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Evaluation of Composting of Municipal Solid Waste

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EVALUATION OF COMPOSTING OF MUNICIPAL SOLID WASTE

by

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ABSTRACT

Evaluation of Composing of Municipal Solid Waste

by

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Utah State University, 2014

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A field-scale commercial compost study was conducted to evaluate the impact of the Bio-Environmental Resource Recovery International (BERRI) Microbial Assisted Regeneration System (MARS) process, specifically its proprietary microbial inocula, on compost production of various agricultural waste and municipal solid waste (MSW) mixtures. Treated and control windrows were constructed to compare the MARS inoculum by quantity and quality of compost produced, organic stabilization time, and individual component sorting (i.e., green waste, wood, agriculture waste, food waste, MSW, C&D debris, and tires). Specific VOC and SVOC compounds, as well as a common pesticide, carbaryl, were added specifically for this study and the compounds were analyzed for degradation rates. The quality of the compost product was assessed using a method developed for classifying municipal solid waste compost. The quantity of compost produced was determined by screening the entire volumes of each pile to determine a gross production of compost for each pile. Compost samples were analyzed by headspace gas chromatography mass spectrometry for VOCs, methylene chloride extraction and gas chromatography mass spectrometry for SVOCs, and methanol extraction and high-performance liquid chromatography mass spectrometry for carbaryl. The quality of compost was found to have a very low nutrient capacity making the compost only useable as a soil conditioner. Treated piles showed a significantly larger amount of compost production and a decreased time for organic stabilization. No significant degradation of plastics or woods components was observed in any of the treatments used in the study.

(127 pages)

PUBLIC ABSTRACT

Evaluation of Composing of Municipal Solid Waste

Millions of tons of organic waste are lost each year by being deposited in landfills instead of being composted. Composting would increase the life of landfills and reduce the loss of renewable resources. Current composting techniques take approximately 6 months to break down the organic components, such as yard trimmings and food waste. In addition, a large amount of area is required for the windrows piles. Recycling techniques help to separate organics, such as yard trimmings and food waste, from the municipal solid waste (MSW) stream for composting. However, these techniques are time consuming, costly, and not extensively practiced. Since separation of the organic faction of MSW is not practical, it is important to seek ways to accelerate the breakdown of organics while composting the entire MSW stream.

The Utah Water Research Laboratory was approached by Bio-Environmental Resource Recovery International (BERRI) to determine the impact of the Microbial Assisted Regeneration System (MARS) process. Various agricultural waste, MSW, construction and demolition waste, and organic contaminant mixtures were assessed to determine the quantity and quality of compost produced using the MARS process.

A field-scale commercial compost study was conducted. Treated and control windrows were constructed to compare the MARS inoculum by quantity and quality of compost produced, organic stabilization time, and individual component sorting (i.e., green waste, wood, agriculture waste, food waste, MSW, C&D debris, and tires). Specific volatile organic compounds (VOCs) and semi-volatile organic compounds (SVOCs), as well as a common pesticide, carbaryl, were added specifically for this study and the compounds were analyzed for degradation rates. The quality of the compost product was assessed using a method developed for classifying municipal solid waste compost. The quantity of compost produced was determined by screening the entire volumes of each pile to determine a gross production of compost for each pile. Compost samples were analyzed for VOCs, SVOCs, and carbaryl.

The quality of compost was found to have a very low nutrient capacity making the compost only useable as a soil conditioner. Treated piles showed a significantly larger amount of compost production and a decreased time for organic stabilization. No significant degradation of plastics or woods components was observed in any of the treatments used in the study.

J. Ryan Stebbins

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INTRODUCTION

Overview

Composting is an aerobic, solid phase process used to biodegrade organic material to a stable end product for use as a fertilizer or as a soil amendment. Government organizations, homeowners, and private companies use composting to reuse presorted yard trimmings and food waste from municipal solid waste (MSW) to decrease the volume of waste in landfills, and to generate a useful end product that can substitute for more costly chemical fertilizers. Compost material is used in personal gardens or sold as fertilizer. Construction and demolition waste (C&D) is not included as a part of MSW, but is commonly discarded at landfills with MSW and is considered to be inert and not degradable. Due to C&D waste being classified as inert it is not composted commercially.

Environmental conditions such as moisture content, oxygen status, and carbon to nitrogen ratio are controlled in composting operations to reduce processing time and to maintain a healthy microbial community (Liang et al. 2003; Ekinci et al. 2004). Composting typically relies on indigenous microbial communities, but some composting operations have evaluated microbial amendments to accelerate the rate and efficiency of composting (Olguin et al. 1993; Takaku et al. 2006; McMahon et al. 2009).

In the absence of an aggressive hazardous waste program in a community, MSW is known to contain volatile organic compounds (VOC) and semi-volatile organic compounds (SVOC) in common household hazardous waste, which can be released to the environment during composting (Smet et al. 1999). C&D debris includes many treated wood components that contain insecticides and preservatives. Nutrients and contaminants contained in organic material are released into the soil by degradation, increasing the nutrient availability and toxicity of the compost (Tognetti et al. 2008).

Full Circle Alliance, a Garden City, UT company, contracted the Utah Water Research Laboratory to evaluate a composting management technique developed by Bio-Environmental Resource Recovery International (BERRI) called the Microbial Assisted Regeneration System (MARS). BERRI claims the MARS process has the potential to rapidly degrade all organic components including organic hazardous contaminants in mixed MSW. This project was initiated to evaluate the effectiveness of the MARS process through a series of field compost experiments conducted over a 9-week period using various mixtures of agricultural waste and mixed MSW. The study involved the side-by-side comparison of compost piles operated with and without the microbial inocula component of the MARS process. Process effectiveness was defined by quantifying the rate and extent of waste component transformation in the piles based on hand sorting of random grab samples collected from the piles over time, organic chemical analysis, and by documenting the production of compost end product versus reject based on mechanical screening and hand sorting of all pile material that remained at the end of the study.

Objectives

The main objective of this study was to evaluate the impact of the BERRI MARS process, specifically its proprietary microbial inocula, on compost production of various agricultural waste and MSW mixtures. The MARS process involves the control of watering frequency, pile turning frequency, mineral nutrient addition, and the use of a bacterial inoculum. The biggest limitation in the evaluation was the lack of information provided on the bacterial inoculum by BERRI. DNA sequencing of the amendment was also forbidden by the owners of the technology. The effect of the inocula on compost performance was evaluated based on side-by-side comparison studies. The rate and extent of pile component transformation to compost end product over time was compared in companion piles with and without the BERRI inocula added at the beginning of the study.

Based on the objective stated above, the following research questions were developed:

1. Does the MARS process significantly affect the rate and extent of decomposition of MSW components, C&D components, and selected organic contaminants found in household hazardous waste compared to conventional composting techniques reported in current literature and practiced at landfills in Utah?
2. Does the MARS process with the inocula significantly affect the rate and extent of decomposition of MSW components, C&D components, and organic contaminants found in household hazardous waste compared to an identical pile without the inocula amendment?
3. Does the microbial inoculum significantly affect the quantity of final compost product, and the quality of the final product (nutrient value and hazard level) based on the method developed by Saha et al. (2010)?

The design of this study included a total of 14 composting windrows. Nine of the windrows were treated with the MARS inoculum and five were not. The windrows contained various mixtures of waste components (i.e., green waste, wood, agriculture waste, food waste, MSW, C&D debris, and tires). To evaluate the impact of the MARS inoculum, all composting windrows were subject to the same composting practices such as turning frequency, watering, and mineral nutrient addition.

The temperature and moisture content throughout each windrow were monitored at random locations each week during the course of the study. Routine measurements of the piles included water extractable pH, electrical conductivity (EC), and total organic carbon (TOC). Samples for analysis of specific compound concentrations (34 volatile organic compounds (VOCs), 19 semi-volatile organic compounds (SVOCs), and a commonly used pesticide, carbaryl) were collected at approximately 0, 4, and 9 weeks following initial pile construction. Final fertility analysis was performed by Utah State University Analytical Laboratory to determine the compost's value for commercial use based on nutrient availability and metal toxicity. Bulk characterizations were performed each week by determining the physical observation of pile composition, bulk density of pile material, and the moisture content of pile material. Physical observation of pile composition was performed by sorting samples by component type (i.e., plastic, paper, wood, organic, inorganic, metal and glass, tires, bones, and soil).

LITERATURE REVIEW

Introduction

The rapid increase in MSW generation during the 1980s and 1990s has motivated government agencies to focus on waste reduction and recycling. The Year 2010 was the first recorded instance where there was a reduction in total MSW generation since to the 1960s in the US. With an ever-increasing population, a reduction in total MSW generation would be difficult to maintain as residential waste accounts for 55 to 65 percent of total MSW generation (EPA 2012b). Reducing the amount of landfilled waste will increase the life of landfills and reduce the loss of renewable resources. Composting of mixed organics, grass, and food scraps decreases the amount of greenhouse gasses released into the global environment when compared to waste disposal in landfills contribute to, however it increases the amount of greenhouse gasses released for leaves and branches (EPA 2012a). Composting of MSW is being investigated by numerous private companies and researchers for more efficient procedures, accelerants, and amendments to ensure the quality and viability of MSW compost (Takaku et al. 2006; McMahon et al. 2009; Mingyan et al. 2011; Delgado-Rodriguez et al. 2011).

Most current large-scale composting practices generally involve only green waste and a small portion of food waste from the MSW stream. For example, the Salt Lake Valley, UT, landfill composting system involves mostly green waste, wood chips, and some food waste; the piles are rarely turned or aerated; and it requires approximately 6 months to produce a stabilized compost product. Testing is generally performed on finished product for organic carbon, phosphorus, nitrogen, and for metal toxicity (Lasley

2012). The Trans-Jordan, UT, landfill has a completely different system in which they turn the piles twice a week for the first 2 weeks and then weekly after that for approximately 4 months. Nutrient testing is generally performed on piles only twice a year (Jolley 2012).

Many research projects have focused on the identification of bacteria and microbial communities that degrade contaminants allowing for improved remediation (Larkin and Day 1986; Chaudhry and Ali 1988; Kastner et al. 1994; Mueller et al. 1997; Ho et al. 2000; Bastiaens et al. 2000; Swetha and Phale 2005; Mingyan et al. 2011). VOCs are commonly present in MSW and MSW waste treatment facility emission rates are currently being studied (He et al. 2012; Delgado-Rodriguez et al. 2012; Gallego et al. 2012). Pesticides, such as carbaryl, and SVOCs, such as fluorine and pyrene, have been found to persist in the environment, with research focusing on composting as a remediation tool for these recalcitrant chemicals (Brown et al. 1997; Sayara et al. 2010; Naqvi et al. 2011).

The grade and quality of finished compost can be determined using a fertility analysis by determining the nutrient availability of the compost, in unison with metal concentrations for toxicity, to generate an index for grading compost (Saha et al. 2010). Fertility analysis is used to determine whether the compost is viable as a fertilizer or can only be used as a basic soil conditioner to improve soil structure.

Generation of Landfill Waste

MSW

After recycling, approximately 74 percent, or 185 million tons, of the total U.S. MSW generated could be composted, with approximately 70 percent of that 185 million tons being organics that are considered to biodegrade (EPA 2012b). With the use of microbial amendments to assist in making slowly degrading materials break down at a more rapid pace, the recovery of the organic fraction of MSW may be greatly increased through composting. Household hazardous waste is also considered a part of the MSW stream and is legally disposed of at non-hazardous landfills by individual citizens.

The primary source of landfill waste is from residential sources, such as households and apartment complexes, which the EPA estimates is about 55 to 65 percent of the total MSW generation. Industrial and commercial waste accounts for the balance of the waste generated. Organic material is the primary component of MSW and is composed of paper, food scraps, yard trimmings, wood, plastic, rubber, leather, and textiles. The inorganic components of MSW include metal, glass, and a small amount of other miscellaneous wastes. After recovery of materials by recycling, component percentages of MSW that is discarded in landfills or recovered through combustion is shown in Table 1.

Table 1. Component percentage of typical MSW (EPA 2012)

Paper and Paperboard	Plastic	Wood	Misc. Organic	Metal and Glass	Misc. Inorganics
14.5%	15.4%	7.3%	46.5%	12.4%	2.1%

C&D

C&D debris, 170 million tons generated in the US in 2003, is another waste component that is causing difficulties for governments (EPA 2012b). Typical materials found in C&D are concrete/rock/brick, asphalt products, lumber, gypsum board, soil/fines, and other C&D materials with composition percentage by wet mass being 11.3, 14.0, 39.7, 9.7, 11.5, and 13.9, respectively (Staley and Barlaz 2009). Residential C&D debris is approximately 49.4 percent organic material comprised of wood and gypsum board, which theoretically could be composted, but is considered inert. The costs for disposing of C&D debris at landfills are continually increasing.

McMahon et al. (2008) determined that various types of timber products such as chipboard, medium density fiber, hardboard, and melamine can be degraded while adding poultry manure and green waste for nutrient supplements. The wood component of C&D waste was successfully composted in an EcoPOD composting system manufactured by QBF Ltd (Bakewell, Derbyshire, UK). McMahon et al. (2009) composted different wood mixtures of untreated timber, creosote treated timber and chromated copper arsenate treated timber. It was determined that there was a need for a microbial inoculum to support composting of this material as the treated wood by itself did not contain an adequate microbial community to effectively support aerobic decomposition of the wood mixture.

Chemicals in MSW

VOCs

Volatile organic compounds (VOCs) readily volatilize due to their high vapor pressure at room temperature. This general class of chemicals is commonly found in gasoline, paints, solvents, particleboard, cosmetics, and house cleaning chemicals. These products are also commonly found in MSW and C&D debris, and are commonly disposed of at local landfills with other mixed MSW. Some typical VOCs that have been monitored in MSW composting by air sampling are benzene, styrene, xylene, toluene, and ethyl benzene (Gallego et al. 2012; He et al. 2012). VOCs such as benzene and xylene are known to be carcinogenic and can cause headaches, dizziness, and chronic respiratory problems (Ireland 2011).

Brown et al. (1997) determined in a laboratory scale study that the majority of the most volatile VOCs present in the composting of MSW, including benzene and xylene, are lost from the compost in the initial 48 hours due to volatilization. Benzene and xylene showed 100% removal at approximately 0.25 and 0.75 days. After 1 week, spiked VOC concentrations were below detection limits in both the compost and leachate. Genovese et al. (2008) determined that biopiles are efficient at bioremediation of benzene, toluene, ethylbenzene, and xylene by allowing a 90% removal of total hydrocarbons after 15 days without the effects of volatilization.

SVOCs

SVOCs include a class of organic pollutants called polycyclic aromatic hydrocarbons (PAHs), which are generated by the incomplete combustion of organic matter. Sources such as forest fires, fuel combustion, and home heating create a vast quantity of low-level PAHs that are distributed worldwide. With a generally low aqueous water solubility and high soil-water distribution coefficient, their availability for microbial degradation is low compared to the accumulation on solid phases (Johnsen et al. 2005). However, PAHs with low molecular weight, such as naphthalene, phenanthrene, and anthracene are considered to be easily degradable (Cerniglia 1992). PAHs are known to cause cataracts, kidney and liver damage, jaundice, and an increased risk of skin, lung, bladder, and gastrointestinal cancers (Xu and Zhang 2011).

Composting has been found to be particularly effective for remediating soils polluted with petroleum hydrocarbons, especially the PAH fraction (Anitzar-Ladislao et al. 2004). Sayara et al. (2010) studied the biodegradation of pyrene in compost from the organic fraction of MSW with different levels of stability, ranging from fully-stable to unstable compost, determined by the Dynamic Respirometric Index (DRI) (Adani et al. 2004). The DRI is based on the oxygen consumption rate of the compost. A higher oxygen consumption rate indicates a less stable compost. It was determined that the highest pyrene degradation rate was seen with the more stable compost, demonstrating that slowly degrading compounds like pyrene will persist until the rapidly degrading organic material is consumed, then organisms begin to degrade pyrene as well. Pyrene degradation of 86% was seen after 10 days and 100% after 30 days with highly stable compost (Sayara et al. 2010).

Contamination of soil and wastes by fuels and oils may be determined by analyzing for molecular weight ranges of hydrocarbons. The range for the hydrocarbons is based on a gas chromatograph retention time range to represent a petroleum hydrocarbon source. Adekunle (2011) determined that compost from the organic fraction of MSW could be used on soils contaminated with petroleum products for bioremediation. A reduction of total petroleum hydrocarbons from 40-76% was seen in 21 days (Adekunle 2011).

Carbaryl

Carbaryl, or 1-naphthyl methylcarbamate, is an odorless, non-corrosive, white to grayish crystalline solid that is used as a pesticide in over 300 products all over the world (Purdue Research Foundation 2001; Tomlin 2011). The structure of carbaryl is shown in Figure 1. Carbaryl acts as a nervous system disruptor by adding a carbamyl moiety to the acetylcholinesterase enzyme active site, preventing it from breaking down acetylcholine (Klaasen et al. 1996). Over time, a surplus of acetylcholine in the synapse is produced, causing overstimulation of the nervous system (WHO 1986). Carbaryl is considered to be a likely human carcinogen (EPA 2004).

The physical-chemical properties of carbaryl are: a molecular weight of 201.2 g/mol, a log K_{OW} of 2.36 (Hansch and Leo 1985), a solubility of 104 mg/L (Bowman and

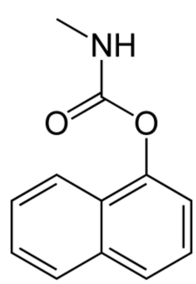

Figure 1: Chemical Structure of Carbaryl (CAS#:65-25-2).

Sans 1983), a vapor pressure of 1.36 x 10^{-6} mm Hg (Ferreira and Seiber 1981), a Henry's law constant of 3.46 x 10^{-9} atm*m^3/mol (Syracuse Research Corporation 1988), and a K_{OC} value of 102 (Lord et al. 1980). Carbaryl has been found to degrade abiotically through hydrolysis under alkaline conditions in about 45 hours at a pH of 8.0 (Chapman and Cole 1982).

Carybaryl has been found to abiotically break down, primarily by hydrolysis, and to microbially degrade to 1-naphthol and carbon dioxide. Rao and Davidson (1982) determined that carbaryl is moderatly persistent in aerobic soil systems with a half live of 22 days. Under flooded conditions in alluvial soil 59% carbaryl removal was observed after 15 days compared to 27% removal in nonflooded conditions, or at 50% of a soils water holding capacity (Venkateswarlu et al. 1980a). Carbaryl degradation rates double if soil is flooded due to compounding effects of hydrolysis and microbial degradation, presumably due to anaerobic metabolism (Venkateswarlu et al. 1980b).

Amendments

A composting amendment is the addition of nutrients to support the growth of microbial communities already present or the addition of new microbial communities to accelerate the decomposition and degradation of materials or contaminants. Research has been increasing on determining specific bacterial strains and microbial communities that assist in the degradation and assimilation of organic contaminants for remediation (Genovese et al. 2008; Sayara et al. 2010; Llado et al. 2013). PAHs degradation is limited to very specific bacterial strains such as *Sphingomonas*, *Burkholderia*, *Pseudomonas*, and *Mycobacterium* (Kastner et al. 1994; Mueller et al. 1997; Ho et al. 2000; Bastiaens et al.

2000). Numerous bacteria have been isolated from soil, which are known to degrade carbamate pesticides (Chaudhry and Ali 1988; Larkin and Day 1986).

Most compost research involves the addition of manure, preferably from poultry, to increase the number of organisms and diversity of the microbial community to assist in the degradation of organic matter (McMahon et al. 2008; McMahon et al. 2009; Naqvi et al. 2011). In certain cases, the addition of nitrogen or phosphorus also takes place to provide requisite nutrients to maintain microbial communities (Naqvi et al. 2011).

Fertility

The quality of compost produced from MSW depends on many sources of variation including composting facility design, control parameters, length of maturation, and the source of the waste (Hargreaves et al. 2008). Inorganic fertilizers are required by law to declare the nitrogen, phosphorus, and potassium content, however there is no required declaration for the content of compost, which contains various nutrients and organic matter, in respect to its quality or potential toxicity (Brinton 2000).

Saha et al. (2010) developed a method for assigning quality indices to grade compost quality based on: (1) a fertilizing value, and (2) the environmental threats due to its metal content. Metal contaminated compost has been shown to significantly increase metal concentrations in compost-amended soils and results in a general increase in plant uptake of metals with primary accumulation in the root tissue (Ayari et al. 2010).

MATERIALS AND METHODS

Windrow Compost Site

The compost site was located at the Garden City, UT sewer treatment lagoons. Figure 2 shows a general layout for the compost windrows. A liner of approximately 3 to 6 inches of compacted clay was constructed across the site before windrows were built to minimize groundwater contamination potential and control water runoff for the entire site. Piles 1 to 9 were amended with the MARS process microbial inocula and separated by a 3-foot tall clay barrier to reduce contamination of the control piles 1a, 2a, 3a, 4a, and 6a. Separate access to the control piles was provided to maintain separation of the microbially amended and control piles in case of heavy rainfall and pile runoff.

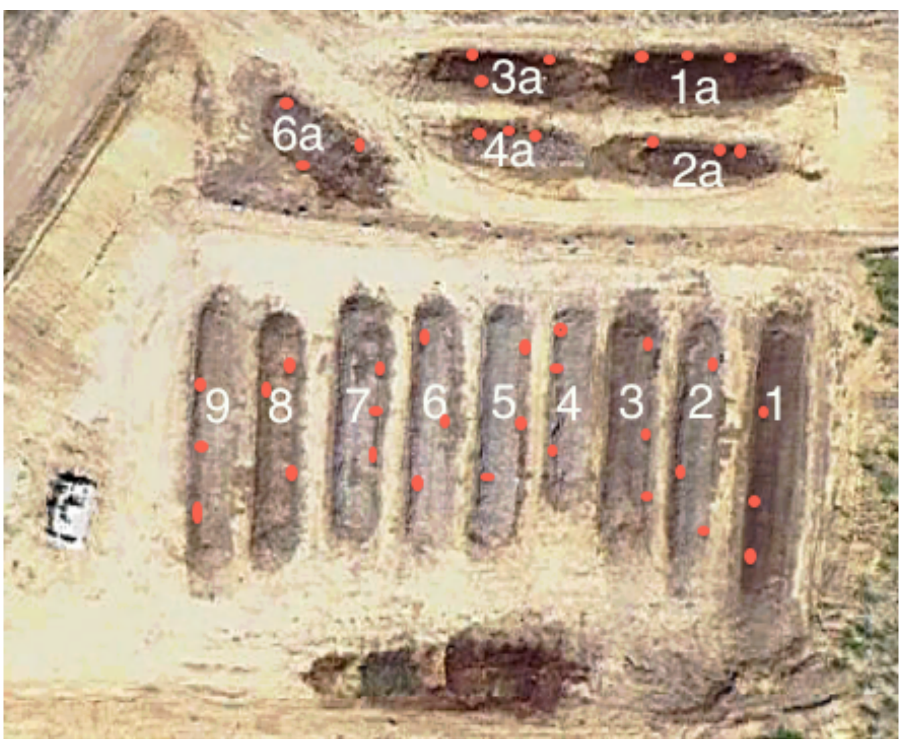

Figure 2: Windrow Compost Site Layout in Garden City, UT. Piles 1-9 are treated piles while piles 1a, 2a, 3a, 4a, and 6a are controls. Red dots show example of sampling points.

Compost Materials

The MSW for this study was obtained and shredded at the Rich County Landfill, which services a total population of approximately 2,300 people (United States Census Bureau 2012). The landfill accepts municipal, commercial, industrial, and C&D wastes. C&D debris was taken from residential demolition projects in the Rich County area with only large metal objects removed. This C&D waste contained a large percentage of wood, roughly 60%, with some plastics, drywall, and various inorganic materials. Food waste (FW) was collected from local restaurants and green waste (GW) primarily contained grass clippings obtained from city departments in Garden City, UT. Agriculture waste (AgW) was a mixture of bedding and animal manure collected from local farmers. Wood waste was obtained by grinding railroad ties, treated wood, and locally removed trees to an approximate size of 2-4 inches. A horse and cow carcass were obtained locally and placed in windrow Piles 3 and 3a without grinding or processing along with various amounts of carp, chicken waste, and commercial food waste. MSW and C&D debris were processed through an industrial grinder (Rexworks, Milwaukee, WI) to an approximate size of 2-4 inches.

Pile Construction

A list and weight percent of composition of materials in each pile are provided in Table 2. Starting pile components were selected based on availability and to have a range of different starting components. Once C&D waste and MSW were available they were included in pile construction. Piles were constructed by creating a single bulk pile of materials to be composted that was then mixed by a CAT 966G front-end loader. To create similar treated and control windrow piles the raw material was taken from the bulk mixture and placed in two different treatment areas, one for microbial amended piles (Piles 1 through 9, Figure 2) and one for unamended piles (Piles 1a, 2a, 3a, 4a, and 6a, Figure 2). Material weights were measured using a scale attached to the bucket of a frontend loader while the bulk pile of materials was prepared. Individual pile weights were obtained from frontend loader scale measurements as the windrows were being built.

To evaluate the fate of a range of organic chemicals common to MSW in select compost piles in this study, 3 gallons each of diesel fuel, kerosene, and form oil were applied to the bulk pile of materials used to construct Piles 2, 2a, 6, and 6a using a form oil applicator. The bulk material was then mixed and moved to the composting locations of the designated piles. This application rate yielded a target initial concentration in Piles

Table 2: Composting pile material components† on a weight % basis

Pile	Total Wt. (T)	GW	Wood	AgW	MSW	C&D	FW	Tires
1	188.7	7.8	2.9	89.4				
1a	96.3	7.2	2.9	89.9				
2	78.8	43.4				55.1		1.5
2a	30.8	43.8				55.6		0.6
3	74.4	53.9	4.0	22.3		12.8	7.0	
3a	32.5	56.9	2.8	23.3		13.4	3.6	
4	40.1		14.4		57.5	28.1		
4a	17.5		8.0		61.7	30.2		
5	73.0	16.3			56.1	27.6		
6	78.1	14.0	23.3		41.8	20.6		
6a	44.8	14.0	14.3		47.9	23.6		
7	97.5	12.7			58.5	28.8		
8*	99				33	67		
9		Unable to estimate composition						

*Pile weights estimated due to scale malfunction

† GW= green waste; Wood = railroad ties, treated wood, trees; AgW = Agricultural Waste consisting of bedding and animal manure; FW = food waste

2 and 2a of approximately 140 mg/kg dry material, and for Piles 6 and 6a of approximately 100 mg/kg dry material. One gallon of Sevin, a pesticide containing carbaryl, was also added to Piles 6 and 6a to produce an initial concentration of approximately 0.05 mg of carbaryl/kg dry material in those piles. A horse carcass was added to Pile 3, while a cow carcass was added to the center of Piles 3a. The addition of the carcasses was performed during the construction, and they were fully covered with composting material at the start of the study. Compost piles were completely turned every 2 weeks using a Scarab (Scarab, White Dear, TX) windrow turner.

Pile Sampling

Sampling for pile bulk characterization was performed during each pile turning event. Sampling for VOC, SVOC, carbaryl, and general chemical characterization was performed at approximately 0, 4, and 9 weeks. Sampling sites were determined by dividing the length of each windrow into thirds and using a random number generator to determine three sampling locations within each windrow. Samples were obtained by digging with a posthole digger at a 45° angle approximately 1 to 2 feet into the pile at vertical positions 1 to 2 feet below the peak of the windrow at the randomly selected locations. Samples were transferred directly to sampling containers via the posthole digger or by gloved hands.

General chemical characterization samples were transported to the laboratory for analysis in 110 mL glass containers (Figure 3 A), while SVOC samples were transported in 225 mL glass containers (Figure 3 B). Triplicate grab VOC samples were transported in a container made by installing a bulkhead fitting with a septum into the lid of a 1 gallon Teflon lined metal paint can (Figure 3 C). A matrix modifier solution was made by dissolving 4 kg of sodium chloride in 12 L of de-ionized water. The empty cans were weighed, then 2 L of matrix modifier were added to each can and weighed again. Finally, the cans were weighed again after the addition of approximately 1.5 kg of compost prior to being sealed and stored for analysis. This mixture of compost and matrix modifier solution left approximately 5 to 7 cm of headspace in the paint can for headspace analysis. All samples were brought to the lab and stored in a 4°C refrigerator prior to analysis.

Composite bulk characterization samples were obtained by compositing approximately equal volumes of sample from each of the three randomly selected sampling locations for each of the windrows. These samples were transported in 38 L storage tubs (Figure 3 D). Each tub was transported to the lab and stored at 4°C prior to sorting. Triplicate samples for analysis of dry weights were taken from bulk characterization tubs before sorting of the compost components.

Initial piles sizes were estimated by measuring the height, width, and length of each of the windrows, as piles were initially pyramidal in shape. After initial turning of the windrows the piles trapezoidal, requiring an additional measurement of the width at the top of the pile. At the end of the study, the entire volumes of Piles 1, 1a, 2, 2a, 3, 3a, 4, 4a, 6, 6a, 7, and 9 were screened and separated into “compost” – that fraction of each pile passing a ¾” screen, and “reject” – that fraction retained on the ¾” screen, to determine the gross production of compost for each waste mixture and compost treatment. Composite fertility analysis samples were obtained from the “compost” fraction, were stored in gallon size Ziploc bags, and were taken directly to USU Analytical Labs for analysis.

