Treatment of Timtek Process Water by Co-Composting

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A six month study was conducted to evaluate the effectiveness of co-composting of the TimTek process water with wood waste and chicken manure as a method of remediation. Wood waste from the pilot facility in Shuqualak, MS was ground into sawdust. This sawdust was composted using four treatments with deionized water or process water to adjust moisture content. Two treatments were amended with manure to provide a nitrogen source; two received only deionized water or process water. The compost end-products for all treatments were then evaluated for relative toxicity, and weight loss. Additional testing was conducted to determine the toxicity of compost leachate and to evaluate the effects on germination rates of sensitive plant species. Co-composting successfully reduced the bulk and toxicity for all treatments. Treatments containing manure and process water showed over 90% emergence rate of radish seeds by day 90.

Key words: Treatment, Wastewater and Water Use

Introduction

According to U.S. Census data, as of 1997, there were over 890 wood product manufacturing facilities in Mississippi. These facilities produce several million tons of waste every year, and less than 75 percent of this waste is utilized for energy or other economical purposes (Borazjani et al., 2004). The demand for high quality, construction sized wooden beams has outpaced reforestation, and fast-grown timbers do not provide the quality beams necessary for construction purposes. In the near future, it is anticipated that a new facility creating steam-pressed scrim lumber from small diameter trees will open in Lauderdale County, MS and begin production of structural quality timbers. This process involves an initial crushing process, which yields long fibers of wood called scrim, some of which is unusable, and must be disposed. The initial crushing and the steam press process also yield a water effluent that contains a high concentration of organic material, wood extractives, and fibers. This effluent water is the main concern for disposal as it has a high biological oxygen demand (BOD), making disposal as a hazardous waste very costly. BOD is a measurement of the rate at which the available oxygen in an aqueous environment is depleted by microorganisms. Current methods of treating waste water with a high BOD are aerated ponds, bioreactors, and coagulation and flocculation followed by filtration (Ali and Skreerishnan, 2001; Huang et al., 2004; Pokhrel and Viraraghavan, 2004). These processes are costly and disposal of spent filtrate or filter cakes produced by flocculation and coagulation remains an issue. A new method of treatment that would allow for the timely discharge of treated water into the environment is necessary.

A viable alternative to separate treatment of wastes is co-composting. Composting is the aerobic biodegradation of organic material into stable, humus material by microorganisms at elevated temperatures. Composting reduces the overall volume and toxicity of waste products, yielding a valuable, nutrient rich product that can be used as a soil amendment (Borazjani, 2000). Co-composting process of forest products wastes, such as waste wood waste from the furniture manufacturing industry, preservative treated wood waste, as well as the composting of wastewater sludge from the paper and pulp industry has been previously conducted (Borazjani et al. 2004; Marche et al., 2003; Wiltcher et al., 2000). Additionally, the positive effects of co-composted paper and pulp industry sludge and different residuals on soil properties and cereal yields has documented (Sippola et al., 2003). Co-composting of wastewater and wood waste generated on site, combined with poultry manure from nearby broiler houses provides a simple and cost effective solution to problems posed by these three waste materials. Poultry manure was chosen as a nitrogen source because it is in abundant supply in Mississippi as a waste product. In 2007, Mississippi alone produced 824 million broiler chickens (http://www.nass.usda.gov/Charts_and_Maps/Poultry/brlmap.asp, 2008). According to estimates of 1.5 kg of manure per bird per year (Moore et al., 1998) this yields more than 1.26 million metric tons of broiler manure for the 2007 production year. As these three wastes contain only natural material and chemicals, biological decomposition through composting leads to an end product that is stable and can be sold as a soil additive or container media.

Methods

Characterization of Process Water An initial sample of process water was collected from the facility in Lauderdale County, MS. This initial sample was diluted to an approximately 1 to 4 ratio using distilled water. Two identical samples of this initial dilution were collected and sent to an off-campus environmental testing facility to determine the BOD (EPA method 405.1), COD (EPA method 8000), total suspended solids (EPA method 160.2), and total K and N content (EPA method 351.4). Metal content was determined at this time. In order to further characterize the process water, additional testing was conducted to determine the glucose content of undiluted water. HPLC analysis for glucose content was conducted at the Mississippi State Chemistry Laboratory on the MSU campus.(Table 1).

