Volume: 84, Issue: 5, Pages: 437-470, 1984.

Carter, WPL, *Development of Ozone Reactivity Scales for Volatile Organic Compounds*, Journal of the Air & Waste Management Association, Volume: 44 Issue: 7 Pages: 881-899 July, 1994.

Carter, WPL, Pierce, JA, Luo, DM et al, *Environmental Chamber Study of Maximum Incremental Reactivities of Volatile Organic Compounds*, Atmospheric Environment, Volume: 29 Issue: 18 Pages: 2499-2511 September, 1995.

Carter, WPL; Luo, DM; Malkina, IL *Investigation of the atmospheric reactions of chloropicrin*, Atmospheric Environment, Volume: 31 Issue: 10 Pages: 1425-1439 May 1997.

For a complete list of all William Carter's papers and reports:

http://www.engr.ucr.edu/~carter/wplcpubs.htm

Links to all his programs including list of reactivities:

http://www.engr.ucr.edu/~carter/wplcpubs.htm

Direct link to all reactivities:

http://www.engr.ucr.edu/~carter/SAPRC/scales07.xls

Appendix C

Compost Analyses

ANALYTICAL CHEMISTS
and
BACTERIOLOGISTS
Approved by State of California

SOIL CONTROL LAB

42 HANGAR WAY
WATSONVILLE
CALIFORNIA
95076
USA

TEL: 831-724-5422
FAX: 831-724-3188
www.compostlab.com

Account #: 0080700-2/2-6680
Group: Aug.10 D #12
Reporting Date: September 8, 2010

UC Davis- Civil & Environmental Engir.
One Shields Ave., Ghausi Hall, Room 2001
Davis, CA 95616
Attn: Isabel Faria

Date Received: 26 Aug. 10
Sample Identification: SR C1 finished compost
Sample ID #: 0080700 - 2/2

Nutrients	Dry wt.	As Rcvd.	units
Total Nitrogen:	1.7	0.98	%
Ammonia (NH_4-N):	910	540	mg/kg
Nitrate (NO_3-N):	69	41	mg/kg
Org. Nitrogen (Org.-N):	1.6	0.95	%
Phosphorus (as P_2O_5):	1.7	0.98	%
Phosphorus (P):	7300	4300	mg/kg
Potassium (as K_2O):	0.79	0.47	%
Potassium (K):	6600	3900	mg/kg
Calcium (Ca):	2.1	1.3	%
Magnesium (Mg):	0.58	0.35	%
Sulfate (SO_4-S):	590	350	mg/kg
Boron (Total B):	23	14	mg/kg
Moisture:	0	40.8	%
Sodium (Na):	0.093	0.055	%
Chloride (Cl):	0.13	0.076	%
pH Value:	NA	8.18	unit
Bulk Density :	21	36	lb/cu ft
Carbonates ($CaCO_3$):	6.2	3.7	lb/ton
Conductivity (EC5):	3.1	NA	mmhos/cm
Organic Matter:	48.1	28.5	%
Organic Carbon:	29.0	17.0	%
Ash:	51.9	30.7	%
C/N Ratio	18	18	ratio
AgIndex	> 10	> 10	ratio

Stability Indicator:		Biologically
CO2 Evolution	Respirometery	Available C
mg CO_2-C/g OM/day	0.72	1.2
mg CO_2-C/g TS/day	0.34	0.57
Stability Rating	*very stable*	*very stable*

Maturity Indicator: Cucumber Bioassay		
Compost:Vermiculite(v:v)	1:1	1:3
Emergence (%)	100	100
Seedling Vigor (%)	92	93
Description of Plants	*healthy*	*healthy*

Pathogens	Results	Units	Rating
Fecal Coliform	9.2	MPN/g	*pass*
Salmonella	< 3	MPN/4g	*pass*

Date Tested: 26 Aug. 10

Inerts	% by weight
Plastic	< 0.5
Glass	< 0.5
Metal	< 0.5
Sharps	ND

Metals	Dry wt.	EPA Limit	units
Aluminum (Al)	7900	-	mg/kg
Arsenic (As):	3.7	41	mg/kg
Cadmium (Cd):	< 1.0	39	mg/kg
Chromium (Cr):	28	1200	mg/kg
Cobalt (Co)	5.4	-	mg/kg
Copper (Cu):	90	1500	mg/kg
Iron (Fe):	15000	-	mg/kg
Lead (Pb):	21	300	mg/kg
Manganese (Mn):	420	-	mg/kg
Mercury (Hg):	< 1.0	17	mg/kg
Molybdenum (Mo):	4.0	75	mg/kg
Nickel (Ni):	30	420	mg/kg
Selenium (Se):	1.6	36	mg/kg
Zinc (Zn):	280	2800	mg/kg

Size & Volume Distribution

MM	% by weight	% by volume	BD g/cc
> 50	0.0	0.0	0.00
25 to 50	0.0	0.0	0.00
16 to 25	0.0	0.0	0.00
9.5 to 16	1.1	0.4	1.28
6.3 to 9.5	7.8	9.1	0.40
4.0 to 6.3	10.3	16.2	0.29
2.0 to 4.0	18.8	22.6	0.38
< 2.0	62.0	51.7	0.56

Bulk Density Description:<.35 Light Materials, .35-.60 medium weight materials, >.60 Heavy Materials

Analyst: Assaf Sadeh

*Sample was received and handled in accordance with TMECC procedures.

Account No.:		Date Received	26 Aug. 10
0080700 - 2/2 - 6680		Sample i.d.	SR C1
Group:	Aug.10 D No. 12	Sample I.d. No.	2/2 0080700

INTERPRETATION:

Is Your Compost Stable?

Respiration Rate — Biodegradation Rate of Your Pile
0.72 mg CO2-C/ g OM/day
++
< Stable >|< Moderately Stable >|< Unstable >|< High For Mulch

Biologically Available Carbon (BAC) — Optimum Degradation Rate
1.2 mg CO2-C/ g OM/day
++++
< Stable >|< Moderately Stable >|< Unstable >|< High For Mulch

Is Your Compost Mature?

AmmoniaN/NitrateN ratio
13 Ratio
++
VeryMature>|< Mature >|< Immature

Ammonia N ppm
910 mg/kg dry wt.
++
VeryMature>|< Mature >|< Immature

Nitrate N ppm
69 mg/kg dry wt.
+++
< Immature >|< Mature

pH value
8.18 units
+++
< Immature >|< Mature >|< Immature

Cucumber Emergence
100.0 percent
++
< Immature >|< Mature

Is Your Compost Safe Regarding Health?

Fecal Coliform
< 1000 MPN/g dry wt.
+++++++
< Safe >|< High Fecal Coliform

Salmonella
Less than 3 /4g dry wt.
+++++++
<Safe (none detected) >|< High Salmonella Count(> 3 per 4 grams)

Metals US EPA 503
Pass dry wt.
+++++++++
<All Metals Pass >|< One or more Metals Fail

Does Your Compost Provide Nutrients or Organic Matter?

Nutrients (N+P2O5+K2O)
4.2 Percent dry wt.
++++++++++++++++++++++++++++++++++++
<Low >|< Average >|< High Nutrient Content

AgIndex (Nutrients / Sodium and Chloride Salts) ((N+P2O5+K2O) / (Na + Cl))
15 Ratio
++
Na & Cl >|< Nutrient and Sodium and Chloride Provider >|< Nutrient Provider

Plant Available Nitrogen (PAN) — Estimated release for first season
14 lbs/ton wet wt.
++
Low Nitrogen Provider>|< Average Nitrogen Provider >|<High Nitrogen Provider

C/N Ratio
18 Ratio
++
< Nitrogen Release >|< N-Neutral >|< N-Demand>|< High Nitrogen Demand

Soluble Available Nutrients & Salts (EC5 w/w dw)
3.1 mmhos/cm dry wt.
++++++++++++++++++
SloRelease>|< Average Nutrient Release Rate >|<High Available Nutrients

Lime Content (CaCO3)
6.2 Lbs/ton dry wt.
++++++++++
< Low >|< Average >|< High Lime Content (as CaCO3)

What are the physical properties of your compost?

Percent Ash
51.9 Percent dry wt.
+++
< High Organic Matter >|< Average >|< High Ash Content

Sieve Size % > 6.3 MM (0.25")
8.9 Percent dry wt.
+++
All Uses >|< Size May Restrict Uses for Potting mix and Golf Courses

Account No.:		Date Received	26 Aug. 10
0080700 - 2/2 - 6680		Sample i.d.	SR C1
Group:	Aug.10 D No. 12	Sample I.d. No.	2/2 0080700

INTERPRETATION:

Is Your Compost Stable?

Respiration Rate

0.72 Low: Good for all uses mg CO2-C/g OM/day

The respiration rate is a measurement of the biodegradation rate of the organic matter in the sample (as received). The respiration rate is determined by measuring the rate at which CO2 is released under optimized moisture and temperature conditions.

Biologically Available Carbon

1.2 Low: Good for all uses mg CO2-C/g OM/day

Biologically Available Carbon (BAC) is a measurement of the rate at which CO2 is released under optimized moisture, temperature, porosity, nutrients, pH and microbial conditions. If both the RR and the BAC test values are close to the same value, the pile is optimized for composting. If both values are high the compost pile just needs more time. If both values are low the compost has stabilized and should be moved to curing. BAC test values that are higher than RR indicate that the compost pile has stalled. This could be due to anaerobic conditions, lack of available nitrogen due to excessive air converting ammonia to the unavailable nitrate form, lack of nitrogen or other nutrients due to poor choice of feedstock, pH value out of range, or microbes rendered non-active.

Is Your Compost Mature?

AmmoniaN:NitrateN ratio

13 immature

Ammonia N ppm

910 immature

Nitrate N ppm

69 mature

pH value

8.18 immature

Composting to stabilize carbon can occur at such a rapid rate that sometimes phytotoxins remain in the compost and must be neutralized before using in high concentrations or in high-end uses. This step is called curing. Typically ammonia is in excess with the break-down of organic materials resulting in an increase in pH. This combination results in a loss of volatile ammonia (it smells). Once this toxic ammonia has been reduced and the pH drops, the microbes convert the ammonia to nitrates. A low ammonia + high nitrate score is indicative of a mature compost, however there are many exceptions. For example, a compost with a low pH (<7) will retain ammonia, while a compost with high lime content can lose ammonia before the organic fraction becomes stable. Composts must first be stable before curing indicators apply.

Cucumber Bioassay

100.0 Percent

Cucumbers are chosen for this test because they are salt tolerant and very sensitive to ammonia and organic acid toxicity. Therefore, we can germinate seeds in high concentrations of compost to measure phytotoxic effects without soluble salts being the limiting factor. Values above 80% for both percent emergence and vigor are indicative of a well-cured compost. Exceptions include very high salts that affect the cucumbers, excessive concentrations of nitrates and other nutrients that will be in range when formulated to make a growing media. In addition to testing a 1:1 compost: vermiculite blend, we also test a diluted 1:4 blend to indicate a more sensitive toxicity level.

Is Your Compost Safe Regarding Health?

Fecal Coliform

< 1000 / g dry wt.

Fecal coliforms can survive in both aerobic and anaerobic conditions and is common in all initial compost piles. Most human pathogens occur from fecal matter and all fecal matter is loaded in fecal coliforms. Therefore fecal coliforms are used as an indicator to determine if the chosen method for pathogen reduction (heat for compost) has met the requirements of sufficient temperature, time and mixing. If the fecal coliforms are reduced to below 1000 per gram dry wt. it is assumed all others pathogens are eliminated. Potential problems are that fecal coliform can regrow during the curing phase or during shipping. This is because the conditions are now more favorable for growth than during the composting process.

Salmonella Bacteria

Less than 3 3 / 4g dry wt.

Salmonella is not only another indicator organism but also a toxic microbe. It has been used in the case of biosolids industry to determine adequate pathogen reduction.

Metals

Pass

The ten heavy metals listed in the EPA 503 regulations are chosen to determine if compost can be applied to ag land and handled without toxic effects. Most high concentrations of heavy metals are derived from woodwaste feedstock such as chrome-arsenic treated or lead painted demolition wood. Biosolids are rarely a problem.

Does Your Compost Provide Nutrients or Organic Matter?

Nutrients (N+P2O5+K2O)

4.2 Average nutrient content

This value is the sum of the primary nutrients Nitrogen, Phosphorus and Potassium. Reported units are consistent with those found on fertilizer formulations. A sum greater than 5 is indicative of a compost with high nutrient content, and best used to supply nutrients to a receiving soil. A sum below 2 indicates low nutrient content, and is best-used to improve soil structure via the addition of organic matter. Most compost falls between 2 and 5.

Account No.:		Date Received	26 Aug. 10	
0080700 - 2/2 - 6680		Sample i.d.	SR C1	
Group:	Aug.10 D No. 12	Sample I.d. No.	2/2	0080700

INTERPRETATION:

AgIndex (Nutrients/Na+Cl)

15 High nutrient ratio Composts with low AgIndex values have high concentrations of sodium and/or chloride compared to nutrients. Repeated use of a compost with a low AgIndex (< 2) may result in sodium and/or chloride acting as the limiting factor compared to nutrients, governing application rates. These composts may be used on well-draining soils and/or with salt-tolerant plants. Additional nutrients form another source may be needed if the application rate is limited by sodium or chloride. If the AgIndex is above 10, nutrients optimal for plant growth will be available without concern of sodium and/or chloride toxicity. Composts with an AgIndex of above 10 are good for increasing nutrient levels for all soils. Most composts score between 2 and 10. Concentrations of nutrients, sodium, and chloride in the receiving soil should be considered when determining compost application rates. The AgIndex is a product of feedstock quality. Feedstock from dairy manure, marine waste, industrial wastes, and halophytic plants are likely to produce a finished compost with a low AgIndex.

Plant Available Nitrogen (lbs/ton)

14 Average N Provider Plant Available Nitrogen (PAN) is calculated by estimating the release rate of Nitrogen from the organic fraction of the compost. This estimate is based on information gathered from the BAC test and measured ammonia and nitrate values. Despite the PAN value of the compost, additional sources of Nitrogen may be needed during he growing season to off-set the Nitrogen demand of the microbes present in the compost. With ample nutrients these microbes can further breakdown organic matter in the compost and release bound Nitrogen. Nitrogen demand based on a high C/N ratio is not considered in the PAN calculation because additional Nitrogen should always be supplemented to the receiving soil when composts with a high C/N ratio are applied.

C/N Ratio

18 Indicates immaturity As a guiding principal, a C/N ratio below 14 indicates maturity and above 14 indicates immaturity, however, there are many exceptions. Large woodchips (>6.3mm), bark, and redwood are slow to breakdown and therefore can result in a relatively stable product while the C/N ratio value is high. Additionally, some composts with chicken manure and/or green grass feedstocks can start with a C/N ratio below 15 and are very unstable. A C/N ratio below 10 supplies Nitrogen, while a ratio above 20 can deplete Nitrogen from the soil. The rate at which Nitrogen will be released or used by the microbes is indicated by the respiration rate (BAC). If the respiration rate is too high the transfer of Nitrogen will not be controlable.

Soluble Nutrients & Salts (EC5 w/w dw - mmhos/cm)

3.1 Average salts This value refers to all soluble ions including nutrients, sodium, chloride and some soluble organic compounds. The concentration of salts will change due to the release of salts from the organic matter as it degrades, volatilization of ammonia, decomposition of soluble organics, and conversion of molecular structure. High salts + high AgIndex is indicative of a compost high in readily available nutrients. The application rate of these composts should be limited by the optimum nutrient value based on soil analysis of the receiving soil. High Salts + low AgIndex is indicative of a compost low in nutrients with high concentrations of sodium and/or chloride. Limit the application rate according to the toxicity level of thesodium and/or chloride. Low salts indicates that the compost can be applied without risking salt toxicity, is likely a good source of organic matter, and that nutrients will release slowly over time.

Lime Content (lbs. per ton)

6.2 Average lime content Compost high in lime or carbonates are often those produced from chicken manure (layers) ash materials, and lime products. These are excellent products to use on a receiving soil where lime has been recommended by soil analysis to raise the pH. Composts with a high lime content should be closely considered for pH requirements when formulating potting mixes.

Physical Properties

Percent Ash

51.9 Average ash content Ash is the non-organic fraction of a compost. Most composts contain approximately 50% ash (dry weight basis). Compost can be high in ash content for many reasons including: excess minerilzation(old compost), contamination with soil base material during turning, poor quality feedstock, and soil or mineral products added. Finding the source and reducing high ash content is often the fastest means to increasing nutrient quality of a compost.

Particle Size % > 6.3 MM (0.25")

8.9 May restrict use Large particles may restrict use for potting soils, golf course topdressings, seed-starter mixes, and where a fine size distribution is required. Composts with large particles can still be used as excellent additions to field soils, shrub mixes and mulches.

Particle Size Distribution

Each size fraction is measured by weight, volume and bulk density. These results are particularly relevent with decisions to screen or not, and if screening, which size screen to use. The bulk density indicates if the fraction screened is made of light weight organic material or heavy mineral material. Removing large mineral material can greatly improve compost quality by increasing nutrient and organic concentrations.

Appendix:

Plant Available Nitrogen (PAN) calculations:
PAN = (X * (organic N)) + ((NH4-N) + (NO3-N))
X value = If BAC < 2 then X = 0.1
If BAC =2.1 to 5 then X = 0.2
If BAC =5.1 to 10 then X = 0.3
If BAC > 10 then X = 0.4
Note: If C/N ratio > 15 additional N should be applied.