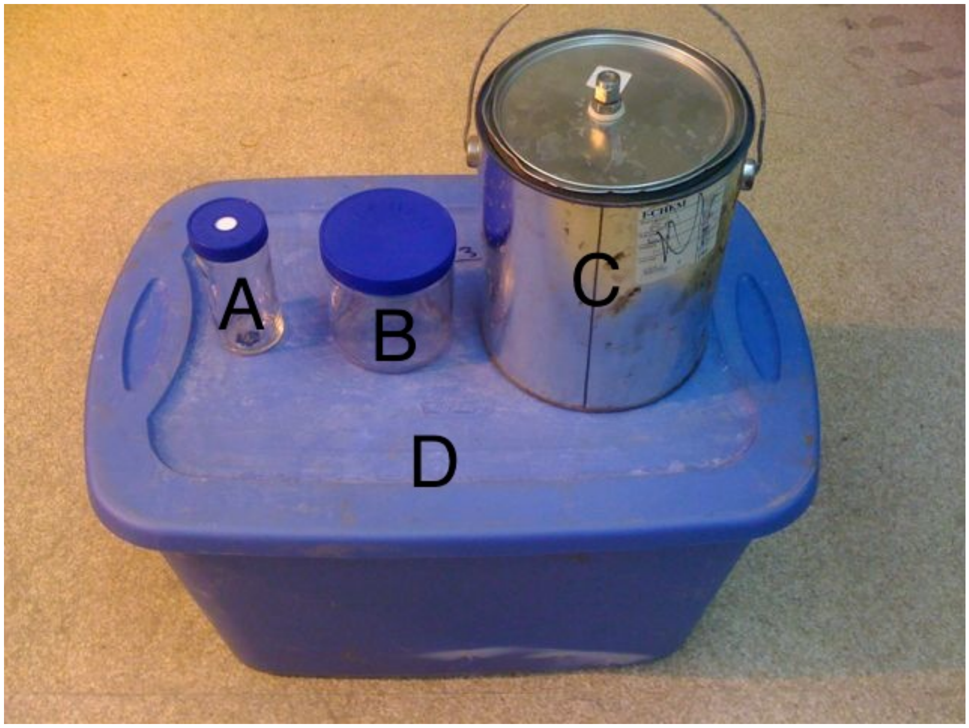

Figure 3. Containers used for sample collection and analysis

Analytical Methods

VOC Analysis

A total of 34 different VOCs were analyzed in this study over time and are summarized in Table A-1 in Appendix A, along with their various relevant chemical properties. These compounds were selected to be representative of a range of common organic contaminants in fuels, oils, paints, etc., that are of concern due to their toxicity and environmental contamination potential. Concentrations were found and analyzed to determine degradation rates and residual concentrations in the final compost.

The 2 L of the saturated sodium chloride matrix modifier solution was added to the compost material in the VOC sample containers. The high salinity was used to increase the Henry's law constant and drive more VOCs into the headspace. No spikes were analyzed. The sample containers were allowed to reach room temperature upon removal from the 4°C refrigerator before headspace samples were collected by injecting a 10 mL volume of the headspace atmosphere from each paint can onto separate Supleco carbopack sampling with a syringe. The sample tubes were analyzed by thermal desorption gas chromatography/mass spectrometry. Desorption was performed on a Perkin Elmer ATD 150 thermal desorption unit with the primary desorb temperature being 310°C and primary desorb time of 20 minutes. The secondary trap loading temperature was -30°C with the secondary trap desorb temperature being 320°C and the secondary trap desorb time of 1 minute, while using a splitless injection method.

The desorbed analytes were loaded onto a 60-m RTX-5 capillary GC column, 0.25 mm ID, 1.0 µm stationary phase. An Agilent 6890 GC oven performed the chromatographic separation. The Agilent 5973 mass selective detector was operated in scan mode, scanning 35-350 amu at 2.5 amu/s. An external calibration curve was used for quantification of all target analytes. An external standard curve was prepared by adding known concentrations of a standard gas mixture containing the analytes of interest onto a carbopack sample tube, then analyzing the standard by the same method as the samples. Data processing consisted of confirming the presence of at least two diagnostic ions for each compound, at the retention time determined by standard analysis. Quantification was achieved by comparison of the peak area from the compound specific extracted ion chromatogram to the standard curve.

Initial VOC concentrations in parts per billion by volume (ppbv) from the GC/MS were reduced to µg contaminant/kg compost concentrations. This was done by first multiplying the ppbv by the volume of the headspace of the sample container and the molecular weight, then dividing by the number of moles of gas per liter, and finally converting units to μg contaminant/kg compost as shown in Equation 1.

SVOC Analysis

A total of 19 different SVOCs and three boiling point range organic mixtures were analyzed over time in this study and are summarized in Table A-2 in Appendix A along with their various relevant chemical properties. These compounds were selected to be representative of a range of hydrocarbon contaminants and other chemicals that can be found in typical MSW, and that can volatize during the composting process due to high internal pile temperatures.

Aliquots of the solid waste were extracted under elevated temperature and pressure using a Dionex Accelerated solvent extractor. Aliquots ranging from 5 to 10 g were taken from each homogenized solid sample, mixed with 5 to 10 g of diatomaceous earth (DE), and loaded into 66 mL stainless steel extraction vessels. The surrogate 1-chlorooctane was spiked (50 μg) into each sample cell to monitor extraction efficiency. QC samples (blank DE spikes) were prepared by spiking methanol solutions of appropriate analyte mixes into the DE support before the cells were sealed. The samples were extracted with a 100% methylene chloride, an extraction temperature of 150°C, an average static pressure of 1500 psi, a static time of 10 minutes, and two static cycles.

$$\frac{ppbv * V * MW * 10^{6} \frac{\mu g}{g}}{10^{9} * \frac{24 L_{air}}{mol} * g_{dryweight} * 10^{-3} \frac{kg}{g}} = \frac{\mu g}{kg} \qquad (1)$$

This first extraction step produced approximately 75 mL of methylene chloride extract. This solution was dried by passing it through 2 g of 30 mesh anhydrous sodium sulfate in a 3 mm diameter glass column. The dried extract was concentrated under a nitrogen stream to 1 mL in a Turbovap evaporative concentrator. After final concentration, the samples were spiked with 50 µg Naphthalene-d8 internal standard and stored at 4°C until GC/MS analysis.

A 1-µL aliquot of each sample solution were injected onto an Agilent 6890/5973 GC/MS system. The injection mode was splitless for 30 seconds, and then 20:1 split after that. It was run on a 30 m x 0.25 mm diameter Restek RTX-5MS with 0.5 µm film with helium at 30 cm/s velocity as the carrier gas. The oven parameters were 40°C for 2 minutes, 10ºC/min to 310°C, and then hold for 10 minutes. The MS scanned from 30-300 amu at 3 scans/s.

The analytes of concern for this project include a list of 13 individual PAHs and three refined petroleum fractions: Kerosene, Diesel, and Motor Oil. Quantitative data for each analyte or mixture were obtained using a response factor determined by the analysis of a known standard. For specific PAHs the most prevalent ion in the mass spectrum was used to generate an Extracted Ion Chromatogram (EIC). The peak representing the analyte at the proper retention time was integrated and the integrated area was used to calculate the concentration of the analyte in the extract. The petroleum mixtures were quantitated similarly, with the exception that the response was determined by summing the integrated values of all peaks within a certain boiling point range over specified retention time windows, rather than a single discrete peak at an exact retention time.

Initial SVOC concentrations in µg/sample from the Agilent Technologies 6220 Accerate-Mass TOF LC/MS were reduced to g compound/g sample concentrations. The concentrations for motor oil, diesel, and kerosene range organics were adjusted by subtraction of the background response. The background response was determined by averaging the concentrations of all control and lab samples not spiked with motor, diesel, or kerosene range organics, including continuing calibration verification (CCV) samples, quality control spikes, blanks, and standard curve samples.

Carbaryl Analysis

The pesticide carbaryl was examined in this study in four different compost piles. This compound is a commonly used pesticide found in products such as Sevin and Carylderm shampoo. Carbaryl has also been shown to have high toxicity towards fish and aquatic invertebrates (Erickson and Turner 2003).

A weighed aliquot of the sample was shaken for 30 minutes with 10 mL methanol. Aliquots from 5 to 10 g in size were added to 40 mL centrifuge tubes, then 10 mL of Fisher Optima grade methanol were added to the tubes, which was capped and placed in a shaker for 30 minutes. After shaking, the tubes were centrifuged at 10,000 rpm for 20 minutes. A 1.0 mL aliquot of the clear supernatant was transferred to a clear 2 mL LC sample vial for analysis.

A 10 µL aliquot of each sample solution was injected onto an Agilent 1200 series HPLC/6220 TOF/MS. The injection volume was 10 µL with a column of 5 cm x 1.8 um sphere C18. The mobile phase "A" was 0.1% Formic acid and 0.1% methanol in DI water, with the mobile phase "B" being 90/10 acetonitrile/DI water.

An extracted ion chromatogram of the exact mass of [Carbaryl + H^+] = 202.0863 +/- 20 ppm was created for each standard and sample. All peaks were integrated. Initial testing shows the carbaryl peak elutes at 5.56 minutes. An external response (peak area) versus concentration curve for the peak at 5.56 was used to quantitate the samples.

General Chemical Characterization

General chemical characterization was performed by using SW-846 Method 9045 for water extractable pH and EC. The pH was measured in suspension using a Corning 313 pH/Temperature meter and the EC was measured in suspension using an Accumet Model 30 conductivity meter. To determine the DOC, DI water and compost samples were mixed and the water was extracted with a 1 mL pipette and centrifuged at 10,000 g for 10 minutes. The resulting supernatant was run on a Teledyne Tekmar Apollo 9000 combustion TOC analyzer following the SW-846 Method 9060A.

Fertility Analysis

Composite compost samples were taken to USU Analytical Laboratories to perform the fertility analysis on screened final compost samples. The USU laboratory's Manure Analysis was performed to determine the total elemental composition, which consisted of N, P, K, Ca, Mg, Na, S, B, Zn, Cu, Fe, and Mn, along with moisture content, pH, and EC. The Pb, Cd, Ni, and Cr were analyzed at the Utah Water Research Laboratory (UWRL) using EPA method 3050B for use with the Environmental Express HotBlock Digestion System. Digested samples were then run on an Agilent Technologies 7500 Series ICP-MS. All standard quality assurance and quality control checks were passes before sample results were considered acceptable. Compost classifications for each final product were then determined using the method of Saha et al. (2010).

The “fertilizing index” (Saha et al. 2010) for compost was based on a ‘weighing factor’ for organic carbon, nitrogen, phosphorus, potassium, the C:N ratio, and the respiration activity, and a ‘score value’ based on the % dry matter as shown in Table 3. The weighing factor and score value are then used to calculate a fertility index shown in Equation 2.

The “clean index” (Saha et al. 2010) for compost is based on a ‘weighing factor’ for zinc, copper, cadmium, lead, nickel, and chromium and a ‘score value’ based on the mg/kg dry matter as shown in Table 4. The weighing factor and score value are then used to calculate a clean index shown in Equation 3. After the fertilizing index and the clean index have been calculated the classification of the compost can be determined by following Table 5. The quality control compliance column in Table 5 refers to the regulatory limits for metal content in the compost for the country in which the compost is being sold. The remark section shows the quality of the compost. Class A to C are marketable composts ranging from Best Quality to Medium Quality due to fertilizer quality and compliance with metal standards. Class RU-1 complies for metal content, but has low fertilizing capacity. RU-2 and RU-3 both do not comply with regulatory limits for metals in the country where the compost is being sold.

Table 3: Criteria for assigning weighing factor and score value for fertility index. Saha et al. (2010)

	Score value (S*i*)					Weighing Factor (W*i*)	Recommended Values
	5	4	3	2	1		
Total organic C (% dm)	>20.0	15.1-20.0	12.1-15.0	9.1-12.0	<9.1	5	20-35
Total N (% dm)	>1.25	1.01-1.25	0.81-1.00	0.51-0.80	<0.51	3	1.0-2.0
Total P (% dm)	>0.60	0.41-0.60	0.21-0.40	0.11-0.20	<0.11	3	800-2500 mg/L
Total K (% dm)	>1.00	0.76-1.00	0.51-0.75	0.26-0.50	<0.26	1	500-2000 mg/L
C:N	<10.1	10.1-15	15.1-20	20.1-25	>25	3	<17:1
*Respiration Activity (mg CO_2-C/g /d)	<2.1	2.1-6.0	6.1-10.0	10.1-15	>15	4	

* Not analyzed in this study

$$F = \frac{\sum_{n}^{i=1} SiWi}{\sum_{n}^{i=1} Wi} \qquad (2)$$

Bulk Characterization and Dry Weight

Composted material for triplicate dry weight analysis was taken from the bulk characterization composite samples prior to sorting. Samples were held in a 100 mL beaker and dried in an oven at 100°C. Weights were checked every 24 hours until no change was measured. The primary sorting for bulk characterization was done on a single large sample of approximately 20 L of compost material. At the end of the study at least

Table 4: Criteria for assigning weighing factor and score value for clean index. Saha et al. (2010)

Metal	Score value (S*j*)						Weighing Factor (W*j*)	*Biosolids Standards, US EPA (mg/kg)	†Agronomic Limits for Toxicity
	5	4	3	2	1	0			
Zn (mg/kg)	<151	151-300	301-500	501-700	701-900	>900	1	7500	400
Cu (mg/kg)	<51	51-100	101-200	201-400	401-600	>600	2	4300	200
Cd (mg/kg)	<0.3	0.3-0.6	0.7-1.0	1.1-2.0	2.0-4.0	>4.0	5	85	1.5
Pb (mg/kg)	<51	51-100	101-150	151-250	251-400	>400	3	840	200
Ni (mg/kg)	<21	21-40	41-80	81-120	121-160	>160	1	420	50
Cr (mg/kg)	<51	51-100	101-150	151-250	251-350	>350	3	3000	100

* Ceiling concentrations for land application (EPA 1993); † Upper limit for toxic elements (WRAP 2011)

$$C = \frac{\sum_{n}^{j=1} SjWj}{\sum_{n}^{j=1} Wj} \tag{3}$$

one larger composite sample, approximately 30 L, was separated and sorted in triplicate to determine a 95% confidence interval for the average of triplicate samples.

Preparation for single sample sorting was performed by recording the initial weight of a bucket, volume of the waste sample, the bucket number, and by taking initial photos of the solid waste. For triplicate sample sorting, the solid waste was first separated into smaller buckets and then weighed and photographed. Sorting was performed by

Table 5: Classification of composts for their marketability and use. Saha et al. (2010)

Class	Fertilizing index (F)	Clean index ©	Quality control compliance	Remark
A	>3.5	>4.0	Complying for all metal parameters	Best Quality
B	3.1-3.5	>4.0	Complying for all metal parameters	Very good quality
C	>3.5	3.1-4.0	Complying for all metal parameters	Good quality
D	3.1-3.5	3.1-4.0	Complying for all metal parameters	Medium quality
RU-1	<3.1	-	Complying for all metal parameters	Should not be allowed to market. Can be used as soil conditioner
RU-2	>3.5	>4.0	Not complying for all metal parameters	Should not be allowed to market. Restricted use
RU-3	>3.5	-	Not complying for all metal parameters	Should not be allowed to market. Restricted use

using a ¼" sieve to remove the compost and then sorting the remaining solid waste into their respected components which included paper, plastic, wood, organic (green waste), compost, metal & glass, tires, inorganic (brick and rock), and bones. After recording the weight of each sorted material, all the waste material was transferred back to the original bucket for disposal.

Data Reduction Methods

Decomposition rates were determined for all target components and organic contaminants. Checking for outliers for organic contaminants was done using a Grubbs' T-test for small data sets in triplicate measurements. Values that were below the method detection limit were estimated using an imputation method (Gillion and Helsel 1986; Helsel and Gilliom 1986; Bethouex and Brown 2002; Helsel 2005). The determination of reaction rate kinetics was performed by comparing the zero order reaction regression analysis to the first order reaction regression analysis, testing for the significance of the slope, residual sum of squares (RSS), and by visual inspection of the regression line. The 95% confidence interval of the slope for degradation rates of organic contaminants were then compared against degradation rates between treated and control piles. R Statistical Software (R Development Core Team, 2008) was used to determine the 95% confidence interval of the slope, the p-value for the regression analysis, RSS value, and graphing for visual inspection.

The extent of the reaction for components and organic contaminants was defined by using both the percent removed and percent residual after compost stabilization. Time for stabilization was determined based on the degradation rate of organic material being at least one order of magnitude lower that the initial rate. To check for statistical differences, analysis of variance was performed on stabilization time for treated and control piles. A 95% confidence interval was calculated for Piles 5, 6, and 7 and compared to Pile 6.

The values for the quantity of compost produced, for treated and control piles, were compared to determine possible differences for the microbial amendment. Analysis of variance was performed on the “clean index” and “fertilizing index” score values for treated and control piles to check for significantly different values. The “fertilizing index” and “clean index” was then used to determine the overall class and use for the compost produced for the treated and control piles.

RESULTS AND DISCUSSION

Compost Component Stabilization

Organics

All organic material, such as green waste and food waste, was considered the organic fraction except for paper and cardboard products. The slope of the percent organic fraction between sampling points was graphed to determine the time of compost stabilization as demonstrated in Figure 4 for Piles 1 and 1a (approximately 90% AgW and 10% GW). Stabilization time was determined once a change in the slope of the percent organic fraction stabilized at least one order of magnitude lower than the initial percent organic fraction of the pile. Figure 4 shows that Pile 1 had an initial slope of -0.60, which then dropped to -2.0. At day 34, Pile 1 stabilizes between 0.003 and -0.22. Figure 4 shows that Pile 1a displays a large initial slope of -3.5 and then stabilizes between 0.005 and -0.63 for the remainder of the study. The estimated time of stabilization is 34 days for Piles 1 and 1a. Organic stabilization plots are shown in Appendix B for all piles.

Table 6 shows the determined stabilization time for each pile. The organic stabilization time for Piles 1 and 1a and 2 and 2a (approximately 55% C&D and 44% GW) show no difference, while Pile 3 (approximately 55% GW, 23% AgW, and 13% C&D) has a shorter stabilization time than 3a by seven days. Pile 4 and 4a (approximately 60% MSW, 30% C&D, and 10% Wood) were built with little organics added and Pile 4 showed no time for stabilization due to high variability in the slope values of percent organics. No error estimation was made due to lack of similar piles for

Piles 1, 1a, 2, 2a, 3, 3a, 4, 4a, 8, and 9. The results for Piles 1, 1a, 2, 2a, 3, 3a, 4, and 4a show no practical differences between the inoculated and non-inoculated piles, however all piles show a reduction in stabilization time compared to current composting stabilization time in Utah, which is approximately 4-6 months (Lasley 2012; Jolley 2012). Piles 8 and 9 also show a reduced organic stabilization time compared to current composting practices in Utah.

Piles 5, 6, and 7 (approximately 50% MSW, 20% C&D, and 15% GW) have similar compositions and showed an average stabilization time of 29 days and a 95% confidence interval of 2 days. Pile 6a is the only comparable control pile to Piles 5, 6, and7 and shows a significantly longer stabilization time of 55 days based on the 95% confidence interval for Piles 5, 6, and7. This displays a highly beneficial effect due to the microbial inoculum of decreasing the amount of time for organic stabilization in the presence of MSW and C&D waste by approximately 26 days. The longer organic

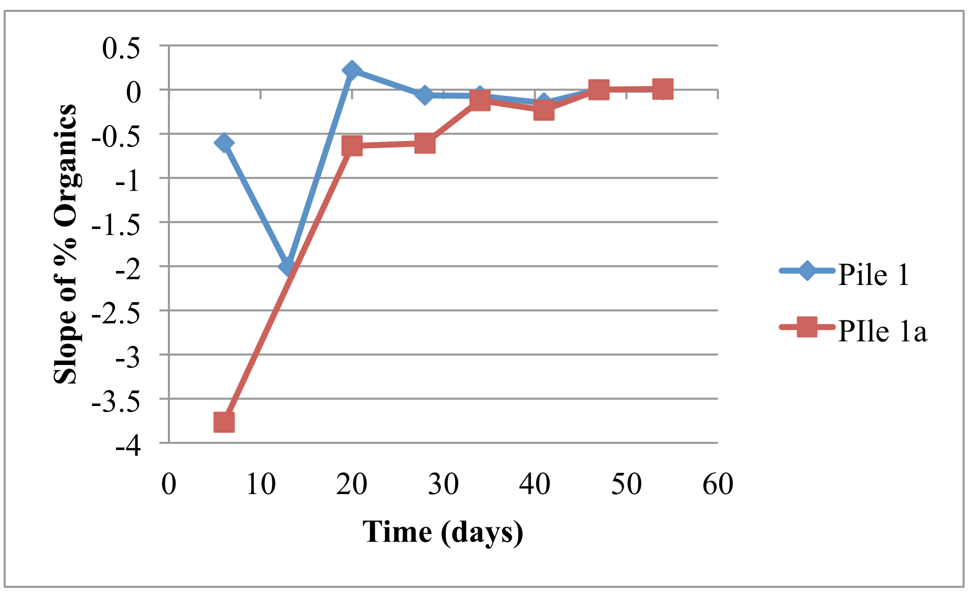

Figure 4: Organic stabilization for Piles 1 and 1a

stabilization time for Pile 6a must be due to the lack of essential microbial communities to break down the organics, but is provided by the addition of the inoculum in Pile 5, 6, and 7.

The weight % of Organics in the piles was graphed over time to determine the degradation rate in the piles. It was determined by visual inspection and regression analysis that all piles had a first order degradation rate. Only piles 4, 7, and 8 showed a non-significant slope for the degradation of organics. Table 7 shows the results for the natural log transformation regression analysis for the weight % Organics over time for all piles.

<u>Paper</u>

The weight % of Paper was graphed over time for all piles except for Piles 1 and 1a. Piles 1 and 1a had no paper containing components added and no weight % of paper was found during the course of the experiment. The weight % of Paper for Piles 4 and 4a (approximately 60% MSW, 30% C&D, and 10% Wood) is shown in Figure 5. There is a

Table 6: Organic stabilization in piles

<table>
<tr><th>Pile</th><th>Major Starting Components</th><th>Stabilization (days)</th><th>Pile</th><th>Stabilization (days)</th></tr>
<tr><td>1</td><td>90% AgW and 10% GW</td><td>34</td><td>1a</td><td>34</td></tr>
<tr><td>2</td><td>55% C&D and 44% GW</td><td>43</td><td>2a</td><td>43</td></tr>
<tr><td>3</td><td>55% GW, 23% AgW, and 13% C&D</td><td>56</td><td>3a</td><td>63</td></tr>
<tr><td>4</td><td>60% MSW, 30% C&D, and 10% Wood</td><td>NA</td><td>4a</td><td>47</td></tr>
<tr><td>5</td><td>56% MSW, 28% C&D, and 16% GW</td><td>31</td><td rowspan="3">6a</td><td rowspan="3">55</td></tr>
<tr><td>6</td><td>44% MSW, 22% C&D, and 20% Wood</td><td>28</td></tr>
<tr><td>7</td><td>58% MSW, 30% CD, 13% GW</td><td>28</td></tr>
<tr><td>8</td><td>67% CD, 33% MSW</td><td>34</td><td></td><td></td></tr>
<tr><td>9</td><td>Undefined</td><td>41</td><td></td><td></td></tr>
</table>

general decreasing trend for both piles. Pile 4 appears to stabilize around day 34, while Pile 4a stabilized around day 47. The degradation rate was determined to be linear for Piles 4 and 4a with a slope of -0.163 (pvalue = 0.002) and -0.119 (pvalue = 0.004), respectively. There is no significant difference for the slopes of Piles 4 and 4a based on a 95% confidence interval of the slopes.

The weight % of Paper over time for Piles 6 and 6a are shown in Figure 6. Both piles appear to stabilize on approximately day 35. The degradation rate was determined to be zero order and values after stabilization (day 35) were removed for regression analysis. The slope for Piles 6 and 6a were -0.141 (pvalue = .007) and -0.112 (pvalue = .002), respectively. There is no significant difference for the slopes of Piles 6 and 6a based on a 95% confidence interval of the slopes. Table 8 shows the linear regression analysis for the weight % Paper over time for all piles except for Piles 1 and 1a.

Table 7: Natural log transformation regression analysis for the weight % Organics over time for all piles

Pile	Slope	R^2	95% CI	P value	df
1	-0.111	0.798	0.050	0.001	7
1a	-0.107	0.930	0.029	1.10E-04	6
2	-0.055	0.450	0.050	0.034	8
2a	-0.069	0.674	0.039	0.004	8
3	-0.085	0.876	0.032	0.001	6
3a	-0.086	0.915	0.021	1.50E-05	8
4	0.040	0.207	0.077	0.258	6
4a	-0.042	0.534	0.039	0.039	6
6	-0.058	0.555	0.042	0.013	8
6a	-0.034	0.566	0.024	0.012	8
5	-0.069	0.738	0.037	0.003	7
7	-0.038	0.246	0.054	0.145	8
8	-0.057	0.357	0.076	0.118	6
9	-0.049	0.702	0.032	0.009	6

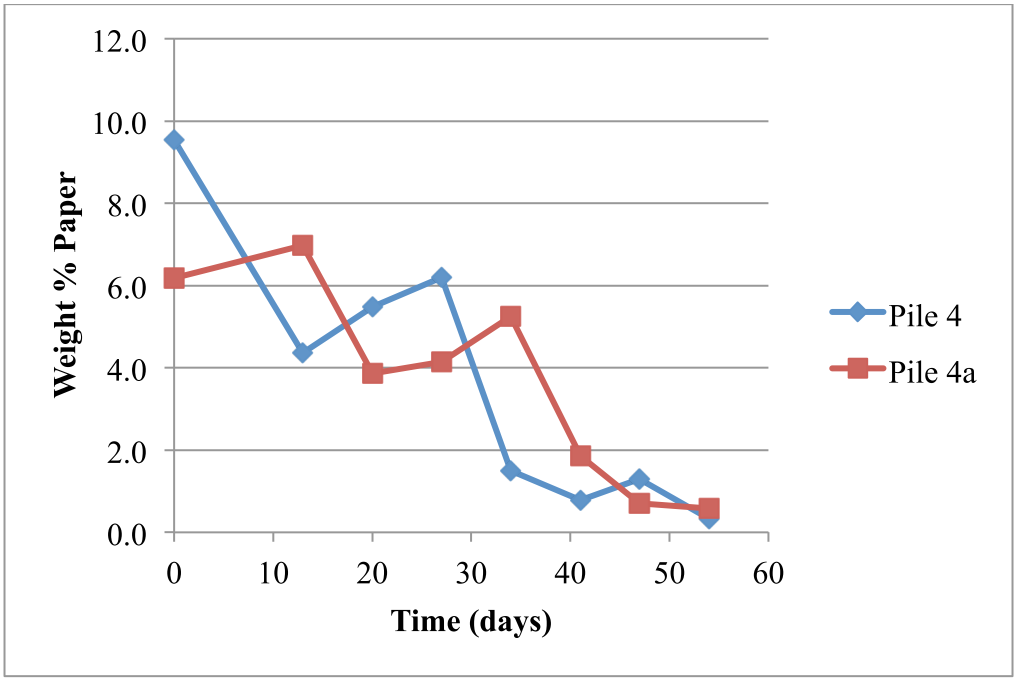

Figure 5: Weight % Paper over time for Piles 4 and 4a

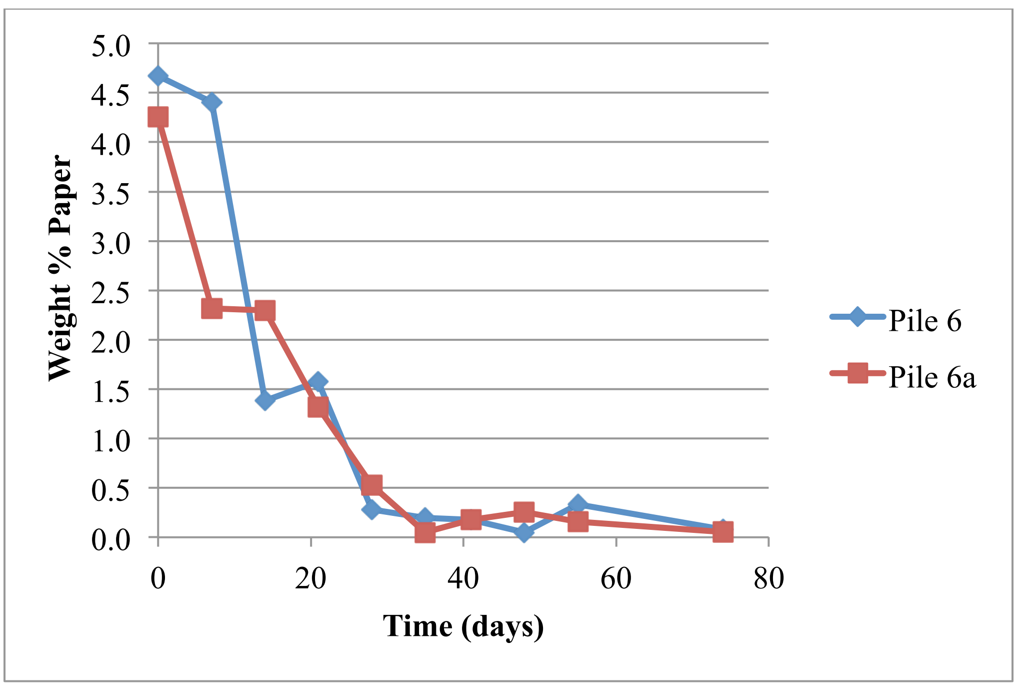

Figure 6: Weight % Paper over time for Piles 6 and 6a

Table 8: Linear regression analysis for the weight % Paper over time for all piles except for Piles 1 and 1a

Pile	slope	R^2	95% CI	P value	df
2	-0.042	0.630	0.026	0.006	8
2a	-0.023	0.321	0.028	0.088	8
3	-0.009	0.828	0.003	3E-04	8
3a	-0.009	0.493	0.007	0.024	8
4	-0.163	0.820	0.076	0.002	6
4a	-0.119	0.779	0.063	0.004	6
6	-0.141	0.868	0.076	0.007	4
6a	-0.112	0.935	0.041	0.002	4
5	-0.113	0.700	0.06	0.003	8
7	-0.017	0.461	0.015	0.031	8
8	-0.020	0.695	0.012	0.005	7
9	-0.021	0.621	4E-16	5E-97	7

Plastics

The weight % Plastic in Piles 2 and 2a (approximately 55% C&D and 44% GW) over time is shown in Figure 7. Figure 7 shows continual fluctuations and no stabilization for plastics at any time in Piles 2 and 2a. Plastics weight % Plastic over time plots for all piles are presented in Appendix B. Inspection of Piles 3, 3a, 4, 4a, 5, 6, 6a, 7, 8, and 9 for plastic component stabilization shows similar characteristics of Piles 2 and 2a, thus it was determined that no degradation of the plastic component was seen in any pile.