Compost Setup

Chicken manure was used as an N source in the composting process. The manure was collected from the Poultry Science Department on the MSU campus. The manure was obtained from caged chickens and contained little sawdust or bedding material. The manure was spread in a dry, covered area to allow for some moisture evaporation (the manure was saturated) over the course of 48 hours. After the 48 hour drying period, samples were taken from the manure in order to determine the overall moisture content, which was determined to be 50% by weight.

Scrim material was collected from the pilot plant. This scrim was ground into sawdust using a mill to approximately 5mm size particles. The moisture content of the wood waste was determined to be approximately 10% by weight. These measurements were needed to ensure accurate calculation of weight loss on a dry weight basis. Before the experiment began, additional process water was collected from the pilot plant. When the process water was added to the composting replicates, it was diluted 1:1 with DI water.

Compost experimental design was a modified version of that used by Hatten et al (2009). Twelve 30L cans were prepared for experiment. Five 3cm holes were drilled into the bottom of each can and a layer of gardener's fabric was placed on the bottom of each can to prevent compost from falling through the holes. On day zero of the composting experiment, each can was weighed individually and the weight was recorded. Five Kg of sawdust was weighed out and then added to each can, and .45Kg of chicken manure was added to six of the treatments The compost in these cans was thoroughly mixed and 3 L of water, either distilled or a 1:1 dilution of distilled water and process water was added to each can. The cans were weighed again and set in a permanent location. The treatments were as follows:

1. Sawdust using rain water to provide moisture

(control)

2. Sawdust using only process water to provide moisture
3. Sawdust using rain water and 10% poultry litter (dry weight basis)
4. Sawdust using process water and 10% poultry litter (dry weight basis)

A complete randomized design with three replications for each treatment was used in this study. The compost treatments were placed outside and were aerated by hand once per week to ensure an aerobic environment. Moisture content was assessed weekly and was adjusted accordingly to keep the moisture levels at 50-65% range using either distilled water or a 1:1 dilution of process water and distilled water. Samples were taken at forty-five day intervals. At each sampling interval, samples were tested for pH, toxicity, compost maturity, and moisture content.

Aeration

Aeration of all treatments and replications was performed weekly by physically turning the compost by hand to ensure thorough mixing. Aeration of the compost ensured that the moisture content remained around 50%-70% within each container to prevent anaerobic conditions. Moisture content was adjusted through rain fall or by adding either distilled water or a 1:1 mixture of distilled water and process water. Compost cans were aerated once or twice per week depending on precipitation conditions or how much water was added.

Pile temperatures above that of the ambient air temperature served as an indicator of the composting process. In the thermophilic stage of composting, approximately 160°F, the pile should be significantly warmer than the surrounding air. To ensure that the treatments were composting properly, temperatures were monitored on and in-between sampling days.

Sampling

At each sampling period, each container was thoroughly mixed before sampling was conducted to ensure a homogenous sample was obtained. Before collecting samples, each compost container was weighed to determine the overall weight of the compost. Samples weighing 150g were collected from each container. Small sub-samples were taken for moisture content and toxicity. Percent moisture content was determined for each sample and then extrapolated to determine the overall moisture content of the pile.

Toxicity

Toxicity was determined using the Microtox® technique which has been shown to be effective in measuring toxicity of compost leachates (Kapanen and Itavaara, 2001). 18 ml aliquots of distilled water were added to twelve clean, 50 ml culture tubes and these tubes were labeled with the appropriate corresponding sample number. To each tube, 2 grams of compost sample was added. These samples were vortexed, followed by sonication in a water bath for 10 minutes. The samples were then placed in the refrigerator overnight. After refrigeration, each sample was centrifuged at 50,000 rpm for 20 minutes. The pH of each sample was measured following the Microtox and accordingly adjusted to a range of 6.0-8.0. Cuvettes were prepared with 0.05 g NaCl. 2.5 ml of each sample was mixed and properly distributed among prepared cuvettes. Toxicity readings were taken for each sample and toxicity was determined as more than a 5% difference between the control and leachate readings.