Estimated available nutrients for use when calculating application rates

	lbs/ton
Plant Available Nitrogen (PAN)	13.9
Ammonia (NH4-N)	1.08
Nitrate (NO3-N)	0.08
Available Phosphorus (P2O5*0.64)	12.5
Available Potassium (K2O)	9.4

ANALYTICAL CHEMISTS
and
BACTERIOLOGISTS
Approved by State of California

SOIL CONTROL LAB

42 HANGAR WAY
WATSONVILLE
CALIFORNIA
95076
USA

TEL: 831-724-5422
FAX: 831-724-3188
www.compostlab.com

Account #: 0080700-1/2-6680
Group: Aug.10 D #11
Reporting Date: September 8, 2010

UC Davis- Civil & Environmental Engir.
One Shields Ave., Ghausi Hall, Room 2001
Davis, CA 95616
Attn: Isabel Faria

Date Received: 26 Aug. 10
Sample Identification: SR C0 average compost
Sample ID #: 0080700 - 1/2

Nutrients	Dry wt.	As Rcvd.	units
Total Nitrogen:	1.3	0.79	%
Ammonia (NH_4-N):	570	340	mg/kg
Nitrate (NO_3-N):	40	24	mg/kg
Org. Nitrogen (Org.-N):	1.2	0.71	%
Phosphorus (as P_2O_5):	0.98	0.58	%
Phosphorus (P):	4300	2600	mg/kg
Potassium (as K_2O):	0.77	0.45	%
Potassium (K):	6400	3800	mg/kg
Calcium (Ca):	1.4	0.81	%
Magnesium (Mg):	0.43	0.25	%
Sulfate (SO_4-S):	620	370	mg/kg
Boron (Total B):	18	11	mg/kg
Moisture:	0	40.6	%
Sodium (Na):	0.074	0.044	%
Chloride (Cl):	0.11	0.062	%
pH Value:	NA	7.71	unit
Bulk Density :	22	37	lb/cu ft
Carbonates ($CaCO_3$):	2.3	1.3	lb/ton
Conductivity (EC5):	2.4	NA	mmhos/cm
Organic Matter:	62.5	37.1	%
Organic Carbon:	30.0	18.0	%
Ash:	37.5	22.3	%
C/N Ratio	23	23	ratio
AgIndex	> 10	> 10	ratio

Stability Indicator:		Biologically
CO2 Evolution	Respirometery	Available C
mg CO_2-C/g OM/day	2.5	2.6
mg CO_2-C/g TS/day	1.6	1.6
Stability Rating	*stable*	*stable*

Maturity Indicator: Cucumber Bioassay		
Compost:Vermiculite(v:v)	1:1	1:3
Emergence (%)	100	100
Seedling Vigor (%)	100	100
Description of Plants	*healthy*	*healthy*

Pathogens	Results	Units	Rating
Fecal Coliform	250	MPN/g	*pass*
Salmonella	< 3	MPN/4g	*pass*

Date Tested: 26 Aug. 10

Inerts	% by weight
Plastic	< 0.5
Glass	< 0.5
Metal	1.2
Sharps	ND

Metals	Dry wt.	EPA Limit	units
Aluminum (Al)	6600	-	mg/kg
Arsenic (As):	2.5	41	mg/kg
Cadmium (Cd):	< 1.0	39	mg/kg
Chromium (Cr):	50	1200	mg/kg
Cobalt (Co)	4.2	-	mg/kg
Copper (Cu):	62	1500	mg/kg
Iron (Fe):	12000	-	mg/kg
Lead (Pb):	12	300	mg/kg
Manganese (Mn):	290	-	mg/kg
Mercury (Hg):	< 1.0	17	mg/kg
Molybdenum (Mo):	4.3	75	mg/kg
Nickel (Ni):	24	420	mg/kg
Selenium (Se):	0.96	36	mg/kg
Zinc (Zn):	170	2800	mg/kg

Size & Volume Distribution			
MM	% by weight	% by volume	BD g/cc
> 50	0.0	0.0	0.00
25 to 50	0.0	0.0	0.00
16 to 25	29.2	21.3	0.62
9.5 to 16	37.2	34.4	0.49
6.3 to 9.5	9.6	16.4	0.26
4.0 to 6.3	4.5	6.6	0.31
2.0 to 4.0	5.9	8.2	0.32
< 2.0	13.5	13.1	0.46

Bulk Density Description:<.35 Light Materials, .35-.60 medium weight materials, >.60 Heavy Materials

Analyst: Assaf Sadeh

*Sample was received and handled in accordance with TMECC procedures.

Account No.:		Date Received	26 Aug. 10
0080700 - 1/2 - 6680		Sample i.d.	SR C0
Group:	Aug.10 D No. 11	Sample I.d. No.	1/2 0080700

INTERPRETATION:

Is Your Compost Stable?

Respiration Rate — Biodegradation Rate of Your Pile

2.5 mg CO2-C/ g OM/day

```
++++++++++
< Stable >|< Moderately Stable >|< Unstable >|< High For Mulch
```

Biologically Available Carbon (BAC) — Optimum Degradation Rate

2.6 mg CO2-C/ g OM/day

```
++++++++++
< Stable >|< Moderately Stable >|< Unstable >|< High For Mulch
```

Is Your Compost Mature?

AmmoniaN/NitrateN ratio

14 Ratio

```
++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
VeryMature>|< Mature >|< Immature
```

Ammonia N ppm

570 mg/kg dry wt.

```
++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
VeryMature>|< Mature >|< Immature
```

Nitrate N ppm

40 mg/kg dry wt.

```
++++++++++++++++++++++++++++++++++
< Immature >|< Mature
```

pH value

7.71 units

```
++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
< Immature >|< Mature >|< Immature
```

Cucumber Emergence

100.0 percent

```
++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
< Immature >|< Mature
```

Is Your Compost Safe Regarding Health?

Fecal Coliform

< 1000 MPN/g dry wt.

```
+++++++
< Safe >|< High Fecal Coliform
```

Salmonella

Less than 3 /4g dry wt.

```
+++++++
<Safe (none detected) >|< High Salmonella Count(> 3 per 4 grams)
```

Metals US EPA 503

Pass dry wt.

```
++++++++++
<All Metals Pass >|< One or more Metals Fail
```

Does Your Compost Provide Nutrients or Organic Matter?

Nutrients (N+P2O5+K2O)

3.0 Percent dry wt.

```
++++++++++++++++++++++++++
<Low >|< Average >|< High Nutrient Content
```

AgIndex (Nutrients / Sodium and Chloride Salts) — ((N+P2O5+K2O) / (Na + Cl))

15 Ratio

```
++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Na & Cl >|< Nutrient and Sodium and Chloride Provider >|< Nutrient Provider
```

Plant Available Nitrogen (PAN) — Estimated release for first season

11 lbs/ton wet wt.

```
++++++++++++++++++++++++++++++++++++++++++++
Low Nitrogen Provider>|< Average Nitrogen Provider >|<High Nitrogen Provider
```

C/N Ratio

23 Ratio

```
++++++++++++++++++++++++++++++++++++++++++++++++
< Nitrogen Release >|< N-Neutral >|< N-Demand>|< High Nitrogen Demand
```

Soluble Available Nutrients & Salts (EC5 w/w dw)

2.4 mmhos/cm dry wt.

```
++++++++++++
SloRelease>|< Average Nutrient Release Rate >|<High Available Nutrients
```

Lime Content (CaCO3)

2.3 Lbs/ton dry wt.

```
+++
< Low >|< Average >|< High Lime Content (as CaCO3)
```

What are the physical properties of your compost?

Percent Ash

37.5 Percent dry wt.

```
++++++++++++++++++++++++++++++
< High Organic Matter >|< Average >|< High Ash Content
```

Sieve Size % > 6.3 MM (0.25")

76.1 Percent dry wt.

```
++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
All Uses >|< Size May Restrict Uses for Potting mix and Golf Courses
```

Account No.:		Date Received	26 Aug. 10
0080700 - 1/2 - 6680		Sample i.d.	SR C0
Group:	Aug.10 D No. 11	Sample I.d. No.	1/2 0080700

INTERPRETATION:

Is Your Compost Stable?

Respiration Rate

2.5 Low: Good for all uses mg CO2-C/g OM/day

The respiration rate is a measurement of the biodegradation rate of the organic matter in the sample (as received). The respiration rate is determined by measuring the rate at which CO2 is released under optimized moisture and temperature conditions.

Biologically Available Carbon

2.6 Low: Good for all uses mg CO2-C/g OM/day

Biologically Available Carbon (BAC) is a measurement of the rate at which CO2 is released under optimized moisture, temperature, porosity, nutrients, pH and microbial conditions. If both the RR and the BAC test values are close to the same value, the pile is optimized for composting. If both values are high the compost pile just needs more time. If both values are low the compost has stabilized and should be moved to curing. BAC test values that are higher than RR indicate that the compost pile has stalled. This could be due to anaerobic conditions, lack of available nitrogen due to excessive air converting ammonia to the unavailable nitrate form, lack of nitrogen or other nutrients due to poor choice of feedstock, pH value out of range, or microbes rendered non-active.

Is Your Compost Mature?

AmmoniaN:NitrateN ratio

14 immature

Ammonia N ppm

570 immature

Nitrate N ppm

40 immature

pH value

7.71 mature

Composting to stabilize carbon can occur at such a rapid rate that sometimes phytotoxins remain in the compost and must be neutralized before using in high concentrations or in high-end uses. This step is called curing. Typically ammonia is in excess with the break-down of organic materials resulting in an increase in pH. This combination results in a loss of volatile ammonia (it smells). Once this toxic ammonia has been reduced and the pH drops, the microbes convert the ammonia to nitrates. A low ammonia + high nitrate score is indicative of a mature compost, however there are many exceptions. For example, a compost with a low pH (<7) will retain ammonia, while a compost with high lime content can lose ammonia before the organic fraction becomes stable. Composts must first be stable before curing indicators apply.

Cucumber Bioassay

100.0 Percent

Cucumbers are chosen for this test because they are salt tolerant and very sensitive to ammonia and organic acid toxicity. Therefore, we can germinate seeds in high concentrations of compost to measure phytotoxic effects without soluble salts being the limiting factor. Values above 80% for both percent emergence and vigor are indicative of a well-cured compost. Exceptions include very high salts that affect the cucumbers, excessive concentrations of nitrates and other nutrients that will be in range when formulated to make a growing media. In addition to testing a 1:1 compost: vermiculite blend, we also test a diluted 1:4 blend to indicate a more sensitive toxicity level.

Is Your Compost Safe Regarding Health?

Fecal Coliform

< 1000 / g dry wt. Fecal coliforms can survive in both aerobic and anaerobic conditions and is common in all initial compost piles. Most human pathogens occur from fecal matter and all fecal matter is loaded in fecal coliforms. Therefore fecal coliforms are used as an indicator to determine if the chosen method for pathogen reduction (heat for compost) has met the requirements of sufficient temperature, time and mixing. If the fecal coliforms are reduced to below 1000 per gram dry wt. it is assumed all others pathogens are eliminated. Potential problems are that fecal coliform can regrow during the curing phase or during shipping. This is because the conditions are now more favorable for growth than during the composting process.

Salmonella Bacteria

Less than 3 3 / 4g dry wt. Salmonella is not only another indicator organism but also a toxic microbe. It has been used in the case of biosolids industry to determine adequate pathogen reduction.

Metals

Pass The ten heavy metals listed in the EPA 503 regulations are chosen to determine if compost can be applied to ag land and handled without toxic effects. Most high concentrations of heavy metals are derived from woodwaste feedstock such as chrome-arsenic treated or lead painted demolition wood. Biosolids are rarely a problem.

Does Your Compost Provide Nutrients or Organic Matter?

Nutrients (N+P2O5+K2O)

3.0 Average nutrient content

This value is the sum of the primary nutrients Nitrogen, Phosphorus and Potassium. Reported units are consistent with those found on fertilizer formulations. A sum greater than 5 is indicative of a compost with high nutrient content, and best used to supply nutrients to a receiving soil. A sum below 2 indicates low nutrient content, and is best-used to improve soil structure via the addition of organic matter. Most compost falls between 2 and 5.

Account No.:		Date Received	26 Aug. 10	
0080700 - 1/2 - 6680		Sample i.d.	SR C0	
Group:	Aug.10 D No. 11	Sample I.d. No.	1/2	0080700

INTERPRETATION:

AgIndex (Nutrients/Na+Cl)

15 High nutrient ratio Composts with low AgIndex values have high concentrations of sodium and/or chloride compared to nutrients. Repeated use of a compost with a low AgIndex (< 2) may result in sodium and/or chloride acting as the limiting factor compared to nutrients, governing application rates. These composts may be used on well-draining soils and/or with salt-tolerant plants. Additional nutrients form another source may be needed if the application rate is limited by sodium or chloride. If the AgIndex is above 10, nutrients optimal for plant growth will be available without concern of sodium and/or chloride toxicity. Composts with an AgIndex of above 10 are good for increasing nutrient levels for all soils. Most composts score between 2 and 10. Concentrations of nutrients, sodium, and chloride in the receiving soil should be considered when determining compost application rates. The AgIndex is a product of feedstock quality. Feedstock from dairy manure, marine waste, industrial wastes, and halophytic plants are likely to produce a finished compost with a low AgIndex.

Plant Available Nitrogen (lbs/ton)

11 Average N Provider Plant Available Nitrogen (PAN) is calculated by estimating the release rate of Nitrogen from the organic fraction of the compost. This estimate is based on information gathered from the BAC test and measured ammonia and nitrate values. Despite the PAN value of the compost, additional sources of Nitrogen may be needed during he growing season to off-set the Nitrogen demand of the microbes present in the compost. With ample nutrients these microbes can further breakdown organic matter in the compost and release bound Nitrogen. Nitrogen demand based on a high C/N ratio is not considered in the PAN calculation because additional Nitrogen should always be supplemented to the receiving soil when composts with a high C/N ratio are applied.

C/N Ratio

23 Indicates immaturity As a guiding principal, a C/N ratio below 14 indicates maturity and above 14 indicates immaturity, however, there are many exceptions. Large woodchips (>6.3mm), bark, and redwood are slow to breakdown and therefore can result in a relatively stable product while the C/N ratio value is high. Additionally, some composts with chicken manure and/or green grass feedstocks can start with a C/N ratio below 15 and are very unstable. A C/N ratio below 10 supplies Nitrogen, while a ratio above 20 can deplete Nitrogen from the soil. The rate at which Nitrogen will be released or used by the microbes is indicated by the respiration rate (BAC). If the respiration rate is too high the transfer of Nitrogen will not be controlable.

Soluble Nutrients & Salts (EC5 w/w dw - mmhos/cm)

2.4 Average salts This value refers to all soluble ions including nutrients, sodium, chloride and some soluble organic compounds. The concentration of salts will change due to the release of salts from the organic matter as it degrades, volatilization of ammonia, decomposition of soluble organics, and conversion of molecular structure. High salts + high AgIndex is indicative of a compost high in readily available nutrients. The application rate of these composts should be limited by the optimum nutrient value based on soil analysis of the receiving soil. High Salts + low AgIndex is indicative of a compost low in nutrients with high concentrations of sodium and/or chloride. Limit the application rate according to the toxicity level of thesodium and/or chloride. Low salts indicates that the compost can be applied without risking salt toxicity, is likely a good source of organic matter, and that nutrients will release slowly over time.

Lime Content (lbs. per ton)

2.3 Low lime content Compost high in lime or carbonates are often those produced from chicken manure (layers) ash materials, and lime products. These are excellent products to use on a receiving soil where lime has been recommended by soil analysis to raise the pH. Composts with a high lime content should be closely considered for pH requirements when formulating potting mixes.

Physical Properties

Percent Ash

37.5 Average ash content Ash is the non-organic fraction of a compost. Most composts contain approximately 50% ash (dry weight basis). Compost can be high in ash content for many reasons including: excess minerilzation(old compost), contamination with soil base material during turning, poor quality feedstock, and soil or mineral products added. Finding the source and reducing high ash content is often the fastest means to increasing nutrient quality of a compost.

Particle Size % > 6.3 MM (0.25")

76.1 May restrict use Large particles may restrict use for potting soils, golf course topdressings, seed-starter mixes, and where a fine size distribution is required. Composts with large particles can still be used as excellent additions to field soils, shrub mixes and mulches.

Particle Size Distribution

Each size fraction is measured by weight, volume and bulk density. These results are particularly relevent with decisions to screen or not, and if screening, which size screen to use. The bulk density indicates if the fraction screened is made of light weight organic material or heavy mineral material. Removing large mineral material can greatly improve compost quality by increasing nutrient and organic concentrations.

Appendix:

Plant Available Nitrogen (PAN) calculations:
PAN = (X * (organic N)) + ((NH4-N) + (NO3-N))

X value =	If BAC < 2 then X = 0.1
	If BAC =2.1 to 5 then X = 0.2
	If BAC =5.1 to 10 then X = 0.3
	If BAC > 10 then X = 0.4

Note: If C/N ratio > 15 additional N should be applied.

Estimated available nutrients for use when calculating application rates

	lbs/ton
Plant Available Nitrogen (PAN)	10.6
Ammonia (NH4-N)	0.68
Nitrate (NO3-N)	0.05
Available Phosphorus (P2O5*0.64)	7.6
Available Potassium (K2O)	9.2

ANALYTICAL CHEMISTS
and
BACTERIOLOGISTS
Approved by State of California

SOIL CONTROL LAB

42 HANGAR WAY
WATSONVILLE
CALIFORNIA
95076
USA

TEL: 831-724-5422
FAX: 831-724-3188
www.compostlab.com

Account #: 0100335-1/6-6680
Group: Oct.10 C #12
Reporting Date: October 27, 2010

UC Davis- Civil & Environmental Engir.
One Shields Ave., Ghausi Hall, Room 2001
Davis, CA 95616
Attn: Isabel Faria

Date Received: 13 Oct. 10
Sample Identification: #1A Merced 2 Wk Comp
Sample ID #: 0100335 - 1/6

Nutrients	Dry wt.	As Rcvd.	units
Total Nitrogen:	2.1	0.95	%
Ammonia (NH_4-N):	4200	1900	mg/kg
Nitrate (NO_3-N):	1.9	0.88	mg/kg
Org. Nitrogen (Org.-N):	1.7	0.77	%
Phosphorus (as P_2O_5):	3.5	1.6	%
Phosphorus (P):	15000	7000	mg/kg
Potassium (as K_2O):	0.80	0.36	%
Potassium (K):	6600	3000	mg/kg
Calcium (Ca):	2.0	0.91	%
Magnesium (Mg):	0.68	0.31	%
Sulfate (SO_4-S):	1900	860	mg/kg
Boron (Total B):	25	11	mg/kg
Moisture:	0	54.6	%
Sodium (Na):	0.17	0.076	%
Chloride (Cl):	0.4	0.18	%
pH Value:	NA	8.00	unit
Bulk Density :	20	45	lb/cu ft
Carbonates ($CaCO_3$):	11	4.9	lb/ton
Conductivity (EC5):	8.9	NA	mmhos/cm
Organic Matter:	48.7	22.1	%
Organic Carbon:	24.0	11.0	%
Ash:	51.3	23.3	%
C/N Ratio	12	12	ratio
AgIndex	> 10	> 10	ratio

Stability Indicator:		Biologically
CO2 Evolution	Respirometery	Available C
mg CO_2-C/g OM/day	2.5	4.5
mg CO_2-C/g TS/day	1.2	2.2
Stability Rating	*stable*	*stable*

Maturity Indicator: Cucumber Bioassay		
Compost:Vermiculite(v:v)	1:1	1:3
Emergence (%)	42	100
Seedling Vigor (%)	0	70
Description of Plants	*stunted*	*stunted*

Pathogens	Results	Units	Rating
Fecal Coliform	> 1700	MPN/g	*fail*
Salmonella	< 3	MPN/4g	*pass*

Date Tested: 13 Oct. 10

Inerts	% by weight
Plastic	0.58
Glass	< 0.5
Metal	< 0.5
Sharps	ND

Metals	Dry wt.	EPA Limit	units
Aluminum (Al)	7100	-	mg/kg
Arsenic (As):	3.8	41	mg/kg
Cadmium (Cd):	< 1.0	39	mg/kg
Chromium (Cr):	45	1200	mg/kg
Cobalt (Co)	3.7	-	mg/kg
Copper (Cu):	160	1500	mg/kg
Iron (Fe):	49000	-	mg/kg
Lead (Pb):	17	300	mg/kg
Manganese (Mn):	240	-	mg/kg
Mercury (Hg):	< 1.0	17	mg/kg
Molybdenum (Mo):	7.6	75	mg/kg
Nickel (Ni):	22	420	mg/kg
Selenium (Se):	1.3	36	mg/kg
Zinc (Zn):	390	2800	mg/kg

Size & Volume Distribution			
MM	% by weight	% by volume	BD g/cc
> 50	0.0	0.0	0.00
25 to 50	0.0	0.0	0.00
16 to 25	9.7	12.6	0.31
9.5 to 16	11.1	18.9	0.24
6.3 to 9.5	8.7	10.5	0.34
4.0 to 6.3	4.6	4.2	0.44
2.0 to 4.0	10.9	9.5	0.47
< 2.0	55.0	44.2	0.51

Bulk Density Description:<.35 Light Materials, .35-.60 medium weight materials, >.60 Heavy Materials

Analyst: Assaf Sadeh

*Sample was received and handled in accordance with TMECC procedures.