Wood

The weight % of wood over time in Piles 6 and 6a (approximately 44% MSW, 22% C&D, and 20% Wood) is demonstrated in Figure 8. Figure 8 shows continual fluctuations and general increasing trend for both Piles 6 and 6a. Weight % wood plots

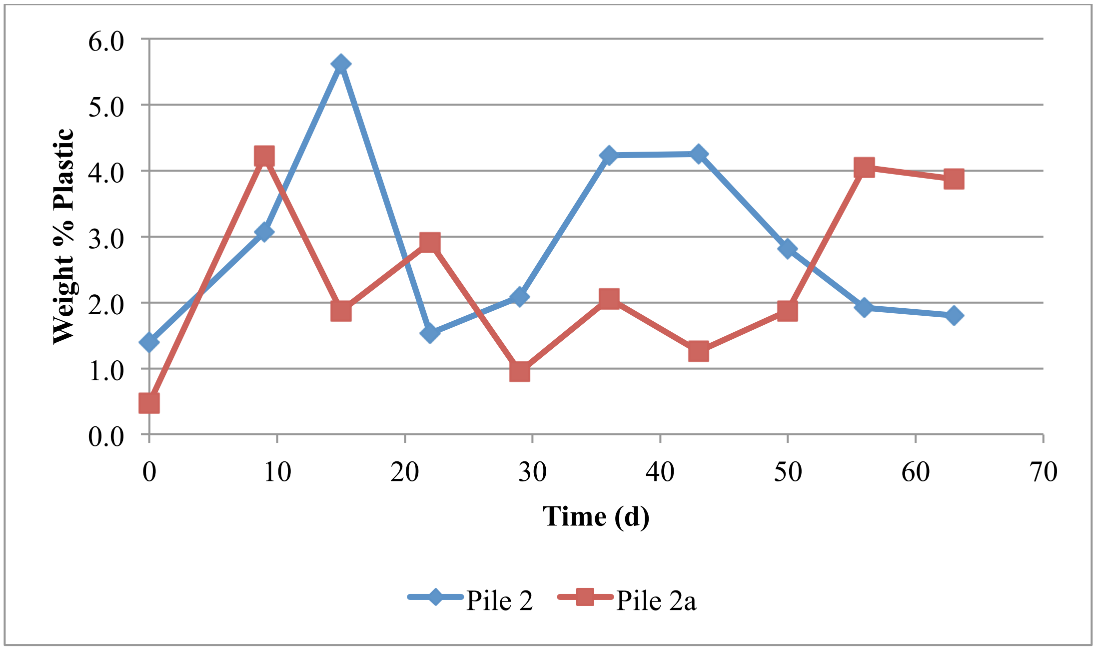

Figure 7: Plastic stabilization for Piles 2 and 2a

for all piles are presented in Appendix B. Inspection of Piles 3, 3a, 4, 4a, 5, 6, 6a, 7, 8, and 9 for wood component stabilization shows similar characteristics of Piles 6 and 6a, thus it was determined that no degradation of the wood component was seen in any pile. High variation due to sampling quality was seen as pieces of wood 10" long would periodically be found.

General Chemical Measurement Results

Temperature

Temperature measurements were made after turning and periodically in-between turning events. The temperature probe was four feet long and had four reading points.

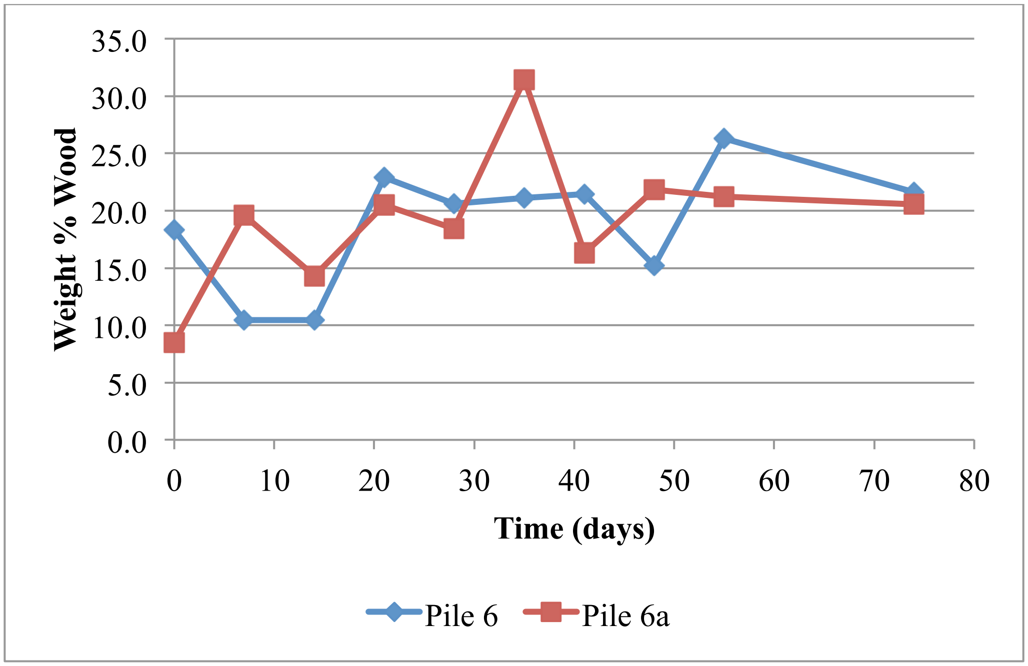

Figure 8: Wood Stabilization for Piles 6 and 6a

The three inner most temperature values were recorded at three randomly selected areas on each pile. The shallow point was approximately one foot into the pile, the midpoint point was approximately two feet into the pile, and the deep point was approximately three feet into the pile. Figure 9 shows the average temperatures with 95% confidence interval over time for Piles 1 and 1a (approximately 90% AgW and 10% GW). Figure 10 shows the average temperatures with 95% confidence interval over time for Piles 2 and 2a (approximately 55% C&D and 44% GW). The raw data is presented in Appendix C.

Figure 9 shows that there are significantly higher average temperatures for Pile 1 at the deep temperature readings than for Pile 1a. Pile 1a deep temperature readings are significantly lower than the midpoint temperature readings for Pile 1 after day 6. On Day 18 the piles were turned and we can see a significant reduction in temperature following for the midpoint and deep temperature readings for Pile 1a. For Pile 1, only the shallow

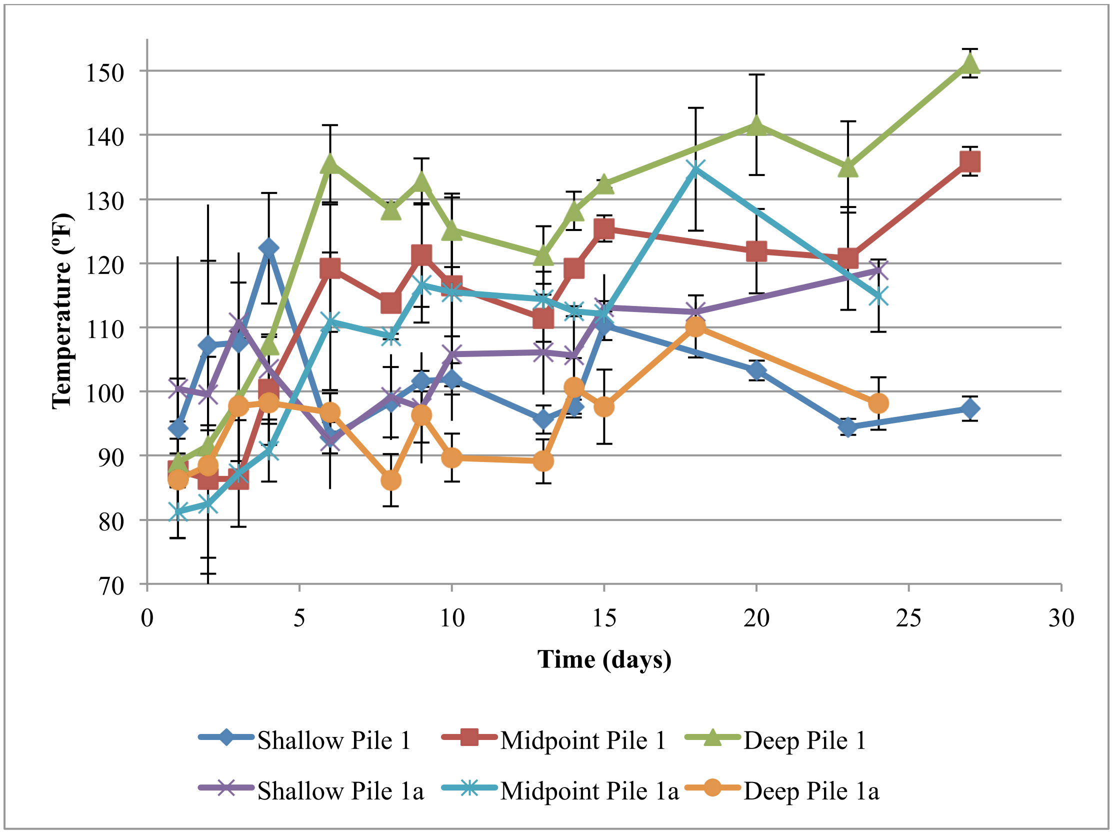

Figure 9: Average temperatures for Piles 1 and 1a (error base show 95% confidence interval)

temperature reading shows a significant reduction following turning. Pile 1 shows a maximum average temperature of 151ºF, with the average deep temperature being above 130ºF six times, and consistently above 130ºF after day 15. Pile 1a had a maximum average temperature of 135ºF with no other average readings being over 119ºF.

Figure 10 shows that there are significantly higher average temperatures for Pile 2 at the deep temperature readings than for Pile 2a. The higher temperature in Pile 2 can increase the degradation of organic products and increase the volatility of low molecular weight compounds. Pile 2a deep temperature readings are significantly lower than the midpoint temperature readings for Pile 2 and 2a after day 3. On Day 16 the piles were turned and we can see decline in temperature on day 16 for all temperature readings for

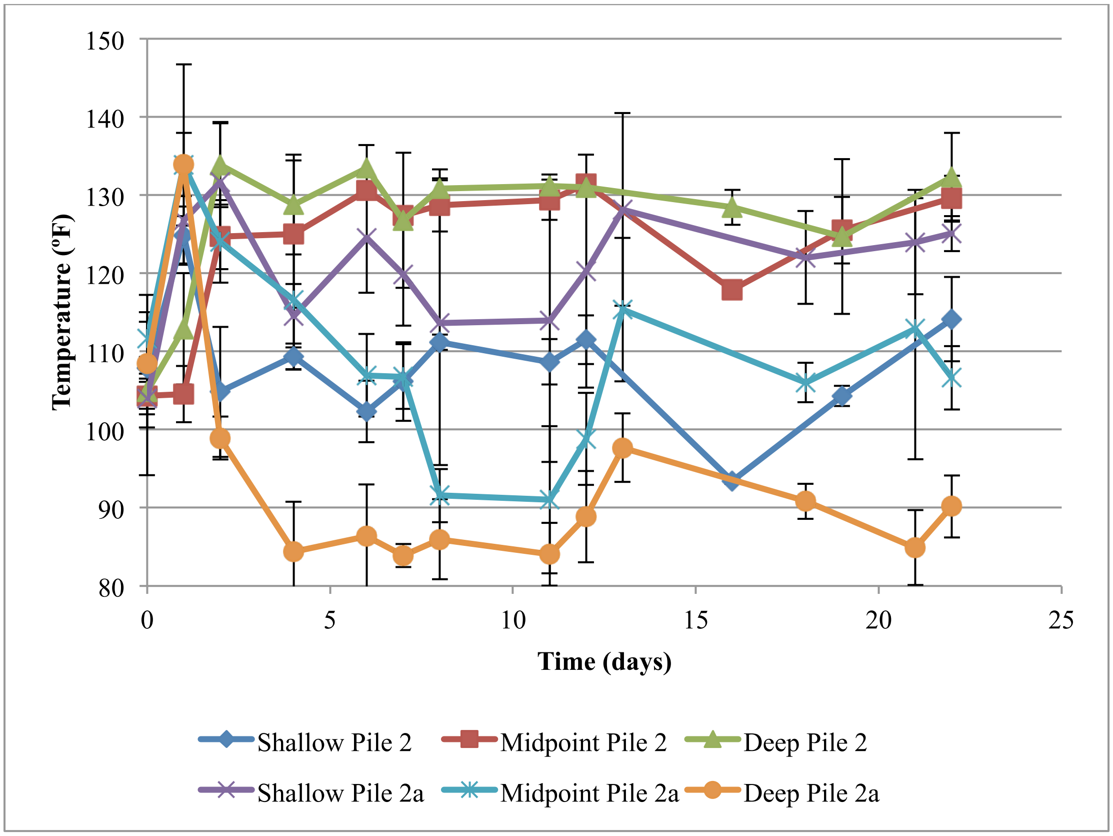

Figure 10: Average temperatures for Piles 2 and 2a (error base show 95% confidence interval)

Piles 2 and 2a. Pile 2 shows a maximum average temperature of 134ºF, with the average deep temperature being above 120ºF, and consistently above 120ºF after day 3. Pile 2a had a maximum average temperature of 134ºF with no other average readings for the midpoint and deep temperature readings being over 120ºF after day 4.

<u>Moisture Content</u>

The moisture content of bulk characterization samples was analyzed for percent dry weight in triplicate. Figure 11 shows the percent dry weight of Piles 1 and 1a over time and shows that there are significant differences between the piles on day 34 and 54. Pile 1 has a higher final percent dry weight than Pile 1a.

Figure 12 shows the percent dry weight of Piles 2 and 2a over time and shows that there are significant differences in percent dry weight at day 43 and 56. There is no significant difference at the final analysis. Charts for the percent dry weight over time for Piles 3, 3a, 4, 4a, 5, 6, 6a, and 7 and displayed in Appendix B. The raw data is presented in Appendix C.

pH, EC, and % Carbon

The results for the USU analytical lab fertility analysis for general chemical measurements are shown in Table 9. There were no replicate measurements so there are no estimates of error. Analysis of variance was performed to check for significant difference between treated and control piles for final pH and percent carbon. It was determined that there was no significant difference between for pH ($p = 0.835$) and percent carbon ($p = 0.227$).

The results for the general chemical measurements monitored over time for Piles 2, 2a, 6, and 6a are displayed in Table 10. All pile averages for pH and corresponding 95% confidence intervals fall above the desired pH range of 6 to 7 (Fröhlich 1993; Wiemer and Kern 1993). Comparing Piles 2 and 2a shows no significant difference for the pH of the piles ($p = 0.6532$) or for the EC ($p = 0.2193$) in using a student t test in R statistical software. Similarly, for Piles 6 and 6a there is no significant difference for pH ($p = 0.6821$) or EC ($p = 0.1013$) between inoculated and non-inoculated treatments. This shows that the microbial inoculum has no effect on the pH or EC of the composting windrows. The analysis for the DOC was found to be out of the linear range for the standard curve and unusable.

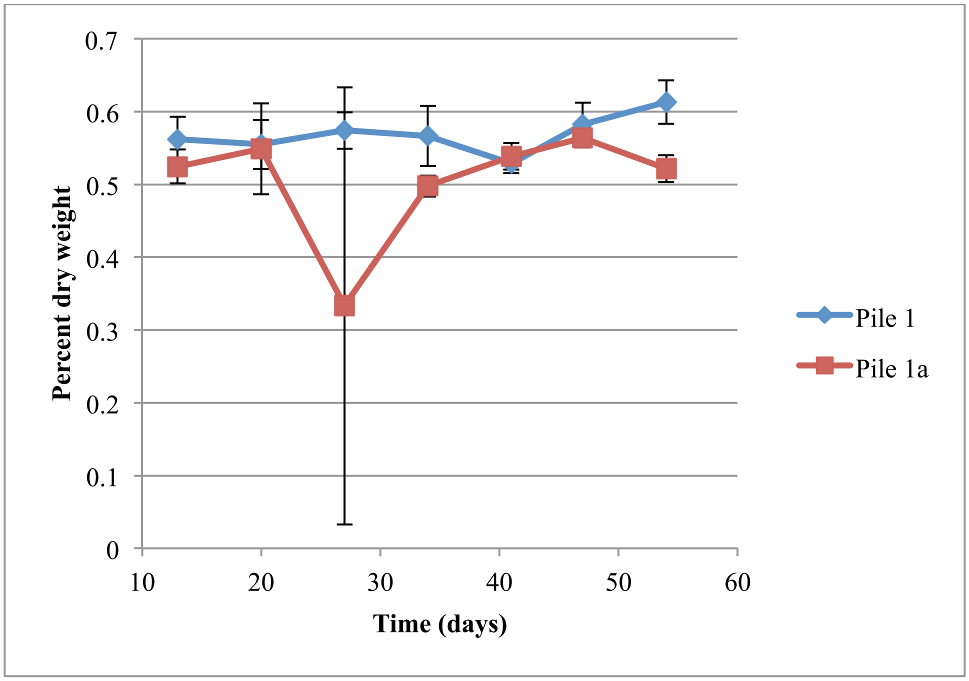

Figure 11: Percent dry weight of Piles 1 and 1a over time (error bars represent the 95% confidence interval of triplicate measurement)

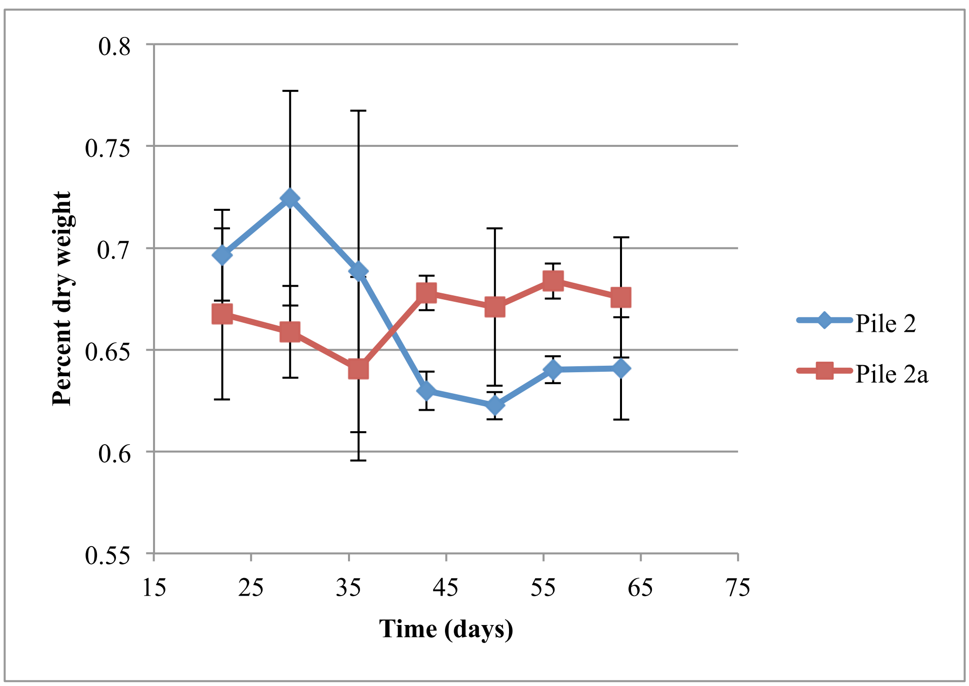

Figure 12: Percent dry weight of Piles 2 and 2a over time (error bars represent the 95% confidence interval of triplicate measurement)

Table 9: USU analytical lab fertility results

Pile	pH	%Carbon
1	8.07	7.65
1a	7.88	7.49
2	7.59	5.29
2a	7.21	6.83
3	7.40	7.59
3a	7.40	7.84
4	7.78	6.06
4a	7.59	5.77
6	7.50	7.01
6a	7.50	4.94
7	7.40	7.55
9	7.12	5.79

Chemical Analysis Results

Carbaryl

The averages of triplicate sample results for carbaryl in Piles 6 and 6a (approximately 44% MSW, 22% C&D, and 20% Wood) are displayed in Table 11 and the raw data is presented in Table C-2 (Appendix C). Due to high variability, no sampling events showed a value significantly different from zero except for Day 74 for Pile 6a. Upon graphing, neither of the piles showed a slope significantly different than zero for the linear or natural log transform regression analysis due to very large error as seen in Table 11.

Due to a Henrys law constant of 3.46×10^{-9} atm*m^3/mol (Syracuse Research Corporation 1988), the carbaryl would be expected not to volatize from the piles during the experiment. Only Pile 6a had an average concentration significantly different from zero of 1.88 µg/kg on Day 74, while Pile 6 measurements on Day 74 were all non-detect showing a significantly lower residual of carbaryl in the inoculum treated pile.

Table 10: General chemical measurements for Piles 2, 2a, 6, and 6a.

Pile	Date	Average pH	95% CI	Average EC (μS/cm)	95% CI
2	7/14	7.60	0.06	3.12	0.28
	8/11	7.62	0.20	2.93	0.68
	8/31	7.64	0.16	3.93	0.21
2a	7/14	7.42	0.36	4.05	1.36
	8/11	7.61	0.19	3.41	0.39
	8/31	7.70	0.06	4.29	0.67
6	7/14	7.53	0.27	3.85	2.12
	8/11	7.62	0.17	4.21	2.26
	9/26	7.52	0.06	3.50	0.42
6a	7/14	7.26	0.38	2.99	0.96
	8/11	7.74	0.16	3.55	0.65
	9/26	7.47	0.11	3.33	0.36

VOC

Upon inspection of VOC data, the imputation method for estimating values below the method detection limit could not be used. The imputation method needs at least three values above the method detection limit for estimation and VOC analysis was done in triplicate thus leaving only two values above the method detection limit when the method is to be applied. Consequently one-half the detection limit was used to estimate values below the detection limit. VOC concentrations were checked for outliers using Grubb's T-test. Regression analysis was performed on VOC concentrations by using the natural log transformation of the concentration divided by each of the initial concentration. The natural log transform resulted in a better fit, i.e., higher R^2 value, for the regressions, and the residuals appeared more random than the zero order regression. R statistical software (R Development Core Team 2008) was used to determine the slope, R^2 value, 95% confidence interval (CI) for the slope, and the p-value for the slope. The regression analysis for VOC with at least one sampling event showing an average concentration significantly different from zero for Piles 2 and 2a (approximately 55% C&D and 44%

Table 11: Average and 95% confidence intervals for carbaryl concentrations in Piles 6 and 6a

Day	Pile 6 (µg/kg)	Pile 6a (µg/kg)
0	5.54 ± 9.44	33.32 ± 47.33
28	2.07 ± 4.06	4.01 ± 5.95
74	0.00 ± 0.00	1.88 ± 0.87

GW) are displayed in Table 12. A complete table for VOC is presented in Table A-3 (Appendix A).

Pile 2 had nine compounds that showed no detection, seven compounds whose concentrations were not significantly different from zero due to high variability based on the 95% confidence interval of triplicate measurements, and nine compounds that showed at least one sampling period with concentrations that were significantly different from zero based on the 95% confidence interval of triplicate measurements. Pile 2a had eight compounds that showed no detection, six compounds that due to high variability it was determined that the concentration was not significantly different from zero based on the 95% confidence interval of triplicate measurements, and 12 compounds that showed at least one sampling period with concentrations that were significantly difference from zero based on the 95% confidence interval of triplicate measurements.

Only heptane and octane showed a significant slope based on a 95% confidence interval for both the treated and control piles, however neither of the VOC show a significant difference between the piles. In addition to heptane and octane, Pile 2, displayed significant slopes for toluene, m,p-xylene, and styrene.

Table 12: VOC regression analysis for Piles 2 and 2a

Pile	2					2a				
Compound	slope	R2	95% CI	P value	df	slope	R2	95% CI	P value	df
Benzene	-0.023	0.210	0.018	0.016	25					
n-Heptane						-0.032	0.641	0.010	0.000	25
Toluene	-0.024	0.341	0.014	0.001	25	-0.020	0.302	0.013	0.003	25
n-Octane	-0.067	0.431	0.032	0.000	25	-0.045	0.615	0.015	0.000	25
Nonane	-0.042	0.281	0.028	0.004	25	-0.030	0.309	0.019	0.003	25
n-decane	-0.041	0.229	0.031	0.012	25	-0.018	0.233	0.014	0.011	25
Benzene, 1,2,4-trimethyl-	-0.054	0.452	0.025	0.000	25	-0.049	0.498	0.020	0.000	25
1,2,3-Trimethylbenzene	-0.035	0.200	0.029	0.019	25					
n-Undecane	-0.046	0.293	0.029	0.004	25	-0.029	0.357	0.016	0.001	25
n-dodecane						-0.046	0.300	0.029	0.003	25

* One sampling event with average concentration significantly different from zero based on 95% confidence interval of triplicate measurements

The regression analysis for compounds that show a significant slope based on a 95% confidence interval for Piles 6 and 6a (approximately 44% MSW, 22% C&D, and 20% Wood) are shown in Table 13. The complete table for all VOC in Piles 6 and 6a are displayed in Table A-4 (Appendix A). All VOCs in this analysis were detected in Piles 6 and 6a in at least one sampling during the study. Pile 6 had nine compounds that showed at least one sampling period with concentrations that were significantly different from zero based on the 95% confidence interval of triplicate measurements. Pile 6a had nine compounds that showed at least one sampling period with concentrations that were significantly different from zero based on the 95% confidence interval of triplicate measurements.

Comparing Piles 2 and 2a for VOC reductions shows that Pile 2 has higher percent removal for heptane and octane than Pile 2a, however their degradation rates are not significantly different showing a possible greater extent of the reaction for the treated piles. Pile 6 had 11 compounds with significant slopes, however Pile 6a showed high variability to the extent of showing no significant slopes or final VOC concentrations that were significantly different from zero. Residual concentrations were found for many VOCs at 63 days for Piles 2 and 2a and 74 days for Piles 6 and 6a, which shows a large difference compared to the study by Brown et al. (1997) in which all VOCs were non-detect after one week.

Table 13: VOC regression analysis for Piles 6 and 6a

Pile	6					6a				
Compound	slope	R2	95% CI	P value	df	slope	R2	95% CI	P value	df
Hexane, 2-methyl-						-0.053	0.291	0.034	0.004	25
Benzene	-0.054	0.618	0.018	0.000	25	-0.028	0.236	0.021	0.010	25
Cyclohexane	-0.078	0.587	0.027	0.000	25					
Hexane, 3-methyl-						-0.035	0.241	0.025	0.009	25
Pentane, 2,2,4-trimethyl-	-0.036	0.193	0.031	0.022	25					
n-Heptane	-0.078	0.748	0.019	0.000	25	-0.055	0.481	0.023	0.000	25
Cyclohexane, methyl-	-0.096	0.624	0.031	0.000	25	-0.075	0.381	0.039	0.001	25
Heptane, 2-methyl-	-0.073	0.563	0.027	0.000	25					
Heptane, 3-methyl-	-0.068	0.609	0.022	0.000	25					
Toluene	-0.034	0.885	0.005	0.000	25	-0.029	0.307	0.018	0.003	25
n-Octane	-0.070	0.617	0.023	0.000	25	-0.067	0.525	0.026	0.000	25
Ethylbenzene	-0.039	0.809	0.008	0.000	25					
m,p-xylene	-0.047	0.777	0.010	0.000	25	-0.027	0.150	0.027	0.046	25
Nonane	-0.057	0.608	0.019	0.000	25	-0.051	0.324	0.030	0.002	25
styrene	-0.038	0.651	0.012	0.000	25					
o-xylene	-0.049	0.629	0.015	0.000	25					
Benzene, 1,3,5-trimethyl-	-0.035	0.336	0.020	0.002	25					
n-decane	-0.056	0.585	0.019	0.000	25	-0.036	0.185	0.031	0.025	25
o-ethyl toluene	-0.026	0.266	0.018	0.006	25					
n-Undecane	-0.061	0.749	0.014	0.000	25	-0.041	0.180	0.036	0.027	25
n-dodecane						-0.039	0.317	0.024	0.002	25

* One sampling event with average concentration significantly different from zero based on 95% confidence interval of triplicate measurements

† Average concentration of sampling events showed no significant difference from zero based on 95% confidence interval of triplicate measurements

SVOC

Upon inspection of SVOC data, the imputation method for estimating values below the method detection limit could not be used. The imputation method needs at least three values above the method detection limit for estimation and SVOC analysis was only done in triplicate. Consequently one-half the detection limit was used to estimate values below the detection limit. SVOC concentrations were checked for outliers using Grubb's T-test. Regression analysis was performed on SVOC concentrations by using the natural log transformation of the concentration divided by the initial concentration. The natural log transform resulted in a better fit, i.e., higher R^2 value, for the regressions, and the residuals appeared more random than the zero order regression. R statistical software (R Development Core Team 2008) was used to determine the R^2 value, slope, 95% confidence interval (CI) for the slope, and the p-value for the slope. The regression analysis for SVOC with at least one sampling event showing an average concentration significantly different from zero for Piles 2 and 2a (approximately 55% C&D and 44% GW) are displayed in Table 14. The complete table for all SVOC in Piles 2 and 2a are displayed in Table A-5 (Appendix A) and Piles 6 and 6a are displayed in Table A-6 (Appendix A).

Due to high variability in SVOC concentrations throughout Piles 2 and 2a following their application and mixing, no SVOC were detected at concentrations significantly different from zero and therefore only MORO and acenaphthene in Pile 2a

Table 14: SVOC regression analysis for Piles 2 and 2a

Pile	2					2a				
Compound	slope	R2	95% CI	P value	df	slope	R2	95% CI	P value	df
MORO	*					-0.012	0.160	0.011	0.038	25
Acenaphthene	*					-0.048	0.306	0.030	0.003	25

* One sampling event with average concentration significantly different from zero based on 95% confidence interval of triplicate measurements

had a reportable degradation slope based on a 95% confidence interval. SVOC comparisons proved difficult due to the high variability found in the triplicate measurements for Piles. Sample locations could be from 10 to 30 feet apart on the same pile allowing for large changes in concentrations if the pile mixtures were not homogenous.

The regression analysis results for Piles 6 and 6a are shown in Table 15. Pile 6 showed no SVOC with a significant slope based on a 95% confidence interval, while Pile 6a had five compounds with a significant slope. Significant SVOC reductions are only seen on Pile 6a indicating that the microbial inoculum has a negative significant effect of restricting SVOC degradation during composting.

Table 15: SVOC regression analysis for Piles 6 and 6a

Pile	6					6a				
Compound	slope	R2	95% CI	P value	df	slope	R2	95% CI	P value	df
DRO	-0.017	0.288	0.011	0.004	25	-0.026	0.376	0.014	0.001	25
MORO	-0.011	0.232	0.008	0.011	25	-0.020	0.268	0.013	0.006	25
Acenaphthylene	†					-0.036	0.309	0.022	0.003	25
Acenaphthene	†					-0.052	0.327	0.031	0.002	25
Fluorene	†					-0.048	0.336	0.028	0.002	25
Phenanthrene	†					-0.049	0.343	0.028	0.001	25
Anthracene	†					-0.046	0.234	0.034	0.011	25
Fluoranthene	†					-0.037	0.179	0.033	0.028	25
Pyrene	†					-0.033	0.146	0.033	0.049	25
Benzo[a]pyrene	†					-0.041	0.260	0.028	0.007	25

† Average concentration of sampling events showed no significant difference from zero based on 95% confidence interval of triplicate measurements

Fertility Analysis Results

The results from the fertility analysis performed by USU analytical lab and USU Water Research Laboratory on machine screened compost samples are shown in Table 16. After comparing the results with Table 3, for the fertility index, and Table 4, for the clean index, the compost fertility score, toxicity score, and class are displayed in Table 17. All piles display a fertility score of 2.5 or lower with only piles that had agriculture waste being over 2. This is due to the final low carbon, nitrogen, and phosphorus percentage in each pile (see Table 14). Due to a low fertility score, all piles are unacceptable to be put on the market as a fertilizer according to Saha et al. (2010). This can possibly be corrected by the addition of compostable materials that are rich in carbon, nitrogen, and phosphorus making the finished compost a marketable fertilizer.