Emergence Test

Compost maturity was determined using a modified radish seed emergence test, based on the maturity tests described by Florida's Online Composting Center (compostinfo.com). The radish test is an indication of how the compost performs as a soil additive and if it is harmful to the plants. Radishes are very sensitive and need specific growth parameters so if the compost affects those parameters in a negative way the test allows for the visualization of these negative effects.

Analysis of Composting Data

Weight loss and toxicity results from the co-composting study were statistically analyzed to determine significant differences among treatments. Mean comparisons were made using a least significant difference at the α=0.05 probability level by the Statistical Analysis System (SAS) using Duncan's multiple range analysis. Co-composting treatments are listed below in table 2.

Results

Weight Loss Results

Dry weight for each sampling period as well as weight loss results are summarized in figures 1 and 2, respectively. Within treatments, day 0 and day 180 dry weights were significantly different. In terms of percent weight loss there was no statistical difference when rain water was added versus TimTek process water. However, the addition of manure did statistically increase the amount of weight loss.

Toxicity Screening

Composting resulted in a decrease in the overall toxicity of all treatments. In all treatments, compost was significantly less toxic by day 45, showing at least a 50% drop in toxicity levels. Statistical analysis of treatments showed that there was a significant difference in toxicity between day 0 and all other sampling periods. There was not a significant difference in toxicity within treatments between day 90 and day 180. Figure 3 illustrates the toxicity levels for all treatments on all sampling days.

Plant Germination Rates

It can be said that compost was fully matured, as evidenced by radish seed germination tests. By day 180, all amendments showed seed germination rates of 100%, indicating a mature product. Seed germination rates for all sampling periods are listed in table 3.

Conclusions

This study found that this process water has a high BOD, COD, and TSS. Further characterization of the process water determined that metal content was not a major concern as most metals, aside from Zn, were present in low concentrations. Co-composting offer a potential solution to the problems that may be presented by the Timtek manufacturing process. This study has shown it is possible to co-compost two wastes from the same facility, sawdust and process water, with chicken manure to produce a mature product. Lowered toxicity and higher germination rates can be achieved without the addition of poultry manure; however, it will occur at a much slower rate. Radish seed germination tests have indicated that the mature compost is a non-toxic media that can offers nutrients to plants. However, the composted material did not attain a humus-like texture. It can be said that the compost did partially compost as it did reach sustained temperatures of approximately 120-130oF. As such, the composted material might be more suited as a soil additive that could be effectively mixed with top soil, to produce a suitable potting media. The composted material could potentially be popular with nurseries and sold to farmers as a bulking agent and nutrient source, adding revenue to the future facility.

More studies are needed to determine optimal ratios of process water, wood waste, and chicken manure to accelerate the composting process.

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Table 1. Background analytical results of TimTek process water in terms of mg/L.

Chemicals	Results in mg/L	Detection limit (mg/L)	Method Used
Arsenic	<0.002	0.002	200.7
Beryllium	<0.001	0.001	200.7
Cadmium	0.0044	0.001	200.7
Chromium	0.034	0.01	200.7
Copper	0.21	0.001	200.7
Lead	0.0092	0.005	200.7
Nickel	0.032	0.007	200.7
Selenium	<0.002	0.002	200.7
Silver	<0.002	0.002	200.7
Antimony	<0.006	0.006	200.7
Thallium	<0.01	0.01	200.7
Mercury	<.0002	0.0002	245.1
Glucose	Non Detect	10	977.20
BOD	>5190	100	405.1
COD	>6135	100	8000
TKN	>10	0.10	351.4
TSS	>235	10	160.2

Table 2. Description of each treatment of co-composting study.

Treatment descriptions	Percent manure	Treatment number	Replicates
Sawdust + DI Water	0	Treatment 1	3
Sawdust + Timtek	0	Treatment 2	3
Sawdust + DI Water + Manure	10	Treatment 3	3
Sawdust + Timtek + Manure	10	Treatment 4	3

Table 3. Percent seed germination rates

Treatment	Day 0	Day 45	Day 90	Day 135	Day 180
Sawdust+DI water	96	92	100	100	100
Sawdust+DI water	92	79	83	100	96
Sawdust+DI water	79	79	92	83	100
Sawdust+Timtek Water	96	71	100	75	100
Sawdust+Timtek Water	71	88	96	92	100
Sawdust+Timtek Water	58	79	100	96	100
Sawdust+DI water+Manure	83	79	100	100	100
Sawdust+DI water+Manure	92	92	88	100	100
Sawdust+DI water+Manure	67	96	100	96	100
Sawdust+Timtek water+Manure	75	92	100	100	100
Sawdust+Timtek water+Manure	83	75	88	100	100
Sawdust+Timtek water+Manure	100	100	100	100	100
Control Potting Mix	100	100	100	100	100