Account No.:		Date Received	13 Oct. 10
0100335 - 1/6 - 6680		Sample i.d.	#1A Merced 2 Wk Comp
Group:	Oct.10 C No. 12	Sample I.d. No.	1/6 0100335

INTERPRETATION: Page one of three

Is Your Compost Stable?

Respiration Rate — Biodegradation Rate of Your Pile

2.5 mg CO2-C/ g OM/day

```
+++++++++
< Stable      >|<  Moderately Stable  >|<  Unstable                >|< High For Mulch
```

Biologically Available Carbon (BAC) — Optimum Degradation Rate

4.5 mg CO2-C/ g OM/day

```
++++++++++++++++++
< Stable      >|< Moderately Stable   >|<  Unstable                >|< High For Mulch
```

Is Your Compost Mature?

AmmoniaN/NitrateN ratio

2200 Ratio

```
+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
VeryMature>|<                Mature                                  >|<  Immature
```

Ammonia N ppm

4200 mg/kg dry wt.

```
+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
VeryMature>|<                Mature                                  >|<  Immature
```

Nitrate N ppm

1.9 mg/kg dry wt.

```
+
<   Immature                                  >|<  Mature
```

pH value

8.00 units

```
+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
<   Immature                                          >|< Mature        >|< Immature
```

Cucumber Emergence

41.7 percent

```
++++++++++++++++++++++++++++++++++
<   Immature                                                    >|< Mature
```

Is Your Compost Safe Regarding Health?

Fecal Coliform

> 1000 MPN/g dry wt.

```
+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
<  Safe                                                  >|< High Fecal Coliform
```

Salmonella

Less than 3 /4g dry wt.

```
+++++++
<Safe   (none detected)                    >|< High Salmonella Count(> 3 per 4 grams)
```

Metals US EPA 503

Pass dry wt.

```
+++++++++
<All Metals Pass                           >|< One or more Metals Fail
```

Does Your Compost Provide Nutrients or Organic Matter?

Nutrients (N+P2O5+K2O)

6.3 Percent dry wt.

```
++++++++++++++++++++++++++++++++++++++++++++++++++
<Low            >|< Average                >|< High Nutrient Content
```

AgIndex (Nutrients / Sodium and Chloride Salts) ((N+P2O5+K2O) / (Na + Cl))

11 Ratio

```
+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Na & Cl    >|<  Nutrient and Sodium and Chloride Provider      >|<  Nutrient Provider
```

Plant Available Nitrogen (PAN) — Estimated release for first season

18 lbs/ton wet wt.

```
++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Low Nitrogen Provider>|<        Average Nitrogen Provider                >|<High Nitrogen Provider
```

C/N Ratio

12 Ratio

```
++++++++++++++++++++++++
< Nitrogen Release    >|< N-Neutral >|< N-Demand>|<  High Nitrogen Demand
```

Soluble Available Nutrients & Salts (EC5 w/w dw)

8.9 mmhos/cm dry wt.

```
++++++++++++++++++++++++++++++++++++++++++++++++
SloRelease>|<  Average Nutrient Release Rate     >|<High Available Nutrients
```

Lime Content (CaCO3)

11 Lbs/ton dry wt.

```
++++++++++++++++++
<  Low  >|<            Average            >|<  High  Lime Content (as CaCO3)
```

What are the physical properties of your compost?

Percent Ash

51.3 Percent dry wt.

```
+++++++++++++++++++++++++++++++++++++++++++
<  High Organic Matter          >|<   Average                >|<  High Ash Content
```

Sieve Size % > 6.3 MM (0.25")

29.5 Percent dry wt.

```
+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
All Uses          >|< Size May Restrict Uses for Potting mix and Golf Courses
```

Account No.:		Date Received	13 Oct. 10
0100335 - 1/6 - 6680		Sample i.d.	#1A Merced 2 Wk Comp
Group:	Oct.10 C No. 12	Sample I.d. No.	1/6 0100335

INTERPRETATION:

Is Your Compost Stable?

Respiration Rate

2.5 Low: Good for all uses mg CO2-C/g OM/day

The respiration rate is a measurement of the biodegradation rate of the organic matter in the sample (as received). The respiration rate is determined by measuring the rate at which CO2 is released under optimized moisture and temperature conditions.

Biologically Available Carbon

4.5 Moderate-selected use mg CO2-C/g OM/day

Biologically Available Carbon (BAC) is a measurement of the rate at which CO2 is released under optimized moisture, temperature, porosity, nutrients, pH and microbial conditions. If both the RR and the BAC test values are close to the same value, the pile is optimized for composting. If both values are high the compost pile just needs more time. If both values are low the compost has stabilized and should be moved to curing. BAC test values that are higher than RR indicate that the compost pile has stalled. This could be due to anaerobic conditions, lack of available nitrogen due to excessive air converting ammonia to the unavailable nitrate form, lack of nitrogen or other nutrients due to poor choice of feedstock, pH value out of range, or microbes rendered non-active.

Is Your Compost Mature?

AmmoniaN:NitrateN ratio

2200 immature

Ammonia N ppm

4200 immature

Nitrate N ppm

1.9 immature

pH value

8.00 mature

Composting to stabilize carbon can occur at such a rapid rate that sometimes phytotoxins remain in the compost and must be neutralized before using in high concentrations or in high-end uses. This step is called curing. Typically ammonia is in excess with the break-down of organic materials resulting in an increase in pH. This combination results in a loss of volatile ammonia (it smells). Once this toxic ammonia has been reduced and the pH drops, the microbes convert the ammonia to nitrates. A low ammonia + high nitrate score is indicative of a mature compost, however there are many exceptions. For example, a compost with a low pH (<7) will retain ammonia, while a compost with high lime content can lose ammonia before the organic fraction becomes stable. Composts must first be stable before curing indicators apply.

Cucumber Bioassay

41.7 Percent

Cucumbers are chosen for this test because they are salt tolerant and very sensitive to ammonia and organic acid toxicity. Therefore, we can germinate seeds in high concentrations of compost to measure phytotoxic effects without soluble salts being the limiting factor. Values above 80% for both percent emergence and vigor are indicative of a well-cured compost. Exceptions include very high salts that affect the cucumbers, excessive concentrations of nitrates and other nutrients that will be in range when formulated to make a growing media. In addition to testing a 1:1 compost: vermiculite blend, we also test a diluted 1:4 blend to indicate a more sensitive toxicity level.

Is Your Compost Safe Regarding Health?

Fecal Coliform

> 1000 / g dry wt.

Fecal coliforms can survive in both aerobic and anaerobic conditions and is common in all initial compost piles. Most human pathogens occur from fecal matter and all fecal matter is loaded in fecal coliforms. Therefore fecal coliforms are used as an indicator to determine if the chosen method for pathogen reduction (heat for compost) has met the requirements of sufficient temperature, time and mixing. If the fecal coliforms are reduced to below 1000 per gram dry wt. it is assumed all others pathogens are eliminated. Potential problems are that fecal coliform can regrow during the curing phase or during shipping. This is because the conditions are now more favorable for growth than during the composting process.

Salmonella Bacteria

Less than 3 3 / 4g dry wt.

Salmonella is not only another indicator organism but also a toxic microbe. It has been used in the case of biosolids industry to determine adequate pathogen reduction.

Metals

Pass

The ten heavy metals listed in the EPA 503 regulations are chosen to determine if compost can be applied to ag land and handled without toxic effects. Most high concentrations of heavy metals are derived from woodwaste feedstock such as chrome-arsenic treated or lead painted demolition wood. Biosolids are rarely a problem.

Does Your Compost Provide Nutrients or Organic Matter?

Nutrients (N+P2O5+K2O)

6.3 High nutrient content

This value is the sum of the primary nutrients Nitrogen, Phosphorus and Potassium. Reported units are consistent with those found on fertilizer formulations. A sum greater than 5 is indicative of a compost with high nutrient content, and best used to supply nutrients to a receiving soil. A sum below 2 indicates low nutrient content, and is best-used to improve soil structure via the addition of organic matter. Most compost falls between 2 and 5.

Account No.:		Date Received	13 Oct. 10
0100335 - 1/6 - 6680		Sample i.d.	#1A Merced 2 Wk Comp
Group:	Oct.10 C No. 12	Sample I.d. No.	1/6 0100335

INTERPRETATION:

AgIndex (Nutrients/Na+Cl)

11 High nutrient ratio Composts with low AgIndex values have high concentrations of sodium and/or chloride compared to nutrients. Repeated use of a compost with a low AgIndex (< 2) may result in sodium and/or chloride acting as the limiting factor compared to nutrients, governing application rates. These composts may be used on well-draining soils and/or with salt-tolerant plants. Additional nutrients form another source may be needed if the application rate is limited by sodium or chloride. If the AgIndex is above 10, nutrients optimal for plant growth will be available without concern of sodium and/or chloride toxicity. Composts with an AgIndex of above 10 are good for increasing nutrient levels for all soils. Most composts score between 2 and 10. Concentrations of nutrients, sodium, and chloride in the receiving soil should be considered when determining compost application rates. The AgIndex is a product of feedstock quality. Feedstock from dairy manure, marine waste, industrial wastes, and halophytic plants are likely to produce a finished compost with a low AgIndex.

Plant Available Nitrogen (lbs/ton)

18 High N Provider Plant Available Nitrogen (PAN) is calculated by estimating the release rate of Nitrogen from the organic fraction of the compost. This estimate is based on information gathered from the BAC test and measured ammonia and nitrate values. Despite the PAN value of the compost, additional sources of Nitrogen may be needed during he growing season to off-set the Nitrogen demand of the microbes present in the compost. With ample nutrients these microbes can further breakdown organic matter in the compost and release bound Nitrogen. Nitrogen demand based on a high C/N ratio is not considered in the PAN calculation because additional Nitrogen should always be supplemented to the receiving soil when composts with a high C/N ratio are applied.

C/N Ratio

12 Indicates maturity As a guiding principal, a C/N ratio below 14 indicates maturity and above 14 indicates immaturity, however, there are many exceptions. Large woodchips (>6.3mm), bark, and redwood are slow to breakdown and therefore can result in a relatively stable product while the C/N ratio value is high. Additionally, some composts with chicken manure and/or green grass feedstocks can start with a C/N ratio below 15 and are very unstable. A C/N ratio below 10 supplies Nitrogen, while a ratio above 20 can deplete Nitrogen from the soil. The rate at which Nitrogen will be released or used by the microbes is indicated by the respiration rate (BAC). If the respiration rate is too high the transfer of Nitrogen will not be controlable.

Soluble Nutrients & Salts (EC5 w/w dw - mmhos/cm)

8.9 High salts This value refers to all soluble ions including nutrients, sodium, chloride and some soluble organic compounds. The concentration of salts will change due to the release of salts from the organic matter as it degrades, volatilization of ammonia, decomposition of soluble organics, and conversion of molecular structure. High salts + high AgIndex is indicative of a compost high in readily available nutrients. The application rate of these composts should be limited by the optimum nutrient value based on soil analysis of the receiving soil. High Salts + low AgIndex is indicative of a compost low in nutrients with high concentrations of sodium and/or chloride. Limit the application rate according to the toxicity level of thesodium and/or chloride. Low salts indicates that the compost can be applied without risking salt toxicity, is likely a good source of organic matter, and that nutrients will release slowly over time.

Lime Content (lbs. per ton)

11 Average lime content Compost high in lime or carbonates are often those produced from chicken manure (layers) ash materials, and lime products. These are excellent products to use on a receiving soil where lime has been recommended by soil analysis to raise the pH. Composts with a high lime content should be closely considered for pH requirements when formulating potting mixes.

Physical Properties

Percent Ash

51.3 Average ash content Ash is the non-organic fraction of a compost. Most composts contain approximately 50% ash (dry weight basis). Compost can be high in ash content for many reasons including: excess minerilzation(old compost), contamination with soil base material during turning, poor quality feedstock, and soil or mineral products added. Finding the source and reducing high ash content is often the fastest means to increasing nutrient quality of a compost.

Particle Size % > 6.3 MM (0.25")

29.5 May restrict use Large particles may restrict use for potting soils, golf course topdressings, seed-starter mixes, and where a fine size distribution is required. Composts with large particles can still be used as excellent additions to field soils, shrub mixes and mulches.

Particle Size Distribution

Each size fraction is measured by weight, volume and bulk density. These results are particularly relevent with decisions to screen or not, and if screening, which size screen to use. The bulk density indicates if the fraction screened is made of light weight organic material or heavy mineral material. Removing large mineral material can greatly improve compost quality by increasing nutrient and organic concentrations.

Appendix:

Plant Available Nitrogen (PAN) calculations:
PAN = (X * (organic N)) + ((NH4-N) + (NO3-N))

X value =	If BAC < 2 then X = 0.1
	If BAC =2.1 to 5 then X = 0.2
	If BAC =5.1 to 10 then X = 0.3
	If BAC > 10 then X = 0.4

Note: If C/N ratio > 15 additional N should be applied.

Estimated available nutrients for use when calculating application rates

	lbs/ton
Plant Available Nitrogen (PAN)	17.6
Ammonia (NH4-N)	3.80
Nitrate (NO3-N)	0.00
Available Phosphorus (P2O5*0.64)	20.4
Available Potassium (K2O)	7.2

ANALYTICAL CHEMISTS
and
BACTERIOLOGISTS
Approved by State of California

SOIL CONTROL LAB

42 HANGAR WAY
WATSONVILLE
CALIFORNIA
95076
USA

TEL: 831-724-5422
FAX: 831-724-3188
www.compostlab.com

Account #: 0100335-3/6-6680
Group: Oct.10 C #14
Reporting Date: October 27, 2010

UC Davis- Civil & Environmental Engir.
One Shields Ave., Ghausi Hall, Room 2001
Davis, CA 95616
Attn: Isabel Faria

Date Received: 13 Oct. 10
Sample Identification: #3A Merced 2 Wk Comp
Sample ID #: 0100335 - 3/6

Nutrients	Dry wt.	As Rcvd.	units
Total Nitrogen:	2.7	1.1	%
Ammonia (NH_4-N):	4100	1700	mg/kg
Nitrate (NO_3-N):	1.8	0.74	mg/kg
Org. Nitrogen (Org.-N):	2.3	0.95	%
Phosphorus (as P_2O_5):	2.6	1.1	%
Phosphorus (P):	12000	4800	mg/kg
Potassium (as K_2O):	0.82	0.34	%
Potassium (K):	6800	2800	mg/kg
Calcium (Ca):	1.7	0.70	%
Magnesium (Mg):	0.62	0.26	%
Sulfate (SO_4-S):	800	330	mg/kg
Boron (Total B):	33	14	mg/kg
Moisture:	0	58.6	%
Sodium (Na):	0.16	0.065	%
Chloride (Cl):	0.22	0.091	%
pH Value:	NA	7.95	unit
Bulk Density :	18	44	lb/cu ft
Carbonates ($CaCO_3$):	7.7	3.2	lb/ton
Conductivity (EC5):	7.5	NA	mmhos/cm
Organic Matter:	52.5	21.7	%
Organic Carbon:	26.0	11.0	%
Ash:	47.5	19.7	%
C/N Ratio	9.4	9.4	ratio
AgIndex	> 10	> 10	ratio

Stability Indicator:		Biologically
CO2 Evolution	Respirometery	Available C
mg CO_2-C/g OM/day	4.7	5.3
mg CO_2-C/g TS/day	2.5	2.8
Stability Rating	*stable*	*stable*

Maturity Indicator: Cucumber Bioassay		
Compost:Vermiculite(v:v)	1:1	1:3
Emergence (%)	0	100
Seedling Vigor (%)	NA	40
Description of Plants		*stunted*

Pathogens	Results	Units	Rating
Fecal Coliform	> 1800	MPN/g	*fail*
Salmonella	< 3	MPN/4g	*pass*

Date Tested: 13 Oct. 10

Inerts	% by weight
Plastic	< 0.5
Glass	< 0.5
Metal	< 0.5
Sharps	ND

Metals	Dry wt.	EPA Limit	units
Aluminum (Al)	9100	-	mg/kg
Arsenic (As):	1.9	41	mg/kg
Cadmium (Cd):	< 1.0	39	mg/kg
Chromium (Cr):	30	1200	mg/kg
Cobalt (Co)	2.9	-	mg/kg
Copper (Cu):	180	1500	mg/kg
Iron (Fe):	12000	-	mg/kg
Lead (Pb):	15	300	mg/kg
Manganese (Mn):	690	-	mg/kg
Mercury (Hg):	< 1.0	17	mg/kg
Molybdenum (Mo):	4.4	75	mg/kg
Nickel (Ni):	22	420	mg/kg
Selenium (Se):	2.7	36	mg/kg
Zinc (Zn):	390	2800	mg/kg

Size & Volume Distribution			
MM	% by weight	% by volume	BD g/cc
> 50	0.0	0.0	0.00
25 to 50	0.0	0.0	0.00
16 to 25	1.2	1.5	0.35
9.5 to 16	3.1	4.5	0.30
6.3 to 9.5	4.4	6.6	0.29
4.0 to 6.3	6.6	9.0	0.31
2.0 to 4.0	19.1	17.3	0.47
< 2.0	65.5	61.2	0.45

Bulk Density Description:<.35 Light Materials, .35-.60 medium weight materials, >.60 Heavy Materials

Analyst: Assaf Sadeh

*Sample was received and handled in accordance with TMECC procedures.

Account No.:		Date Received	13 Oct. 10
0100335 - 3/6 - 6680		Sample i.d.	#3A Merced 2 Wk Comp
Group:	Oct.10 C No. 14	Sample I.d. No.	3/6 0100335

INTERPRETATION:

Is Your Compost Stable?

Respiration Rate — Biodegradation Rate of Your Pile

4.7 mg CO2-C/ g OM/day

++++++++++++++++++
< Stable >|< Moderately Stable >|< Unstable >|< High For Mulch

Biologically Available Carbon (BAC) — Optimum Degradation Rate

5.3 mg CO2-C/ g OM/day

++++++++++++++++++++
< Stable >|< Moderately Stable >|< Unstable >|< High For Mulch

Is Your Compost Mature?

AmmoniaN/NitrateN ratio

2300 Ratio

++
VeryMature>|< Mature >|< Immature

Ammonia N ppm

4100 mg/kg dry wt.

++
VeryMature>|< Mature >|< Immature

Nitrate N ppm

1.8 mg/kg dry wt.