The calculated toxicity score for the best quality of compost is >4 of which all piles are, except for Piles 6 and 7 which are 3.4 and 3.8, respectively. All pile metal concentrations are within metal parameters for land application. The criteria for the class of the compost produced are taken from Table 5. Every pile was assessed as a RU-1 class meaning the compost complies for all metal parameters, but it does not meet the fertility score required for marketable fertilizer, however it can be used as a soil condition.

Pile Screening Results

At the end of the study, the entire volume of each pile was screened and separated into “compost” – that fraction of each pile passing a ¾” screen, and “reject” – that fraction retained on the ¾” screen, to determine a gross production of compost for each pile. In addition to this coarse separation of finished product, triplicate samples of each

Table 16: Nutrient and metal data from USU analytical lab and Water Research Laboratory for finished compost samples

Pile	C, %	N, %	P, %	K, %	Zn, mg/kg	Cu, mg/kg	Cd, mg/kg	Pb, mg/kg	Ni, mg/kg	Cr, mg/kg
1	7.65	0.71	0.19	0.93	201.1	40.8	0.572	24.0	18.1	24.3
1a	7.49	0.67	0.24	1.19	187.4	34.0	0.513	21.8	18.9	23.1
2	5.29	0.31	0.12	0.32	186.7	24.9	0.554	19.5	16.1	22.4
2a	6.83	0.42	0.09	0.34	239.2	25.9	0.5883	18.7	19.7	22.7
3	7.59	0.57	0.15	0.48	216.8	33.6	0.4662	16.9	13.4	20.6
3a	7.84	0.60	0.13	0.49	175.9	27.2	0.5886	48.9	14.3	18.3
4	6.06	0.31	0.1	0.36	317.9	29.6	0.5364	59.0	18.7	25.4
4a	5.77	0.32	0.08	0.32	273.6	27.7	0.6617	83.1	18.9	24.6
6	7.01	0.37	0.08	0.25	395.2	50.1	0.7114	270.0	16.6	25.4
6a	4.94	0.25	0.08	0.27	302.9	35.9	0.6917	66.0	18.9	21.8
7	7.55	0.2	0.08	0.21	378.1	71.0	0.7722	96.1	25.6	24.1
9	5.79	0.4	0.11	0.4	276.7	39.0	0.6709	51.6	17.8	21.5

Table 17: Pile fertility analysis results based on index of Saha et al. (2010)

Pile	Fertility Score	Toxicity Score	Class
1	2.2	4.6	RU-1
1a	2.5	4.6	RU-1
2	1.7	4.6	RU-1
2a	1.5	4.6	RU-1
3	2.1	4.6	RU-1
3a	2.1	4.6	RU-1
4	1.5	4.3	RU-1
4a	1.5	4.4	RU-1
6	1.4	3.4	RU-1
6a	1.5	4.3	RU-1
7	1	3.8	RU-1
9	1.9	4.4	RU-1

fraction were hand sorted into various waste components to yield an overall, detailed quantification of the conversion of waste mixture into compost over the duration of the study. This extra hand sorting helps quantify the efficiency of mechanical screening of the compost piles and the residual reject material still found in the compost after mechanical screening. Only Piles 1, 1a, 2, 2a, 3, 3a, 4, and 4a were screened and weight data obtained for calculations due to the onset of winter and the piles were semi frozen making screening impossible. Table 18 presents the results of this analysis.

A significantly higher compost production rate (almost double) based on gross finished pile screening resulted for Pile 1 as compared to Pile 1a (approximately 90% AgW and 10% GW). When compost and reject streams for the finished piles were hand sorted, however, a significant quantity of Soil and Organics fractions were observed in the reject screenings for both Pile 1 and 1a. Including the compost found in the reject screening portion by hand sorting, the total compost production number raised the

Table 18: Compost production in Piles 1, 1a, 2, 2a, 3, 3a, 4, and 4a based on hand sorting of bulk screening samples

Pile	Compost Production Based on Single Pass Screening (%)	Compost Production Including Hand Sorting of Reject (%)
1	69.4	92.2
1a	35.4	89.4
2	75.5	74.8
2a	62.9	60.4
3	80.7	79.4
3a	71.9	65.2
4	62.3	68.6
4a	62.2	61.8

estimate of overall compost production for Pile 1 to >92% and for Pile 1a to >89%. The compost material generated from Pile 1 was easier to segregate using gross screening than that from Pile 1a, but by the end of the compost study both displayed a high compost production efficiency based on hand sorting of these piles initially composting of these piles originally composed of approximately 90 wt% agriculture waste and 10 wt% green waste/wood.

A higher compost production rate based on gross finished pile screening resulted for Pile 2 as compared to Pile 2a (approximately 55% C&D and 44% GW). With mechanical screening and further hand sorting, the estimate of overall compost production for Pile 2 of ≈ 75% was greater than the value of ≈ 60% for Pile 2a. The compost material generated from the gross screening of Pile 2 was also of higher quality than Pile 2a (Table C-2), with Pile 2 "compost" having a "reject" content of only 7 wt%, while Pile 2a had a "reject" content of 14% at the end of the composting of these piles originally composed of approximately 55 wt% C&D and 45 wt% green waste.

A higher compost production rate based on gross finished pile screening resulted for Pile 3 as compared to Pile 3a (approximately 55% GW, 23% AgW, and 13% C&D). With mechanical screening and further hand sorting, the estimate of overall compost production for Pile 3 of >79% was greater than for Pile 3a of ≈ 65%. The compost material generated from the gross screening of Pile 3 was also of higher quality than Pile 3a (Table C-2), with Pile 3 "compost" having a "reject" content of only 7 wt%, while Pile 3a had a "reject" content of 20% at the end of the 12-week compost study composting of these piles originally composed of approximately 58 wt% green waste/grass/wood, 13 wt% C&D, 23 wt% agriculture waste, and 6 wt% food waste.

A higher compost production rate based on gross finished pile screening resulted for Pile 4 as compared to Pile 4a (approximately 60% MSW, 30% C&D, and 10% Wood). With mechanical screening and further hand sorting, the estimate of overall compost production for Pile 4 of >68% was greater than for Pile 4a of ≈ 62%. The compost material generated from the gross screening of Pile 4 was of higher quality than Pile 4a (Table C-2), with Pile 4 "compost" having a "reject" content of only 8 wt%, while Pile 4a had a "reject" content of 16% at the end of 8-week composting of these piles originally composed of approximately 12 wt% wood, 29 wt% C&D, and 59 wt% mixed MSW.

SUMMARY AND CONCLUSIONS

The MARS process was applied to 14 composting windrows, with five of the piles used as controls without the addition of microbial inoculum, to evaluate the effects the microbial inoculum has on the rate and extent of compost production using a wide range of starting materials including green waste, agricultural waste, C&D waste, and mixed MSW. General process measurements (pH, EC, temperature, moisture content, organic carbon), individual waste/pile component sorting (Organic, Paper, Plastic, Metal, Glass, Misc. Inorganics, Bone), and specific compound analyses (carbaryl, SVOCs, VOCs) were conducted over the course of the compost study.

1. Stabilization time for organics in MSW and C&D waste was significantly reduced from 55 days (Piles 5, 6, and 7) to 29 days (Pile 6a) with the addition of the inoculum.
2. C&D waste (Plastic and Wood) was not found to degrade, however the organic portion of mixed MSW was found to degrade and could be used to produce compost via the MARS process.
3. Fertility analysis was performed to assess the quality of compost produced. All piles were determined to have the same classification of RU-1 (Saha et al. 2010), which qualifies it as a non-toxic soil conditioner.
4. Mechanical screening of the entire mass of all finished piles indicated that with the addition of the microbial inoculum, the total amount of compost produced was significantly increased for Piles 2-4 compared to their individual control piles.

5. General chemical measurements show that the microbial inoculum has no impact on the pH, EC, percent Carbon, or the moisture content of the final product.
6. Residual concentrations were found for carbaryl in the control pile, while carbaryl concentrations in the treated pile were non-detect.

ENGINEERING SIGNIFICANCE

The ability to consistently and timely compost a mixture of MSW and C&D debris to a stable end product can reduce the amount of waste disposed of in landfills. Maintaining the quality of this compost is essential in making it available for reuse and consumer purchase. Analysis of residuals for VOCs, SVOCs, nutrient availability, and metals determined the fertility grade and ultimately its possible uses for consumers as a soil conditioner. More importantly this study showed that focusing on control measures (turning, moisture management, nutrient addition) would decrease organic stabilization time, while cocompsting with agriculture waste, and significantly reduce specific VOC and SVOC.

The addition of the microbial inoculum significantly increased pile temperature greater than 3 feet deep. Without agriculture waste, addition of a microbial amendment showed a significant reduction in organic stabilization time by 26 days, while also composting high component percentages of MSW and C&D waste. The addition of the microbial amendment showed a significantly lower residual concentration of carbaryl and significant reductions of specific VOC (Table 11).

It is recommended that the use of the MARS process with microbial inoculum be used only when remediating for specific VOC (Table 11) or carbaryl and when agriculture waste is not being used in the starting components. When agriculture waste is being cocomposted the MARS process without the microbial inoculum sufficient to significantly reduce organic stabilization time and specific SVOC (Table 12).

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APPENDICES

Appendix A

Chemical Properties and Results

Table A-1. VOC Chemical Properties

Chemical	Cas #	MW	K_{OW}	S (mg/L)	P_V (mm Hg)	H (atm*m^3/mole)	K_{OC} (L/kg)
benzene	71-43-2	78.06	2.13[1]	1790[2]	95.0[3]	5.55E-3[4]	49[5]
cyclohexane	110-82-7	84.162	3.44[1]	55[9]	96.86[10]	0.195[8]	482[8]
methylcyclopentane	96-37-7	84.18	3.314[8]	42[9]	137.5[7]	0.363[8]	559[8]
hexane	110-54-3	86.18	3.90[20]	12.40[6]	151.3[7]	1.80[22]	131.5[21]
toluene	108-88-3	92.141	2.73[1]	526[11]	28.4[3]	6.64E-3[4]	95[12]
methylcyclohexane	108-87-2	98.19	3.61[20]	14[28]	46.0[3]	0.430[34]	233.9[21]
2,4-dimethylpentane	108-08-7	100.21	3.63[23]	5.5[28]	79.4[3]	1.90[35]	169.6[21]
2-methylhexane	591-76-4	100.21	3.71[23]	2.54[28]	66[3]	3.43[35]	201.6[21]
2,3-dimethylpentane	565-59-3	100.21	3.63[23]	5.25[28]	68.9[3]	1.73[35]	181.1[21]
3-methylhexane	589-34-4	100.21	3.71[23]	4.95[28]	61.5[3]	1.64[35]	211[21]
n-heptane	142-82-5	100.21	4.66[24]	3.4[28]	46.0[3]	2.00[35]	239.7[21]
styrene	100-42-5	104.15	2.95[1]	310[15]	6.12[3]	2.83E-3[8]	920[16]
ethylbenzene	100-41-4	106.17	3.15[1]	169[11]	9.60[3]	7.88E-3[11]	250[13]
m-xylene	108-38-3	106.17	3.20[1]	161[11]	8.454[3]	7.34E-3[8]	190[12]
p-xylene	106-42-3	106.17	3.15[1]	162.4[11]	8.90[3]	7.66E-6[8]	260[14]
o-xylene	95-47-6	106.17	3.12[1]	178[11]	6.61[3]	5.19E-3[11]	129[5]
2,2,4-trimethylpentane	540-84-1	114.23	4.09[23]	2.44[28]	49.3[3]	3.04[35]	240.3[21]
2,3,4-trimethylpentane	565-75-3	114.23	4.05[23]	2.3[28]	27.10[3]	1.77[35]	283.3[21]
2-methylheptane	592-27-8	114.23	4.20[23]	7.965[29]	20.70[3]	3.01[36]	367.4[21]
3-methylheptane	589-81-1	114.23	4.20[23]	0.792[28]	19.60[3]	3.72[35]	384.5[21]
n-octane	111-65-9	114.23	5.18[24]	0.66[28]	14.8[33]	3.21[35]	436.8[21]
n-propylbenzene	103-65-1	120.20	3.570[1]	52.20[18]	3.42[3]	1.050E-2[11]	741[14]
m-ethyltoluene	620-14-4	120.20	3.98[25]	39.99[29]	3.040[3]	8.71E-3[36]	715.8[21]
p-ethyltoluene	622-96-8	120.20	3.63[26]	74.5[18]	3.000[3]	5.01E-3[35]	715.8[21]
o-ethyltoluene	611-14-3	120.20	3.53[20]	74.6[28]	2.610[3]	5.53E-3[35]	730.4[21]
1,3,5-trimethylbenzene	108-67-8	120.20	3.42[20]	48.2[28]	24.8[3]	8.77E-3[35]	661[19]
1,2,4-trimethylbenzene	95-63-6	120.20	3.78[1]	57[9]	2.10[10]	6.16E-3[11]	2712[8]
1,2,3-trimethylbenzene	526-73-8	120.20	3.66[20]	75.2[28]	1.17[33]	4.36E-3[11]	631[19]
nonane	111-84-2	128.26	4.76[23]	0.22[30]	4.450[3]	3.40[35]	796[21]
m-diethylbenzene	141-93-5	134.22	4.57[25]	24[31]	1.130[3]	8.32E-3[35]	1365[21]
p-diethylbenzene	105-05-5	134.22	4.58[25]	24.8[28]	1.060[3]	7.55E-3[35]	1365[21]
n-decane	124-18-5	142.29	5.01[27]	0.052[28]	1.430[3]	5.15[35]	1451[21]
n-undecane	1120-21-4	156.31	5.74[23]	0.0044[28]	0.4119[3]	1.93[35]	2644[21]
n-dodecane	112-40-3	170.34	6.10[27]	0.0037[32]	0.1360[3]	8.18[35]	4818[21]
Isopropylbenzene	25640-78-2	196.31	5.2[17]	0.6[17]	5.0E-4[17]	2.15E-4[8]	1.6E4

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Table A-2. SVOC Chemical Properties and MS Data Extraction Values

Analyte	CAS #	MW	Retention time, min, or range.	K_{OW}	S (mg/L)	P_V (mm Hg)	H (atm*m^3/mol)	K_{OC} (L/kg)
acenaphthylene	208-96-8	152.196	11.87	4.07[1]	16.1[2]	9.12E-4[3]	1.13E-3[4]	5620[5]
fluorene	86-73-7	166.223	12.98	4.18[6]	1.98 ppm[7]	6.33E-4[8]	6.36E-5[9]	2.83E3[10]
phenanthrene	85-01-8	178.234	14.51	4.46[6]	1.15 ppm[11]	1.12E-4[12]	2.33E-5[9]	1.88E4[13]
anthracene	120-12-7	178.234	14.59	4.45[6]	4.34E-2[14]	2.67E-6[12]	1.93E-5[4]	1.58E4[15]
pyrene	129-00-0	202.256	16.80	4.88[6]	1.35[16]	2.45E-6[17]	1.10E-5[7]	6.27E4[18]
benz(a)anthracene	56-55-3	228.294	18.73	5.664[1]	9.40E-3[14]	1.05E-7[19]	3.35E-6[1]	2E5[20]
chrysene	218-01-9	228.294	18.80	5.664[1]	6.30E-3[21]	6.23E-9[22]	9.46E-5[1]	1.33E5[1]
benzo(b)fluoranthene	205-99-2	252.32	20.39	6.124[1]	1.5E-3[23]	5E-7[24]	1.11E-4[1]	1.56E5[1]
benzo(k)fluoranthene	207-08-9	252.32	20.42	6.124[1]	8.0E-4[23]	2.0E-9[19]	8.29E-7[1]	2.2E4[1]
benzo(a)pyrene	50-32-8	252.32	20.89	5.97[6]	1.62E-3[14]	5.49E-9[19]	1.13E-6[1]	5.07E6[25]
benzo(ghi)perylene	191-24-2	276.34	22.98	6.58[1]	2.60E-4[7]	1.01E-10[19]	1.41E-7[1]	4.06E5[1]
dibenz(a,h)anthracene	53-70-3	278.36	23.03	6.50[6]	2.49E-3[26]	1.0E-10[27]	1.47E-8[1]	2.029E6[26]
indeno(1,2,3)perylene			23.55					
Kerosene Range Organics (KRO)			2.95 - 6.95					
Diesel Range Organics (DRO)			7.00 - 21.00					
Motor Oil Range Organics (MORO)			21.00 - 36.00					

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Table A-3: VOC results for Piles 2 and 2a

Pile	2					2a				
Compound	Slope	R2	95% CI	P Value	df	Slope	R2	95% CI	P Value	df
Hexane				†					ND	
Pentane, 2,4-dimethyl-				†					ND	
Cyclopentane, methyl-				ND					ND	
Hexane, 2-methyl-				ND					ND	
Benzene				0.062					0.606	
Cyclohexane				*					†	
2,3 dimethylpentane				*					*	
Hexane, 3-methyl-				†					ND	
Pentane, 2,2,4-trimethyl-				*					ND	
n-Heptane	-0.061	0.5977	0.05	0.024	6	-0.032	0.7028	0.019	0.005	7
Cyclohexane, methyl-				*					*	
Pentane, 2,3,4-trimethyl-				†					ND	
Heptane, 2-methyl-				†					*	
Heptane, 3-methyl-				†					*	
Toluene	-0.024	0.4624	0.023	0.044	7				0.085	
n-Octane	-0.068	0.5205	0.058	0.028	7	-0.045	0.7556	0.023	0.002	7
Ethylbenzene				*					*	
m,p-Xylene	-0.037	0.6289	0.028	0.019	6				*	
Nonane				0.331					*	
Styrene	-0.04	0.8014	0.023	0.006	5				0.432	
o-xylene				ND					†	
Benzene, isopropyl				ND					†	
Benzene, n-propyl-				†					*	
m-ethyl toluene				ND					†	
p-ethyl toluene				ND					†	
Benzene, 1,3,5-trimethyl-				ND					ND	
n-Decane				*					0.183	
o-Ethyltoluene				†					†	
Benzene, 1,2,4-trimethyl-				0.062					•	
1,2,3-Trimethylbenzene				†					•	
Benzene, m-diethyl-				ND					•	
Benzene, p-diethyl-				ND					•	
n-Undecane				0.137					0.093	
n-Dodecane				*					0.361	

Table A-4: VOC results for Piles 6 and 6a

Pile	6					6a				
Compound	Slope	R2	95% CI	P Value	df	Slope	R2	95% CI	P Value	df
Hexane				*					†	
Pentane, 2,4-dimethyl-				†					†	
Cyclopentane, methyl-				†					†	
Hexane, 2-methyl-				†					†	
Benzene	-0.042	0.7849	0.022	0.003	6				0.069	
Cyclohexane				†					0.329	
2,3 dimethylpentane				†					*	
Hexane, 3-methyl-	-0.052	0.9687	0.028	0.016	2				0.303	
Pentane, 2,2,4-trimethyl-				†					†	
n-Heptane				*					0.067	
Cyclohexane, methyl-				†					0.102	
Pentane, 2,3,4-trimethyl-				†					*	
Heptane, 2-methyl-				†					*	
Heptane, 3-methyl-				†					*	
Toluene	-0.034	0.8856	0.011	0.000	7				0.28	
n-Octane	-0.067	0.5948	0.055	0.025	6				0.074	
Ethylbenzene	-0.036	0.7947	0.018	0.003	6				*	
m,p-Xylene	-0.039	0.771	0.021	0.004	6				*	
Nonane				0.066					0.393	
Styrene	-0.03	0.6375	0.023	0.018	6				0.852	
o-xylene				*					*	
Benzene, isopropyl				*					†	
Benzene, n-propyl-				†					†	
m-ethyl toluene				*					*	
p-ethyl toluene				*					†	
Benzene, 1,3,5-trimethyl-	≥-006	0.916	0.0058	0.043	2				†	
n-Decane				0.114					*	
o-Ethyltoluene				0.855					†	
Benzene, 1,2,4-trimethyl-	-0.078	0.914	0.072	0.044	2				†	
1,2,3-Trimethylbenzene				*					†	
Benzene, m-diethyl-				*					†	
Benzene, p-diethyl-				*					†	
n-Undecane	-0.052	0.5235	0.051	0.046	6				*	
n-Dodecane	-0.073	0.7592	0.057	0.024	4				0.553	

Table A-5: SVOC results for Piles 2 and 2a

Pile	2					2a				
Compound	slope	R2	95% CI	P value	df	slope	R2	95% CI	P value	df
KRO				0.521					0.167	
DRO				0.721					0.386	
MORO				0.722					0.623	
Naphthalene				0.490					0.283	
Acenaphthylene						ND				
Acenaphthene	ND					ND				
Fluorene	ND					ND				
Phenanthrene				0.620					0.103	
Anthracene				0.963		ND				
Fluoranthene				0.763					0.232	
Pyrene				0.847					0.185	
Benz[a]anthracene	ND								0.480	
Chrysene	†								0.055	
Benz[b]fluoranthene	ND					ND				
Benz[k]fluoranthene	ND					ND				
Benzo[a]pyrene	ND					ND				
Indeno(123-cd)perylene	ND					ND				
Dibenz[a,h]anthracene	ND					ND				
Benzo[ghi]perylene	ND					ND				

Table A-6: SVOC results for Piles 6 and 6a

Pile	6					6a				
Compound	Slope	R4	95% CI	P value	df	Slope	R5	95% CI	P value	df
KRO				0.760					0.777	
DRO				0.061					0.085	
MORO				0.117					0.251	
Naphthalene				0.178					0.785	
Acenaphthylene				0.471		-0.036	0.450	0.035	0.048	7
Acenaphthene				0.224		-0.052	0.535	0.044	0.025	7
Fluorene				0.277		-0.048	0.536	0.040	0.025	7
Phenanthrene				0.472		-0.049	0.558	0.039	0.021	7
Anthracene				0.672					0.055	
Fluoranthene				0.682					0.101	
Pyrene				0.633					0.138	
Benz[a]anthracene				0.683					0.200	
Chrysene				0.741					0.227	
Benz[b]fluoranthene				0.793					0.250	
Benz[k]fluoranthene				0.324					0.260	
Benzo[a]pyrene				0.928		-0.041	0.495	0.037	0.034	7
Indeno(123-cd)perylene	ND								0.840	
Dibenz[a,h]anthracene	ND					ND				
Benzo[ghi]perylene	ND					ND				