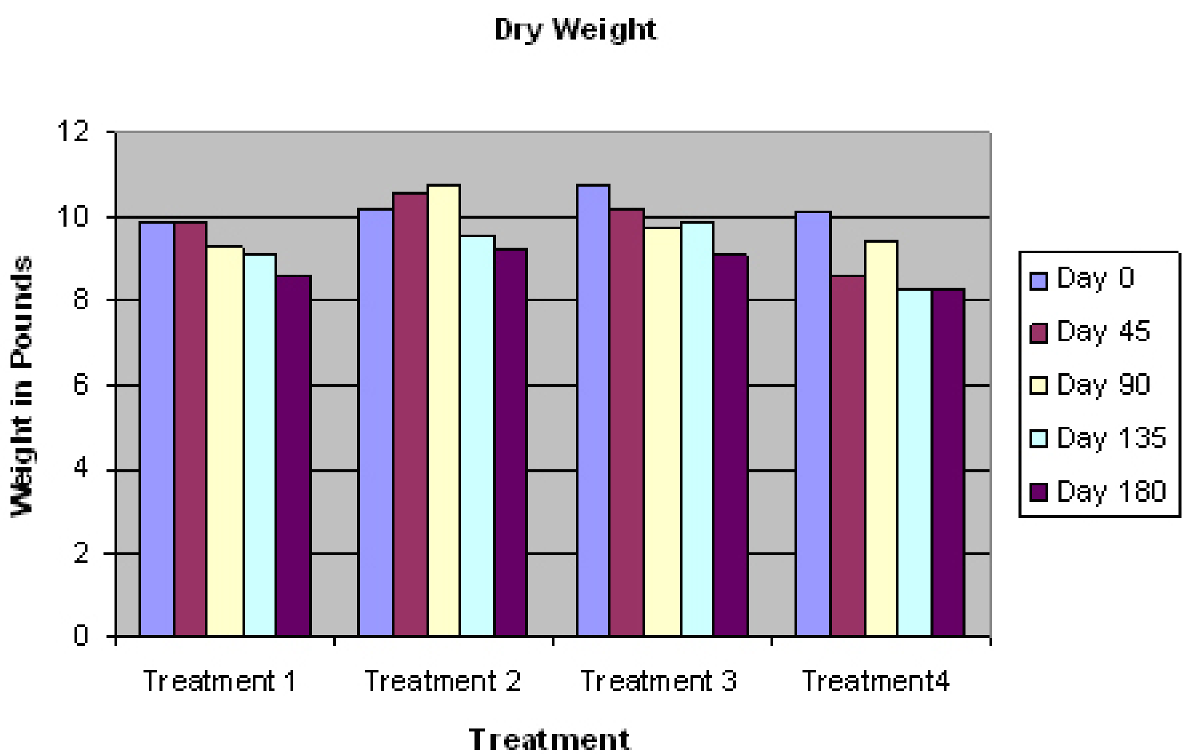

Figure 1: Reduction in dry weight at each sampling period for all treatments.