+
< Immature >|< Mature

pH value

7.95 units

++
< Immature >|< Mature >|< Immature

Cucumber Emergence

0.0 percent

+
< Immature >|< Mature

Is Your Compost Safe Regarding Health?

Fecal Coliform

> 1000 MPN/g dry wt.

++
< Safe >|< High Fecal Coliform

Salmonella

Less than 3 /4g dry wt.

+++++++
<Safe (none detected) >|< High Salmonella Count(> 3 per 4 grams)

Metals US EPA 503

Pass dry wt.

+++++++++
<All Metals Pass >|< One or more Metals Fail

Does Your Compost Provide Nutrients or Organic Matter?

Nutrients (N+P2O5+K2O)

6.2 Percent dry wt.

++
<Low >|< Average >|< High Nutrient Content

AgIndex (Nutrients / Sodium and Chloride Salts) ((N+P2O5+K2O) / (Na + Cl))

15 Ratio

++
Na & Cl >|< Nutrient and Sodium and Chloride Provider >|< Nutrient Provider

Plant Available Nitrogen (PAN) — Estimated release for first season

22 lbs/ton wet wt.

++
Low Nitrogen Provider>|< Average Nitrogen Provider >|<High Nitrogen Provider

C/N Ratio

9.4 Ratio

++++++++++++++++++
< Nitrogen Release >|< N-Neutral >|< N-Demand>|< High Nitrogen Demand

Soluble Available Nutrients & Salts (EC5 w/w dw)

7.5 mmhos/cm dry wt.

++
SloRelease>|< Average Nutrient Release Rate >|<High Available Nutrients

Lime Content (CaCO3)

7.7 Lbs/ton dry wt.

++++++++++++
< Low >|< Average >|< High Lime Content (as CaCO3)

What are the physical properties of your compost?

Percent Ash

47.5 Percent dry wt.

++
< High Organic Matter >|< Average >|< High Ash Content

Sieve Size % > 6.3 MM (0.25")

8.8 Percent dry wt.

++
All Uses >|< Size May Restrict Uses for Potting mix and Golf Courses

Account No.:		Date Received	13 Oct. 10
0100335 - 3/6 - 6680		Sample i.d.	#3A Merced 2 Wk Comp
Group:	Oct.10 C No. 14	Sample I.d. No.	3/6 0100335

INTERPRETATION:

Is Your Compost Stable?

Respiration Rate

4.7 Moderate-selected use mg CO2-C/g OM/day

The respiration rate is a measurement of the biodegradation rate of the organic matter in the sample (as received). The respiration rate is determined by measuring the rate at which CO2 is released under optimized moisture and temperature conditions.

Biologically Available Carbon

5.3 Moderate-selected use mg CO2-C/g OM/day

Biologically Available Carbon (BAC) is a measurement of the rate at which CO2 is released under optimized moisture, temperature, porosity, nutrients, pH and microbial conditions. If both the RR and the BAC test values are close to the same value, the pile is optimized for composting. If both values are high the compost pile just needs more time. If both values are low the compost has stabilized and should be moved to curing. BAC test values that are higher than RR indicate that the compost pile has stalled. This could be due to anaerobic conditions, lack of available nitrogen due to excessive air converting ammonia to the unavailable nitrate form, lack of nitrogen or other nutrients due to poor choice of feedstock, pH value out of range, or microbes rendered non-active.

Is Your Compost Mature?

AmmoniaN:NitrateN ratio

2300 immature

Ammonia N ppm

4100 immature

Nitrate N ppm

1.8 immature

pH value

7.95 mature

Composting to stabilize carbon can occur at such a rapid rate that sometimes phytotoxins remain in the compost and must be neutralized before using in high concentrations or in high-end uses. This step is called curing. Typically ammonia is in excess with the break-down of organic materials resulting in an increase in pH. This combination results in a loss of volatile ammonia (it smells). Once this toxic ammonia has been reduced and the pH drops, the microbes convert the ammonia to nitrates. A low ammonia + high nitrate score is indicative of a mature compost, however there are many exceptions. For example, a compost with a low pH (<7) will retain ammonia, while a compost with high lime content can lose ammonia before the organic fraction becomes stable. Composts must first be stable before curing indicators apply.

Cucumber Bioassay

0.0 Percent

Cucumbers are chosen for this test because they are salt tolerant and very sensitive to ammonia and organic acid toxicity. Therefore, we can germinate seeds in high concentrations of compost to measure phytotoxic effects without soluble salts being the limiting factor. Values above 80% for both percent emergence and vigor are indicative of a well-cured compost. Exceptions include very high salts that affect the cucumbers, excessive concentrations of nitrates and other nutrients that will be in range when formulated to make a growing media. In addition to testing a 1:1 compost: vermiculite blend, we also test a diluted 1:4 blend to indicate a more sensitive toxicity level.

Is Your Compost Safe Regarding Health?

Fecal Coliform

> 1000 / g dry wt.

Fecal coliforms can survive in both aerobic and anaerobic conditions and is common in all initial compost piles. Most human pathogens occur from fecal matter and all fecal matter is loaded in fecal coliforms. Therefore fecal coliforms are used as an indicator to determine if the chosen method for pathogen reduction (heat for compost) has met the requirements of sufficient temperature, time and mixing. If the fecal coliforms are reduced to below 1000 per gram dry wt. it is assumed all others pathogens are eliminated. Potential problems are that fecal coliform can regrow during the curing phase or during shipping. This is because the conditions are now more favorable for growth than during the composting process.

Salmonella Bacteria

Less than 3 3 / 4g dry wt.

Salmonella is not only another indicator organism but also a toxic microbe. It has been used in the case of biosolids industry to determine adequate pathogen reduction.

Metals

Pass

The ten heavy metals listed in the EPA 503 regulations are chosen to determine if compost can be applied to ag land and handled without toxic effects. Most high concentrations of heavy metals are derived from woodwaste feedstock such as chrome-arsenic treated or lead painted demolition wood. Biosolids are rarely a problem.

Does Your Compost Provide Nutrients or Organic Matter?

Nutrients (N+P2O5+K2O)

6.2 High nutrient content

This value is the sum of the primary nutrients Nitrogen, Phosphorus and Potassium. Reported units are consistent with those found on fertilizer formulations. A sum greater than 5 is indicative of a compost with high nutrient content, and best used to supply nutrients to a receiving soil. A sum below 2 indicates low nutrient content, and is best-used to improve soil structure via the addition of organic matter. Most compost falls between 2 and 5.

Account No.:		Date Received	13 Oct. 10
0100335 - 3/6 - 6680		Sample i.d.	#3A Merced 2 Wk Comp
Group:	Oct.10 C No. 14	Sample I.d. No.	3/6 0100335

INTERPRETATION:

AgIndex (Nutrients/Na+Cl)

15 High nutrient ratio Composts with low AgIndex values have high concentrations of sodium and/or chloride compared to nutrients. Repeated use of a compost with a low AgIndex (< 2) may result in sodium and/or chloride acting as the limiting factor compared to nutrients, governing application rates. These composts may be used on well-draining soils and/or with salt-tolerant plants. Additional nutrients form another source may be needed if the application rate is limited by sodium or chloride. If the AgIndex is above 10, nutrients optimal for plant growth will be available without concern of sodium and/or chloride toxicity. Composts with an AgIndex of above 10 are good for increasing nutrient levels for all soils. Most composts score between 2 and 10. Concentrations of nutrients, sodium, and chloride in the receiving soil should be considered when determining compost application rates. The AgIndex is a product of feedstock quality. Feedstock from dairy manure, marine waste, industrial wastes, and halophytic plants are likely to produce a finished compost with a low AgIndex.

Plant Available Nitrogen (lbs/ton)

22 High N Provider Plant Available Nitrogen (PAN) is calculated by estimating the release rate of Nitrogen from the organic fraction of the compost. This estimate is based on information gathered from the BAC test and measured ammonia and nitrate values. Despite the PAN value of the compost, additional sources of Nitrogen may be needed during he growing season to off-set the Nitrogen demand of the microbes present in the compost. With ample nutrients these microbes can further breakdown organic matter in the compost and release bound Nitrogen. Nitrogen demand based on a high C/N ratio is not considered in the PAN calculation because additional Nitrogen should always be supplemented to the receiving soil when composts with a high C/N ratio are applied.

C/N Ratio

9.4 Indicates maturity As a guiding principal, a C/N ratio below 14 indicates maturity and above 14 indicates immaturity, however, there are many exceptions. Large woodchips (>6.3mm), bark, and redwood are slow to breakdown and therefore can result in a relatively stable product while the C/N ratio value is high. Additionally, some composts with chicken manure and/or green grass feedstocks can start with a C/N ratio below 15 and are very unstable. A C/N ratio below 10 supplies Nitrogen, while a ratio above 20 can deplete Nitrogen from the soil. The rate at which Nitrogen will be released or used by the microbes is indicated by the respiration rate (BAC). If the respiration rate is too high the transfer of Nitrogen will not be controlable.

Soluble Nutrients & Salts (EC5 w/w dw - mmhos/cm)

7.5 Average salts This value refers to all soluble ions including nutrients, sodium, chloride and some soluble organic compounds. The concentration of salts will change due to the release of salts from the organic matter as it degrades, volatilization of ammonia, decomposition of soluble organics, and conversion of molecular structure. High salts + high AgIndex is indicative of a compost high in readily available nutrients. The application rate of these composts should be limited by the optimum nutrient value based on soil analysis of the receiving soil. High Salts + low AgIndex is indicative of a compost low in nutrients with high concentrations of sodium and/or chloride. Limit the application rate according to the toxicity level of thesodium and/or chloride. Low salts indicates that the compost can be applied without risking salt toxicity, is likely a good source of organic matter, and that nutrients will release slowly over time.

Lime Content (lbs. per ton)

7.7 Average lime content Compost high in lime or carbonates are often those produced from chicken manure (layers) ash materials, and lime products. These are excellent products to use on a receiving soil where lime has been recommended by soil analysis to raise the pH. Composts with a high lime content should be closely considered for pH requirements when formulating potting mixes.

Physical Properties

Percent Ash

47.5 Average ash content Ash is the non-organic fraction of a compost. Most composts contain approximately 50% ash (dry weight basis). Compost can be high in ash content for many reasons including: excess minerilzation(old compost), contamination with soil base material during turning, poor quality feedstock, and soil or mineral products added. Finding the source and reducing high ash content is often the fastest means to increasing nutrient quality of a compost.

Particle Size % > 6.3 MM (0.25")

8.8 May restrict use Large particles may restrict use for potting soils, golf course topdressings, seed-starter mixes, and where a fine size distribution is required. Composts with large particles can still be used as excellent additions to field soils, shrub mixes and mulches.

Particle Size Distribution

Each size fraction is measured by weight, volume and bulk density. These results are particularly relevent with decisions to screen or not, and if screening, which size screen to use. The bulk density indicates if the fraction screened is made of light weight organic material or heavy mineral material. Removing large mineral material can greatly improve compost quality by increasing nutrient and organic concentrations.

Appendix:

Plant Available Nitrogen (PAN) calculations:

PAN = (X * (organic N)) + ((NH4-N) + (NO3-N))

X value =	If BAC < 2 then X = 0.1
	If BAC =2.1 to 5 then X = 0.2
	If BAC =5.1 to 10 then X = 0.3
	If BAC > 10 then X = 0.4

Note: If C/N ratio > 15 additional N should be applied.

Estimated available nutrients for use when calculating application rates

	lbs/ton
Plant Available Nitrogen (PAN)	22.4
Ammonia (NH4-N)	3.40
Nitrate (NO3-N)	0.00
Available Phosphorus (P2O5*0.64)	14.0
Available Potassium (K2O)	6.7

ANALYTICAL CHEMISTS
and
BACTERIOLOGISTS
Approved by State of California

SOIL CONTROL LAB

42 HANGAR WAY
WATSONVILLE
CALIFORNIA
95076
USA

TEL: 831-724-5422
FAX: 831-724-3188
www.compostlab.com

Account #: 0100335-4/6-6680
Group: Oct.10 C #15
Reporting Date: October 27, 2010

UC Davis- Civil & Environmental Engir.
One Shields Ave., Ghausi Hall, Room 2001
Davis, CA 95616
Attn: Isabel Faria

Date Received: 13 Oct. 10
Sample Identification: #4A Merced 3 Wk
Sample ID #: 0100335 - 4/6

Nutrients	Dry wt.	As Rcvd.	units
Total Nitrogen:	2.2	1.2	%
Ammonia (NH_4-N):	2900	1600	mg/kg
Nitrate (NO_3-N):	0.11	0.061	mg/kg
Org. Nitrogen (Org.-N):	1.9	1.0	%
Phosphorus (as P_2O_5):	2.6	1.4	%
Phosphorus (P):	11000	6100	mg/kg
Potassium (as K_2O):	0.89	0.48	%
Potassium (K):	7400	4000	mg/kg
Calcium (Ca):	1.7	0.91	%
Magnesium (Mg):	0.58	0.31	%
Sulfate (SO_4-S):	920	490	mg/kg
Boron (Total B):	32	17	mg/kg
Moisture:	0	46.4	%
Sodium (Na):	0.16	0.088	%
Chloride (Cl):	0.26	0.14	%
pH Value:	NA	8.08	unit
Bulk Density :	23	43	lb/cu ft
Carbonates ($CaCO_3$):	3.6	2.0	lb/ton
Conductivity (EC5):	5.7	NA	mmhos/cm
Organic Matter:	46.4	24.9	%
Organic Carbon:	22.0	12.0	%
Ash:	53.6	28.7	%
C/N Ratio	10	10	ratio
AgIndex	> 10	> 10	ratio

Stability Indicator:		Biologically
CO2 Evolution	Respirometery	Available C
mg CO_2-C/g OM/day	3.2	5.6
mg CO_2-C/g TS/day	1.5	2.6
Stability Rating	*stable*	*stable*

Maturity Indicator: Cucumber Bioassay		
Compost:Vermiculite(v:v)	1:1	1:3
Emergence (%)	0	100
Seedling Vigor (%)	NA	47
Description of Plants		*stunted*

Pathogens	Results	Units	Rating
Fecal Coliform	3.5	MPN/g	*pass*
Salmonella	< 3	MPN/4g	*pass*

Date Tested: 13 Oct. 10

Inerts	% by weight
Plastic	< 0.5
Glass	< 0.5
Metal	< 0.5
Sharps	ND

Metals	Dry wt.	EPA Limit	units
Aluminum (Al)	7900	-	mg/kg
Arsenic (As):	1.6	41	mg/kg
Cadmium (Cd):	< 1.0	39	mg/kg
Chromium (Cr):	30	1200	mg/kg
Cobalt (Co)	2.7	-	mg/kg
Copper (Cu):	130	1500	mg/kg
Iron (Fe):	12000	-	mg/kg
Lead (Pb):	13	300	mg/kg
Manganese (Mn):	560	-	mg/kg
Mercury (Hg):	< 1.0	17	mg/kg
Molybdenum (Mo):	4.9	75	mg/kg
Nickel (Ni):	17	420	mg/kg
Selenium (Se):	2.4	36	mg/kg
Zinc (Zn):	350	2800	mg/kg

Size & Volume Distribution			
MM	% by weight	% by volume	BD g/cc
> 50	0.0	0.0	0.00
25 to 50	0.0	0.0	0.00
16 to 25	0.0	0.0	0.00
9.5 to 16	9.2	11.2	0.43
6.3 to 9.5	4.1	7.0	0.31
4.0 to 6.3	2.4	3.4	0.38
2.0 to 4.0	8.7	8.4	0.55
< 2.0	75.6	70.0	0.57

Bulk Density Description:<.35 Light Materials, .35-.60 medium weight materials, >.60 Heavy Materials

Analyst: Assaf Sadeh

*Sample was received and handled in accordance with TMECC procedures.

Account No.:		Date Received	13 Oct. 10
0100335 - 4/6 - 6680		Sample i.d.	#4A Merced 3 Wk
Group:	Oct.10 C No. 15	Sample I.d. No.	4/6 0100335

INTERPRETATION:

Is Your Compost Stable?

Respiration Rate — Biodegradation Rate of Your Pile

3.2 mg CO2-C/ g OM/day

```
++++++++++++
< Stable    >|<  Moderately Stable  >|<  Unstable                >|< High For Mulch
```

Biologically Available Carbon (BAC) — Optimum Degradation Rate

5.6 mg CO2-C/ g OM/day

```
++++++++++++++++++++++
< Stable    >|< Moderately Stable   >|<  Unstable                >|< High For Mulch
```

Is Your Compost Mature?

AmmoniaN/NitrateN ratio

26000 Ratio

```
++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
VeryMature>|<                Mature                                >|<  Immature
```

Ammonia N ppm

2900 mg/kg dry wt.

```
++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
VeryMature>|<                Mature                                >|<  Immature
```

Nitrate N ppm

0.11 mg/kg dry wt.

```
+
<  Immature                                  >|< Mature
```

pH value

8.08 units

```
++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
<  Immature                                  >|< Mature      >|< Immature
```

Cucumber Emergence

0.0 percent

```
+
<  Immature                                                     >|< Mature
```

Is Your Compost Safe Regarding Health?

Fecal Coliform

< 1000 MPN/g dry wt.

```
+++++++
< Safe                                                  >|< High Fecal Coliform
```

Salmonella

Less than 3 /4g dry wt.

```
+++++++
<Safe  (none detected)                  >|< High Salmonella Count(> 3 per 4 grams)
```

Metals US EPA 503

Pass dry wt.

```
+++++++++
<All Metals Pass                        >|< One or more Metals Fail
```

Does Your Compost Provide Nutrients or Organic Matter?

Nutrients (N+P2O5+K2O)

5.6 Percent dry wt.

```
+++++++++++++++++++++++++++++++++++++++++++++
<Low          >|< Average                >|< High Nutrient Content
```

AgIndex (Nutrients / Sodium and Chloride Salts) — ((N+P2O5+K2O) / (Na + Cl))

13 Ratio

```
++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Na & Cl    >|<  Nutrient and Sodium and Chloride Provider      >|<  Nutrient Provider
```

Plant Available Nitrogen (PAN) — Estimated release for first season

18 lbs/ton wet wt.

```
++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Low Nitrogen Provider>|<      Average Nitrogen Provider              >|<High Nitrogen Provider
```

C/N Ratio

10 Ratio

```
++++++++++++++++++++
< Nitrogen Release   >|< N-Neutral >|< N-Demand>|<  High Nitrogen Demand
```

Soluble Available Nutrients & Salts (EC5 w/w dw)

5.7 mmhos/cm dry wt.

```
+++++++++++++++++++++++++++++++
SloRelease>|<  Average Nutrient Release Rate     >|<High Available Nutrients
```

Lime Content (CaCO3)

3.6 Lbs/ton dry wt.

```
+++++
<  Low  >|<          Average          >|<  High  Lime Content (as CaCO3)
```

What are the physical properties of your compost?