Appendix B

Figures

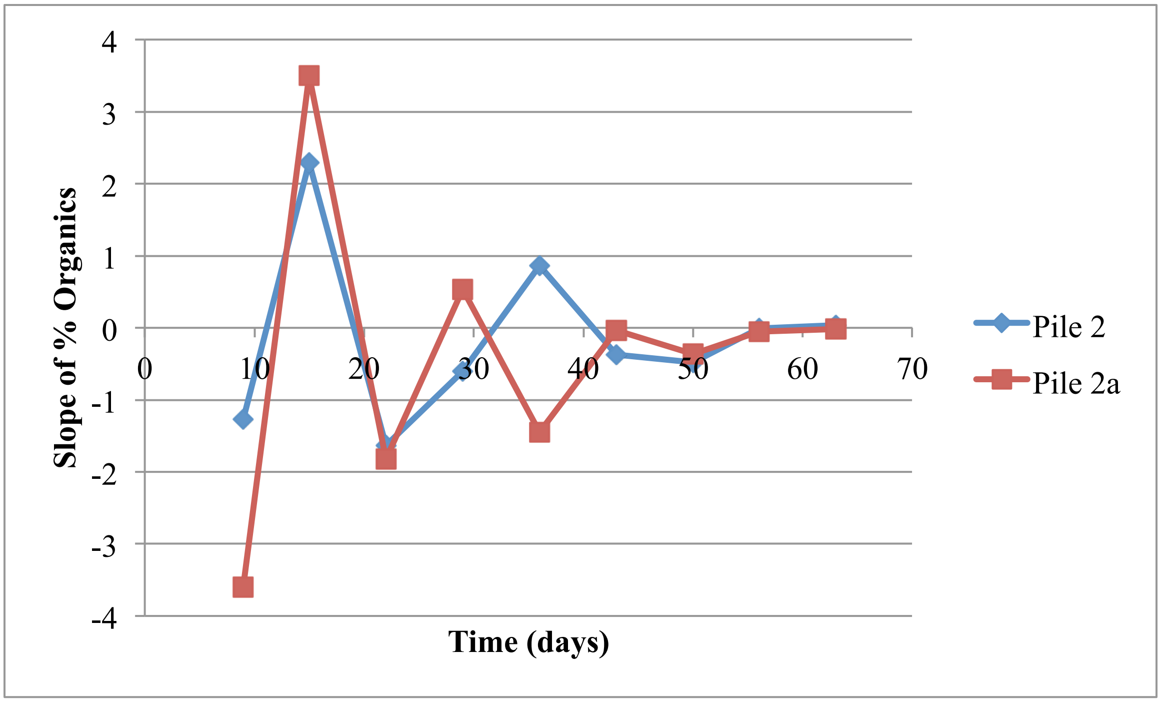

Figure B-1: Organic stabilization for Piles 2 and 2a

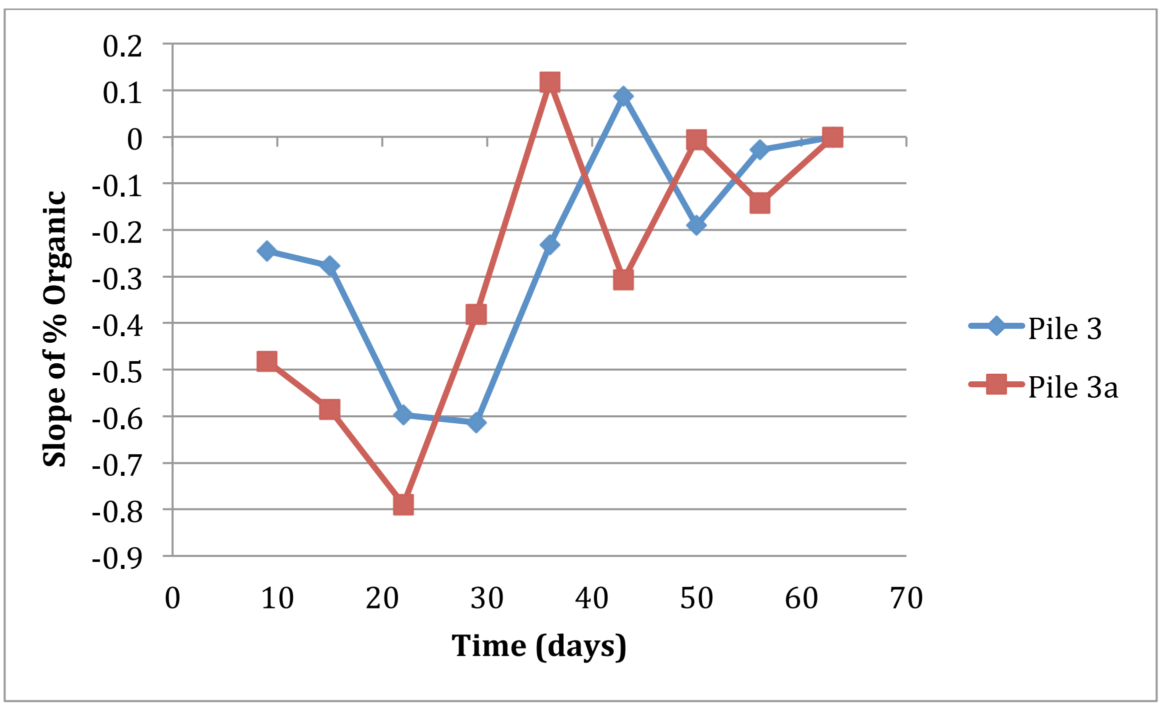

Figure B-2: Organic stabilization for Piles 3 and 3a

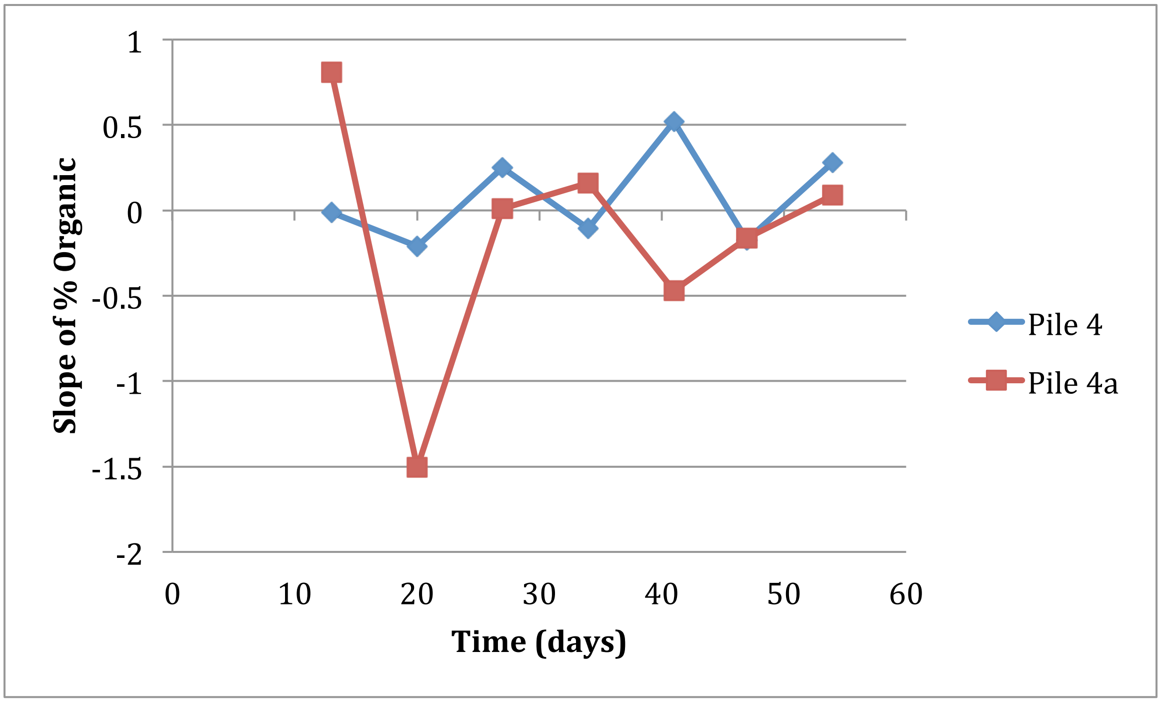

Figure B-3: Organic stabilization for Piles 4 and 4a

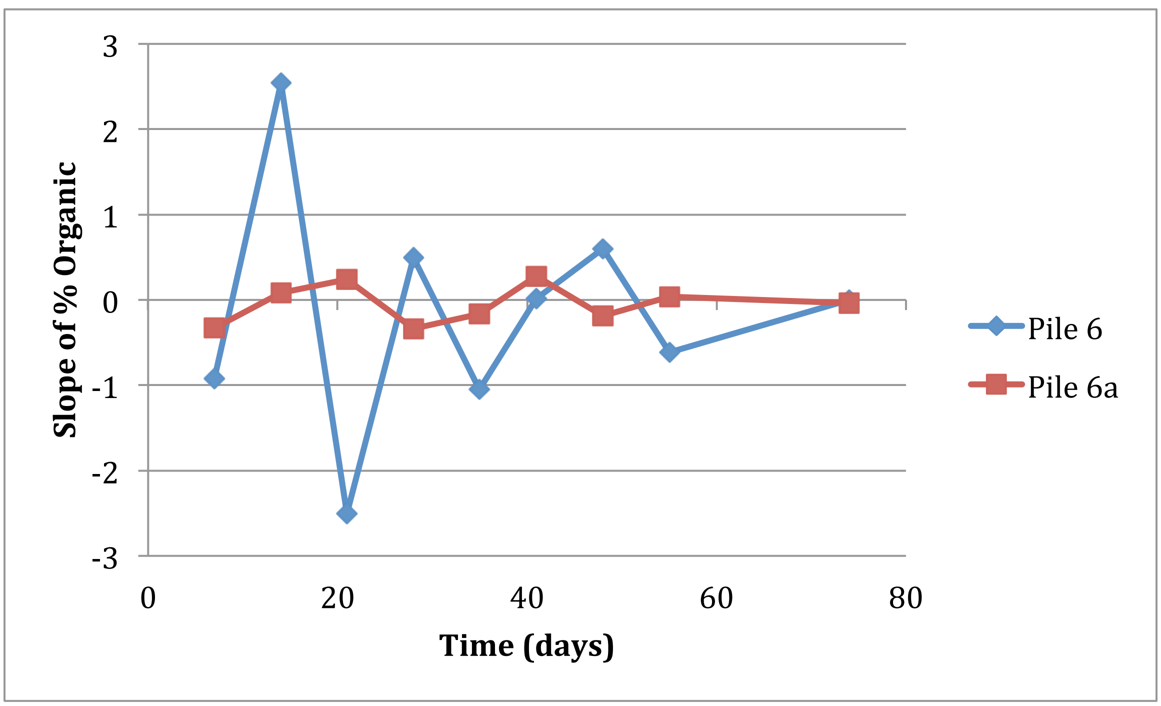

Figure B-4: Organic stabilization for Piles 6 and 6a

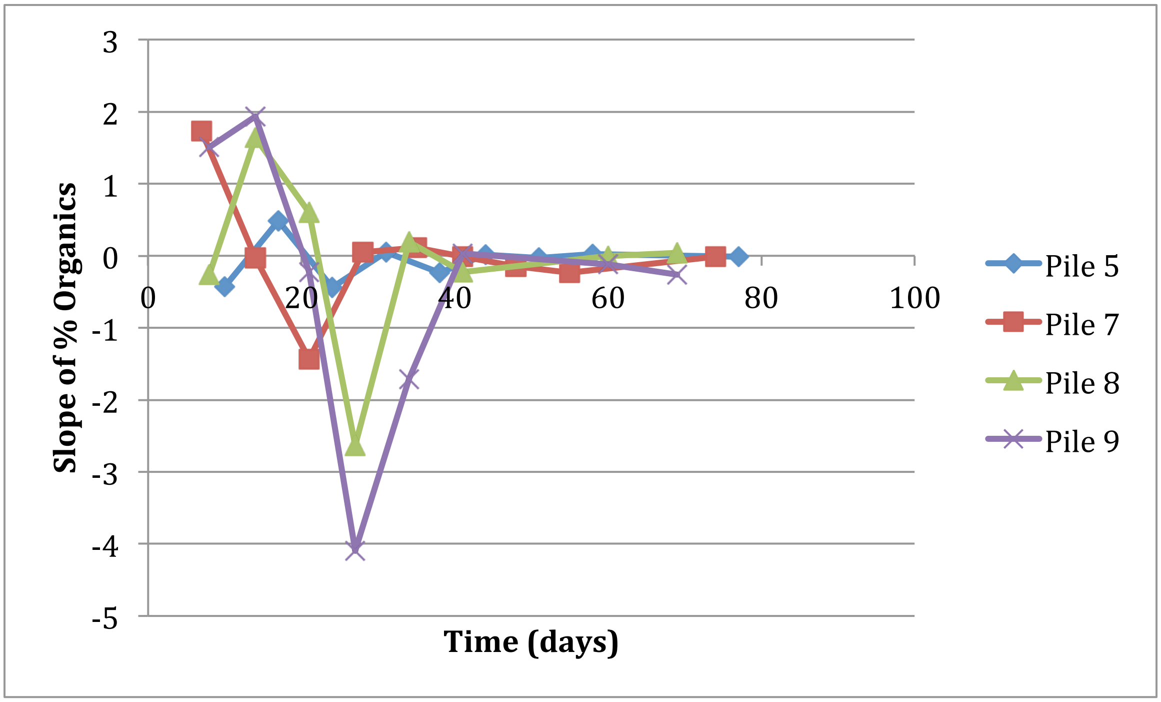

Figure B-5: Organic stabilization for Piles 5, 7, 8, and 9

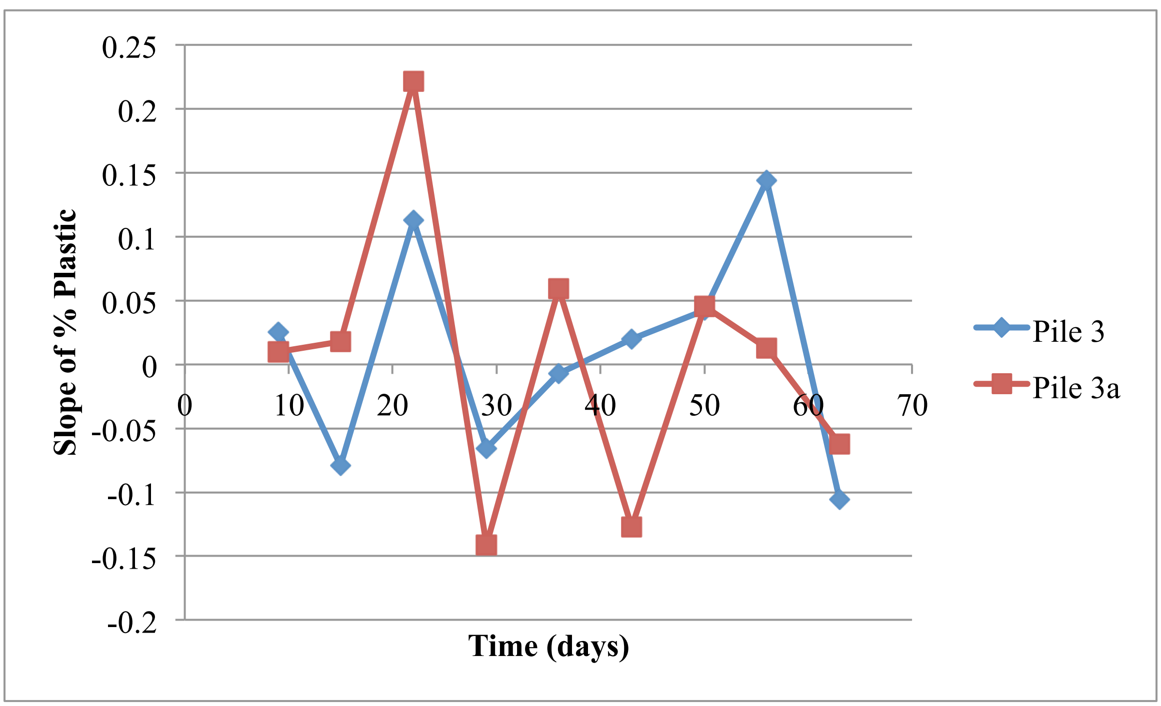

Figure B-6: Plastic stabilization for Piles 3 and 3a

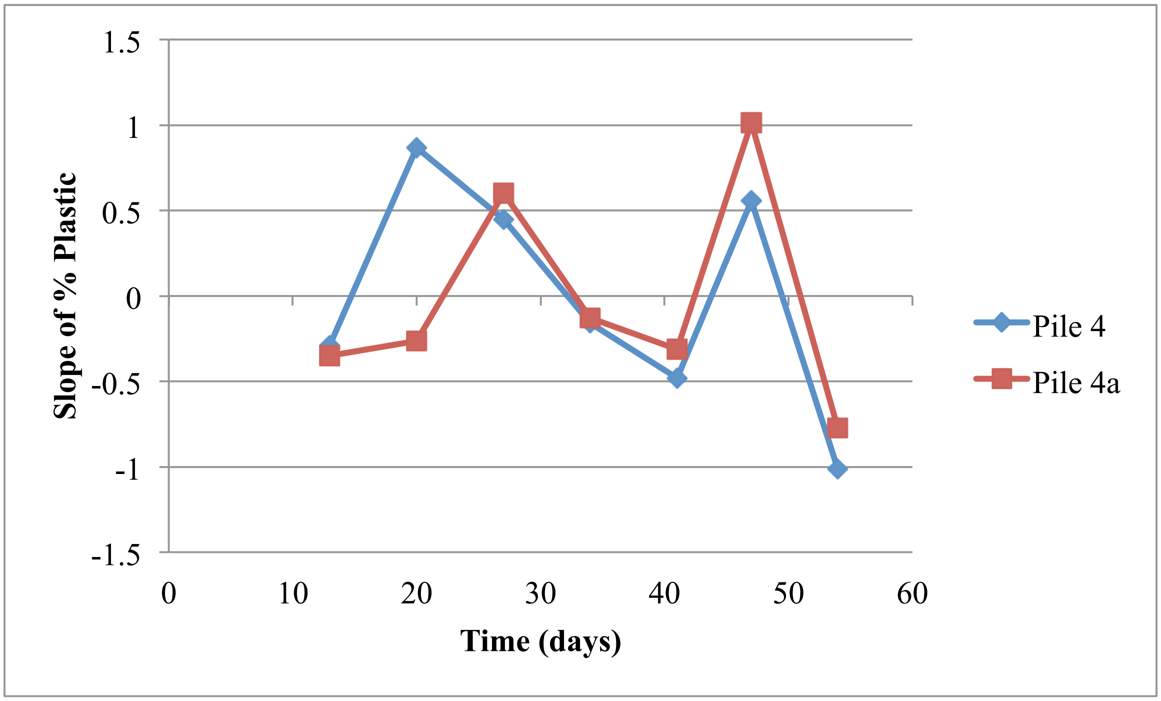

Figure B-7: Plastic stabilization for Piles 4 and 4a

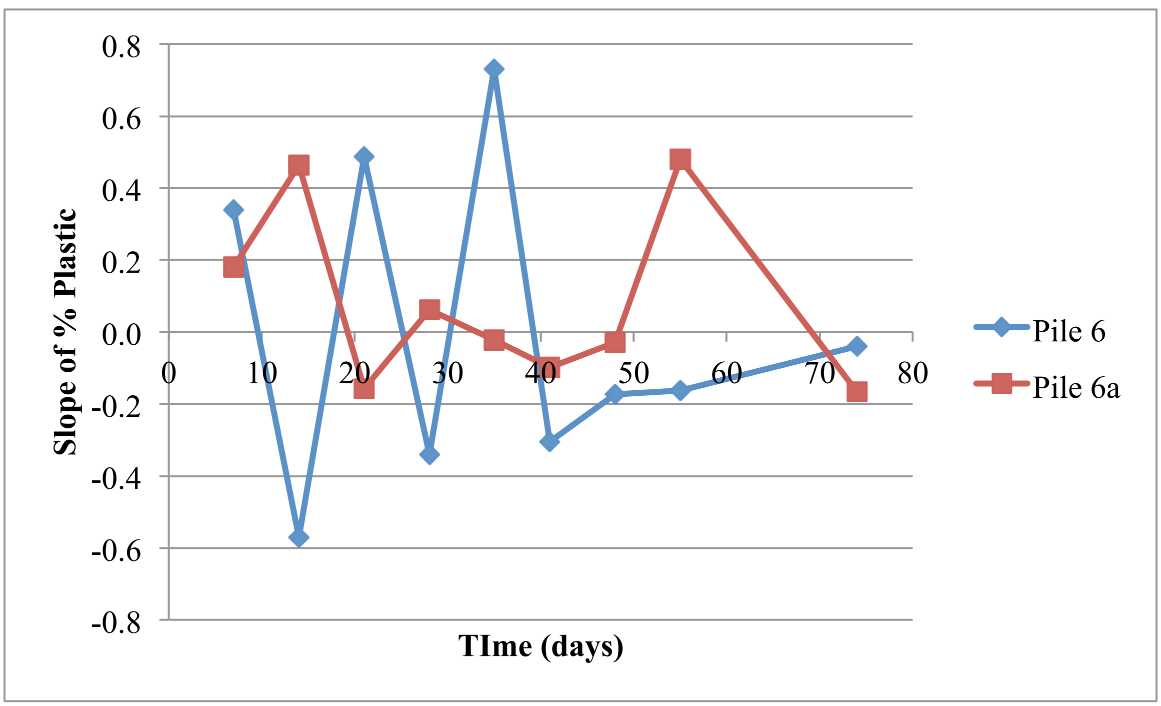

Figure B-8: Plastic stabilization for Piles 6 and 6a

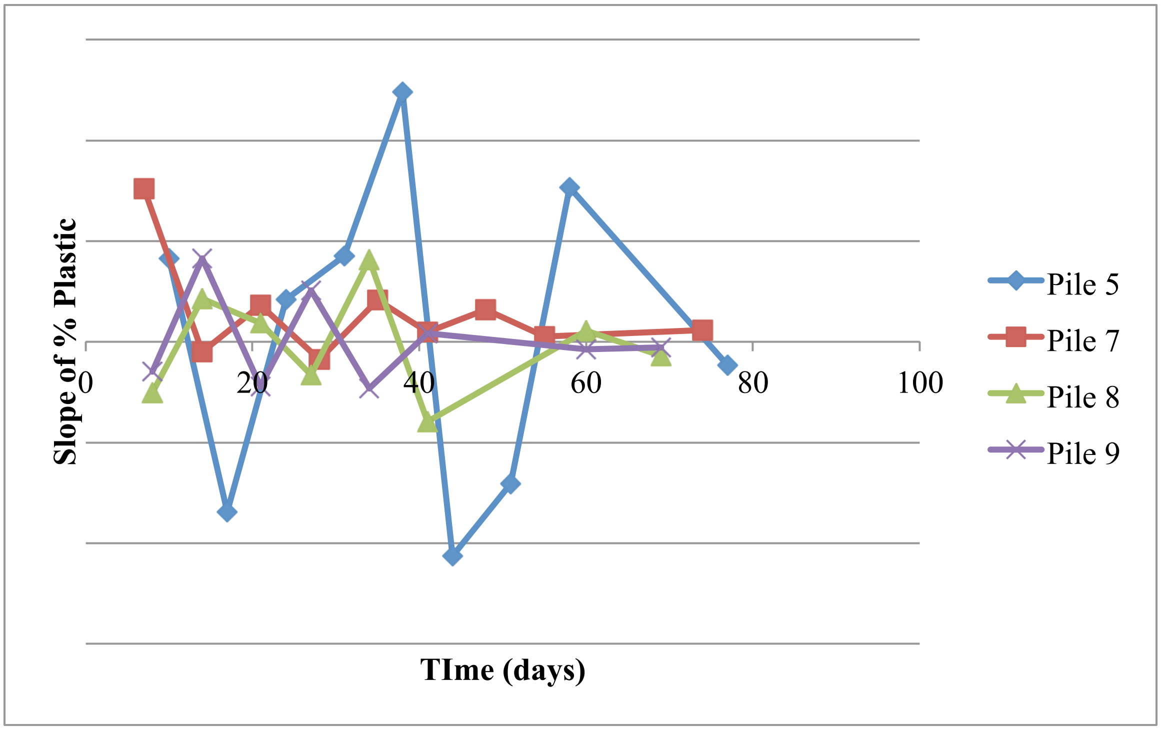

Figure B-9: Plastic stabilization for Piles 5, 7, 8 and 9

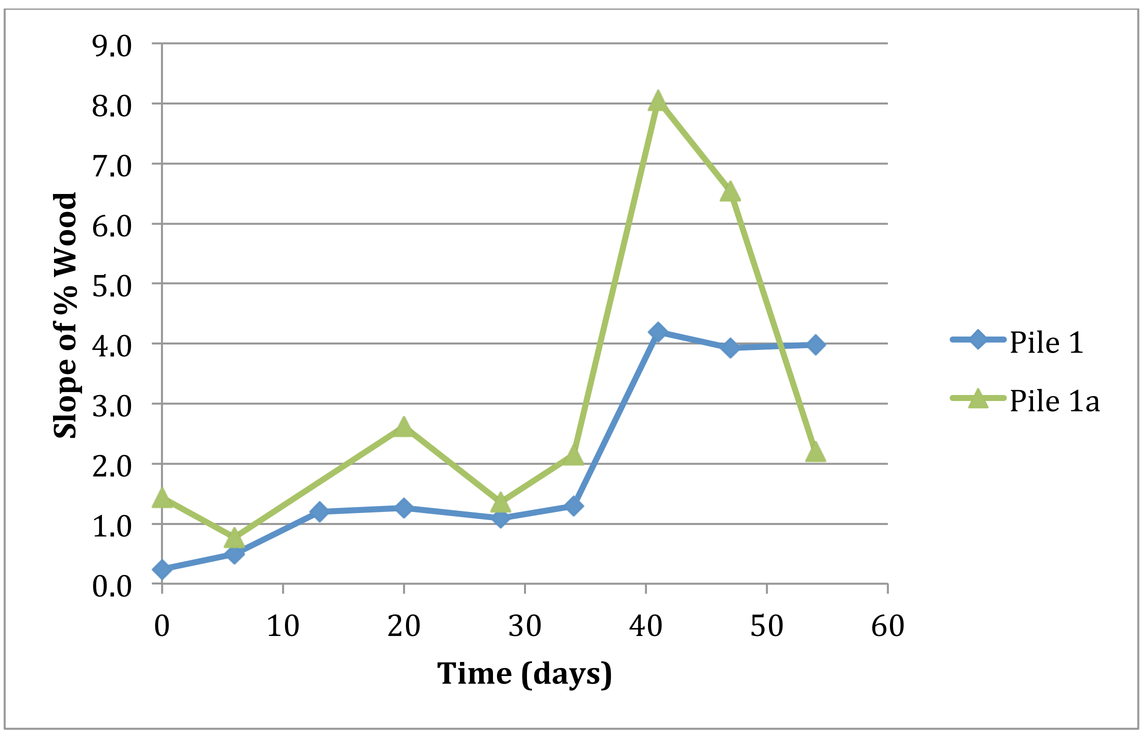

Figure B-10: Weight % wood for Piles 1 and 1a

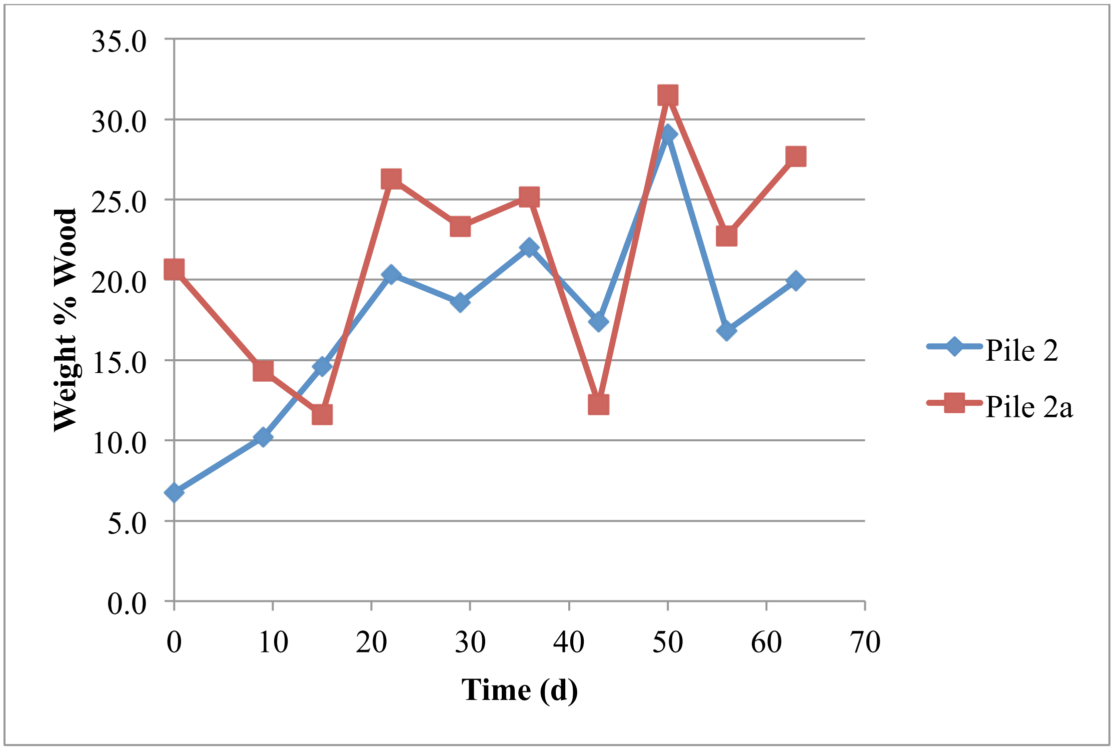

Figure B-11: Weight % wood for Piles 2 and 2a

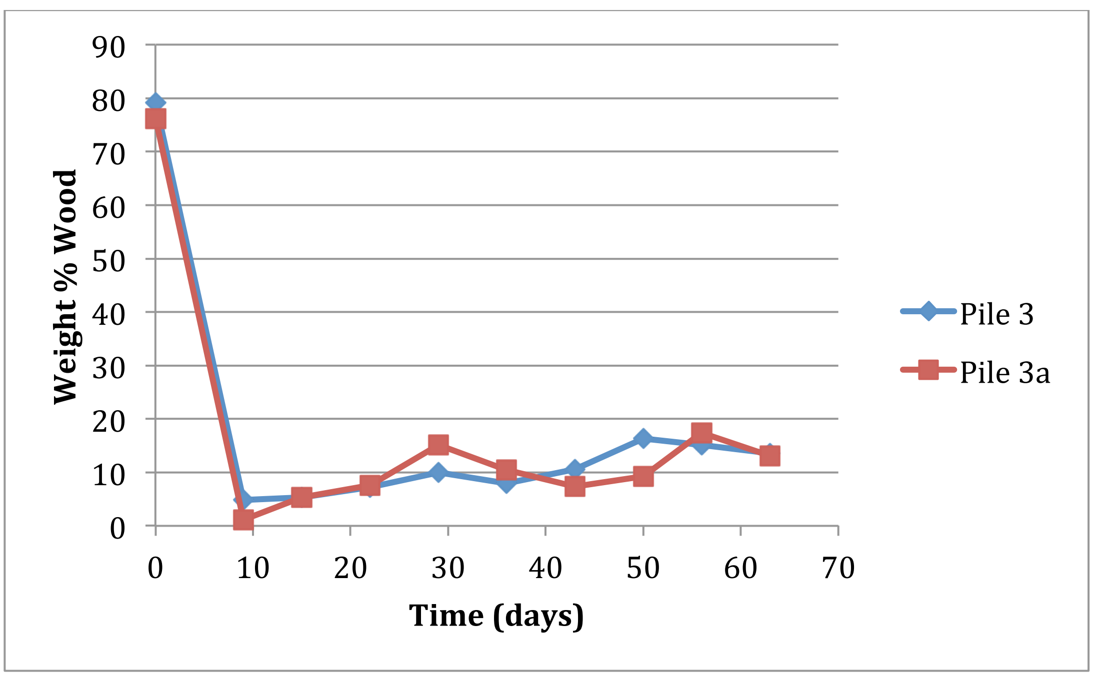

Figure B-12: Weight % wood for Piles 3 and 3a

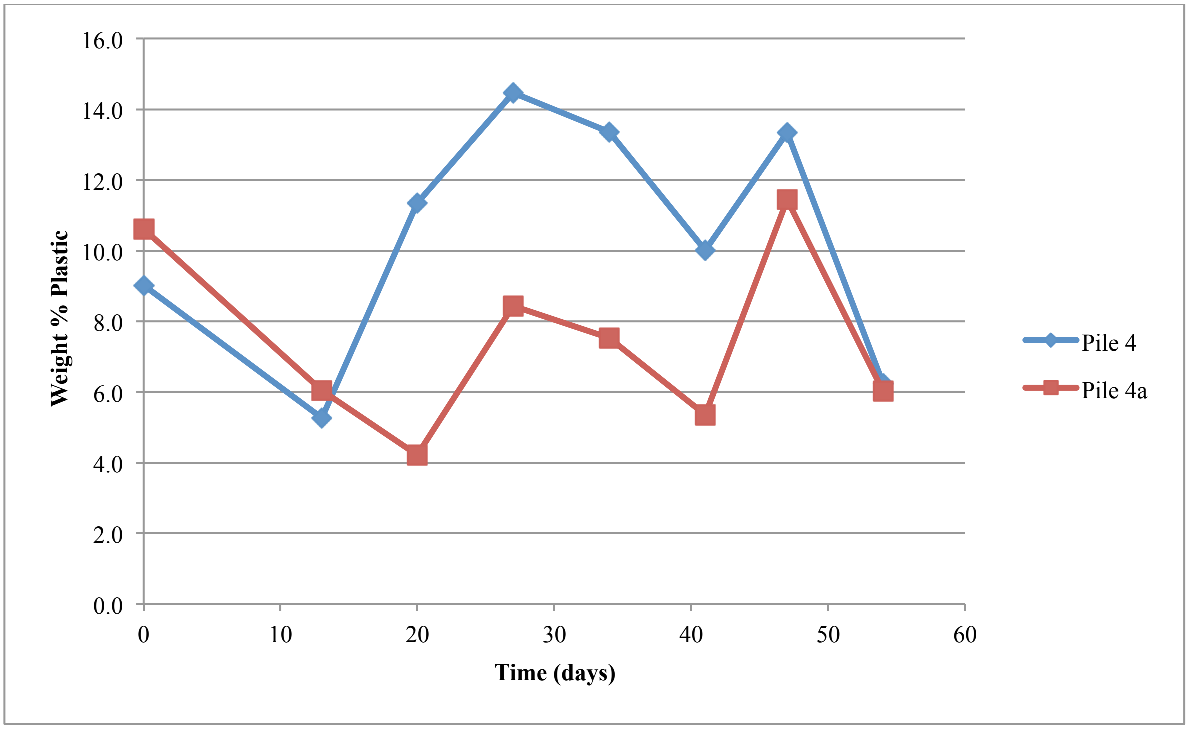

Figure B-13: Weight % wood for Piles 4 and 4a

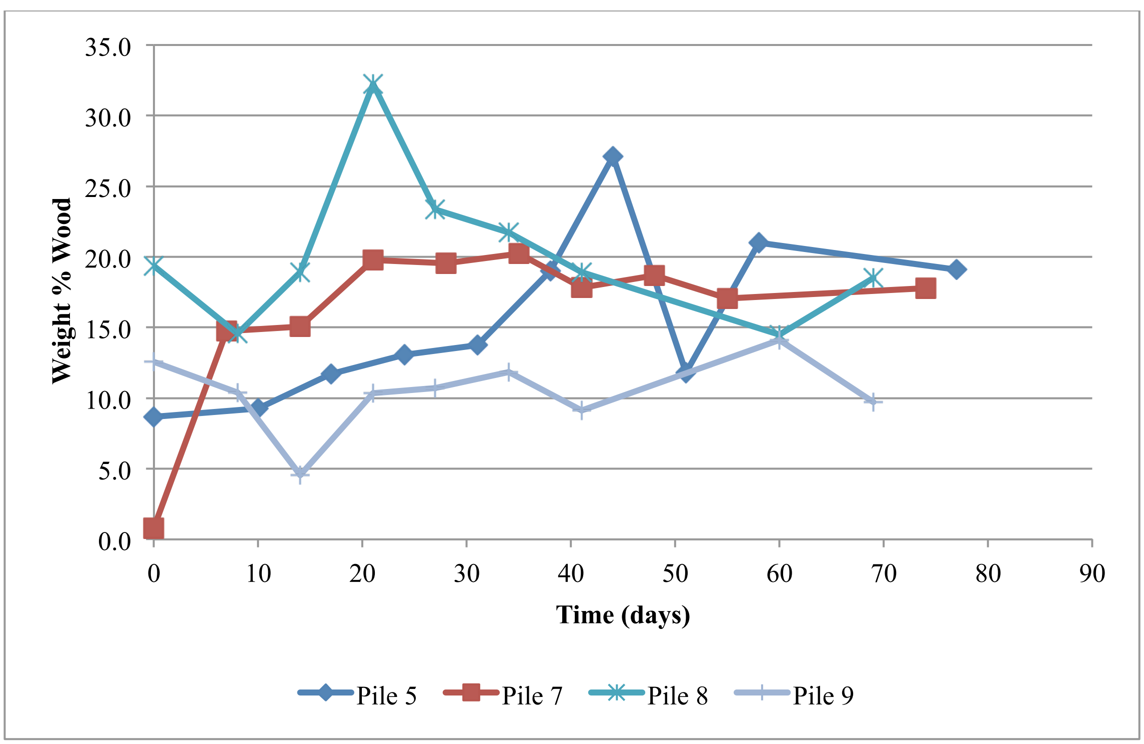

Figure B-14: Weight % wood for Piles 5, 7, 8, and 9

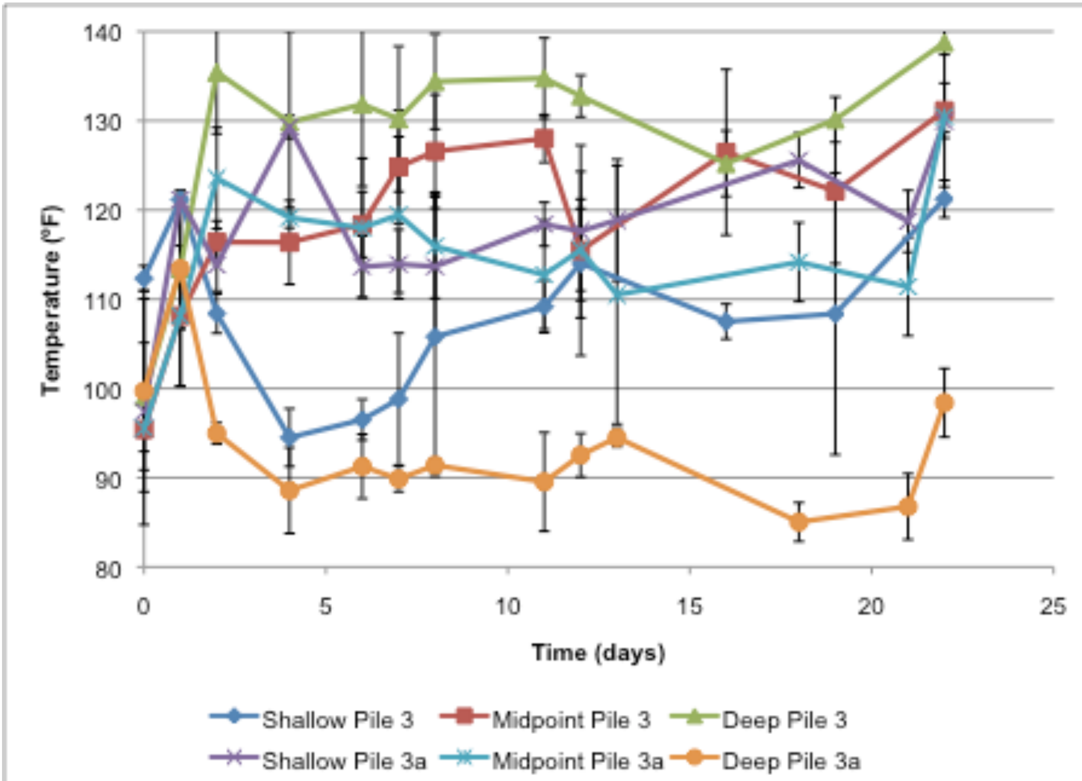

Figure B-15: Average temperatures for Piles 3 and 3a (error base show 95% confidence interval)