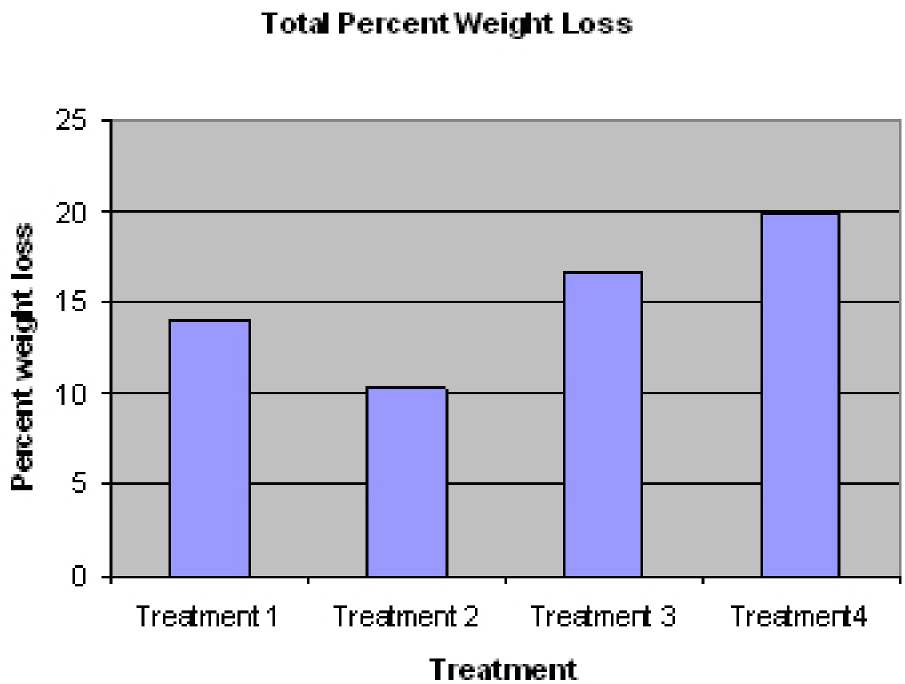

Figure 2. Percent weight loss at day 180. Columns with different letters indicate a significant difference between weight loss at the α=.05 level of significance.

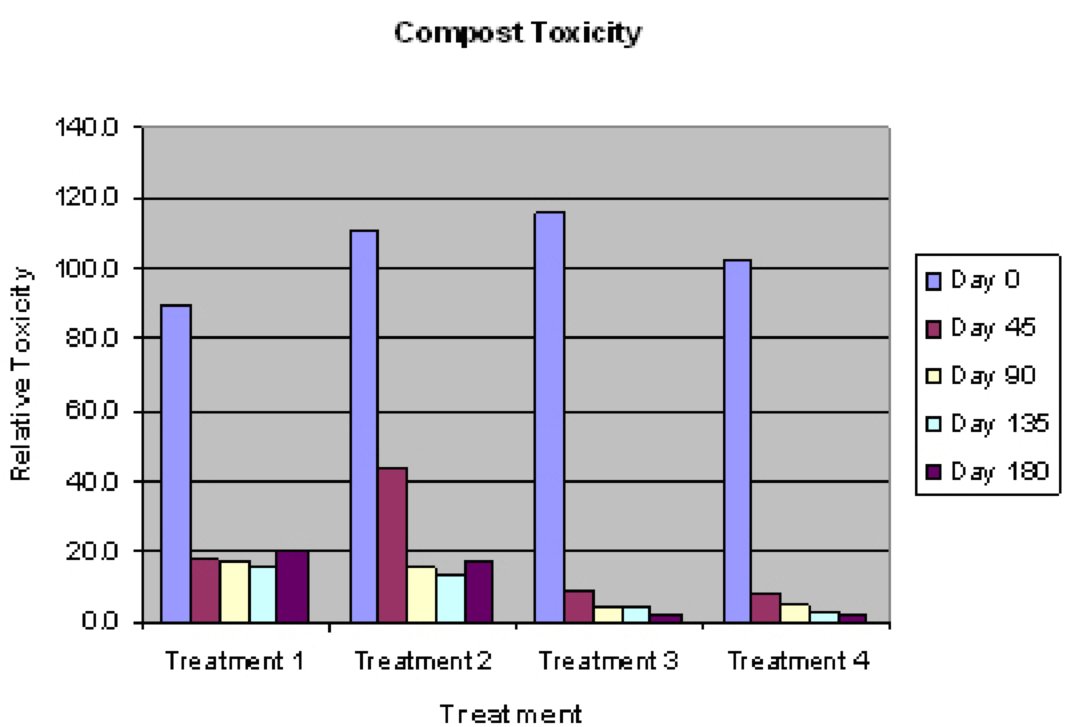

Figure 3. Relative percent toxicity of compost leachate as compared to distilled water. Columns with different letters above them indicate a significant difference between toxicity measurements at the α=.05 level of significance. "A" statistical grouping refers only to Day 0. All other sampling periods fall under "B" statistical group, indicating no significant difference between all other sampling periods.