Percent Ash

53.6 Percent dry wt.

```
+++++++++++++++++++++++++++++++++++++++++++++
<  High Organic Matter        >|<   Average                >|<  High Ash Content
```

Sieve Size % > 6.3 MM (0.25")

13.3 Percent dry wt.

```
++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
All Uses        >|< Size May Restrict Uses for Potting mix and Golf Courses
```

Account No.:		Date Received	13 Oct. 10
0100335 - 4/6 - 6680		Sample i.d.	#4A Merced 3 Wk
Group:	Oct.10 C No. 15	Sample I.d. No.	4/6 0100335

INTERPRETATION:

Is Your Compost Stable?

Respiration Rate

3.2 Low: Good for all uses mg CO2-C/g OM/day

The respiration rate is a measurement of the biodegradation rate of the organic matter in the sample (as received). The respiration rate is determined by measuring the rate at which CO2 is released under optimized moisture and temperature conditions.

Biologically Available Carbon

5.6 Moderate-selected use mg CO2-C/g OM/day

Biologically Available Carbon (BAC) is a measurement of the rate at which CO2 is released under optimized moisture, temperature, porosity, nutrients, pH and microbial conditions. If both the RR and the BAC test values are close to the same value, the pile is optimized for composting. If both values are high the compost pile just needs more time. If both values are low the compost has stabilized and should be moved to curing. BAC test values that are higher than RR indicate that the compost pile has stalled. This could be due to anaerobic conditions, lack of available nitrogen due to excessive air converting ammonia to the unavailable nitrate form, lack of nitrogen or other nutrients due to poor choice of feedstock, pH value out of range, or microbes rendered non-active.

Is Your Compost Mature?

AmmoniaN:NitrateN ratio

26000 immature

Ammonia N ppm

2900 immature

Nitrate N ppm

0.11 immature

pH value

8.08 mature

Composting to stabilize carbon can occur at such a rapid rate that sometimes phytotoxins remain in the compost and must be neutralized before using in high concentrations or in high-end uses. This step is called curing. Typically ammonia is in excess with the break-down of organic materials resulting in an increase in pH. This combination results in a loss of volatile ammonia (it smells). Once this toxic ammonia has been reduced and the pH drops, the microbes convert the ammonia to nitrates. A low ammonia + high nitrate score is indicative of a mature compost, however there are many exceptions. For example, a compost with a low pH (<7) will retain ammonia, while a compost with high lime content can lose ammonia before the organic fraction becomes stable. Composts must first be stable before curing indicators apply.

Cucumber Bioassay

0.0 Percent

Cucumbers are chosen for this test because they are salt tolerant and very sensitive to ammonia and organic acid toxicity. Therefore, we can germinate seeds in high concentrations of compost to measure phytotoxic effects without soluble salts being the limiting factor. Values above 80% for both percent emergence and vigor are indicative of a well-cured compost. Exceptions include very high salts that affect the cucumbers, excessive concentrations of nitrates and other nutrients that will be in range when formulated to make a growing media. In addition to testing a 1:1 compost: vermiculite blend, we also test a diluted 1:4 blend to indicate a more sensitive toxicity level.

Is Your Compost Safe Regarding Health?

Fecal Coliform

< 1000 / g dry wt.

Fecal coliforms can survive in both aerobic and anaerobic conditions and is common in all initial compost piles. Most human pathogens occur from fecal matter and all fecal matter is loaded in fecal coliforms. Therefore fecal coliforms are used as an indicator to determine if the chosen method for pathogen reduction (heat for compost) has met the requirements of sufficient temperature, time and mixing. If the fecal coliforms are reduced to below 1000 per gram dry wt. it is assumed all others pathogens are eliminated. Potential problems are that fecal coliform can regrow during the curing phase or during shipping. This is because the conditions are now more favorable for growth than during the composting process.

Salmonella Bacteria

Less than 3 3 / 4g dry wt.

Salmonella is not only another indicator organism but also a toxic microbe. It has been used in the case of biosolids industry to determine adequate pathogen reduction.

Metals

Pass

The ten heavy metals listed in the EPA 503 regulations are chosen to determine if compost can be applied to ag land and handled without toxic effects. Most high concentrations of heavy metals are derived from woodwaste feedstock such as chrome-arsenic treated or lead painted demolition wood. Biosolids are rarely a problem.

Does Your Compost Provide Nutrients or Organic Matter?

Nutrients (N+P2O5+K2O)

5.6 High nutrient content

This value is the sum of the primary nutrients Nitrogen, Phosphorus and Potassium. Reported units are consistent with those found on fertilizer formulations. A sum greater than 5 is indicative of a compost with high nutrient content, and best used to supply nutrients to a receiving soil. A sum below 2 indicates low nutrient content, and is best-used to improve soil structure via the addition of organic matter. Most compost falls between 2 and 5.

Account No.:		Date Received	13 Oct. 10
0100335 - 4/6 - 6680		Sample i.d.	#4A Merced 3 Wk
Group:	Oct.10 C No. 15	Sample I.d. No.	4/6 0100335

INTERPRETATION:

AgIndex (Nutrients/Na+Cl)

13 High nutrient ratio Composts with low AgIndex values have high concentrations of sodium and/or chloride compared to nutrients. Repeated use of a compost with a low AgIndex (< 2) may result in sodium and/or chloride acting as the limiting factor compared to nutrients, governing application rates. These composts may be used on well-draining soils and/or with salt-tolerant plants. Additional nutrients form another source may be needed if the application rate is limited by sodium or chloride. If the AgIndex is above 10, nutrients optimal for plant growth will be available without concern of sodium and/or chloride toxicity. Composts with an AgIndex of above 10 are good for increasing nutrient levels for all soils. Most composts score between 2 and 10. Concentrations of nutrients, sodium, and chloride in the receiving soil should be considered when determining compost application rates. The AgIndex is a product of feedstock quality. Feedstock from dairy manure, marine waste, industrial wastes, and halophytic plants are likely to produce a finished compost with a low AgIndex.

Plant Available Nitrogen (lbs/ton)

18 High N Provider Plant Available Nitrogen (PAN) is calculated by estimating the release rate of Nitrogen from the organic fraction of the compost. This estimate is based on information gathered from the BAC test and measured ammonia and nitrate values. Despite the PAN value of the compost, additional sources of Nitrogen may be needed during he growing season to off-set the Nitrogen demand of the microbes present in the compost. With ample nutrients these microbes can further breakdown organic matter in the compost and release bound Nitrogen. Nitrogen demand based on a high C/N ratio is not considered in the PAN calculation because additional Nitrogen should always be supplemented to the receiving soil when composts with a high C/N ratio are applied.

C/N Ratio

10 Indicates maturity As a guiding principal, a C/N ratio below 14 indicates maturity and above 14 indicates immaturity, however, there are many exceptions. Large woodchips (>6.3mm), bark, and redwood are slow to breakdown and therefore can result in a relatively stable product while the C/N ratio value is high. Additionally, some composts with chicken manure and/or green grass feedstocks can start with a C/N ratio below 15 and are very unstable. A C/N ratio below 10 supplies Nitrogen, while a ratio above 20 can deplete Nitrogen from the soil. The rate at which Nitrogen will be released or used by the microbes is indicated by the respiration rate (BAC). If the respiration rate is too high the transfer of Nitrogen will not be controlable.

Soluble Nutrients & Salts (EC5 w/w dw - mmhos/cm)

5.7 Average salts This value refers to all soluble ions including nutrients, sodium, chloride and some soluble organic compounds. The concentration of salts will change due to the release of salts from the organic matter as it degrades, volatilization of ammonia, decomposition of soluble organics, and conversion of molecular structure. High salts + high AgIndex is indicative of a compost high in readily available nutrients. The application rate of these composts should be limited by the optimum nutrient value based on soil analysis of the receiving soil. High Salts + low AgIndex is indicative of a compost low in nutrients with high concentrations of sodium and/or chloride. Limit the application rate according to the toxicity level of thesodium and/or chloride. Low salts indicates that the compost can be applied without risking salt toxicity, is likely a good source of organic matter, and that nutrients will release slowly over time.

Lime Content (lbs. per ton)

3.6 Low lime content Compost high in lime or carbonates are often those produced from chicken manure (layers) ash materials, and lime products. These are excellent products to use on a receiving soil where lime has been recommended by soil analysis to raise the pH. Composts with a high lime content should be closely considered for pH requirements when formulating potting mixes.

Physical Properties

Percent Ash

53.6 Average ash content Ash is the non-organic fraction of a compost. Most composts contain approximately 50% ash (dry weight basis). Compost can be high in ash content for many reasons including: excess minerilzation(old compost), contamination with soil base material during turning, poor quality feedstock, and soil or mineral products added. Finding the source and reducing high ash content is often the fastest means to increasing nutrient quality of a compost.

Particle Size % > 6.3 MM (0.25")

13.3 May restrict use Large particles may restrict use for potting soils, golf course topdressings, seed-starter mixes, and where a fine size distribution is required. Composts with large particles can still be used as excellent additions to field soils, shrub mixes and mulches.

Particle Size Distribution

Each size fraction is measured by weight, volume and bulk density. These results are particularly relevent with decisions to screen or not, and if screening, which size screen to use. The bulk density indicates if the fraction screened is made of light weight organic material or heavy mineral material. Removing large mineral material can greatly improve compost quality by increasing nutrient and organic concentrations.

Appendix:

Plant Available Nitrogen (PAN) calculations:
PAN = (X * (organic N)) + ((NH4-N) + (NO3-N))

X value =	If BAC < 2 then X = 0.1
	If BAC =2.1 to 5 then X = 0.2
	If BAC =5.1 to 10 then X = 0.3
	If BAC > 10 then X = 0.4

Note: If C/N ratio > 15 additional N should be applied.

Estimated available nutrients for use when calculating application rates

	lbs/ton
Plant Available Nitrogen (PAN)	18.2
Ammonia (NH4-N)	3.20
Nitrate (NO3-N)	0.00
Available Phosphorus (P2O5*0.64)	17.7
Available Potassium (K2O)	9.6

ANALYTICAL CHEMISTS and BACTERIOLOGISTS
Approved by State of California

SOIL CONTROL LAB

42 HANGAR WAY
WATSONVILLE
CALIFORNIA
95076
USA

TEL: 831-724-5422
FAX: 831-724-3188
www.compostlab.com

Account #: 0100335-2/6-6680
Group: Oct.10 C #13
Reporting Date: October 27, 2010

UC Davis- Civil & Environmental Engir.
One Shields Ave., Ghausi Hall, Room 2001
Davis, CA 95616
Attn: Isabel Faria

Date Received: 13 Oct. 10
Sample Identification: #2A Merced 8.5 Wk Comp
Sample ID #: 0100335 - 2/6

Nutrients	Dry wt.	As Rcvd.	units
Total Nitrogen:	1.5	1.2	%
Ammonia (NH_4-N):	2800	2100	mg/kg
Nitrate (NO_3-N):	12	9.3	mg/kg
Org. Nitrogen (Org.-N):	1.2	0.91	%
Phosphorus (as P_2O_5):	3.2	2.4	%
Phosphorus (P):	14000	11000	mg/kg
Potassium (as K_2O):	0.73	0.56	%
Potassium (K):	6100	4600	mg/kg
Calcium (Ca):	2.3	1.8	%
Magnesium (Mg):	0.79	0.60	%
Sulfate (SO_4-S):	1700	1300	mg/kg
Boron (Total B):	22	17	mg/kg
Moisture:	0	23.8	%
Sodium (Na):	0.17	0.13	%
Chloride (Cl):	0.27	0.2	%
pH Value:	NA	8.01	unit
Bulk Density :	43	56	lb/cu ft
Carbonates ($CaCO_3$):	20	15	lb/ton
Conductivity (EC5):	6.1	NA	mmhos/cm
Organic Matter:	29.9	22.8	%
Organic Carbon:	15.0	12.0	%
Ash:	70.1	53.4	%
C/N Ratio	10	10	ratio
AgIndex	> 10	> 10	ratio

Stability Indicator:		Biologically
CO2 Evolution	Respirometery	Available C
mg CO_2-C/g OM/day	1.3	1.6
mg CO_2-C/g TS/day	0.39	0.48
Stability Rating	*very stable*	*very stable*

Maturity Indicator: Cucumber Bioassay		
Compost:Vermiculite(v:v)	1:1	1:3
Emergence (%)	0	0
Seedling Vigor (%)	NA	NA
Description of Plants		

Pathogens	Results	Units	Rating
Fecal Coliform	< 2.0	MPN/g	*pass*
Salmonella	< 3	MPN/4g	*pass*

Date Tested: 13 Oct. 10

Inerts	% by weight
Plastic	0.25
Glass	< 0.5
Metal	2.2
Sharps	ND

Metals	Dry wt.	EPA Limit	units
Aluminum (Al)	10000	-	mg/kg
Arsenic (As):	2.6	41	mg/kg
Cadmium (Cd):	< 1.0	39	mg/kg
Chromium (Cr):	36	1200	mg/kg
Cobalt (Co)	3.6	-	mg/kg
Copper (Cu):	110	1500	mg/kg
Iron (Fe):	23000	-	mg/kg
Lead (Pb):	18	300	mg/kg
Manganese (Mn):	210	-	mg/kg
Mercury (Hg):	< 1.0	17	mg/kg
Molybdenum (Mo):	6.0	75	mg/kg
Nickel (Ni):	24	420	mg/kg
Selenium (Se):	1.2	36	mg/kg
Zinc (Zn):	320	2800	mg/kg

Size & Volume Distribution			
MM	% by weight	% by volume	BD g/cc
> 50	0.0	0.0	0.00
25 to 50	0.0	0.0	0.00
16 to 25	1.3	2.2	0.42
9.5 to 16	3.5	5.9	0.43
6.3 to 9.5	3.0	6.6	0.33
4.0 to 6.3	3.1	4.7	0.47
2.0 to 4.0	4.4	5.2	0.61
< 2.0	84.7	75.3	0.81

Bulk Density Description:<.35 Light Materials, .35-.60 medium weight materials, >.60 Heavy Materials

Analyst: Assaf Sadeh

*Sample was received and handled in accordance with TMECC procedures.

Account No.:		Date Received	13 Oct. 10
0100335 - 2/6 - 6680		Sample i.d.	#2A Merced 8.5 Wk Comp
Group:	Oct.10 C No. 13	Sample I.d. No.	2/6 0100335

INTERPRETATION:

Is Your Compost Stable?

Respiration Rate — Biodegradation Rate of Your Pile

1.3 mg CO2-C/ g OM/day

```
+++++
< Stable    >|<  Moderately Stable  >|<  Unstable                >|< High For Mulch
```

Biologically Available Carbon (BAC) — Optimum Degradation Rate

1.6 mg CO2-C/ g OM/day

```
++++++
< Stable    >|< Moderately Stable   >|<  Unstable                >|< High For Mulch
```

Is Your Compost Mature?

AmmoniaN/NitrateN ratio

230 Ratio

```
+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
VeryMature>|<              Mature                          >|<   Immature
```

Ammonia N ppm

2800 mg/kg dry wt.

```
+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
VeryMature>|<              Mature                          >|<   Immature
```

Nitrate N ppm

12 mg/kg dry wt.

```
+++++++++
<   Immature                          >|<  Mature
```

pH value

8.01 units

```
++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
<   Immature                                  >|< Mature      >|< Immature
```

Cucumber Emergence

0.0 percent

```
+
<   Immature                                                  >|< Mature
```

Is Your Compost Safe Regarding Health?

Fecal Coliform

< 1000 MPN/g dry wt.

```
+++++++
<  Safe                                          >|< High Fecal Coliform
```

Salmonella

Less than 3 /4g dry wt.

```
+++++++
<Safe   (none detected)                  >|< High Salmonella Count(> 3 per 4 grams)
```

Metals US EPA 503

Pass dry wt.

```
+++++++++
<All Metals Pass                         >|< One or more Metals Fail
```

Does Your Compost Provide Nutrients or Organic Matter?

Nutrients (N+P2O5+K2O)

5.4 Percent dry wt.

```
+++++++++++++++++++++++++++++++++++++++++++
<Low          >|< Average                >|< High Nutrient Content
```

AgIndex (Nutrients / Sodium and Chloride Salts) — ((N+P2O5+K2O) / (Na + Cl))

12 Ratio

```
++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Na & Cl    >|<  Nutrient and Sodium and Chloride Provider      >|<  Nutrient Provider
```

Plant Available Nitrogen (PAN) — Estimated release for first season

13 lbs/ton wet wt.

```
++++++++++++++++++++++++++++++++++++++++++++++++++
Low Nitrogen Provider>|<       Average Nitrogen Provider              >|<High Nitrogen Provider
```

C/N Ratio

10 Ratio

```
++++++++++++++++++++
< Nitrogen Release   >|< N-Neutral >|< N-Demand>|<  High Nitrogen Demand
```

Soluble Available Nutrients & Salts (EC5 w/w dw)

6.1 mmhos/cm dry wt.

```
++++++++++++++++++++++++++++++++++
SloRelease>|<  Average Nutrient Release Rate     >|<High Available Nutrients
```

Lime Content (CaCO3)

20 Lbs/ton dry wt.

```
++++++++++++++++++++++++++++++++++
<  Low  >|<            Average          >|<  High  Lime Content (as CaCO3)
```

What are the physical properties of your compost?

Percent Ash

70.1 Percent dry wt.

```
+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
<  High Organic Matter          >|<   Average                >|<  High Ash Content
```

Sieve Size % > 6.3 MM (0.25")

7.9 Percent dry wt.

```
++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
All Uses          >|< Size May Restrict Uses for Potting mix and Golf Courses
```

Account No.:		Date Received	13 Oct. 10
0100335 - 2/6 - 6680		Sample i.d.	#2A Merced 8.5 Wk Comp
Group:	Oct.10 C No. 13	Sample I.d. No.	2/6 0100335

INTERPRETATION:

Is Your Compost Stable?

Respiration Rate

1.3 Low: Good for all uses mg CO2-C/g OM/day

The respiration rate is a measurement of the biodegradation rate of the organic matter in the sample (as received). The respiration rate is determined by measuring the rate at which CO2 is released under optimized moisture and temperature conditions.

Biologically Available Carbon

1.6 Low: Good for all uses mg CO2-C/g OM/day

Biologically Available Carbon (BAC) is a measurement of the rate at which CO2 is released under optimized moisture, temperature, porosity, nutrients, pH and microbial conditions. If both the RR and the BAC test values are close to the same value, the pile is optimized for composting. If both values are high the compost pile just needs more time. If both values are low the compost has stabilized and should be moved to curing. BAC test values that are higher than RR indicate that the compost pile has stalled. This could be due to anaerobic conditions, lack of available nitrogen due to excessive air converting ammonia to the unavailable nitrate form, lack of nitrogen or other nutrients due to poor choice of feedstock, pH value out of range, or microbes rendered non-active.

Is Your Compost Mature?

AmmoniaN:NitrateN ratio

230 immature

Ammonia N ppm

2800 immature

Nitrate N ppm

12 immature

pH value

8.01 mature

Composting to stabilize carbon can occur at such a rapid rate that sometimes phytotoxins remain in the compost and must be neutralized before using in high concentrations or in high-end uses. This step is called curing. Typically ammonia is in excess with the break-down of organic materials resulting in an increase in pH. This combination results in a loss of volatile ammonia (it smells). Once this toxic ammonia has been reduced and the pH drops, the microbes convert the ammonia to nitrates. A low ammonia + high nitrate score is indicative of a mature compost, however there are many exceptions. For example, a compost with a low pH (<7) will retain ammonia, while a compost with high lime content can lose ammonia before the organic fraction becomes stable. Composts must first be stable before curing indicators apply.