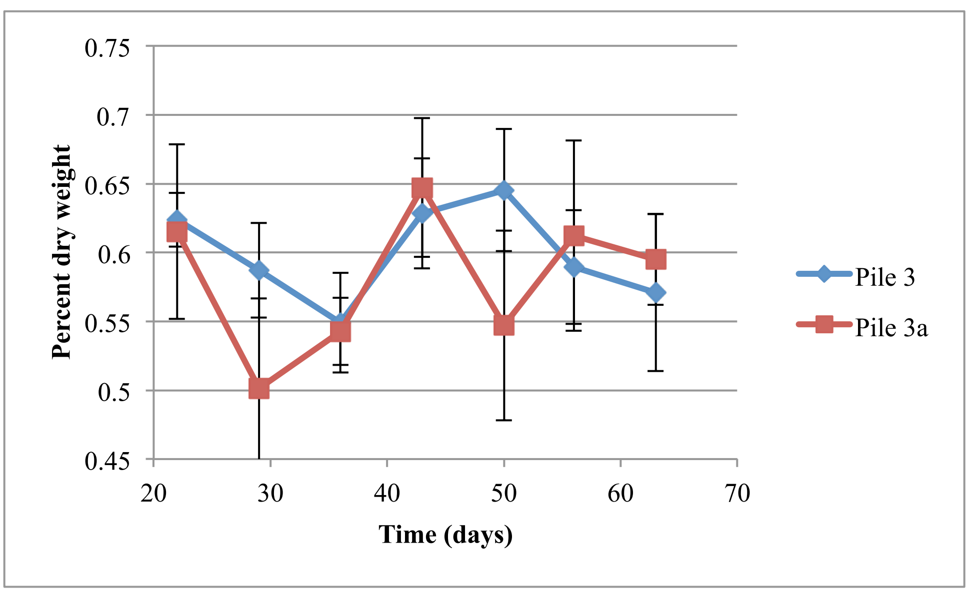

Figure B-16: Percent dry weight of Piles 3 and 3a over time (error bars represent the 95% confidence interval of triplicate measurement)

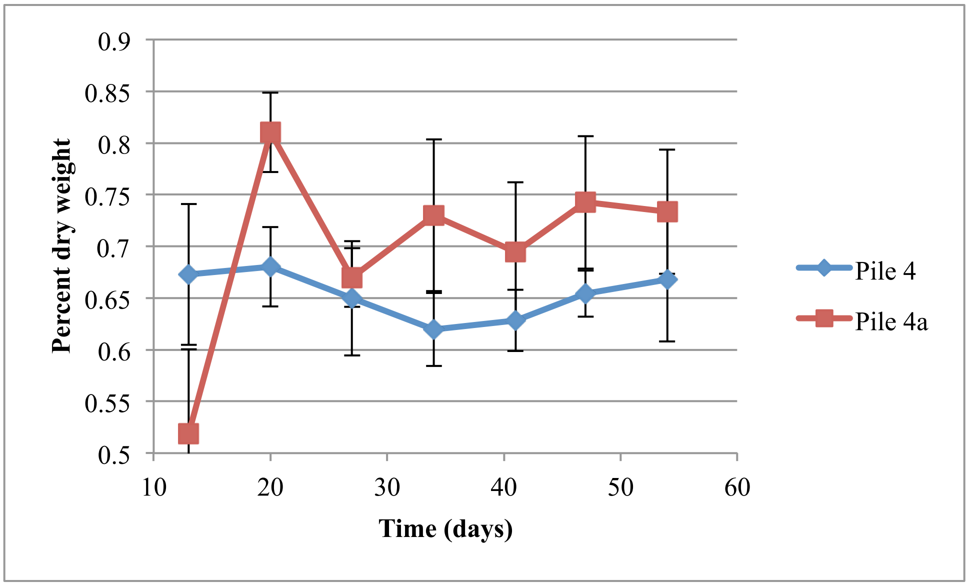

Figure B-17: Percent dry weight of Piles 4 and 4a over time (error bars represent the 95% confidence interval of triplicate measurement)

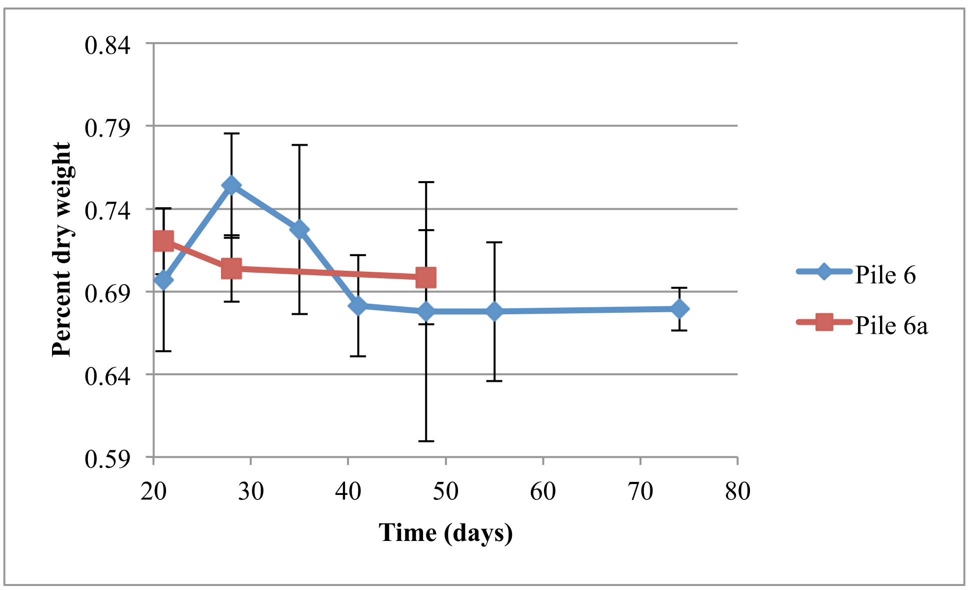

Figure B-18: Percent dry weight of Piles 6 and 6a over time (error bars represent the 95% confidence interval of triplicate measurement)

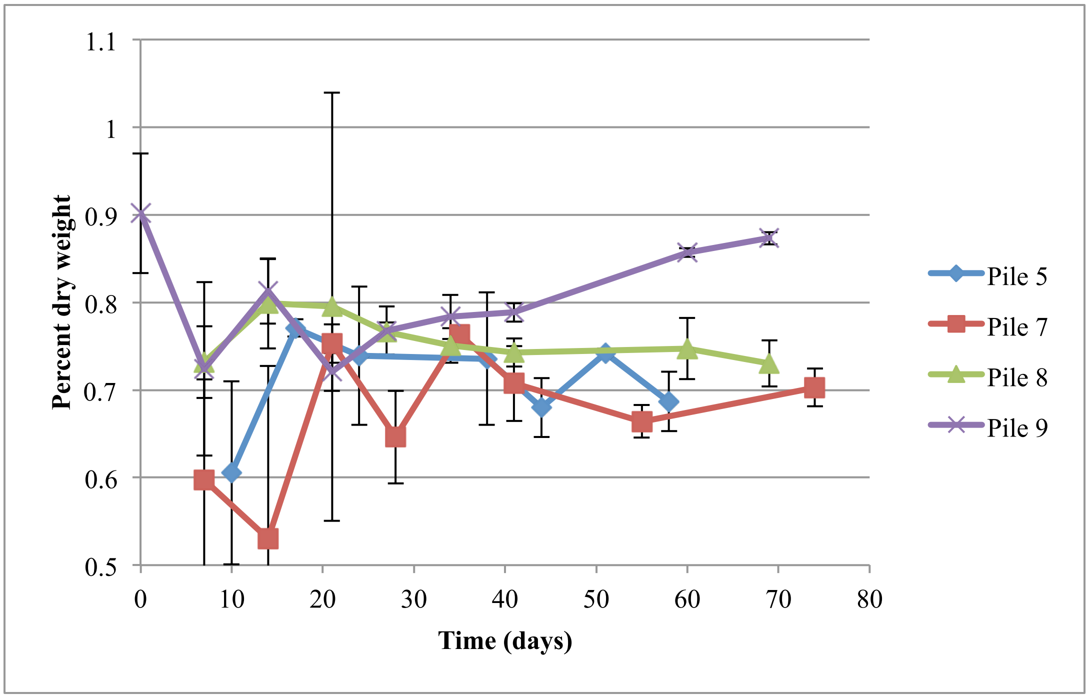

Figure B-19: Percent dry weight of Piles 5, 7, 8 and 9 over time (error bars represent the 95% confidence interval of triplicate measurement)

Appendix C

Raw Data

Table C-1: Carbaryl Raw Data

Pile	Sample Date	Concentration (μg/kg)
6	7/14	1.49
		0.00
		15.14
	8/11	0.00
		0.00
		6.21
	9/26	0.00
		0.00
		0.00
6a	7/14	10.67
		81.59
		7.70
	8/11	0.00
		2.08
		9.96
	9/26	1.19
		1.74
		2.71

Table C-2: Screening results for Piles 1, 1a, 2, 2a, 3, 3a, 4, and 4a

Pile	Compost (t)	Reject (t)	Total (t)
1	73.99	32.59	107.06
1a	22.61	41.24	67.95
2	53.3	17.26	71.83
2a	18.48	10.92	28.73
3	64.57	15.43	82.67
3a	27.19	10.65	38.48
4	36.19	21.88	56.59
4a	16.91	10.26	27.09

Table C-3: Pile 2 raw VOC data (µg/kg)

Day	0	0	0	28	28	28	48	48	48
Hexane	0.0000	0.0000	0.0000	0.0047	0.0000	0.0000	0.0140	0.0000	0.0394
Pentane, 2,4-dimethyl-	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0056	0.0000	0.0000
Cyclopentane, methyl-	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Hexane, 2-methyl-	0.0000	0.2192	0.3311	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Benzene	0.0402	0.1806	0.1664	0.1642	0.0548	0.0735	0.0422	0.0292	0.0309
Cyclohexane	0.0000	0.3741	0.4077	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2,3 dimethylpentane	0.0000	0.1493	0.1537	0.0000	0.0000	0.0000	0.0435	0.0408	0.0330
Hexane, 3-methyl-	0.0000	0.1707	0.1749	0.0000	0.0000	0.0000	0.0127	0.0000	0.0000
Pentane, 2,2,4-trimethyl-	0.0000	0.0000	0.0000	0.0098	0.0047	0.0147	0.0000	0.0071	0.0000
n-Heptane	0.0000	0.5403	0.6777	0.0904	0.0065	0.0460	0.0355	0.0328	0.0270
Cyclohexane, methyl-	0.0401	0.6513	0.9499	0.0269	0.0000	0.0000	0.0000	0.0000	0.0000
Pentane, 2,3,4-trimethyl-	0.0000	0.3058	0.0000	0.0000	0.0000	0.0000	0.0033	0.0000	0.0000
Heptane, 2-methyl-	0.0000	0.3010	0.4985	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Heptane, 3-methyl-	0.0000	0.3162	0.5042	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Toluene	0.1024	0.2743	0.1434	0.2867	0.0809	0.1285	0.0348	0.0459	0.0685
n-Octane	0.0786	0.4816	0.7220	0.0330	0.0020	0.0055	0.0115	0.0115	0.0228
Ethylbenzene	0.0000	0.0481	0.0338	0.0212	0.0033	0.0000	0.0141	0.0190	0.0000
m,p-xylene	0.0000	0.0486	0.0390	0.0205	0.0039	0.0075	0.0094	0.0062	0.0068
Nonane	0.1017	0.3154	0.3906	0.0469	0.0019	0.0137	0.0159	0.0418	0.0812
styrene	0.0000	0.3117	0.2805	0.2492	0.0736	0.1084	0.0425	0.0000	0.0407
o-xylene	0.0000	0.0311	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Benzene, isopropyl	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Benzene, n-propyl-	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0407	0.0240
m-ethyl toluene	0.0401	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
p-ethyl toluene	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Benzene, 1,3,5-trimethyl-	0.0000	0.0352	0.0413	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
n-decane	0.2673	0.3173	0.2617	0.0902	0.0000	0.0161	0.0000	0.1481	0.1438
o-ethyl toluene	0.0000	0.0538	0.0323	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Benzene, 1,2,4-trimethyl-	0.0606	0.1485	0.1047	0.0314	0.0000	0.0000	0.0046	0.0000	0.0418
1,2,3-Trimethylbenzene	0.0771	0.1210	0.0000	0.0098	0.0000	0.0000	0.0000	0.0000	0.0210
Benzene, m-diethyl-	0.0000	0.1622	0.0000	0.0101	0.0000	0.0000	0.0000	0.0000	0.0000
Benzene, p-diethyl-	0.0000	0.0543	0.0000	0.0102	0.0000	0.0000	0.0000	0.0000	0.0000
n-Undecane	0.3782	0.2712	0.2997	0.0593	0.0056	0.0126	0.0000	0.0658	0.2910
n-dodecane	0.0000	0.5612	0.2957	0.0152	0.0179	0.0145	0.0000	0.0000	0.3491

Table C-4: Pile 2a raw VOC data (μg/kg)

Days	0	0	0	28	28	28	48	48	48
Hexane	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Pentane, 2,4-dimethyl-	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Cyclopentane, methyl-	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Hexane, 2-methyl-	0.0259	0.0000	0.0560	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Benzene	0.0442	0.0332	0.0746	0.2955	0.0952	0.1317	0.0252	0.0253	0.0326
Cyclohexane	0.0587	0.0000	0.1011	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2,3 dimethylpentane	0.0392	0.0000	0.0610	0.0000	0.0000	0.0000	0.0272	0.0292	0.0370
Hexane, 3-methyl-	0.0000	0.0000	0.0329	0.0056	0.0000	0.0000	0.0000	0.0000	0.0000
Pentane, 2,2,4-trimethyl-	0.0000	0.0483	0.0000	0.0234	0.0079	0.0000	0.0000	0.0000	0.0000
n-Heptane	0.0804	0.1277	0.1372	0.1069	0.0399	0.0694	0.0160	0.0414	0.0175
Cyclohexane, methyl-	0.1590	0.0301	0.2492	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Pentane, 2,3,4-trimethyl-	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Heptane, 2-methyl-	0.0713	0.0998	0.1331	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Heptane, 3-methyl-	0.0857	0.0571	0.1476	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Toluene	0.0868	0.1381	0.1815	0.2240	0.1283	0.2204	0.0351	0.0432	0.0548
n-Octane	0.1372	0.0710	0.2271	0.0464	0.0108	0.0317	0.0184	0.0120	0.0179
Ethylbenzene	0.0000	0.0000	0.0000	0.0230	0.0095	0.0196	0.0047	0.0000	0.0058
m,p-xylene	0.0000	0.0000	0.0282	0.0102	0.0094	0.0236	0.0048	0.0036	0.0064
Nonane	0.1340	0.1237	0.2113	0.1409	0.0079	0.0289	0.0258	0.0436	0.0535
styrene	0.1401	0.2102	0.1351	0.3539	0.1306	0.1996	0.0000	0.0000	0.0000
o-xylene	0.0000	0.0000	0.0000	0.0000	0.0000	0.0611	0.0222	0.0000	0.0000
Benzene, isopropyl	0.0000	0.0000	0.0000	0.0000	0.0000	0.0099	0.0000	0.0000	0.0000
Benzene, n-propyl-	0.0000	0.0000	0.0000	0.0814	0.0000	0.0000	0.0212	0.0000	0.0284
m-ethyl toluene	0.0000	0.0434	0.0000	0.0000	0.0000	0.0139	0.0000	0.0000	0.0000
p-ethyl toluene	0.0000	0.0438	0.0000	0.0000	0.0000	0.0325	0.0000	0.0000	0.0000
Benzene, 1,3,5-trimethyl-	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
n-decane	0.1127	0.1770	0.1502	0.0384	0.0198	0.0428	0.0581	0.0329	0.1530
o-ethyl toluene	0.0000	0.0363	0.0000	0.0595	0.0000	0.0000	0.0000	0.0000	0.0000
Benzene, 1,2,4-trimethyl-	0.0478	0.0478	0.0796	0.0140	0.0000	0.0147	0.0000	0.0000	0.0347
1,2,3-Trimethylbenzene	0.0000	0.0371	0.0743	0.0268	0.0098	0.0245	0.0000	0.0000	0.0318
Benzene, m-diethyl-	0.0000	0.0000	0.0000	0.0135	0.0102	0.0276	0.0000	0.0000	0.0283
Benzene, p-diethyl-	0.0000	0.0000	0.0000	0.0135	0.0102	0.0453	0.0000	0.0000	0.0249
n-Undecane	0.2406	0.1650	0.3162	0.0601	0.0333	0.0903	0.0491	0.0189	0.2400
n-dodecane	0.2264	0.1023	0.9203	0.0404	0.0233	0.1965	0.0000	0.0000	0.1767

Table C-5: Pile 6 raw VOC data (µg/kg)

Days	0	0	0	28	28	28	74	74	74
Hexane	0.0000	0.0000	0.0000	0.0431	0.0065	0.0000	0.0000	0.0182	0.0000
Pentane, 2,4-dimethyl-	0.8130	0.2879	0.0780	0.0000	0.0999	0.0000	0.0000	0.0000	0.0000
Cyclopentane, methyl-	0.2171	0.0873	0.0000	0.0000	0.0128	0.0000	0.0000	0.0000	0.0000
Hexane, 2-methyl-	3.2644	1.3562	0.2907	0.0000	0.0435	0.0000	0.0000	0.0000	0.0000
Benzene	2.1255	0.9655	0.2390	0.1374	0.2072	0.1151	0.0300	0.0416	0.0000
Cyclohexane	6.5891	3.1137	0.4436	0.0000	0.1081	0.0000	0.0000	0.0112	0.0000
2,3 dimethylpentane	1.5638	0.0000	0.2107	0.0552	0.0000	0.0000	0.0000	0.0000	0.0000
Hexane, 3-methyl-	0.3081	0.2421	0.2283	0.0000	0.0608	0.0000	0.0000	0.0000	0.0000
Pentane, 2,2,4-trimethyl-	0.1382	0.0000	0.0192	0.0339	0.8935	0.0207	0.0000	0.0035	0.0000
n-Heptane	4.6838	1.6832	0.3979	0.0514	0.0155	0.0423	0.0000	0.0077	0.0000
Cyclohexane, methyl-	11.2772	4.6029	0.8249	0.0000	0.1401	0.0031	0.0000	0.0089	0.0000
Pentane, 2,3,4-trimethyl-	0.2610	0.1006	0.0000	0.0054	0.4133	0.0000	0.0000	0.0000	0.0000
Heptane, 2-methyl-	4.0608	0.5868	0.3961	0.0015	0.0304	0.0000	0.0000	0.0117	0.0000
Heptane, 3-methyl-	4.9746	1.8056	0.3854	0.0000	0.0275	0.0000	0.0000	0.0086	0.0000
Toluene	0.1879	0.1751	0.1784	0.0902	0.0804	0.1682	0.0128	0.0291	0.0102
n-Octane	4.7135	1.8818	0.6194	0.0196	0.0076	0.0158	0.0064	0.0205	0.0000
Ethylbenzene	0.1054	0.0901	0.0591	0.0197	0.0074	0.0125	0.0060	0.0053	0.0000
m,p-xylene	0.1613	0.1553	0.0931	0.0215	0.0095	0.0129	0.0074	0.0066	0.0000
Nonane	1.8269	1.9044	0.9487	0.0331	0.0253	0.0123	0.0102	0.0823	0.0000
styrene	0.1406	0.1292	0.0635	0.1969	0.1235	0.1583	0.0098	0.0142	0.0000
o-xylene	0.1555	0.2490	0.1224	0.0475	0.0000	0.0000	0.0053	0.0047	0.0000
Benzene, isopropyl	0.0426	0.0616	0.0000	0.0204	0.0063	0.0021	0.0000	0.0000	0.0000
Benzene, n-propyl-	0.0337	0.0653	0.0000	0.0287	0.0000	0.0000	0.0000	0.0000	0.0000
m-ethyl toluene	0.1544	0.2218	0.0000	0.0134	0.0000	0.0046	0.0000	0.0000	0.0549
p-ethyl toluene	0.0000	0.1237	0.0000	0.0155	0.0000	0.0050	0.0000	0.0000	0.0659
Benzene, 1,3,5-trimethyl-	0.1817	0.1420	0.2072	0.0074	0.0000	0.0000	0.0000	0.0000	0.1108
n-decane	0.8042	1.0777	0.6129	0.0526	0.0000	0.0430	0.0000	0.0884	0.0000
o-ethyl toluene	0.0932	0.1842	0.0618	0.0137	0.0000	0.0000	0.0000	0.0000	0.1035
Benzene, 1,2,4-trimethyl-	0.1781	0.3681	0.3536	0.0325	0.0000	0.0000	0.0000	0.0000	0.0000
1,2,3-Trimethylbenzene	0.2071	0.3810	0.0000	0.0352	0.0096	0.0114	0.0000	0.0000	0.0000
Benzene, m-diethyl-	0.0000	0.0000	0.0000	0.0335	0.0088	0.0056	0.0000	0.0000	0.0000
Benzene, p-diethyl-	0.0272	0.1452	0.0000	0.0468	0.0088	0.0170	0.0000	0.0000	0.0000
n-Undecane	0.5796	0.9483	0.8072	0.0865	0.0410	0.0386	0.0000	0.0713	0.0000
n-dodecane	0.1996	0.3830	0.7011	0.1163	0.0262	0.0372	0.0000	0.0000	0.0000

Table C-6: Pile 6a raw VOC data (μg/kg)

Days	0	0	0	28	28	28	74	74	74
Hexane	0.0000	0.0000	0.1278	0.0000	0.0000	0.0000	0.0173	0.0000	0.1739
Pentane, 2,4-dimethyl-	0.0267	0.2586	1.0813	0.0000	0.0000	0.0000	0.0000	0.0000	0.0277
Cyclopentane, methyl-	0.0000	0.3121	0.2381	0.0000	0.0000	0.0000	0.0156	0.0000	0.1364
Hexane, 2-methyl-	0.1724	1.4038	3.4091	0.0079	0.0000	0.0000	0.0092	0.0000	0.0916
Benzene	0.1647	1.6266	1.9780	0.0575	0.1153	0.1248	0.0615	0.0293	0.2973
Cyclohexane	0.3871	3.9405	6.6516	0.0000	0.0000	0.0000	0.0124	0.0000	2.1409
2,3 dimethylpentane	0.1599	1.3825	2.1890	0.0000	0.0000	0.0000	0.0096	0.0000	0.1492
Hexane, 3-methyl-	0.1208	0.6945	0.3192	0.0033	0.0000	0.0000	0.0138	0.0000	0.0923
Pentane, 2,2,4-trimethyl-	0.0000	0.0000	0.1385	0.0126	0.0000	0.0000	0.0086	0.0017	0.1663
n-Heptane	0.4402	2.3711	4.0714	0.0339	0.0373	0.0504	0.0175	0.0000	0.1591
Cyclohexane, methyl-	1.0520	8.1918	8.2954	0.0026	0.0000	0.0000	0.0083	0.0000	0.0562
Pentane, 2,3,4-trimethyl-	0.0367	0.2688	0.2037	0.0000	0.0000	0.0000	0.0000	0.0000	0.0406
Heptane, 2-methyl-	0.5472	3.2209	3.6194	0.0000	0.0000	0.0000	0.0061	0.0000	0.0343
Heptane, 3-methyl-	0.6375	3.4011	3.5643	0.0000	0.0000	0.0000	0.0000	0.0000	0.0182
Toluene	0.0998	0.4702	0.2179	0.0983	0.1820	0.1885	0.3603	0.0122	-0.0041
n-Octane	1.1817	4.8659	3.6094	0.0114	0.0073	0.0165	0.0118	0.0000	0.0724
Ethylbenzene	0.0760	0.3952	0.1155	0.0073	0.0018	0.0118	0.0137	0.0000	0.2346
m,p-xylene	0.1341	0.6477	0.1729	0.0092	0.0069	0.0130	0.0299	0.0000	0.4129
Nonane	1.1569	7.5894	2.8882	0.0084	0.0156	0.0153	0.0356	0.0000	0.4145
styrene	0.0898	0.1348	0.2323	0.0871	0.1412	0.1114	0.0324	0.0000	0.8608
o-xylene	0.1666	0.7761	0.2112	0.0000	0.0000	0.0000	0.0248	0.0000	0.2579
Benzene, isopropyl	0.0445	0.0000	0.0786	0.0000	0.0000	0.0000	0.0000	0.0000	0.0133
Benzene, n-propyl-	0.0000	0.2688	0.0475	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
m-ethyl toluene	0.1181	0.7482	0.4364	0.0000	0.0000	0.0000	0.0000	0.0000	0.1841
p-ethyl toluene	0.0492	0.3933	0.0964	0.0000	0.0000	0.0000	0.0000	0.0000	0.1210
Benzene, 1,3,5-trimethyl-	0.1159	0.5700	0.1454	0.0000	0.0052	0.0000	0.0000	0.0000	0.0000
n-decane	0.9152	4.9963	1.5203	0.0195	0.0190	0.0087	0.1079	0.0000	1.2786
o-ethyl toluene	0.0593	0.4660	0.1745	0.0000	0.0000	0.0000	0.0000	0.0000	0.1006
Benzene, 1,2,4-trimethyl-	0.2555	1.2776	0.5352	0.0000	0.0000	0.0000	0.0000	0.0000	0.6576
1,2,3-Trimethylbenzene	0.0000	0.0000	0.4248	0.0096	0.0000	0.0000	0.0199	0.0000	0.0592
Benzene, m-diethyl-	0.0000	0.0000	0.0000	0.0060	0.0000	0.0000	0.0000	0.0000	0.2774
Benzene, p-diethyl-	0.0663	0.0000	0.1998	0.0106	0.0000	0.0000	0.0000	0.0000	0.2333
n-Undecane	0.6228	11.2556	1.1556	0.0290	0.0000	0.0315	0.0748	0.0000	1.0042
n-dodecane	0.2504	2.0924	0.9763	0.0473	0.0069	0.0747	0.0000	0.0000	0.4342

Table C-7: Pile 2 raw SVOC data (µg/g)

Days	0	0	0	28	28	28	48	48	48
KRO	64.02	180.79	34.47	52.56	29.96	1946.14	404.56	59.37	152.00
DRO	791.90	3392.18	296.05	217.06	77.90	9362.93	3441.52	728.06	1854.66
MORO	13680.76	6564.78	1507.56	676.52	236.48	21390.08	5546.24	2319.37	3750.80
Naphthalene	0.1385	0.3077	0.0849	0.0239	0.0096	0.1759	0.1633	0.0446	0.0991
Acenaphthylene	0.0402	0.1346	0.0000	0.0000	0.0055	0.0000	0.0000	0.0000	0.0000
Acenaphthene	0.0447	0.2115	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Fluorene	0.0447	0.3269	0.0000	0.0000	0.0000	0.0000	0.0000	0.0260	0.0000
Phenanthrene	0.1742	1.4616	0.0788	0.0334	0.0000	0.0000	0.2993	0.0966	0.1754
Anthracene	0.0402	0.3269	0.0126	0.0099	0.0000	0.0000	0.1089	0.0000	0.0381
Fluoranthene	0.1519	0.8654	0.0485	0.0429	0.0128	0.6451	0.3538	0.0520	0.1449
Pyrene	0.1251	0.7116	0.0424	0.0525	0.0128	1.0322	0.3129	0.0631	0.1067
Benz[a]anthracene	0.0313	0.1346	0.0162	0.0000	0.0000	0.0000	0.1769	0.0099	0.0534
Chrysene	0.0402	0.1923	0.0000	0.0123	0.0000	0.0000	0.2585	0.0334	0.0534
Benz[b]fluoranthene	0.0268	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Benz[k]fluoranthene	0.0126	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Benzo[a]pyrene	0.0223	0.0000	0.0000	0.0000	0.0000	0.0000	0.0680	0.0000	0.0000
Indeno(123-cd)perylene	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Dibenz[a,h]anthracene	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Benzo[ghi]perylene	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1276	0.0000	0.0000

Table C-8: Pile 2a raw SVOC data (µg/g)

Days	0	0	0	28	28	28	48	48	48
KRO	40.81	60.44	49.06	53.14	435.01	68.86	115.21	151.76	78.16
DRO	565.07	323.82	959.49	193.07	340.85	315.96	927.91	1709.70	777.10
MORO	1887.04	1424.41	3767.84	806.94	891.88	1309.99	2382.13	2168.43	1304.82
Naphthalene	0.0727	0.1390	0.3365	0.0314	0.0669	0.0342	0.0921	0.1373	0.0436
Acenaphthylene	0.0000	0.0080	0.0732	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Acenaphthene	0.0229	0.0510	0.3121	0.0000	0.0000	0.0615	0.0102	0.0000	0.0000
Fluorene	0.0000	0.0463	0.7023	0.0000	0.0000	0.0000	0.0000	0.0392	0.0000
Phenanthrene	0.1606	0.2641	14.6890	0.0524	0.0573	0.0683	0.0665	0.2060	0.0582
Anthracene	0.0229	0.0417	3.9990	0.0000	0.0000	0.0000	0.0000	0.0392	0.0000
Fluoranthene	0.0382	0.1158	22.2481	0.0576	0.0478	0.0683	0.0409	0.1717	0.0388
Pyrene	0.0612	0.0973	15.1084	0.0524	0.0382	0.1093	0.0486	0.1324	0.0339
Benz[a]anthracene	0.0102	0.0124	7.8224	0.0140	0.0128	0.0183	0.0000	0.0294	0.0000
Chrysene	0.0000	0.0000	7.9395	0.0135	0.0287	0.0478	0.0614	0.0589	0.0125
Benz[b]fluoranthene	0.0000	0.0000	3.7113	0.0000	0.0000	0.0000	0.0000	0.0134	0.0000
Benz[k]fluoranthene	0.0000	0.0000	3.9063	0.0000	0.0000	0.0000	0.0000	0.0139	0.0000
Benzo[a]pyrene	0.0000	0.0000	4.5842	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Indeno(123-cd)perylene	0.0000	0.0000	2.8773	0.0000	0.0000	0.0000	0.0274	0.0000	0.0000
Dibenz[a,h]anthracene	0.0000	0.0000	0.7071	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Benzo[ghi]perylene	0.0000	0.0000	2.4530	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Table C-9: Pile 6 raw SVOC data (µg/g)

Days	0	0	0	28	28	28	74	74	74
KRO	132.45	53.56	32.68	23.62	50.69	25.93	116.08	52.51	44.56
DRO	1223.53	955.90	1762.29	377.00	121.44	326.51	294.85	303.09	324.32
MORO	4201.49	2270.95	3555.67	805.92	911.17	1346.28	1359.72	1001.02	1744.45
Naphthalene	1.2550	0.9763	37.6420	0.2136	0.1689	0.3129	0.1983	0.3098	0.9918
Acenaphthylene	0.3800	0.2586	4.3105	0.0246	0.0188	0.1669	0.0256	0.0362	3.0884
Acenaphthene	0.2916	0.2541	25.0252	0.0616	0.0235	0.2434	0.0320	0.0857	0.4520
Fluorene	0.5185	0.4101	26.3494	0.0945	0.0375	0.2468	0.0640	0.1153	1.1299
Phenanthrene	1.6585	1.3106	105.6431	0.3821	0.1126	1.6791	0.1599	0.4350	18.4988
Anthracene	0.3800	0.2675	38.9431	0.0863	0.0328	0.8378	0.1599	0.1022	7.1371
Fluoranthene	0.6334	0.4681	46.5178	0.2794	0.0892	4.6272	0.1152	0.1911	27.3433
Pyrene	0.6628	0.4146	32.6370	0.2506	0.1314	3.8763	0.1216	0.1582	18.5553
Benz[a]anthracene	0.1237	0.0981	6.8709	0.0698	0.0235	1.4149	0.0171	0.0297	8.1101
Chrysene	0.1650	0.1248	7.8016	0.1109	0.0399	1.6096	0.0384	0.0428	9.5475
Benz[b]fluoranthene	0.0442	0.0357	1.8011	0.0493	0.0164	0.6362	0.0174	0.0000	3.4524
Benz[k]fluoranthene	0.0471	0.0401	2.4446	0.0534	0.0211	0.8065	0.0000	0.0000	3.8856
Benzo[a]pyrene	0.0678	0.0669	2.2039	0.0575	0.0305	0.7613	0.0000	0.0165	3.9421
Indeno(123-cd)perylene	0.0412	0.0401	0.8843	0.0000	0.0000	0.3059	0.0000	0.0000	2.2158
Dibenz[a,h]anthracene	0.0000	0.0000	0.2454	0.0000	0.0000	0.0521	0.0000	0.0000	0.5084
Benzo[ghi]perylene	0.0619	0.0000	0.8149	0.0000	0.0000	0.2225	0.0000	0.0000	1.8769

Table C-10: Pile 6a raw SVOC data (µg/g)

Days	0	0	0	28	28	28	74	74	74
KRO	86.93	52.54	40.91	61.75	27.00	27.35	33.86	47.63	137.85
DRO	1149.14	3597.44	1916.64	199.24	280.54	176.54	138.68	252.26	843.06
MORO	4813.43	5650.48	5633.56	440.70	1221.03	577.93	498.74	1142.87	4933.44
Naphthalene	1.2972	4.1354	0.0090	0.4353	0.8364	0.9987	0.1091	0.1987	0.8876
Acenaphthylene	0.3387	0.6709	4.5584	0.0967	0.0786	0.3305	0.0156	0.0310	0.4772
Acenaphthene	0.4936	2.0171	32.5723	0.1397	0.1433	0.7002	0.0134	0.0279	0.4677
Fluorene	0.7134	2.5108	29.8253	0.1397	0.2495	0.6077	0.0245	0.0466	0.6013
Phenanthrene	2.3674	9.5663	105.1152	0.8976	1.1275	1.9228	0.0846	0.1615	2.3289
Anthracene	0.5513	2.4981	61.4223	0.1935	0.2865	1.0165	0.0289	0.0528	1.2026
Fluoranthene	0.8288	3.5320	67.6859	0.8707	0.6793	4.9189	0.0801	0.1211	4.6100
Pyrene	0.6450	2.7007	51.5159	0.7901	0.5268	4.8264	0.0913	0.1304	4.5432
Benz[a]anthracene	0.1297	0.6414	10.4637	0.3386	0.1386	1.8197	0.0245	0.0342	1.7180
Chrysene	0.1694	0.8018	13.3434	0.4515	0.1941	2.3279	0.0356	0.0652	2.2907
Benz[b]fluoranthene	0.0504	0.1772	2.6076	0.1666	0.0601	0.8068	0.0061	0.0217	0.7349
Benz[k]fluoranthene	0.0577	0.2321	3.3972	0.2257	0.0739	1.0236	0.0134	0.0217	0.8685
Benzo[a]pyrene	0.0613	0.2405	3.4901	0.1720	0.0739	1.0662	0.0111	0.0155	0.0477
Indeno(123-cd)perylene	0.0386	0.1604	1.2076	0.0576	0.0495	0.3412	0.0000	0.0000	0.3531
Dibenz[a,h]anthracene	0.0000	0.0633	0.0995	0.0000	0.0000	0.1102	0.0000	0.0000	0.1432
Benzo[ghi]perylene	0.0338	0.1308	1.2939	0.0504	0.0000	0.3341	0.0000	0.0000	0.3913

Table C-11: Piles 1 and 1a component wt% based on hand sorting of bulk samples

Pile 1	Component Wt%							
∑Time (d)	Paper	Plastic	Wood	Organic	Soil	Metal & Glass	Tires	Inorganic
0	0.0	0.0	0.2	18.1	81.6	0.0	0.0	0.0
6	0.0	0.0	0.5	14.5	85.0	0.0	0.0	0.0
13	0.0	0.0	1.2	0.5	98.3	0.0	0.0	0.0
20	0.0	0.0	1.3	2.0	94.1	0.0	0.0	2.6
28	0.0	0.0	1.1	1.5	96.5	0.0	0.0	0.9
34	0.0	0.0	1.3	1.1	96.0	0.0	0.0	1.6
41	0.0	0.0	4.2	0.0	92.9	0.0	0.0	2.9
47	0.0	0.0	3.9	0.1	89.8	0.0	0.0	6.2
54	0.0	0.0	4.0	0.1	89.2	0.0	0.0	6.7
Pile 1a	Component Wt%							
∑Time (d)	Paper	Plastic	Wood	Organic	Soil	Metal & Glass	Tires	Inorganic
0	0.0	0.0	1.4	38.8	59.8	0.0	0.0	0.0
6	0.0	0.0	0.8	16.2	81.5	0.0	0.0	1.5
20	0.0	0.0	2.6	7.3	89.1	0.0	0.0	0.9
28	0.0	0.1	1.4	2.5	94.8	0.0	0.0	1.3
34	0.0	0.0	2.2	1.8	94.4	0.2	0.0	1.4
41	0.0	0.0	8.1	0.2	89.8	0.0	0.0	2.0
47	0.0	0.0	6.5	0.2	87.9	0.0	0.0	5.4
54	0.0	0.0	2.2	0.2	95.8	0.0	0.0	1.8

Table C-12: Piles 2 and 2a component wt% based on hand sorting of bulk samples

Pile 2	Component Wt%							
∑Time (d)	Paper	Plastic	Wood	Organic	Soil	Metal & Glass	Tires	Inorganic
0	0.4	1.4	6.8	13.5	78.0	0.0	0.0	0.0
9	1.8	3.1	10.2	2.0	82.8	0.0	0.0	0.0
15	0.5	5.6	14.6	15.8	62.1	1.3	0.0	0.0
22	0.8	1.5	20.3	4.4	72.1	0.8	0.0	0.0
29	0.5	2.1	18.6	0.2	69.7	0.3	0.0	8.7
36	0.1	4.2	22.0	6.2	64.1	0.0	0.0	3.3
43	0.2	4.3	17.4	3.6	70.9	0.1	0.0	3.5
50	0.2	2.8	29.1	0.3	60.4	0.0	0.0	7.3
56	0.0	1.9	16.8	0.2	71.0	0.4	0.0	9.6
63	0.1	1.8	19.9	0.5	71.7	0.2	0.0	5.8
Pile 2a	Component Wt%							
∑Time (d)	Paper	Plastic	Wood	Organic	Soil	Metal & Glass	Tires	Inorganic
0	0.5	0.5	20.7	33.9	44.5	0.0	0.0	0.0
9	1.8	4.2	14.3	1.5	77.9	0.2	0.0	0.0
15	0.5	1.9	11.6	22.6	63.1	0.3	0.0	0.0
22	1.3	2.9	26.3	9.8	43.3	1.4	0.0	15.0
29	0.7	0.9	23.3	13.6	48.1	0.2	0.0	13.2
36	0.8	2.1	25.2	3.4	56.8	0.0	0.0	11.7
43	0.5	1.3	12.2	3.2	76.8	0.3	0.6	5.1
50	0.3	1.9	31.5	0.7	50.8	0.2	0.8	13.9
56	0.1	4.0	22.7	0.3	63.5	0.0	0.0	9.4
63	0.5	3.9	27.7	0.2	60.5	0.3	0.0	6.9

Table C-13: Piles 3 and 3a component wt% based on hand sorting of bulk samples

Pile 3	Component Wt%							
∑Time (d)	Paper	Plastic	Wood	Organic	Soil	Metal & Glass	Tires	Inorganic
0	0.4	0.6	79.2	14.8	4.9	0.0	0.0	0.0
9	0.5	0.9	4.8	12.6	81.1	0.0	0.0	0.0
15	0.3	0.4	5.3	11.0	83.0	0.1	0.0	0.0
22	0.4	1.2	7.2	6.8	81.6	0.2	0.0	2.5
29	0.2	0.7	10.0	2.5	84.3	0.0	0.0	2.4
36	0.2	0.7	7.9	0.9	87.3	0.0	0.0	3.0
43	0.1	0.8	10.6	1.5	83.6	0.1	0.0	3.3
50	0.0	1.1	16.3	0.2	77.2	0.2	0.0	5.0
56	0.0	2.0	15.1	0.0	75.1	0.1	0.0	7.8
63	0.0	1.2	13.6	0.0	77.1	0.1	0.0	8.0
Pile 3a	Component Wt%							
∑Time (d)	Paper	Plastic	Wood	Organic	Soil	Metal & Glass	Tires	Inorganic
0	0.8	0.2	76.1	18.4	4.6	0.0	0.0	0.0
9	0.0	0.3	1.1	14.0	84.6	0.0	0.0	0.0
15	0.3	0.4	5.3	10.5	83.5	0.0	0.0	0.0
22	0.5	1.9	7.5	5.0	84.8	0.2	0.0	0.0
29	0.3	1.0	15.2	2.3	77.2	0.5	0.0	3.6
36	0.0	1.4	10.4	3.1	80.6	0.4	0.0	4.1
43	0.0	0.5	7.3	1.0	87.3	0.0	0.0	3.9
50	0.0	0.8	9.2	1.0	84.4	0.0	0.0	4.6
56	0.0	0.9	17.3	0.1	69.6	0.3	0.0	11.7
63	0.0	0.4	13.0	0.1	79.0	0.0	0.0	7.5

Table C-14: Piles 4 and 4a component wt% based on hand sorting of bulk samples

Pile 4	Component Wt%							
∑Time (d)	Paper	Plastic	Wood	Organic	Soil	Metal & Glass	Tires	Inorganic
0	9.5	9.0	16.2	1.7	59.8	3.8	0.0	0.0
13	4.4	5.3	10.3	1.5	77.7	0.9	0.0	0.0
20	5.5	11.3	12.3	0.0	60.5	3.6	0.0	6.6
27	6.2	14.5	12.0	1.8	56.4	3.4	0.0	5.7
34	1.5	13.4	16.3	1.1	64.3	1.0	0.0	2.4
41	0.8	10.0	15.3	4.7	60.5	1.0	0.0	7.7
47	1.3	13.3	29.4	3.7	45.7	2.5	0.0	4.1
54	0.3	6.3	12.5	5.6	65.9	1.4	0.0	8.1
Pile 4a	Component Wt%							
∑Time (d)	Paper	Plastic	Wood	Organic	Soil	Metal & Glass	Tires	Inorganic
0	6.2	10.6	16.4	3.6	59.5	3.7	0.0	0.0
13	7.0	6.1	21.8	14.1	47.8	1.1	0.03	2.3
20	3.9	4.2	12.2	3.5	53.7	1.1	0.0	21.4
27	4.1	8.4	14.8	3.6	57.5	7.5	0.0	4.0
34	5.3	7.5	11.9	4.7	61.0	1.1	0.0	8.4
41	1.9	5.4	17.8	1.4	64.5	5.2	0.0	3.8
47	0.7	11.4	11.9	0.5	65.5	1.4	0.0	8.6
54	0.6	6.0	17.1	1.1	51.2	2.4	0.0	21.5

Table C-15: Pile 5 component wt% based on hand sorting of bulk samples

Pile 5	Component Wt%							
∑Time (d)	Paper	Plastic	Wood	Organic	Soil	Metal & Glass	Tires	Inorganic
0	8.9	9.3	8.7	5.5	61.9	5.7	0.0	0.0
10	4.5	13.5	9.3	1.2	69.9	1.7	0.0	0.0
17	7.0	7.5	11.7	4.6	49.7	1.2	0.0	18.3
24	2.5	9.0	13.1	1.5	68.7	1.1	0.0	4.2
31	1.0	12.0	13.8	1.8	67.3	0.6	0.0	3.5
38	0.4	20.7	19.0	0.2	47.3	6.8	0.0	5.6
44	0.5	14.3	27.1	0.3	42.3	2.4	0.0	13.2
51	0.7	9.4	11.8	0.1	73.7	0.9	0.0	3.4
58	0.1	14.7	21.0	0.2	50.0	1.1	0.0	12.9
77	0.0	12.5	19.1	0.0	60.7	1.9	0.0	5.7

Table C-16: Piles 6 and 6a component wt% based on hand sorting of bulk samples

Pile 6	Component Wt%							
∑Time (d)	Paper	Plastic	Wood	Organic	Soil	Metal & Glass	Tires	Inorganic
0	4.7	4.5	18.3	10.4	38.9	3.8	0.0	19.4
7	4.4	6.9	10.4	3.9	61.4	1.8	0.0	11.2
14	1.4	2.9	10.4	21.7	51.8	0.3	0.0	11.5
21	1.6	6.3	22.9	4.1	59.5	0.6	0.0	4.9
28	0.3	3.9	20.6	7.6	59.1	1.1	0.6	6.7
35	0.2	9.1	22.6	0.3	46.6	8.1	0.0	20.2
41	0.2	7.2	22.8	0.3	68.2	0.4	0.0	7.1
48	0.0	6.0	16.1	4.5	71.6	1.4	0.0	6.4
55	0.3	4.9	26.3	0.2	61.3	0.9	0.9	5.2
74	0.1	4.1	21.6	0.2	60.0	1.3	0.0	12.5
Pile 6a	Component Wt%							
∑Time (d)	Paper	Plastic	Wood	Organic	Soil	Metal & Glass	Tires	Inorganic
0	4.3	5.2	8.5	3.8	77.0	1.2	0.0	0.0
7	2.3	6.5	19.6	1.5	68.8	1.3	0.0	0.0
14	2.3	9.7	14.3	2.1	51.4	1.9	0.2	17.2
21	1.3	8.6	20.5	3.8	58.2	1.3	0.0	6.4
28	0.5	9.1	18.4	1.4	61.1	1.4	0.1	7.7
35	0.1	8.9	31.5	0.3	47.3	1.2	0.0	10.8
41	0.2	8.3	16.3	1.9	65.5	1.2	0.0	6.6
48	0.3	8.1	21.9	0.6	59.4	2.9	0.0	6.8
55	0.2	11.5	21.2	0.9	53.5	2.9	0.0	9.8
74	0.1	8.3	20.5	0.2	57.7	2.7	0.0	10.6

Table C-17: Piles 7, 8 and 9 component wt% based on hand sorting of bulk samples

Pile 7	Component Wt%							
∑Time (d)	Paper	Plastic	Wood	Organic	Soil	Metal & Glass	Tires	Inorganic
0	0.3	0.2	0.8	0.2	2.9	0.1	0.0	1.0
7	1.7	5.5	14.8	12.2	57.6	1.5	0.1	6.6
14	1.2	5.2	15.1	12.0	57.7	1.8	0.1	6.9
21	1.0	6.4	19.8	2.0	54.4	1.5	0.0	14.9
28	0.3	5.8	19.6	2.3	54.3	1.5	0.0	16.1
35	0.2	7.3	20.2	3.1	55.2	0.9	0.1	13.1
41	0.1	7.6	17.9	3.0	63.7	2.0	0.1	5.8
48	0.0	8.7	18.7	1.9	61.9	2.1	0.1	6.6
55	0.0	8.8	17.1	0.3	61.7	2.4	0.0	9.6
74	0.0	9.9	17.8	0.1	58.9	1.1	0.0	17.7
Pile 8	Component Wt%							
∑Time (d)	Paper	Plastic	Wood	Organic	Soil	Metal & Glass	Tires	Inorganic
0	1.5	4.1	19.4	4.2	52.1	0.5	0.0	18.2
8	1.3	2.1	14.6	2.1	71.0	0.9	0.0	8.1
14	1.1	3.4	18.9	11.9	54.8	1.2	0.1	8.5
21	0.3	4.0	32.2	16.1	40.9	0.6	0.0	5.8
27	0.4	3.1	23.3	0.3	47.5	2.6	0.0	22.7
34	1.0	5.9	21.7	1.6	47.5	0.5	0.0	21.8
41	0.1	3.1	18.9	0.0	60.7	0.1	0.0	17.0
60	0.1	4.1	14.5	0.0	68.8	2.9	0.0	9.6
69	0.1	3.5	18.5	0.4	68.6	0.7	0.0	8.3
Pile 9	Component Wt%							
∑Time (d)	Paper	Plastic	Wood	Organic	Soil	Metal & Glass	Tires	Inorganic
0	1.9	2.3	12.6	18.8	49.3	0.7	0.0	14.3
8	1.4	1.1	10.4	30.9	46.8	0.7	0.0	8.8
14	0.7	3.6	4.5	42.5	39.7	0.9	0.0	8.2
21	0.3	2.1	10.3	40.9	37.0	1.1	0.0	8.4
27	0.5	3.6	10.7	16.3	60.6	1.0	0.0	7.3
34	0.3	2.0	11.9	4.4	59.7	0.8	0.0	21.0
41	0.3	2.3	9.1	4.6	71.9	0.4	0.0	11.4
60	0.2	1.6	14.1	2.3	68.6	0.5	0.0	12.7
69	0.1	1.3	9.7	0.0	74.2	0.4	0.0	14.3

Table C-18: Hand sorting of screened compost for all piles

	Component Wt %						
Pile	Paper	Plastic	Wood	Organic	Soil	Metal & Glass	Inorganic
1	0	0.01	0.377	0.028	4.294	0	0.461
1	0	0.014	0.551	0.028	4.401	0	0.511
1	0	0.003	0.412	0.022	3.77	0	0.475
1*	0	0.003	0.108	0.005	4.5	0	0.152
1*	0	0.004	0.088	0.007	3.469	0.001	0.107
1*	0	0.003	0.096	0.006	3.333	0.001	0.116
1a	0	0.003	0.182	0.011	3.697	0.001	0.306
1a	0	0.002	0.167	0.006	3.439	0	0.385
1a	0	0.002	0.246	0.008	0.1441	0	0.309
1a*	0	0.003	0.107	0.002	3.763	0	0.197
1a*	0	0.003	0.15	0.005	3.85	0	0.28
1a*	0	0.004	0.144	0.004	4.005	0	0.34
2	0.002	0.144	1.359	0	0.405	0.01	0.643
2	0.001	0.061	1.53	0	0.464	0	0.405
2	0.003	0.138	1.582	0	0.712	0.027	1.314
2*	0.006	0.025	0.202	0.046	3.62	0.002	0.239
2*	0.008	0.034	0.3	0.067	4.088	0.001	0.29
2*	0.002	0.02	0.248	0.044	3.535	0	0.241
2a	0	0.205	0.885	0	0.166	0.017	0.478
2a	0.007	0.148	0.968	0	0.428	0.017	0.91
2a	0.005	0.15	1.176	0	0.601	0.01	0.715
2a*	0.002	0.029	0.294	0.006	4.093	0.002	0.658
2a*	0.002	0.032	0.363	0.003	4.215	0.001	0.71
2a*	0.003	0.024	0.394	0.004	4.005	0.001	0.654
3	0.003	0.155	1.883	0.027	0.822	0.004	1.334
3	0.002	0.17	1.936	0.003	0.868	0.001	1.36
3	0.005	0.146	1.845	0.013	0.758	0.001	1.271
3*	0	0.019	0.31	0.045	4.865	0	0.321
3*	0.002	0.014	0.276	0.037	5.415	0	0.384
3a	0.007	0.092	1.362	0.027	0.762	0	0.598
3a	0.012	0.084	1.48	0.026	0.84	0.123	0.866
3a	0.003	0.072	1.197	0.014	0.866	0.001	0.606
3a*	0.001	0.014	0.355	0.005	2.824	0.001	0.664
3a*	0.002	0.01	0.319	0.004	3.003	0.002	1.059
3a*	0.001	0.012	0.351	0.004	3.254	0.001	0.81

Table C-18: Hand sorting of screened compost for all piles continued

	Component Wt %						
Pile	Paper	Plastic	Wood	Organic	Soil	Metal & Glass	Inorganic
4	0.003	0.372	0.844	0	0.592	0.008	1.513
4	0.025	0.419	0.641	0	1.134	0.042	0.813
4	0	0.321	0.933	0	1.058	0.101	0.563
4*	0.002	0.03	0.233	0.036	3.167	0.006	0.222
4*	0.002	0.047	0.364	0.041	3.764	0.009	0.284
4*	0.004	0.064	0.428	0.074	3.892	0.013	0.402
4a	0.007	0.247	0.677	0.008	0.695	0.124	1.186
4a	0.005	0.179	0.408	0.023	0.635	0.231	0.945
4a	0.022	0.187	0.532	0.015	0.488	0.142	0.802
4a*	0.005	0.054	0.293	0.002	4.033	0.018	0.587
4a*	0.005	0.043	0.247	0.001	3.34	0.02	0.646
4a*	0.005	0.038	0.251	0.002	3.612	0.016	0.747
6	0.002	0.467	1.458	0.011	1.626	0.081	0.854
6	0.002	0.473	1.634	0.004	2.031	0.042	0.941
6	0.003	0.488	1.772	0.004	1.971	0.033	1.206
6*	0	0.037	0.325	0.002	3.46	0.009	0.372
6*	0	0.049	0.294	0.002	3.416	0.005	0.396
6*	0.002	0.055	0.35	0.003	3.276	0.01	0.64
6a	0.002	0.243	1.727	0.017	1.121	0.214	0.537
6a	0.001	0.35	1.42	0.016	1.26	0.128	0.777
6a	0.002	0.283	1.389	0.004	0.685	0.177	0.674
6a*	0.001	0.051	0.187	0.01	2.829	0.011	0.623
6a*	0.002	0.083	0.216	0.026	3.432	0.018	0.624
6a*	0.002	0.081	0.116	0.012	2.856	0.006	0.634
7	0.005	0.433	1.405	0.017	1.885	0.1987	0.672
7	0.007	0.469	1.143	0.007	2.245	0.1	0.811
7*	0.001	0.049	0.134	0.065	3.215	0.015	0.379
7*	0.001	0.047	0.17	0.055	3.32	0.01	0.353
7*	0.001	0.052	0.271	0.046	3.115	0.012	0.385
9	0.003	0.101	0.861	0	0.424	0.002	0.636
9	0.004	0.127	0.923	0	0.399	0.029	0.552
9	0	0.128	0.747	0	0.265	0.032	0.528
9*	0.002	0.011	0.521	0	2.806	0.005	0.1
9*	0.004	0.013	0.592	0	2.257	0	0.064
9*	0	0.01	0.18	0	2.917	0.003	0.292

* Represents the reject portion results from the screening of compost piles

Table C-19: Dry weight raw data for all piles

Date	Pile	Beaker (g)	Initial (g)	Final (g)	Dry Weight %
21-Jul	1	98.4	201.2	153.8	0.539
21-Jul	1	109.4	226.4	174.2	0.554
21-Jul	1	102.3	239.3	183.5	0.593
28-Jul	1	109.7	261.1	197.8	0.582
28-Jul	1	101.3	225.6	170.9	0.560
28-Jul	1	100.6	216.7	161.3	0.523
4-Aug	1	102.9	219.5	168.2	0.560
4-Aug	1	102.0	226.9	172.2	0.562
4-Aug	1	106.6	236.8	184.7	0.600
11-Aug	1	102.8	256.1	196.1	0.609
11-Aug	1	99.8	214.6	162.3	0.544
11-Aug	1	111.0	240.2	181.6	0.546
18-Aug	1	101.0	226.3	168.5	0.539
18-Aug	1	96.6	272.9	190.0	0.530
18-Aug	1	102.9	265.2	186.7	0.516
24-Aug	1	110.3	231.5	182.4	0.595
24-Aug	1	103.8	212.7	163.9	0.552
24-Aug	1	103.8	243.5	187.7	0.601
31-Aug	1	111.5	274.3	207.7	0.591
31-Aug	1	101.9	233.2	186.2	0.642
31-Aug	1	98.7	214.8	169.0	0.606
21-Jul	2	106.3	183.7	161.6	0.714
21-Jul	2	102.6	203.1	172.9	0.700
21-Jul	2	102.9	207.3	173.4	0.675
28-Jul	2	101.3	216.7	178.7	0.671
28-Jul	2	112.2	214.1	189.0	0.754
28-Jul	2	103.3	225.6	194.9	0.749
4-Aug	2	202.4	298.9	266.2	0.661
4-Aug	2	205.8	317.7	291.7	0.768
4-Aug	2	206.9	306.2	270.1	0.636
11-Aug	2	207.5	333.8	286.6	0.626
11-Aug	2	204.8	340.6	289.5	0.624
11-Aug	2	205.3	335.3	288.4	0.639
18-Aug	2	102.4	198.0	161.4	0.617
18-Aug	2	102.7	277.1	211.1	0.622
18-Aug	2	104.5	234.9	186.5	0.629
24-Aug	2	102.9	229.1	183.6	0.639
24-Aug	2	100.3	260.7	204.0	0.647
24-Aug	2	101.1	249.5	195.3	0.635
31-Aug	2	104.2	236.4	189.1	0.642
31-Aug	2	96.6	231.9	180.2	0.618
31-Aug	2	102.3	247.7	198.6	0.662
21-Jul	3	105.5	205.8	166.9	0.612
21-Jul	3	102.6	200.8	165.8	0.644
21-Jul	3	102.3	214.1	171.1	0.615

Table C-19: Dry weight raw data for all piles continued

Date	Pile	Beaker (g)	Initial (g)	Final (g)	Dry Weight %
28-Jul	3	106.9	220.0	176.8	0.618
28-Jul	3	98.7	212.8	162.3	0.557
28-Jul	3	98.4	215.5	167.0	0.586
4-Aug	3	109.4	240.6	183.2	0.563
4-Aug	3	103.8	231.8	177.0	0.572
4-Aug	3	111.1	274.4	194.8	0.513
11-Aug	3	110.5	210.2	173.0	0.627
11-Aug	3	100.8	215.5	168.9	0.594
11-Aug	3	103.8	202.1	169.1	0.664
18-Aug	3	98.5	219.6	182.1	0.690
18-Aug	3	98.8	213.9	170.7	0.625
18-Aug	3	105.0	223.4	178.5	0.621
24-Aug	3	105.8	203.4	163.4	0.590
24-Aug	3	100.2	195.2	152.7	0.553
24-Aug	3	102.8	250.5	195.2	0.626
31-Aug	3	102.7	221.6	176.8	0.623
31-Aug	3	100.6	221.9	164.0	0.523
31-Aug	3	100.2	228.6	173.0	0.567
21-Jul	4	98.7	232.4	177.7	0.591
21-Jul	4	110.9	251.3	209.3	0.701
21-Jul	4	100.3	254.2	212.2	0.727
28-Jul	4	112.8	203.9	171.2	0.641
28-Jul	4	110.5	213.9	183.0	0.701
28-Jul	4	106.3	223.9	188.4	0.698
4-Aug	4	102.3	224.8	183.9	0.666
4-Aug	4	106.3	257.0	206.1	0.662
4-Aug	4	112.1	214.5	175.7	0.621
11-Aug	4	103.8	224.8	174.8	0.587
11-Aug	4	106.5	234.9	180.7	0.578
11-Aug	4	102.1	182.9	158.2	0.694
18-Aug	4	109.7	231.1	184.9	0.619
18-Aug	4	98.0	270.5	217.3	0.692
18-Aug	4	101.1	251.4	187.4	0.574
24-Aug	4	103.8	242.9	203.4	0.716
24-Aug	4	101.4	197.6	163.1	0.641
24-Aug	4	110.3	215.1	173.7	0.605
31-Aug	4	102.0	206.5	166.5	0.617
31-Aug	4	109.7	243.0	206.1	0.723
31-Aug	4	100.7	223.0	181.9	0.664
21-Jul	5	112.1	180.4	159.6	0.695
21-Jul	5	101.3	232.7	168.4	0.511
21-Jul	5	101.9	202.5	163.3	0.610
28-Jul	5	105.5	174.5	158.7	0.771
28-Jul	5	101.0	181.2	163.5	0.779
28-Jul	5	109.7	190.3	171.1	0.762