Cucumber Bioassay

0.0 Percent

Cucumbers are chosen for this test because they are salt tolerant and very sensitive to ammonia and organic acid toxicity. Therefore, we can germinate seeds in high concentrations of compost to measure phytotoxic effects without soluble salts being the limiting factor. Values above 80% for both percent emergence and vigor are indicative of a well-cured compost. Exceptions include very high salts that affect the cucumbers, excessive concentrations of nitrates and other nutrients that will be in range when formulated to make a growing media. In addition to testing a 1:1 compost: vermiculite blend, we also test a diluted 1:4 blend to indicate a more sensitive toxicity level.

Is Your Compost Safe Regarding Health?

Fecal Coliform

< 1000 / g dry wt.

Fecal coliforms can survive in both aerobic and anaerobic conditions and is common in all initial compost piles. Most human pathogens occur from fecal matter and all fecal matter is loaded in fecal coliforms. Therefore fecal coliforms are used as an indicator to determine if the chosen method for pathogen reduction (heat for compost) has met the requirements of sufficient temperature, time and mixing. If the fecal coliforms are reduced to below 1000 per gram dry wt. it is assumed all others pathogens are eliminated. Potential problems are that fecal coliform can regrow during the curing phase or during shipping. This is because the conditions are now more favorable for growth than during the composting process.

Salmonella Bacteria

Less than 3 3 / 4g dry wt.

Salmonella is not only another indicator organism but also a toxic microbe. It has been used in the case of biosolids industry to determine adequate pathogen reduction.

Metals

Pass

The ten heavy metals listed in the EPA 503 regulations are chosen to determine if compost can be applied to ag land and handled without toxic effects. Most high concentrations of heavy metals are derived from woodwaste feedstock such as chrome-arsenic treated or lead painted demolition wood. Biosolids are rarely a problem.

Does Your Compost Provide Nutrients or Organic Matter?

Nutrients (N+P2O5+K2O)

5.4 High nutrient content

This value is the sum of the primary nutrients Nitrogen, Phosphorus and Potassium. Reported units are consistent with those found on fertilizer formulations. A sum greater than 5 is indicative of a compost with high nutrient content, and best used to supply nutrients to a receiving soil. A sum below 2 indicates low nutrient content, and is best-used to improve soil structure via the addition of organic matter. Most compost falls between 2 and 5.

Account No.:		Date Received	13 Oct. 10
0100335 - 2/6 - 6680		Sample i.d.	#2A Merced 8.5 Wk Comp
Group:	Oct.10 C No. 13	Sample I.d. No.	2/6 0100335

INTERPRETATION:

AgIndex (Nutrients/Na+Cl)

12 High nutrient ratio Composts with low AgIndex values have high concentrations of sodium and/or chloride compared to nutrients. Repeated use of a compost with a low AgIndex (< 2) may result in sodium and/or chloride acting as the limiting factor compared to nutrients, governing application rates. These composts may be used on well-draining soils and/or with salt-tolerant plants. Additional nutrients form another source may be needed if the application rate is limited by sodium or chloride. If the AgIndex is above 10, nutrients optimal for plant growth will be available without concern of sodium and/or chloride toxicity. Composts with an AgIndex of above 10 are good for increasing nutrient levels for all soils. Most composts score between 2 and 10. Concentrations of nutrients, sodium, and chloride in the receiving soil should be considered when determining compost application rates. The AgIndex is a product of feedstock quality. Feedstock from dairy manure, marine waste, industrial wastes, and halophytic plants are likely to produce a finished compost with a low AgIndex.

Plant Available Nitrogen (lbs/ton)

13 Average N Provider Plant Available Nitrogen (PAN) is calculated by estimating the release rate of Nitrogen from the organic fraction of the compost. This estimate is based on information gathered from the BAC test and measured ammonia and nitrate values. Despite the PAN value of the compost, additional sources of Nitrogen may be needed during he growing season to off-set the Nitrogen demand of the microbes present in the compost. With ample nutrients these microbes can further breakdown organic matter in the compost and release bound Nitrogen. Nitrogen demand based on a high C/N ratio is not considered in the PAN calculation because additional Nitrogen should always be supplemented to the receiving soil when composts with a high C/N ratio are applied.

C/N Ratio

10 Indicates maturity As a guiding principal, a C/N ratio below 14 indicates maturity and above 14 indicates immaturity, however, there are many exceptions. Large woodchips (>6.3mm), bark, and redwood are slow to breakdown and therefore can result in a relatively stable product while the C/N ratio value is high. Additionally, some composts with chicken manure and/or green grass feedstocks can start with a C/N ratio below 15 and are very unstable. A C/N ratio below 10 supplies Nitrogen, while a ratio above 20 can deplete Nitrogen from the soil. The rate at which Nitrogen will be released or used by the microbes is indicated by the respiration rate (BAC). If the respiration rate is too high the transfer of Nitrogen will not be controlable.

Soluble Nutrients & Salts (EC5 w/w dw - mmhos/cm)

6.1 Average salts This value refers to all soluble ions including nutrients, sodium, chloride and some soluble organic compounds. The concentration of salts will change due to the release of salts from the organic matter as it degrades, volatilization of ammonia, decomposition of soluble organics, and conversion of molecular structure. High salts + high AgIndex is indicative of a compost high in readily available nutrients. The application rate of these composts should be limited by the optimum nutrient value based on soil analysis of the receiving soil. High Salts + low AgIndex is indicative of a compost low in nutrients with high concentrations of sodium and/or chloride. Limit the application rate according to the toxicity level of thesodium and/or chloride. Low salts indicates that the compost can be applied without risking salt toxicity, is likely a good source of organic matter, and that nutrients will release slowly over time.

Lime Content (lbs. per ton)

20 Average lime content Compost high in lime or carbonates are often those produced from chicken manure (layers) ash materials, and lime products. These are excellent products to use on a receiving soil where lime has been recommended by soil analysis to raise the pH. Composts with a high lime content should be closely considered for pH requirements when formulating potting mixes.

Physical Properties

Percent Ash

70.1 High ash content Ash is the non-organic fraction of a compost. Most composts contain approximately 50% ash (dry weight basis). Compost can be high in ash content for many reasons including: excess minerilzation(old compost), contamination with soil base material during turning, poor quality feedstock, and soil or mineral products added. Finding the source and reducing high ash content is often the fastest means to increasing nutrient quality of a compost.

Particle Size % > 6.3 MM (0.25")

7.9 May restrict use Large particles may restrict use for potting soils, golf course topdressings, seed-starter mixes, and where a fine size distribution is required. Composts with large particles can still be used as excellent additions to field soils, shrub mixes and mulches.

Particle Size Distribution

Each size fraction is measured by weight, volume and bulk density. These results are particularly relevent with decisions to screen or not, and if screening, which size screen to use. The bulk density indicates if the fraction screened is made of light weight organic material or heavy mineral material. Removing large mineral material can greatly improve compost quality by increasing nutrient and organic concentrations.

Appendix:

Plant Available Nitrogen (PAN) calculations:

PAN = (X * (organic N)) + ((NH4-N) + (NO3-N))

X value =	If BAC < 2 then X = 0.1
	If BAC =2.1 to 5 then X = 0.2
	If BAC =5.1 to 10 then X = 0.3
	If BAC > 10 then X = 0.4

Note: If C/N ratio > 15 additional N should be applied.

Estimated available nutrients for use when calculating application rates

	lbs/ton
Plant Available Nitrogen (PAN)	12.6
Ammonia (NH4-N)	4.20
Nitrate (NO3-N)	0.02
Available Phosphorus (P2O5*0.64)	32.0
Available Potassium (K2O)	11.1

ANALYTICAL CHEMISTS
and
BACTERIOLOGISTS
Approved by State of California

SOIL CONTROL LAB

42 HANGAR WAY
WATSONVILLE
CALIFORNIA
95076
USA

TEL: 831-724-5422
FAX: 831-724-3188
www.compostlab.com

Account #: 0100335-5/6-6680
Group: Oct.10 C #16
Reporting Date: October 27, 2010

UC Davis- Civil & Environmental Engir.
One Shields Ave., Ghausi Hall, Room 2001
Davis, CA 95616
Attn: Isabel Faria

Date Received: 13 Oct. 10
Sample Identification: Merced 9.5 Wk
Sample ID #: 0100335 - 5/6

Nutrients	Dry wt.	As Rcvd.	units
Total Nitrogen:	2.1	1.6	%
Ammonia (NH_4-N):	3300	2600	mg/kg
Nitrate (NO_3-N):	2.3	1.8	mg/kg
Org. Nitrogen (Org.-N):	1.8	1.4	%
Phosphorus (as P_2O_5):	3.5	2.7	%
Phosphorus (P):	15000	12000	mg/kg
Potassium (as K_2O):	0.81	0.64	%
Potassium (K):	6700	5300	mg/kg
Calcium (Ca):	2.1	1.6	%
Magnesium (Mg):	0.67	0.53	%
Sulfate (SO_4-S):	1600	1300	mg/kg
Boron (Total B):	24	19	mg/kg
Moisture:	0	21.6	%
Sodium (Na):	0.16	0.13	%
Chloride (Cl):	0.33	0.26	%
pH Value:	NA	7.84	unit
Bulk Density :	33	42	lb/cu ft
Carbonates ($CaCO_3$):	8.3	6.5	lb/ton
Conductivity (EC5):	6.7	NA	mmhos/cm
Organic Matter:	44.2	34.6	%
Organic Carbon:	26.0	20.0	%
Ash:	55.8	43.8	%
C/N Ratio	12	12	ratio
AgIndex	> 10	> 10	ratio

Stability Indicator:		Biologically
CO2 Evolution	Respirometery	Available C
mg CO_2-C/g OM/day	2.7	3.5
mg CO_2-C/g TS/day	1.2	1.5
Stability Rating	*stable*	*stable*

Maturity Indicator: Cucumber Bioassay		
Compost:Vermiculite(v:v)	1:1	1:3
Emergence (%)	0	100
Seedling Vigor (%)	NA	0
Description of Plants		*stunted*

Pathogens	Results	Units	Rating
Fecal Coliform	< 2.0	MPN/g	*pass*
Salmonella	< 3	MPN/4g	*pass*

Date Tested: 13 Oct. 10

Inerts	% by weight
Plastic	< 0.5
Glass	< 0.5
Metal	< 0.5
Sharps	ND

Metals	Dry wt.	EPA Limit	units
Aluminum (Al)	7300	-	mg/kg
Arsenic (As):	2.4	41	mg/kg
Cadmium (Cd):	< 1.0	39	mg/kg
Chromium (Cr):	41	1200	mg/kg
Cobalt (Co)	3.1	-	mg/kg
Copper (Cu):	150	1500	mg/kg
Iron (Fe):	23000	-	mg/kg
Lead (Pb):	18	300	mg/kg
Manganese (Mn):	200	-	mg/kg
Mercury (Hg):	< 1.0	17	mg/kg
Molybdenum (Mo):	7.5	75	mg/kg
Nickel (Ni):	20	420	mg/kg
Selenium (Se):	1.5	36	mg/kg
Zinc (Zn):	390	2800	mg/kg

Size & Volume Distribution			
MM	% by weight	% by volume	BD g/cc
> 50	0.0	0.0	0.00
25 to 50	0.0	0.0	0.00
16 to 25	10.5	7.7	0.71
9.5 to 16	8.5	14.0	0.31
6.3 to 9.5	6.7	12.8	0.27
4.0 to 6.3	4.5	6.4	0.36
2.0 to 4.0	3.6	4.9	0.38
< 2.0	66.2	54.3	0.63

Bulk Density Description:<.35 Light Materials,
.35-.60 medium weight materials, >.60 Heavy Materials

Analyst: Assaf Sadeh

*Sample was received and handled in accordance with TMECC procedures.

Account No.:		Date Received	13 Oct. 10
0100335 - 5/6 - 6680		Sample i.d.	Merced 9.5 Wk
Group:	Oct.10 C No. 16	Sample I.d. No.	5/6 0100335

INTERPRETATION:

Is Your Compost Stable?

Respiration Rate — Biodegradation Rate of Your Pile

2.7 mg CO2-C/ g OM/day

```
++++++++++
< Stable    >|<  Moderately Stable  >|<  Unstable                >|< High For Mulch
```

Biologically Available Carbon (BAC) — Optimum Degradation Rate

3.5 mg CO2-C/ g OM/day

```
++++++++++++++
< Stable    >|< Moderately Stable   >|<  Unstable                >|< High For Mulch
```

Is Your Compost Mature?

AmmoniaN/NitrateN ratio

1400 Ratio

```
++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
VeryMature>|<              Mature                                >|<  Immature
```

Ammonia N ppm

3300 mg/kg dry wt.

```
++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
VeryMature>|<              Mature                                >|<  Immature
```

Nitrate N ppm

2.3 mg/kg dry wt.

```
+
<  Immature                                  >|< Mature
```

pH value

7.84 units

```
+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
<  Immature                                  >|< Mature      >|< Immature
```

Cucumber Emergence

0.0 percent

```
+
<  Immature                                                  >|< Mature
```

Is Your Compost Safe Regarding Health?

Fecal Coliform

< 1000 MPN/g dry wt.

```
+++++++
< Safe                                                >|< High Fecal Coliform
```

Salmonella

Less than 3 /4g dry wt.

```
+++++++
<Safe  (none detected)                  >|< High Salmonella Count(> 3 per 4 grams)
```

Metals US EPA 503

Pass dry wt.

```
+++++++++
<All Metals Pass                        >|< One or more Metals Fail
```

Does Your Compost Provide Nutrients or Organic Matter?

Nutrients (N+P2O5+K2O)

6.3 Percent dry wt.

```
+++++++++++++++++++++++++++++++++++++++++++++++++++
<Low          >|< Average                >|< High Nutrient Content
```

AgIndex (Nutrients / Sodium and Chloride Salts) ((N+P2O5+K2O) / (Na + Cl))

13 Ratio

```
++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Na & Cl    >|<  Nutrient and Sodium and Chloride Provider     >|<  Nutrient Provider
```

Plant Available Nitrogen (PAN) Estimated release for first season

17 lbs/ton wet wt.

```
++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Low Nitrogen Provider>|<      Average Nitrogen Provider            >|<High Nitrogen Provider
```

C/N Ratio

12 Ratio

```
++++++++++++++++++++++++
< Nitrogen Release   >|< N-Neutral >|< N-Demand>|<  High Nitrogen Demand
```

Soluble Available Nutrients & Salts (EC5 w/w dw)

6.7 mmhos/cm dry wt.

```
++++++++++++++++++++++++++++++++++++
SloRelease>|<  Average Nutrient Release Rate    >|<High Available Nutrients
```

Lime Content (CaCO3)

8.3 Lbs/ton dry wt.

```
+++++++++++++
<  Low  >|<          Average          >|<  High  Lime Content (as CaCO3)
```

What are the physical properties of your compost?

Percent Ash

55.8 Percent dry wt.

```
++++++++++++++++++++++++++++++++++++++++++++++
<  High Organic Matter        >|<   Average                >|<  High Ash Content
```

Sieve Size % > 6.3 MM (0.25")

25.7 Percent dry wt.

```
++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
All Uses          >|< Size May Restrict Uses for Potting mix and Golf Courses
```

Account No.:		Date Received	13 Oct. 10
0100335 - 5/6 - 6680		Sample i.d.	Merced 9.5 Wk
Group:	Oct.10 C No. 16	Sample I.d. No.	5/6 0100335

INTERPRETATION:

Is Your Compost Stable?

Respiration Rate

2.7 Low: Good for all uses mg CO2-C/g OM/day

The respiration rate is a measurement of the biodegradation rate of the organic matter in the sample (as received). The respiration rate is determined by measuring the rate at which CO2 is released under optimized moisture and temperature conditions.

Biologically Available Carbon

3.5 Low: Good for all uses mg CO2-C/g OM/day

Biologically Available Carbon (BAC) is a measurement of the rate at which CO2 is released under optimized moisture, temperature, porosity, nutrients, pH and microbial conditions. If both the RR and the BAC test values are close to the same value, the pile is optimized for composting. If both values are high the compost pile just needs more time. If both values are low the compost has stabilized and should be moved to curing. BAC test values that are higher than RR indicate that the compost pile has stalled. This could be due to anaerobic conditions, lack of available nitrogen due to excessive air converting ammonia to the unavailable nitrate form, lack of nitrogen or other nutrients due to poor choice of feedstock, pH value out of range, or microbes rendered non-active.

Is Your Compost Mature?

AmmoniaN:NitrateN ratio

1400 immature

Ammonia N ppm

3300 immature

Nitrate N ppm

2.3 immature

pH value

7.84 mature

Composting to stabilize carbon can occur at such a rapid rate that sometimes phytotoxins remain in the compost and must be neutralized before using in high concentrations or in high-end uses. This step is called curing. Typically ammonia is in excess with the break-down of organic materials resulting in an increase in pH. This combination results in a loss of volatile ammonia (it smells). Once this toxic ammonia has been reduced and the pH drops, the microbes convert the ammonia to nitrates. A low ammonia + high nitrate score is indicative of a mature compost, however there are many exceptions. For example, a compost with a low pH (<7) will retain ammonia, while a compost with high lime content can lose ammonia before the organic fraction becomes stable. Composts must first be stable before curing indicators apply.

Cucumber Bioassay

0.0 Percent

Cucumbers are chosen for this test because they are salt tolerant and very sensitive to ammonia and organic acid toxicity. Therefore, we can germinate seeds in high concentrations of compost to measure phytotoxic effects without soluble salts being the limiting factor. Values above 80% for both percent emergence and vigor are indicative of a well-cured compost. Exceptions include very high salts that affect the cucumbers, excessive concentrations of nitrates and other nutrients that will be in range when formulated to make a growing media. In addition to testing a 1:1 compost: vermiculite blend, we also test a diluted 1:4 blend to indicate a more sensitive toxicity level.

Is Your Compost Safe Regarding Health?

Fecal Coliform

< 1000 / g dry wt.

Fecal coliforms can survive in both aerobic and anaerobic conditions and is common in all initial compost piles. Most human pathogens occur from fecal matter and all fecal matter is loaded in fecal coliforms. Therefore fecal coliforms are used as an indicator to determine if the chosen method for pathogen reduction (heat for compost) has met the requirements of sufficient temperature, time and mixing. If the fecal coliforms are reduced to below 1000 per gram dry wt. it is assumed all others pathogens are eliminated. Potential problems are that fecal coliform can regrow during the curing phase or during shipping. This is because the conditions are now more favorable for growth than during the composting process.

Salmonella Bacteria

Less than 3 3 / 4g dry wt.

Salmonella is not only another indicator organism but also a toxic microbe. It has been used in the case of biosolids industry to determine adequate pathogen reduction.

Metals

Pass

The ten heavy metals listed in the EPA 503 regulations are chosen to determine if compost can be applied to ag land and handled without toxic effects. Most high concentrations of heavy metals are derived from woodwaste feedstock such as chrome-arsenic treated or lead painted demolition wood. Biosolids are rarely a problem.

Does Your Compost Provide Nutrients or Organic Matter?

Nutrients (N+P2O5+K2O)

6.3 High nutrient content

This value is the sum of the primary nutrients Nitrogen, Phosphorus and Potassium. Reported units are consistent with those found on fertilizer formulations. A sum greater than 5 is indicative of a compost with high nutrient content, and best used to supply nutrients to a receiving soil. A sum below 2 indicates low nutrient content, and is best-used to improve soil structure via the addition of organic matter. Most compost falls between 2 and 5.

Account No.:		Date Received	13 Oct. 10
0100335 - 5/6 - 6680		Sample i.d.	Merced 9.5 Wk
Group:	Oct.10 C No. 16	Sample I.d. No.	5/6 0100335

INTERPRETATION:

AgIndex (Nutrients/Na+Cl)

13 High nutrient ratio Composts with low AgIndex values have high concentrations of sodium and/or chloride compared to nutrients. Repeated use of a compost with a low AgIndex (< 2) may result in sodium and/or chloride acting as the limiting factor compared to nutrients, governing application rates. These composts may be used on well-draining soils and/or with salt-tolerant plants. Additional nutrients form another source may be needed if the application rate is limited by sodium or chloride. If the AgIndex is above 10, nutrients optimal for plant growth will be available without concern of sodium and/or chloride toxicity. Composts with an AgIndex of above 10 are good for increasing nutrient levels for all soils. Most composts score between 2 and 10. Concentrations of nutrients, sodium, and chloride in the receiving soil should be considered when determining compost application rates. The AgIndex is a product of feedstock quality. Feedstock from dairy manure, marine waste, industrial wastes, and halophytic plants are likely to produce a finished compost with a low AgIndex.

Plant Available Nitrogen (lbs/ton)

17 High N Provider Plant Available Nitrogen (PAN) is calculated by estimating the release rate of Nitrogen from the organic fraction of the compost. This estimate is based on information gathered from the BAC test and measured ammonia and nitrate values. Despite the PAN value of the compost, additional sources of Nitrogen may be needed during he growing season to off-set the Nitrogen demand of the microbes present in the compost. With ample nutrients these microbes can further breakdown organic matter in the compost and release bound Nitrogen. Nitrogen demand based on a high C/N ratio is not considered in the PAN calculation because additional Nitrogen should always be supplemented to the receiving soil when composts with a high C/N ratio are applied.

C/N Ratio

12 Indicates maturity As a guiding principal, a C/N ratio below 14 indicates maturity and above 14 indicates immaturity, however, there are many exceptions. Large woodchips (>6.3mm), bark, and redwood are slow to breakdown and therefore can result in a relatively stable product while the C/N ratio value is high. Additionally, some composts with chicken manure and/or green grass feedstocks can start with a C/N ratio below 15 and are very unstable. A C/N ratio below 10 supplies Nitrogen, while a ratio above 20 can deplete Nitrogen from the soil. The rate at which Nitrogen will be released or used by the microbes is indicated by the respiration rate (BAC). If the respiration rate is too high the transfer of Nitrogen will not be controlable.

Soluble Nutrients & Salts (EC5 w/w dw - mmhos/cm)

6.7 Average salts This value refers to all soluble ions including nutrients, sodium, chloride and some soluble organic compounds. The concentration of salts will change due to the release of salts from the organic matter as it degrades, volatilization of ammonia, decomposition of soluble organics, and conversion of molecular structure. High salts + high AgIndex is indicative of a compost high in readily available nutrients. The application rate of these composts should be limited by the optimum nutrient value based on soil analysis of the receiving soil. High Salts + low AgIndex is indicative of a compost low in nutrients with high concentrations of sodium and/or chloride. Limit the application rate according to the toxicity level of thesodium and/or chloride. Low salts indicates that the compost can be applied without risking salt toxicity, is likely a good source of organic matter, and that nutrients will release slowly over time.

Lime Content (lbs. per ton)

8.3 Average lime content Compost high in lime or carbonates are often those produced from chicken manure (layers) ash materials, and lime products. These are excellent products to use on a receiving soil where lime has been recommended by soil analysis to raise the pH. Composts with a high lime content should be closely considered for pH requirements when formulating potting mixes.

Physical Properties

Percent Ash

55.8 Average ash content Ash is the non-organic fraction of a compost. Most composts contain approximately 50% ash (dry weight basis). Compost can be high in ash content for many reasons including: excess minerilzation(old compost), contamination with soil base material during turning, poor quality feedstock, and soil or mineral products added. Finding the source and reducing high ash content is often the fastest means to increasing nutrient quality of a compost.

Particle Size % > 6.3 MM (0.25")

25.7 May restrict use Large particles may restrict use for potting soils, golf course topdressings, seed-starter mixes, and where a fine size distribution is required. Composts with large particles can still be used as excellent additions to field soils, shrub mixes and mulches.

Particle Size Distribution

Each size fraction is measured by weight, volume and bulk density. These results are particularly relevent with decisions to screen or not, and if screening, which size screen to use. The bulk density indicates if the fraction screened is made of light weight organic material or heavy mineral material. Removing large mineral material can greatly improve compost quality by increasing nutrient and organic concentrations.

Appendix:

Plant Available Nitrogen (PAN) calculations:

PAN = (X * (organic N)) + ((NH4-N) + (NO3-N))

X value = If BAC < 2 then X = 0.1
If BAC =2.1 to 5 then X = 0.2
If BAC =5.1 to 10 then X = 0.3
If BAC > 10 then X = 0.4

Note: If C/N ratio > 15 additional N should be applied.

Estimated available nutrients for use when calculating application rates

	lbs/ton
Plant Available Nitrogen (PAN)	17.5
Ammonia (NH4-N)	5.20
Nitrate (NO3-N)	0.00
Available Phosphorus (P2O5*0.64)	34.9
Available Potassium (K2O)	12.8

ANALYTICAL CHEMISTS
and
BACTERIOLOGISTS
Approved by State of California

SOIL CONTROL LAB

42 HANGAR WAY
WATSONVILLE
CALIFORNIA
95076
USA

TEL: 831-724-5422
FAX: 831-724-3188
www.compostlab.com

Account #: 0100335-6/6-6680
Group: Oct.10 C #17
Reporting Date: October 27, 2010

UC Davis- Civil & Environmental Engir.
One Shields Ave., Ghausi Hall, Room 2001
Davis, CA 95616
Attn: Isabel Faria

Date Received: 13 Oct. 10
Sample Identification: #6A Merced Finish Comp`
Sample ID #: 0100335 - 6/6

Nutrients	Dry wt.	As Rcvd.	units
Total Nitrogen:	1.3	1.2	%
Ammonia (NH_4-N):	1800	1600	mg/kg
Nitrate (NO_3-N):	44	39	mg/kg
Org. Nitrogen (Org.-N):	1.1	0.97	%
Phosphorus (as P_2O_5):	4.6	4.1	%
Phosphorus (P):	20000	18000	mg/kg
Potassium (as K_2O):	0.72	0.63	%
Potassium (K):	6000	5300	mg/kg
Calcium (Ca):	2.9	2.6	%
Magnesium (Mg):	1.0	0.89	%
Sulfate (SO_4-S):	1900	1700	mg/kg
Boron (Total B):	25	22	mg/kg
Moisture:	0	11.8	%
Sodium (Na):	0.16	0.14	%
Chloride (Cl):	0.3	0.27	%
pH Value:	NA	7.12	unit
Bulk Density :	45	51	lb/cu ft
Carbonates ($CaCO_3$):	21	18	lb/ton
Conductivity (EC5):	5.8	NA	mmhos/cm
Organic Matter:	30.4	26.8	%
Organic Carbon:	16.0	14.0	%
Ash:	69.6	61.4	%
C/N Ratio	12	12	ratio
AgIndex	> 10	> 10	ratio

Stability Indicator:		Biologically
CO2 Evolution	Respirometery	Available C
mg CO_2-C/g OM/day	0.62	0.90
mg CO_2-C/g TS/day	0.19	0.27
Stability Rating	*very stable*	*very stable*

Maturity Indicator: Cucumber Bioassay		
Compost:Vermiculite(v:v)	1:1	1:3
Emergence (%)	100	100
Seedling Vigor (%)	0	53
Description of Plants	*stunted*	*stunted*

Pathogens	Results	Units	Rating
Fecal Coliform	< 2.0	MPN/g	*pass*
Salmonella	< 3	MPN/4g	*pass*

Date Tested: 13 Oct. 10

Inerts	% by weight
Plastic	< 0.5
Glass	< 0.5
Metal	< 0.5
Sharps	ND

Metals	Dry wt.	EPA Limit	units
Aluminum (Al)	11000	-	mg/kg
Arsenic (As):	3.6	41	mg/kg
Cadmium (Cd):	1.3	39	mg/kg
Chromium (Cr):	36	1200	mg/kg
Cobalt (Co)	3.7	-	mg/kg
Copper (Cu):	180	1500	mg/kg
Iron (Fe):	28000	-	mg/kg
Lead (Pb):	31	300	mg/kg
Manganese (Mn):	240	-	mg/kg
Mercury (Hg):	2.1	17	mg/kg
Molybdenum (Mo):	7.0	75	mg/kg
Nickel (Ni):	22	420	mg/kg
Selenium (Se):	2.0	36	mg/kg
Zinc (Zn):	480	2800	mg/kg

Size & Volume Distribution			
MM	% by weight	% by volume	BD g/cc
> 50	0.0	0.0	0.00
25 to 50	0.0	0.0	0.00
16 to 25	0.0	0.0	0.00
9.5 to 16	0.0	0.0	0.00
6.3 to 9.5	4.2	4.7	0.67
4.0 to 6.3	1.4	2.6	0.40
2.0 to 4.0	4.5	6.5	0.52
< 2.0	89.9	86.2	0.78

Bulk Density Description:<.35 Light Materials,
.35-.60 medium weight materials, >.60 Heavy Materials

Analyst: Assaf Sadeh

*Sample was received and handled in accordance with TMECC procedures.

Account No.:		Date Received	13 Oct. 10
0100335 - 6/6 - 6680		Sample i.d.	#6A Merced Finish Comp`
Group:	Oct.10 C No. 17	Sample I.d. No.	6/6 0100335

INTERPRETATION:

Is Your Compost Stable?

Respiration Rate — Biodegradation Rate of Your Pile

0.62 mg CO2-C/ g OM/day

```
++
< Stable    >|<  Moderately Stable  >|<  Unstable                >|< High For Mulch
```

Biologically Available Carbon (BAC) — Optimum Degradation Rate

0.90 mg CO2-C/ g OM/day

```
+++
< Stable    >|< Moderately Stable   >|<  Unstable                >|< High For Mulch
```

Is Your Compost Mature?

AmmoniaN/NitrateN ratio

41 Ratio

```
+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
VeryMature>|<              Mature                          >|<   Immature
```

Ammonia N ppm

1800 mg/kg dry wt.

```
+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
VeryMature>|<              Mature                          >|<   Immature
```

Nitrate N ppm

44 mg/kg dry wt.

```
+++++++++++++++++++++++++++++++++++
<   Immature                                >|<  Mature
```

pH value

7.12 units

```
+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
<   Immature                                    >|< Mature        >|< Immature
```

Cucumber Emergence

100.0 percent

```
+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
<   Immature                                                          >|< Mature
```

Is Your Compost Safe Regarding Health?

Fecal Coliform

< 1000 MPN/g dry wt.

```
+++++++
<  Safe                                          >|< High Fecal Coliform
```

Salmonella

Less than 3 /4g dry wt.

```
+++++++
<Safe   (none detected)                  >|< High Salmonella Count(> 3 per 4 grams)
```

Metals US EPA 503

Pass dry wt.

```
+++++++++
<All Metals Pass                         >|< One or more Metals Fail
```

Does Your Compost Provide Nutrients or Organic Matter?

Nutrients (N+P2O5+K2O)

6.6 Percent dry wt.

```
+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
<Low            >|< Average                  >|< High Nutrient Content
```

AgIndex (Nutrients / Sodium and Chloride Salts) ((N+P2O5+K2O) / (Na + Cl))

14 Ratio

```
+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
Na & Cl    >|<  Nutrient and Sodium and Chloride Provider        >|<  Nutrient Provider
```

Plant Available Nitrogen (PAN) — Estimated release for first season

11 lbs/ton wet wt.

```
+++++++++++++++++++++++++++++++++++++++++++++++
Low Nitrogen Provider>|<        Average Nitrogen Provider                >|<High Nitrogen Provider
```

C/N Ratio

12 Ratio

```
++++++++++++++++++++++++
< Nitrogen Release    >|< N-Neutral >|< N-Demand>|<  High Nitrogen Demand
```

Soluble Available Nutrients & Salts (EC5 w/w dw)

5.8 mmhos/cm dry wt.

```
+++++++++++++++++++++++++++++++
SloRelease>|<  Average Nutrient Release Rate     >|<High Available Nutrients
```

Lime Content (CaCO3)

21 Lbs/ton dry wt.

```
++++++++++++++++++++++++++++++++++
<  Low  >|<              Average            >|<  High  Lime Content (as CaCO3)
```

What are the physical properties of your compost?

Percent Ash

69.6 Percent dry wt.

```
+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
<   High Organic Matter          >|<    Average                >|<  High Ash Content
```

Sieve Size % > 6.3 MM (0.25")

4.2 Percent dry wt.

```
++++++++++++++++++++++++++++++++++
All Uses          >|< Size May Restrict Uses for Potting mix and Golf Courses
```

Account No.:		Date Received	13 Oct. 10
0100335 - 6/6 - 6680		Sample i.d.	#6A Merced Finish Comp`
Group:	Oct.10 C No. 17	Sample I.d. No.	6/6 0100335

INTERPRETATION:

Is Your Compost Stable?

Respiration Rate

0.62 Low: Good for all uses mg CO2-C/g OM/day

The respiration rate is a measurement of the biodegradation rate of the organic matter in the sample (as received). The respiration rate is determined by measuring the rate at which CO2 is released under optimized moisture and temperature conditions.

Biologically Available Carbon

0.90 Low: Good for all uses mg CO2-C/g OM/day

Biologically Available Carbon (BAC) is a measurement of the rate at which CO2 is released under optimized moisture, temperature, porosity, nutrients, pH and microbial conditions. If both the RR and the BAC test values are close to the same value, the pile is optimized for composting. If both values are high the compost pile just needs more time. If both values are low the compost has stabilized and should be moved to curing. BAC test values that are higher than RR indicate that the compost pile has stalled. This could be due to anaerobic conditions, lack of available nitrogen due to excessive air converting ammonia to the unavailable nitrate form, lack of nitrogen or other nutrients due to poor choice of feedstock, pH value out of range, or microbes rendered non-active.

Is Your Compost Mature?

AmmoniaN:NitrateN ratio

41 immature

Ammonia N ppm

1800 immature

Nitrate N ppm

44 immature

pH value

7.12 mature

Composting to stabilize carbon can occur at such a rapid rate that sometimes phytotoxins remain in the compost and must be neutralized before using in high concentrations or in high-end uses. This step is called curing. Typically ammonia is in excess with the break-down of organic materials resulting in an increase in pH. This combination results in a loss of volatile ammonia (it smells). Once this toxic ammonia has been reduced and the pH drops, the microbes convert the ammonia to nitrates. A low ammonia + high nitrate score is indicative of a mature compost, however there are many exceptions. For example, a compost with a low pH (<7) will retain ammonia, while a compost with high lime content can lose ammonia before the organic fraction becomes stable. Composts must first be stable before curing indicators apply.

Cucumber Bioassay

100.0 Percent

Cucumbers are chosen for this test because they are salt tolerant and very sensitive to ammonia and organic acid toxicity. Therefore, we can germinate seeds in high concentrations of compost to measure phytotoxic effects without soluble salts being the limiting factor. Values above 80% for both percent emergence and vigor are indicative of a well-cured compost. Exceptions include very high salts that affect the cucumbers, excessive concentrations of nitrates and other nutrients that will be in range when formulated to make a growing media. In addition to testing a 1:1 compost: vermiculite blend, we also test a diluted 1:4 blend to indicate a more sensitive toxicity level.

Is Your Compost Safe Regarding Health?

Fecal Coliform

< 1000 / g dry wt.

Fecal coliforms can survive in both aerobic and anaerobic conditions and is common in all initial compost piles. Most human pathogens occur from fecal matter and all fecal matter is loaded in fecal coliforms. Therefore fecal coliforms are used as an indicator to determine if the chosen method for pathogen reduction (heat for compost) has met the requirements of sufficient temperature, time and mixing. If the fecal coliforms are reduced to below 1000 per gram dry wt. it is assumed all others pathogens are eliminated. Potential problems are that fecal coliform can regrow during the curing phase or during shipping. This is because the conditions are now more favorable for growth than during the composting process.

Salmonella Bacteria

Less than 3 3 / 4g dry wt.

Salmonella is not only another indicator organism but also a toxic microbe. It has been used in the case of biosolids industry to determine adequate pathogen reduction.

Metals

Pass

The ten heavy metals listed in the EPA 503 regulations are chosen to determine if compost can be applied to ag land and handled without toxic effects. Most high concentrations of heavy metals are derived from woodwaste feedstock such as chrome-arsenic treated or lead painted demolition wood. Biosolids are rarely a problem.

Does Your Compost Provide Nutrients or Organic Matter?

Nutrients (N+P2O5+K2O)

6.6 High nutrient content

This value is the sum of the primary nutrients Nitrogen, Phosphorus and Potassium. Reported units are consistent with those found on fertilizer formulations. A sum greater than 5 is indicative of a compost with high nutrient content, and best used to supply nutrients to a receiving soil. A sum below 2 indicates low nutrient content, and is best-used to improve soil structure via the addition of organic matter. Most compost falls between 2 and 5.

Account No.:		Date Received	13 Oct. 10
0100335 - 6/6 - 6680		Sample i.d.	#6A Merced Finish Comp'
Group:	Oct.10 C No. 17	Sample I.d. No.	6/6 0100335

INTERPRETATION: Page three of three

AgIndex (Nutrients/Na+Cl)

14 High nutrient ratio Composts with low AgIndex values have high concentrations of sodium and/or chloride compared to nutrients. Repeated use of a compost with a low AgIndex (< 2) may result in sodium and/or chloride acting as the limiting factor compared to nutrients, governing application rates. These composts may be used on well-draining soils and/or with salt-tolerant plants. Additional nutrients form another source may be needed if the application rate is limited by sodium or chloride. If the AgIndex is above 10, nutrients optimal for plant growth will be available without concern of sodium and/or chloride toxicity. Composts with an AgIndex of above 10 are good for increasing nutrient levels for all soils. Most composts score between 2 and 10. Concentrations of nutrients, sodium, and chloride in the receiving soil should be considered when determining compost application rates. The AgIndex is a product of feedstock quality. Feedstock from dairy manure, marine waste, industrial wastes, and halophytic plants are likely to produce a finished compost with a low AgIndex.