Table C-19: Dry weight raw data for all piles continued

Date	Pile	Beaker (g)	Initial (g)	Final (g)	Dry Weight %
4-Aug	5	101.4	220.1	193.9	0.779
4-Aug	5	109.6	172.5	158.6	0.779
4-Aug	5	110.4	241.3	196.6	0.659
18-Aug	5	102.8	229.3	193.7	0.719
18-Aug	5	100.2	175.2	160.9	0.809
18-Aug	5	101.3	183.2	156.9	0.679
24-Aug	5	103.9	213.7	180.2	0.695
24-Aug	5	100.3	192.1	164.5	0.699
24-Aug	5	102.0	199.1	164.7	0.646
31-Aug	5	104.8	214.5	186.7	0.747
31-Aug	5	101.0	198.0	173.0	0.742
31-Aug	5	102.3	201.7	175.5	0.736
7-Sep	5	101.2	190.2	164.8	0.715
7-Sep	5	102.9	199.2	166.0	0.655
7-Sep	5	102.4	195.2	166.5	0.691
26-Sep	5	102.5	255.1	202.7	0.657
26-Sep	5	103.1	262.8	206.1	0.645
26-Sep	5	99.0	241.1	195.1	0.676
4-Aug	6	104.2	219.1	179.9	0.659
4-Aug	6	98.0	195.3	165.8	0.697
4-Aug	6	109.4	265.7	224.3	0.735
11-Aug	6	203.0	312.5	283.1	0.732
11-Aug	6	205.3	339.4	310.6	0.785
11-Aug	6	206.1	354.9	317.0	0.745
18-Aug	6	112.8	169.0	155.6	0.762
18-Aug	6	102.9	201.4	169.5	0.676
18-Aug	6	100.2	192.2	168.7	0.745
24-Aug	6	103.8	215.4	182.9	0.709
24-Aug	6	104.5	229.9	189.8	0.680
24-Aug	6	100.5	214.1	174.9	0.655
31-Aug	6	103.0	243.8	196.9	0.667
31-Aug	6	100.2	242.2	187.5	0.615
31-Aug	6	100.7	222.8	192.5	0.752
7-Sep	6	102.3	251.8	199.4	0.649
7-Sep	6	104.9	286.0	225.2	0.664
7-Sep	6	100.8	188.6	164.0	0.720
26-Sep	6	110.4	189.4	163.2	0.668
26-Sep	6	112.9	196.4	170.6	0.691
26-Sep	6	98.9	211.5	175.3	0.679
19-Oct	6	98.7	217.6	188.6	0.756
19-Oct	6	103.8	212.6	181.5	0.714
19-Oct	6	112.8	220.4	190.9	0.726
21-Jul	7	98.0	217.9	182.7	0.706
21-Jul	7	107.2	196.6	159.0	0.579
21-Jul	7	100.4	205.1	153.3	0.505

Table C-19: Dry weight raw data for all piles continued

Date	Pile	Beaker (g)	Initial (g)	Final (g)	Dry Weight %
28-Jul	7	100.8	189.4	131.3	0.344
28-Jul	7	102.1	235.9	176.5	0.556
28-Jul	7	100.1	232.6	191.5	0.690
4-Aug	7	103.7	192.1	168.7	0.735
4-Aug	7	102.9	213.3	188.3	0.774
4-Aug	7	101.3	221.2	191.2	0.750
11-Aug	7	98.5	183.5	155.7	0.673
11-Aug	7	100.2	184.9	157.2	0.673
11-Aug	7	101.9	218.4	170.9	0.592
18-Aug	7	102.2	215.7	188.8	0.763
18-Aug	7	96.6	179.7	159.5	0.757
18-Aug	7	98.8	175.6	157.9	0.770
24-Aug	7	101.9	178.7	157.6	0.725
24-Aug	7	112.8	187.8	167.8	0.733
24-Aug	7	104.8	167.9	146.7	0.664
7-Sep	7	102.7	231.5	189.6	0.675
7-Sep	7	102.2	208.5	170.8	0.645
7-Sep	7	111.0	224.0	187.0	0.673
26-Sep	7	110.0	232.3	193.3	0.681
26-Sep	7	106.9	209.7	179.9	0.710
26-Sep	7	111.7	252.1	212.4	0.717
19-Oct	7	103.8	248.8	202.0	0.677
19-Oct	7	104.8	254.9	210.0	0.701
19-Oct	7	100.2	213.7	170.0	0.615
4-Aug	6	104.2	219.1	179.9	0.659
4-Aug	6	98.0	195.3	165.8	0.697
4-Aug	6	109.4	265.7	224.3	0.735
11-Aug	6	203.0	312.5	283.1	0.732
11-Aug	6	205.3	339.4	310.6	0.785
11-Aug	6	206.1	354.9	317.0	0.745
18-Aug	6	112.8	169.0	155.6	0.762
18-Aug	6	102.9	201.4	169.5	0.676
18-Aug	6	100.2	192.2	168.7	0.745
24-Aug	6	103.8	215.4	182.9	0.709
24-Aug	6	104.5	229.9	189.8	0.680
24-Aug	6	100.5	214.1	174.9	0.655
31-Aug	6	103.0	243.8	196.9	0.667
31-Aug	6	100.2	242.2	187.5	0.615
31-Aug	6	100.7	222.8	192.5	0.752
7-Sep	6	102.3	251.8	199.4	0.649
7-Sep	6	104.9	286.0	225.2	0.664
7-Sep	6	100.8	188.6	164.0	0.720
26-Sep	6	110.4	189.4	163.2	0.668
26-Sep	6	112.9	196.4	170.6	0.691
26-Sep	6	98.9	211.5	175.3	0.679

Table C-19: Dry weight raw data for all piles continued

Date	Pile	Beaker (g)	Initial (g)	Final (g)	Dry Weight %
19-Oct	6	98.7	217.6	188.6	0.756
19-Oct	6	103.8	212.6	181.5	0.714
19-Oct	6	112.8	220.4	190.9	0.726
21-Jul	7	98.0	217.9	182.7	0.706
21-Jul	7	107.2	196.6	159.0	0.579
21-Jul	7	100.4	205.1	153.3	0.505
28-Jul	7	100.8	189.4	131.3	0.344
28-Jul	7	102.1	235.9	176.5	0.556
28-Jul	7	100.1	232.6	191.5	0.690
4-Aug	7	103.7	192.1	168.7	0.735
4-Aug	7	102.9	213.3	188.3	0.774
4-Aug	7	101.3	221.2	191.2	0.750
11-Aug	7	98.5	183.5	155.7	0.673
11-Aug	7	100.2	184.9	157.2	0.673
11-Aug	7	101.9	218.4	170.9	0.592
18-Aug	7	102.2	215.7	188.8	0.763
18-Aug	7	96.6	179.7	159.5	0.757
18-Aug	7	98.8	175.6	157.9	0.770
24-Aug	7	101.9	178.7	157.6	0.725
24-Aug	7	112.8	187.8	167.8	0.733
24-Aug	7	104.8	167.9	146.7	0.664
7-Sep	7	102.7	231.5	189.6	0.675
7-Sep	7	102.2	208.5	170.8	0.645
7-Sep	7	111.0	224.0	187.0	0.673
26-Sep	7	110.0	232.3	193.3	0.681
26-Sep	7	106.9	209.7	179.9	0.710
26-Sep	7	111.7	252.1	212.4	0.717
19-Oct	7	103.8	248.8	202.0	0.677
19-Oct	7	104.8	254.9	210.0	0.701
19-Oct	7	100.2	213.7	170.0	0.615
4-Aug	8	100.8	206.2	174.7	0.701
4-Aug	8	98.7	260.6	223.7	0.772
4-Aug	8	102.6	235.1	198.3	0.722
11-Aug	8	109.8	221.5	201.8	0.824
11-Aug	8	111.8	199.4	184.2	0.826
11-Aug	8	106.5	190.9	169.5	0.746
18-Aug	8	104.1	217.7	181.9	0.685
18-Aug	8	106.3	206.4	172.0	0.656
18-Aug	8	1000.4	175.4	138.9	1.044
24-Aug	8	102.6	209.7	185.6	0.775
24-Aug	8	109.4	217.3	191.0	0.756
24-Aug	8	106.3	225.8	198.1	0.768
31-Aug	8	105.2	209.3	184.3	0.760
31-Aug	8	102.7	203.7	176.5	0.731
31-Aug	8	109.7	214.3	189.4	0.762

Table C-19: Dry weight raw data for all piles continued

Date	Pile	Beaker (g)	Initial (g)	Final (g)	Dry Weight %
7-Sep	8	106.8	232.3	198.5	0.731
7-Sep	8	100.8	188.3	165.5	0.739
7-Sep	8	106.3	270.6	230.9	0.758
26-Sep	8	102.6	232.2	199.3	0.746
26-Sep	8	103.8	223.3	189.5	0.717
26-Sep	8	100.2	209.7	185.5	0.779
5-Oct	8	102.6	229.1	198.4	0.757
5-Oct	8	96.6	200.8	171.2	0.716
5-Oct	8	103.9	207.7	178.4	0.718
28-Jul	9	101.3	205.4	195.6	0.906
28-Jul	9	101.0	218.9	210.3	0.927
28-Jul	9	100.5	161.4	154.0	0.878
28-Jul	9	106.5	215.1	206.1	0.917
28-Jul	9	102.8	164.7	154.5	0.835
28-Jul	9	100.2	238.1	231.6	0.953
4-Aug	9	100.3	216.8	196.3	0.824
4-Aug	9	106.5	227.3	189.3	0.685
4-Aug	9	101.2	207	171.3	0.663
11-Aug	9	102.6	187.9	174.1	0.838
11-Aug	9	102.4	189.7	174.3	0.824
11-Aug	9	103.2	184.9	166.6	0.776
18-Aug	9	112.2	178.0	159.9	0.725
18-Aug	9	103.7	185.9	161.2	0.700
18-Aug	9	100.5	216.6	186.1	0.737
24-Aug	9	111.7	171.8	156.5	0.745
24-Aug	9	111.5	213.8	192.7	0.794
24-Aug	9	106.5	173.1	157.4	0.764
31-Aug	9	112.9	202.9	181.1	0.758
31-Aug	9	110.5	201.3	182.7	0.795
31-Aug	9	106.4	186.9	170.6	0.798
7-Sep	9	109.8	208.8	187.0	0.780
7-Sep	9	103.8	193.7	174.6	0.788
7-Sep	9	106.5	173.4	159.9	0.798
26-Sep	9	110.3	200.0	186.8	0.853
26-Sep	9	103.1	195.1	181.9	0.857
26-Sep	9	104.0	191.4	179.3	0.862
5-Oct	9	109.5	249.1	232.2	0.879
5-Oct	9	103.9	215.5	200.6	0.866
5-Oct	9	96.7	246.6	227.8	0.875
19-Oct	9	100.4	190.6	175.5	0.833
19-Oct	9	101.4	181.9	167.1	0.816
19-Oct	9	103.0	150.4	141.6	0.814
21-Jul	1a	111.8	212.6	166.5	0.543
21-Jul	1a	109.4	202.8	158.8	0.529
21-Jul	1a	100.8	206.8	154.0	0.502

Table C-19: Dry weight raw data for all piles continued

Date	Pile	Beaker (g)	Initial (g)	Final (g)	Dry Weight %
28-Jul	1a	102.3	220.5	174.4	0.610
28-Jul	1a	102.6	207.9	158.7	0.533
28-Jul	1a	100.1	240.4	170.7	0.503
4-Aug	1a	109.8	212.1	159.0	0.481
4-Aug	1a	110.9	220.1	164.6	0.492
4-Aug	1a	102.6	2135	156.3	0.026
11-Aug	1a	105.5	238.4	173.2	0.509
11-Aug	1a	104.3	226.4	165.2	0.499
11-Aug	1a	101.5	231.8	164.6	0.484
18-Aug	1a	104.0	223.8	168.3	0.537
18-Aug	1a	102.7	241.6	179.8	0.555
18-Aug	1a	96.6	231.9	167.4	0.523
24-Aug	1a	96.7	248.9	181.8	0.559
24-Aug	1a	99.4	224.7	169.0	0.555
24-Aug	1a	101.1	222.9	171.5	0.578
31-Aug	1a	100.4	223.5	162.7	0.506
31-Aug	1a	110.9	253.1	187.5	0.539
31-Aug	1a	105.6	243.9	177.4	0.519
21-Jul	2a	102.2	201.8	164.7	0.628
21-Jul	2a	110.9	229.9	194.3	0.701
21-Jul	2a	104.8	193.6	164.7	0.675
28-Jul	2a	98.0	198.7	164.9	0.664
28-Jul	2a	101.3	198.2	163.0	0.637
28-Jul	2a	102.8	203.9	171.1	0.676
4-Aug	2a	205.7	278.4	255.3	0.682
4-Aug	2a	208.2	288.8	259.5	0.636
4-Aug	2a	205.2	286.8	254.4	0.603
11-Aug	2a	202.2	323.7	284.9	0.681
11-Aug	2a	198.0	317.8	278.2	0.669
11-Aug	2a	205.1	308.8	276.0	0.684
18-Aug	2a	104.8	208.7	172.9	0.655
18-Aug	2a	102.3	224.2	181.2	0.647
18-Aug	2a	102.6	231.3	194.0	0.710
24-Aug	2a	105.2	237.3	195.6	0.684
24-Aug	2a	104.1	216.7	180.2	0.676
24-Aug	2a	101.3	236.9	195.0	0.691
31-Aug	2a	104.4	230.7	188.8	0.668
31-Aug	2a	110.3	252.5	210.5	0.705
31-Aug	2a	100.6	217.7	177.2	0.654
21-Jul	3a	98.0	213.0	164.1	0.575
21-Jul	3a	102.2	218.9	171.2	0.591
21-Jul	3a	102.3	228.2	187.8	0.679
28-Jul	3a	103.0	181.8	144.3	0.524
28-Jul	3a	100.5	222.1	166.7	0.544
28-Jul	3a	103.7	240.1	163.1	0.435

Table C-19: Dry weight raw data for all piles continued

Date	Pile	Beaker (g)	Initial (g)	Final (g)	Dry Weight %
4-Aug	3a	205.4	317.3	268.9	0.567
4-Aug	3a	202.2	317.9	263.5	0.530
4-Aug	3a	202.5	297.5	252.9	0.531
11-Aug	3a	102.6	243.5	194.6	0.653
11-Aug	3a	96.5	232.9	190.4	0.688
11-Aug	3a	98.7	220.2	171.6	0.600
18-Aug	3a	102.9	226.8	165.8	0.508
18-Aug	3a	100.2	229.2	179.8	0.617
18-Aug	3a	109.8	226.8	170.2	0.516
24-Aug	3a	109.7	232.4	176.4	0.544
24-Aug	3a	104.8	250.0	200.7	0.660
24-Aug	3a	112.8	238.9	192.6	0.633
31-Aug	3a	110.9	241.6	188.1	0.591
31-Aug	3a	98.0	212.6	163.1	0.568
31-Aug	3a	101.0	232.6	183.4	0.626
21-Jul	4a	103.8	171.2	134.1	0.450
21-Jul	4a	103.3	179.5	144.8	0.545
21-Jul	4a	112.2	202.9	163.1	0.561
28-Jul	4a	101.9	170.6	155.0	0.773
28-Jul	4a	106.3	176.3	163.6	0.819
28-Jul	4a	102.3	196.1	181.0	0.839
4-Aug	4a	101.3	211.0	168.8	0.615
4-Aug	4a	105.5	199.9	172.5	0.710
4-Aug	4a	100.5	191.4	162.7	0.684
11-Aug	4a	101.3	202.4	175.9	0.738
11-Aug	4a	110.8	191.6	167.0	0.696
11-Aug	4a	102.6	219.4	191.0	0.757
18-Aug	4a	101.1	167.3	145.1	0.665
18-Aug	4a	100.2	190.3	164.1	0.709
18-Aug	4a	102.8	169.5	150.2	0.711
24-Aug	4a	103.8	229.3	194.7	0.724
24-Aug	4a	100.4	237.8	202.1	0.740
24-Aug	4a	103.8	214.5	188.3	0.763
31-Aug	4a	100.5	169.0	154.7	0.791
31-Aug	4a	104.5	227.7	193.5	0.722
31-Aug	4a	101.4	223.4	185.2	0.687
4-Aug	6a	202.4	298.3	269.8	0.703
4-Aug	6a	203.4	310.7	282.6	0.738
4-Aug	6a	206.0	302.9	275.8	0.720
11-Aug	6a	202.5	314.4	283.5	0.724
11-Aug	6a	206.7	313.8	281.5	0.698
11-Aug	6a	196.8	304.1	270.8	0.690
11-Aug	6a	102.1	200.7	161.3	0.600
11-Aug	6a	106.8	204.2	170.7	0.656
11-Aug	6a	102.2	214.3	176.3	0.661

Table C-19: Dry weight raw data for all piles continued

Date	Pile	Beaker (g)	Initial (g)	Final (g)	Dry Weight %
18-Aug	6a	104.1	207.5	175.8	0.693
18-Aug	6a	102.0	220.6	178.3	0.643
18-Aug	6a	104.9	205.9	177.0	0.714
31-Aug	6a	98.7	244.6	203.7	0.720
31-Aug	6a	102.6	241.9	199.0	0.692
31-Aug	6a	105.5	213.1	172.7	0.625
31-Aug	6a	102.9	217.3	185.5	0.722
31-Aug	6a	102.4	224.3	184.3	0.672
31-Aug	6a	98.8	248.4	203.8	0.702
7-Sep	6a	104.1	192.2	163.3	0.672
7-Sep	6a	109.7	224.8	185.0	0.654
7-Sep	6a	102.8	196.3	170.9	0.728
26-Sep	6a	96.5	212.6	181.7	0.734
26-Sep	6a	104.8	209.2	182.6	0.745
26-Sep	6a	101.5	200.4	173.4	0.727

Table C-20: Raw temperature data for Piles 1, 1a, 2, and 2a in ºF

Pile	1	1	1	1a	1a	1a	2	2	2	2a	2a	2a
6/28/11	89.4	90	90.2	113.4	78.3	89.8	NA	NA	NA	NA	NA	NA
6/28/11	102.1	87.7	91.4	108.3	85.3	91.8	NA	NA	NA	NA	NA	NA
6/28/11	91.2	85.3	85.1	79.6	80.1	77	NA	NA	NA	NA	NA	NA
6/29/11	120.4	85	93.6	129.5	89.5	105.4	NA	NA	NA	NA	NA	NA
6/29/11	102.8	87.1	92.6	88.1	83.2	83	NA	NA	NA	NA	NA	NA
6/29/11	98.3	87	88.3	80.9	74.7	77	NA	NA	NA	NA	NA	NA
6/30/11	117	85	108.5	100.1	79.3	86	109.3	106.1	106.7	103.1	115.7	113.9
6/30/11	101.2	87.1	93.9	118.6	88.5	103.1	107.2	100.2	102.8	95.8	106.2	102.4
6/30/11	104.7	87	93.7	113.8	93.8	104.2	107.2	106.7	105.2	113.1	113.1	109.2
7/1/11	128.7	95.8	106.9	102.1	87.1	96.7	121.3	101.2	105.8	127.3	131.6	136.2
7/1/11	113.9	109.1	108.5	100	89.7	96.4	125.9	104.9	115	126.2	123.9	129.8
7/1/11	124.4	96	106.6	108.5	95.5	101.5	127.5	107.5	117.9	126.7	146.2	135.8
7/3/11	94	129.4	138.2	84.8	100	97.8	110.5	121.1	129.1	125.5	118.7	96.7
7/3/11	90.3	114.3	139	94.5	116.1	98.7	96.5	128.4	138.6	139	126.6	98.5
7/3/11	94.1	114	129.4	97.3	116.7	93.7	107.5	124.5	133.8	130.4	126.9	101.5
7/5/11	93.5	114.5	129.2	95	109	90.2	110.9	118.6	122.8	112.2	113.2	82.2
7/5/11	98.3	112.4	127.4	96.5	108.6	83.3	109.1	122	129.6	112.8	111	80.2
7/5/11	103.2	114.5	128.6	105.9	108.2	85	108	134.4	134	118.7	125.5	90.8
7/6/11	100	118.2	135	91.7	112.7	94	100	130.6	135.7	118.2	101.6	92.7
7/6/11	102.2	116.2	130.5	106.1	122.4	94.3	106.3	130.2	130.7	130.6	110.2	85.3
7/6/11	102.7	129.5		94.5	114.6	100.8	100.6	130.9	134.1	124.8	109	81.1
7/7/11	101.8	111	124.2	103.8	110	90.5	110.5	126.9	118	113.6	103.3	82.4
7/7/11	99.9	114.1	120.6	97.8	106.2	92.5	101.6	127.2	130.5	1125.1	110.6	84.9
7/7/11	104.2	124.3	130.6	115.8	130.4	86	106.4	128.1	131.8	120.9	106.4	84.3
7/10/11	94.4	109.9	119	101.3	112.7	86.1	110.3	131.9	132.6	95.2	88.4	91.1
7/10/11	97.9	115.1	125.9	104.4	118.7	89.1	111.2	125.9	128.4	124.6	91.9	84.2
7/10/11	94.6	109.2	119	112.6	111.8	92.2	112	128.4	131.5	121.2	94.4	82.6
7/11/11	96.7	119.2	131.1	98.4	111.8	97.3	109.5	131.9	131.4	95.5	83.1	82.5
7/11/11	97.5	119.4	127.4	106.3	113.2	105.2	105.8	127.5	129.7	122.9	90.3	81.5
7/11/11	98.7	118.9	126	112	112.6	99.3	110.7	128.8	132.3	123.4	99.7	88.1
7/12/11	112	123.6	132.9	107.8	112.9	95.7	114.2	131.7	130.7	105.5	103.3	87.4
7/12/11	110.7	125.4	131.8	116.3	110.1	93.7	108.7	130.9	130.5	130.8	93.1	94.6
7/12/11	108.1	127.2	132.3	115.1	113.3	103.4	111.5	131.6	131.8	124.6	100.1	84.6
7/15/11	NA	NA	NA	112.6	140.8	115.1	NA	NA	NA	115.6	106.1	102.1
7/15/11	NA	NA	NA	111.1	138.2	107.6	NA	NA	NA	134.3	121.3	96
7/15/11	NA	NA	NA	113.6	125	107.7	NA	NA	NA	134.6	118.7	94.9
7/17/11	104.5	128.5	149.5	NA	NA	NA	93.8	117.2	127.4	NA	NA	NA
7/17/11	101.8	119.7	138.6	NA	NA	NA	93.1	117.6	127.2	NA	NA	NA
7/17/11	103.6	117.5	136.6	NA	NA	NA	93.4	118.8	130.7	NA	NA	NA
7/18/11	NA	NA	NA	113.9	127.8	98.1	NA	NA	NA	116	107.7	90
7/18/11	NA	NA	NA	121.1	130.3	98	NA	NA	NA	125.7	106.9	93.1
7/18/11	NA	NA	NA	126.1	130.1	105.8	NA	NA	NA	124.3	103.5	89.4
7/20/11	95.7	115.8	131	NA	NA	NA	103.1	121.4	127.5	NA	NA	NA
7/20/11	93.5	117.6	131.8	NA	NA	NA	104.5	126.4	114.9	NA	NA	NA
7/20/11	94.2	128.9	142.3	NA	NA	NA	105.4	128.8	131.7	NA	NA	NA
7/21/11	NA	NA	NA	120.3	109.4	95.3	NA	NA	NA	117.4	105.3	89.4
7/21/11	NA	NA	NA	117.8	119.1	102.2	NA	NA	NA	125.7	103.5	84.3
7/21/11	NA	NA	NA	118.5	116.2	96.8	NA	NA	NA	128.8	129.9	81
7/24/11	98.6	138.1	153	120.7	132	95.6	109.2	126.8	127	126.3	108.9	93.6
7/24/11	95.4	134.3	149.1	126.2	134.5	100.8	118.7	131.7	137	122.8	102.5	86.6
7/24/11	98	135.2	151.5	124.8	132.5	98.7	114.5	130.4	132.9	126.1	108.5	90.3

Table C-21: Raw temperature data for Piles 3, 3a, 4, and 4a in ºF

Pile	3	3	3	3a	3a	3a	4	4	4	4a	4a	4a
6/30/11	112.9	96.2	95.3	100.1	98.4	105.8	NA	NA	NA	NA	NA	NA
6/30/11	113.2	95.3	96.6	107	97.4	105.1	NA	NA	NA	NA	NA	NA
6/30/11	110.9	94.7	105.2	85.1	90.8	88.2	NA	NA	NA	NA	NA	NA
7/1/11	121.4	113.2	120.1	121.4	113.2	120.1	NA	NA	NA	NA	NA	NA
7/1/11	120.2	100.2	108.6	120.2	100.2	108.6	NA	NA	NA	NA	NA	NA
7/1/11	121.9	111	111.6	121.9	111	111.6	NA	NA	NA	NA	NA	NA
7/3/11	108.3	116.2	128.4	112.4	121.4	93.9	NA	NA	NA	NA	NA	NA
7/3/11	106.5	114.4	138.9	112.3	120	95	NA	NA	NA	NA	NA	NA
7/3/11	110.4	118.6	139	116.8	129.3	96	NA	NA	NA	NA	NA	NA
7/5/11	97.8	113.3	123.8	130.1	119.5	84.4	NA	NA	NA	NA	NA	NA
7/5/11	93	114.7	125.5	128	118	92.9	NA	NA	NA	NA	NA	NA
7/5/11	92.7	121.1	140.2	129.8	119.9	88.4	NA	NA	NA	NA	NA	NA
7/6/11	95	116.7	127.5	110.2	110.1	87.6	NA	NA	NA	NA	NA	NA
7/6/11	98.8	122.1	141.2	114.6	122.7	93	NA	NA	NA	NA	NA	NA
7/6/11	95.7	116.3	126.8	116.1	121.2	93.2	NA	NA	NA	NA	NA	NA
7/7/11	95.8	119.3	124.9	110	113.2	88.5	NA	NA	NA	NA	NA	NA
7/7/11	106.3	130.5	127.3	115.6	128.1	91	NA	NA	NA	NA	NA	NA
7/7/11	94.3	124.7	138.4	116.2	117.1	90.1	NA	NA	NA	NA	NA	NA
7/10/11	100.5	127.9	134	121.5	118.5	90.7	148.2	146.1	127.1	140	126.1	101.7
7/10/11	95.4	120.4	129.9	112.6	119.3	91.4	159.7	158.4	153.2	135.3	121.5	93.4
7/10/11	121.5	131.4	139.3	106.9	110	92.1	156.1	155	152.4	139.1	140.6	101.5
7/11/11	111.3	130.2	139	119	113.3	84.2	146.1	159.3	154	141.3	123	103.4
7/11/11	106.3	125.5	131.1	116	107.1	90.6	159.9	161.3	157.7	134.6	127.7	103.8
7/11/11	109.9	128.3	134.2	120.2	117.8	93.8	160.1	160.8	146.8	141.9	128.1	102.8
7/12/11	107.9	127.4	131.2	121.9	116.5	90.1	158.5	159.8	144.7	133.7	135	116.6
7/12/11	118.1	110.8	135.1	120.1	120	94.2	160.3	160.5	157.4	124.7	115.9	90.5
7/12/11	116.1	108.2	132	110.9	110.1	93.3	159.4	160.2	159	124.2	118.3	90.2
7/15/11	NA	NA	NA	125.1	120.9	94.3	NA	NA	NA	94.7	79.4	90
7/15/11	NA	NA	NA	118.4	114.4	95.5	NA	NA	NA	132.2	114.4	100.6
7/15/11	NA	NA	NA	113.1	96.2	93.7	NA	NA	NA	114.5	107.9	95.3
7/17/11	107.9	131	122.8	NA	NA	NA	150.5	137.8	129.7	NA	NA	NA
7/17/11	105.6	117	123.9	NA	NA	NA	135.9	139	125.2	NA	NA	NA
7/17/11	109	131.4	128.9	NA	NA	NA	142.7	138.4	127.5	NA	NA	NA
7/18/11	NA	NA	NA	122.6	113.4	87.1	NA	NA	NA	104.2	82.6	80.2
7/18/11	NA	NA	NA	126.2	118.4	84.7	NA	NA	NA	105.7	85.3	80.9
7/18/11	NA	NA	NA	127.9	110.7	83.3	NA	NA	NA	88.5	80.2	78.4
7/20/11	124.1	129.3	129.1	NA	NA	NA	134.9	142.2	129.9	NA	NA	NA
7/20/11	97.5	115	128.6	NA	NA	NA	131.1	132.6	126.8	NA	NA	NA
7/20/11	103.5	122	132.7	NA	NA	NA	132.7	137.4	130.5	NA	NA	NA
7/21/11	NA	NA	112.6	120.5	113.8	90.2	NA	NA	NA	111.9	86.9	79.7
7/21/11	NA	NA	106.2	120.5	114.6	86.4	NA	NA	NA	106.8	84.3	75.5
7/21/11	NA	NA	105.3	115.2	105.8	83.7	NA	NA	NA	113.5	85.3	75.5
7/24/11	122.4	134	139.9	128.7	122.7	100	155.2	145.7	126	95.1	98.5	97.6
7/24/11	119.1	128.6	137.5	130.4	132.6	94.5	145.6	141.6	128.3	104.8	90.2	96.2
7/24/11	122.2	130.8	138.9	130.7	136.1	100.7	150.4	143.5	126.9	110.5	102.3	94.2