Plant Available Nitrogen (lbs/ton)

11 Average N Provider Plant Available Nitrogen (PAN) is calculated by estimating the release rate of Nitrogen from the organic fraction of the compost. This estimate is based on information gathered from the BAC test and measured ammonia and nitrate values. Despite the PAN value of the compost, additional sources of Nitrogen may be needed during he growing season to off-set the Nitrogen demand of the microbes present in the compost. With ample nutrients these microbes can further breakdown organic matter in the compost and release bound Nitrogen. Nitrogen demand based on a high C/N ratio is not considered in the PAN calculation because additional Nitrogen should always be supplemented to the receiving soil when composts with a high C/N ratio are applied.

C/N Ratio

12 Indicates maturity As a guiding principal, a C/N ratio below 14 indicates maturity and above 14 indicates immaturity, however, there are many exceptions. Large woodchips (>6.3mm), bark, and redwood are slow to breakdown and therefore can result in a relatively stable product while the C/N ratio value is high. Additionally, some composts with chicken manure and/or green grass feedstocks can start with a C/N ratio below 15 and are very unstable. A C/N ratio below 10 supplies Nitrogen, while a ratio above 20 can deplete Nitrogen from the soil. The rate at which Nitrogen will be released or used by the microbes is indicated by the respiration rate (BAC). If the respiration rate is too high the transfer of Nitrogen will not be controlable.

Soluble Nutrients & Salts (EC5 w/w dw - mmhos/cm)

5.8 Average salts This value refers to all soluble ions including nutrients, sodium, chloride and some soluble organic compounds. The concentration of salts will change due to the release of salts from the organic matter as it degrades, volatilization of ammonia, decomposition of soluble organics, and conversion of molecular structure. High salts + high AgIndex is indicative of a compost high in readily available nutrients. The application rate of these composts should be limited by the optimum nutrient value based on soil analysis of the receiving soil. High Salts + low AgIndex is indicative of a compost low in nutrients with high concentrations of sodium and/or chloride. Limit the application rate according to the toxicity level of thesodium and/or chloride. Low salts indicates that the compost can be applied without risking salt toxicity, is likely a good source of organic matter, and that nutrients will release slowly over time.

Lime Content (lbs. per ton)

21 High lime content Compost high in lime or carbonates are often those produced from chicken manure (layers) ash materials, and lime products. These are excellent products to use on a receiving soil where lime has been recommended by soil analysis to raise the pH. Composts with a high lime content should be closely considered for pH requirements when formulating potting mixes.

Physical Properties

Percent Ash

69.6 High ash content Ash is the non-organic fraction of a compost. Most composts contain approximately 50% ash (dry weight basis). Compost can be high in ash content for many reasons including: excess minerilzation(old compost), contamination with soil base material during turning, poor quality feedstock, and soil or mineral products added. Finding the source and reducing high ash content is often the fastest means to increasing nutrient quality of a compost.

Particle Size % > 6.3 MM (0.25")

4.2 May restrict use Large particles may restrict use for potting soils, golf course topdressings, seed-starter mixes, and where a fine size distribution is required. Composts with large particles can still be used as excellent additions to field soils, shrub mixes and mulches.

Particle Size Distribution

Each size fraction is measured by weight, volume and bulk density. These results are particularly relevent with decisions to screen or not, and if screening, which size screen to use. The bulk density indicates if the fraction screened is made of light weight organic material or heavy mineral material. Removing large mineral material can greatly improve compost quality by increasing nutrient and organic concentrations.

Appendix:

Plant Available Nitrogen (PAN) calculations:
PAN = (X * (organic N)) + ((NH4-N) + (NO3-N))

X value =	If BAC < 2 then X = 0.1
	If BAC =2.1 to 5 then X = 0.2
	If BAC =5.1 to 10 then X = 0.3
	If BAC > 10 then X = 0.4

Note: If C/N ratio > 15 additional N should be applied.

Estimated available nutrients for use when calculating application rates

	lbs/ton
Plant Available Nitrogen (PAN)	10.8
Ammonia (NH4-N)	3.20
Nitrate (NO3-N)	0.08
Available Phosphorus (P2O5*0.64)	52.4
Available Potassium (K2O)	12.8

WASTEWATER UTILITY

Alabama
Montgomery Water Works & Sanitary Sewer Board

Alaska
Anchorage Water & Wastewater Utility

Arizona
Avondale, City of
Glendale, City of,
Mesa, City of
Peoria, City of
Phoenix Water Services Dept.
Pima County Wastewater Reclamation Department
Tempe, City of

Arkansas
Little Rock Wastewater

California
Central Contra Costa Sanitary District
Corona, City of
Crestline Sanitation District
Delta Diablo Sanitation District
Dublin San Ramon Services District
East Bay Dischargers Authority
East Bay Municipal Utility District
Fairfield-Suisun Sewer District
Fresno Department of Public Utilities
Inland Empire Utilities Agency
Irvine Ranch Water District
Las Gallinas Valley Sanitary District
Las Virgenes Municipal Water District
Livermore, City of
Los Angeles, City of
Montecito Sanitary District
Napa Sanitation District
Novato Sanitary District
Orange County Sanitation District
Palo Alto, City of
Riverside, City of
Sacramento Regional County Sanitation District
San Diego, City of
San Francisco Public Utilities, City & County of
San Jose, City of
Sanitation Districts of Los Angeles County
Santa Barbara, City of
Santa Cruz, City of
Santa Rosa, City of
South Bayside System Authority
South Coast Water District
South Orange County Wastewater Authority
Stege Sanitary District
Sunnyvale, City of
Union Sanitary District
West Valley Sanitation District

Colorado
Aurora, City of
Boulder, City of
Greeley, City of
Littleton/Englewood Wastewater Treatment Plant
Metro Wastewater Reclamation District, Denver
Platte Canyon Water & Sanitation District

Connecticut
Greater New Haven WPCA
Stamford, City of

District of Columbia
District of Columbia Water & Sewer Authority

Florida
Broward County
Fort Lauderdale, City of
Jacksonville Electric Authority (JEA)
Loxahatchee River District
Miami-Dade County
Orange County Utilities Department
Pinellas County Utilities
Reedy Creek Improvement District
St. Petersburg, City of
Tallahassee, City of
Toho Water Authority
West Palm Beach, City of

Georgia
Atlanta Department of Watershed Management
Augusta, City of
Clayton County Water Authority
Cobb County Water System
Columbus Water Works
Fulton County
Gwinnett County Department of Public Utilities
Savannah, City of

Hawaii
Honolulu, City & County of

Idaho
Boise, City of

Illinois
Greater Peoria Sanitary District
Kankakee River Metropolitan Agency
Metropolitan Water Reclamation District of Greater Chicago
Wheaton Sanitary District

Indiana
Jeffersonville, City of

Iowa
Ames, City of
Cedar Rapids Water Pollution Control Facilities
Des Moines, City of
Iowa City

Kansas
Johnson County Wastewater
Unified Government of Wyandotte County/ Kansas City, City of

Kentucky
Louisville & Jefferson County Metropolitan Sewer District
Sanitation District No. 1

Louisiana
Sewerage & Water Board of New Orleans

Maine
Bangor, City of
Portland Water District

Maryland
Anne Arundel County Bureau of Utility Operations
Howard County Bureau of Utilities
Washington Suburban Sanitary Commission

Massachusetts
Boston Water & Sewer Commission
Massachusetts Water Resources Authority (MWRA)
Upper Blackstone Water Pollution Abatement District

Michigan
Ann Arbor, City of
Detroit, City of
Holland Board of Public Works
Saginaw, City of
Wayne County Department of Environment
Wyoming, City of

Minnesota
Rochester, City of
Western Lake Superior Sanitary District

Missouri
Independence, City of
Kansas City Missouri Water Services Department
Little Blue Valley Sewer District
Metropolitan St. Louis Sewer District

Nebraska
Lincoln Wastewater & Solid Waste System

Nevada
Henderson, City of

New Jersey
Bergen County Utilities Authority
Ocean County Utilities Authority

New York
New York City Department of Environmental Protection

North Carolina
Charlotte/Mecklenburg Utilities
Durham, City of
Metropolitan Sewerage District of Buncombe County
Orange Water & Sewer Authority

Ohio
Akron, City of
Avon Lake Municipal Utilities
Butler County Water & Sewer
Columbus, City of
Metropolitan Sewer District of Greater Cincinnati
Montgomery County Water Services
Northeast Ohio Regional Sewer District
Summit, County of

Oklahoma
Oklahoma City Water & Wastewater Utility Department
Tulsa, City of

Oregon
Albany, City of
Clean Water Services
Eugene, City of
Gresham, City of
Lake Oswego, City of
Oak Lodge Sanitary District
Portland, City of
Water Environment Services

Pennsylvania
Philadelphia, City of
University Area Joint Authority

South Carolina
Beaufort-Jasper Water & Sewer Authority
Charleston Water System
Mount Pleasant Waterworks & Sewer Commission
Spartanburg Water

Tennessee
Cleveland Utilities
Knoxville Utilities Board
Murfreesboro Water & Sewer Department
Nashville Metro Water Services

Texas
Austin, City of
Dallas Water Utilities
Denton, City of
El Paso Water Utilities
Fort Worth, City of
Houston, City of
San Antonio Water System
Trinity River Authority

Utah
Salt Lake City Department of Public Utilities

Virginia
Alexandria Sanitation Authority
Fairfax, County of
Hampton Roads Sanitation District
Hanover, County of
Henrico, County of
Hopewell Regional Wastewater Treatment Facility
Loudoun Water
Lynchburg Regional Wastewater Treatment Plant
Prince William County Service Authority
Richmond, City of
Rivanna Water & Sewer Authority

Washington
Everett, City of
King County Department of Natural Resources
Seattle Public Utilities
Sunnyside, Port of
Yakima, City of

Wisconsin
Green Bay Metro Sewerage District
Kenosha Water Utility
Madison Metropolitan Sewerage District
Milwaukee Metropolitan Sewerage District
Racine Water & Wastewater Utility
Sheboygan, City of
Wausau Water Works

Water Services Association of Australia
ACTEW Corporation
Barwon Water
Central Highlands Water
City West Water
Coliban Water Corporation
Cradle Mountain Water
Gippsland Water
Gladstone Area Water Board
Gosford City Council
Hunter Water Corporation
Melbourne Water
Onstream
Power & Water Corporation
Queensland Urban Utilities
South Australia Water Corporation
Sydney Catchment Authority
Sydney Water
Unity Water
Wannon Regional Water Corporation
Water Corporation
Water Distribution Brisbane City Council
Western Water
Yarra Valley Water

Canada
Edmonton Waste Management Centre of Excellence
Lethbridge, City of
Regina, City of, Saskatchewan
Toronto, City of, Ontario
Winnipeg, City of, Manitoba

New Zealand
Watercare Services Limited

STORMWATER UTILITY

California
Fresno Metropolitan Flood Control District
Los Angeles, City of, Department of Public Works
Monterey, City of
San Diego County Department of Public Works
San Francisco, City & County of
Santa Rosa, City of
Sunnyvale, City of

Colorado
Aurora, City of
Boulder, City of

Florida
Orlando, City of

Georgia
Griffin, City of

Iowa
Cedar Rapids Water Pollution Control Facilities
Des Moines, City of

Kansas
Lenexa, City of
Overland Park, City of

Kentucky
Louisville & Jefferson County Metropolitan Sewer District

Maine
Portland Water District

North Carolina
Charlotte, City of, Stormwater Services

Pennsylvania
Philadelphia, City of

Tennessee
Chattanooga Stormwater Management

Texas
Harris County Flood Control District

Washington
Bellevue Utilities Department
Seattle Public Utilities

STATE

Connecticut Department of Environmental Protection
Kansas Department of Health & Environment
New England Interstate Water Pollution Control Commission (NEIWPCC)
Ohio River Valley Sanitation Commission
Urban Drainage & Flood Control District, CO

CORPORATE

Advanced Data Mining International
AECOM
Alan Plummer Associates, Inc.
American Cleaning Institute
Aqua-Aerobic Systems Inc.
Aquateam–Norwegian Water Technology Centre A/S
Associated Engineering
Atkins
Bernardin Lochmueller & Associates
Black & Veatch
Brown & Caldwell
Burgess & Niple, Ltd.
Burns & McDonnell
CABE Associates Inc.
Camp Dresser & McKee Inc.
Carollo Engineers Inc.
CET Engineering Services
CH2M HILL
CONTECH Stormwater Solutions
CRA Infrastructure & Engineering
CSIRO (Commonwealth Scientific and Industrial Research Organisation)
D&B/Guarino Engineers, LLC
Damon S. Williams Associates, LLC
Ecovation
EMA Inc.
Environ International Corporation
Environmental Operating Solutions, Inc.
Fay, Spofford, & Thorndike Inc.
Freese & Nichols, Inc.
ftn Associates Inc.
Gannett Fleming Inc.
Garden & Associates, Ltd.
Geosyntec Consultants
GHD Inc.
Global Water Associates
Greeley and Hansen LLC
Hazen & Sawyer, P.C.
HDR I HydroQual
HNTB Corporation
Holmes and McGrath Inc.
Hydromantis Environmental Software Solutions, Inc.
Infilco Degremont Inc.
Jacobs Engineering Group Inc.
Jason Consultants LLC Inc.
KCI Technologies Inc.
Kelly & Weaver, P.C.
Kennedy/Jenks Consultants
Larry Walker Associates
LimnoTech Inc.
Malcolm Pirnie, The Water Division of ARCADIS
MaxWest Environmental Systems, Inc.
McKim & Creed
MWH
Neotex Ltda
NTL Alaska, Inc.
O'Brien & Gere Engineers Inc.
Odor & Corrosion Technology Consultants Inc.
Parametrix Inc.
Parsons
Praxair, Inc.
RMC Water & Environment
Ross & Associates Ltd.
Sanipor, Ltd.
Siemens Water Technologies
Southeast Environmental Engineering, LLC
Stone Environmental Inc.
Stratus Consulting Inc.
Synagro Technologies Inc.
Tata & Howard, Inc.
Tetra Tech Inc.
The Cadmus Group
The Low Impact Development Center Inc.
Trojan Technologies Inc.
Trussell Technologies, Inc.
URS Corporation
Westin Engineering Inc.
Wright Water Engineers
Zoeller Pump Company

INDUSTRY

American Electric Power
American Water
Anglian Water Services, Ltd.
Bill & Melinda Gates Foundation
Chevron Energy Technology
Dow Chemical Company
DuPont Company
Eastman Chemical Company
Eli Lilly & Company
InsinkErator
Johnson & Johnson
Merck & Company Inc.
Procter & Gamble Company
Suez Environnment
United Utilities North West (UUNW)
United Water Services LLC
Veolia Water North America

List as of 5/25/11

WERF Board of Directors

Chair
William P. Dee, P.E., BCEE
Arcadis/Malcolm Pirnie, Inc.

Vice-Chair
Catherine R. Gerali
Metro Wastewater Reclamation District

Secretary
Jeff Eger
Water Environment Federation

Treasurer
Jeff Taylor
Freese and Nichols, Inc.

Patricia J. Anderson, P.E.
Florida Department of Health

John B. Barber, Ph.D.
Eastman Chemical Company

Jeanette A. Brown, P.E., BCEE, D.WRE
Stamford Water Pollution Control Authority

Charles N. Haas, Ph.D., BCEEM
Drexel University

Stephen R. Maguin
Sanitation Districts of Los Angeles County

James Anthony (Tony) Parrott
Metropolitan Sewer District of Greater Cincinnati

Robert A. Reich, P.E.
DuPont Company

Cordell Samuels
Regional Municipality of Durham, ON

R. Rhodes Trussell, Ph.D., P.E.
Trussell Technologies Inc.

Brian L. Wheeler
Toho Water Authority

Joseph E. Zuback
Global Water Advisors, Inc.

Executive Director
Glenn Reinhardt

WERF Research Council

Chair
John B. Barber, Ph.D.
Eastman Chemical Company

Vice-Chair
Terry L. Johnson, Ph.D. P.E., BCEE
Black & Veatch Corporation

Rajendra P. Bhattarai, P.E. BCEE
Austin Water Utility

William J. Cooper, Ph.D.
University of California-Irvine

Ann E. Farrell, P.E.
Central Contra Costa Sanitary District (CCCSD)

Thomas C. Granato, Ph.D.
Metropolitan Water Reclamation District of Greater Chicago

James A. Hanlon
U.S. Environmental Protection Agency

James A. Hodges, CPEng.
Watercare Services Limited

David Jenkins, Ph.D.
University of California at Berkeley

Lloyd W. Johnson, M.P.D., P.E.
Aqua-Aerobic Systems, Inc.

Ted McKim, P.E., BCEE
Reedy Creek Energy Services

Beverley M. Stinson, Ph.D.
AECOM

Susan J. Sullivan
New England Interstate Water Pollution Control Commission (NEIWPCC)

WERF Product Order Form

As a benefit of joining the Water Environment Research Foundation, subscribers are entitled to receive one complimentary copy of all final reports and other products. Additional copies are available at cost (usually $10). To order your complimentary copy of a report, please write "free" in the unit price column. WERF keeps track of all orders. If the charge differs from what is shown here, we will call to confirm the total before processing.

Name _____ Title _____

Organization _____

Address _____

City _____ State _____ Zip Code _____ Country _____

Phone _____ Fax _____ Email _____

Stock #	Product	Quantity	Unit Price	Total

Postage & Handling	
VA Residents Add 5% Sales Tax	
Canadian Residents Add 7% GST	
TOTAL	

Method of Payment:

(All orders must be prepaid.)

- ❑ Check or Money Order Enclosed
- ❑ Visa ❑ Mastercard ❑ American Express

Account No. _____ Exp. Date _____

Signature _____

Shipping & Handling:

Amount of Order	United States	Canada & Mexico	All Others
Up to but not more than:	Add:	Add:	Add:
$20.00	$7.50*	$9.50	50% of amount
30.00	8.00	9.50	40% of amount
40.00	8.50	9.50	
50.00	9.00	18.00	
60.00	10.00	18.00	
80.00	11.00	18.00	
100.00	13.00	24.00	
150.00	15.00	35.00	
200.00	18.00	40.00	
More than $200.00	Add 20% of order	Add 20% of order	

* minimum amount for all orders

Make checks payable to the Water Environment Research Foundation.

To Order (Subscribers Only):

Log on to www. werf.org and click on "Publications."

Phone: 571-384-2100
Fax : 703-299-0742

WERF
Attn: Subscriber Services
635 Slaters Lane
Alexandria, VA 22314-1177

To Order (Non-Subscribers):

Non-subscribers may order WERF publications either through WERF or IWAP (www.iwapublishing.com). Visit WERF's website at www.werf.org for details.

California Association of Sanitation Agencies
1215 K Street, Suite 2290 ▪ Sacramento, CA 95814
Phone: 916-446-0388 ▪ Fax: 916-231-2141
www.casaweb.org

Water Environment Research Foundation
635 Slaters Lane, Suite G-110 ▪ Alexandria, VA 22314-1177
Phone: 571-384-2100 ▪ Fax: 703-299-0742 ▪ Email: werf@werf.org
www.werf.org
WERF Stock No. WERF2C10

Sept 2011