COMPOSTING PROBLEM WASTES PRODUCED ON THE CSU CAMPUS FOR LATER BENEFICIAL CAMPUS USES

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ABSTRACT

Colorado State University's (CSU) Diagnostic Laboratory (DL), located at the Veterinary Teaching Hospital, diagnoses the causes of animal mortality. Some of the carcasses received by the DL contain prions, the infectious agents of Transmissible Spongiform Encephalopathies (TSEs.). The DL disposes of its mortalities in an alkaline digester, which destroys the infectivity of pathological organisms, including prions, after six hours. The end products of the digestion process are bones and more than 130,000 gallons annually of liquid effluent, which is an odiferous, alkaline (pH 10) solution of small peptides, amino acids, sugars and soaps. It is also high in potassium from the potassium hydroxide used in the digestion process. No satisfactory, economical method exists to directly dispose of the effluent. Research was conducted to examine composting the effluent with horse manure mixed with wood shavings, a waste product from the Equine Teaching and Research Center (ETRC) at CSU. The objective of this research is to determine if the quality of compost produced is suitable for general use on the CSU campus. Five composting mixes, including digester effluent, manure, wood shavings and food wastes from CSU were replicated four times in large composting bins. This material was composted aerobically in the bins for four months. Laboratory results showed that the compost had acceptable values for pH and soluble salts. The average ratio of total carbon to total nitrogen was 36:1, which is higher than the acceptable range in compost that would be useful on campus. Further composting research is planned that focuses on identifying a suitable bedding material that produces less waste with lower carbon content.

INTRODUCTION

A waste disposal problem at CSU resulted in a compost study with two objectives: to determine if alkaline digester effluent inhibited the composting process and to determine if the quality of the compost made from other CSU-generated feedstocks and digester effluent was suitable for general use on the CSU campus. Diseased animal carcasses from CSU's Diagnostic Lab (DL) are processed by alkaline digestion, using equipment manufactured by Waste Reduction by Waste Reduction, to remove pathogens, producing liquid digester waste effluent and bones. Bones are separated from the effluent and landfilled. Disposal of the liquid portion of the waste has been difficult.

The waste effluent is a highly odorous, thick liquid. It has a pH of about 10 from the potassium hydroxide used in the digestion process. It is not suitable for disposal to municipal sewer or landfill, nor is it suitable for direct land application. This material contains small peptides, amino acids, sugars, and soaps. It is also high in nitrogen and contains some carbon, resulting in a ratio of carbon to nitrogen of six.

In addition to this problem waste, the Equine Teaching and Research Center (ETRC) at CSU generates over 10,000 cubic yards of horse manure mixed with stall bedding annually. The stall bedding, composed of wood shavings with a wide range of particle sizes, constitutes the greatest proportion of the waste. While horse manure has a C:N of about 40:1, which is in the optimum C:N range for an initial composting mix, the high proportion of wood shavings in this mixture with a C:N of above 100:1 results in a wood shavings-horse manure mix with a C:N that is close to 100:1. This material cannot be directly land-applied, because of the high amount of carbon. It is expensive to haul it to a landfill because of the volume generated. Composting this waste material into finished compost that is suitable for general use on the CSU campus would be a sustainable solution to the waste disposal problem presented by this waste.

The composting process has potential to remediate both wastes. During the composting process, in the presence of oxygen and water, aerobic microorganisms metabolize carbon and nitrogen, producing compost if the process goes to completion. Since digester waste contains mainly carbon and nitrogen, it is a potential compost feedstock. However, it will need to be combined with other materials to optimize the composting process. Combining the high nitrogen digester effluent with the high carbon, absorbent horse manure-wood shavings mixture has the potential to create a feedstock mix that produces good quality compost.

This research was conducted in two phases. Phase one was an unreplicated compost study whose objective was to determine whether the extremely high pH digester effluent would interfere with the composting process. Phase two was a replicated study whose objective was to determine what quality compost could be made when using this material as a feedstock and what feedstock mixes optimize compost quality.

MATERIALS AND METHODS

Phase 1

Two compost windrows were constructed from horse manure from CSU's Equine Teaching and Research Center, some used bedding material and bulking material (leaves). Digester waste was added to one windrow. Within a few hours the liquid digester waste had been absorbed by the dry material in the feedstock mix. The effluent added both nitrogen and moisture to the mix. Both windrows were kept at optimum moisture levels (about 50%) for composting. Temperatures were monitored, and the windrows were turned with a front-end loader when the temperatures decreased. After three turnings, temperatures ceased to rise appreciably after turning. Each compost windrow was sampled and analyzed for pH, total N, and carbon.

Phase 2

To further study how liquid digester waste could be incorporated into composting of University-produced waste products, a study was designed with five feedstock mixes (Table 1) replicated four times. All of the mixes were made with compostable wastes generated on the CSU campus. The first treatment consisted only of the high carbon wood shavings-manure mixture from the ETRC. The second treatment included digester effluent with the wood shavings-manure mixture, which was expected to bring the initial C:N into a more favorable range for composting. The third feedstock mix was composed of the same mix as treatment two with the addition of leaves for a bulking agent, which was expected to improve the composting process. The fourth treatment included the same wood shavings-manure mixture plus digester effluent as treatments two and three, as well as straw-based stall wastes added as an alternative bulking material to leaves. Leaves are not generated in quantity on the CSU campus, while the straw-based stall wastes are generated daily by CSU's Veterinary Teaching Hospital. Treatment five contained the basic wood shavings-manure mixture, plus digester effluent, plus a greater variety of CSU-generated wastes, which were added as bulking material and additional nitrogen. The food wastes in treatment five were fairly high in nitrogen, and were expected to enhance the process by creating a more favorable initial C:N in the initial feedstock mix.

These five feedstock mixes were composted in bins for three months, moisture was kept optimal (about 50%), and temperatures were monitored. Compost was turned into a different bin when temperatures declined. Compost was analyzed after three months for pH, EC, total N, NO_3-N, NH_4-N, and total carbon.

Table 1. Description of initial feedstock mixes.

Initial Feedstock Mixes, Sept. 2004		
	Feedstock Mixes	Quantities/9 yds. ^{3} Bin
1	**Control**: wood shavings waste from horse stalls (WW)	~9 yds. ^{3} WW
2	WW + Digester Effluent (DE) **Basic Mix**	~9 yds. ^{3} WW + 20 gal. DE
3	WW + DE + Leaves **Basic Mix + Bulking Agent**	~9 yds. ^{3} WW + 20 gal. DE + 0.1 yds. ^{3} Leaves
4	WW + DE + Vet Teaching Hospital Straw-based Stall Wastes **(All VTH Wastes)**	~9 yds. ^{3} WW + 20 gal. DE + 0.1 yds. ^{3} VTH Waste
5	WW + DE + VTH Waste + Horticulture Waste (HW) + Food Waste (FW) **All Organic Wastes Produced at CSU**	~9 yds. ^{3} WW + 20 gal. DE + 0.1 yds. ^{3} VTH Waste + 0.1 yds. ^{3} HW Waste

RESULTS AND DISCUSSION

Phase 1

Because this phase was begun during the coldest part of the year, there was some uncertainty that the composting process would occur normally. However, the heating patterns measured in the composting material during the composting process appeared to be normal, in spite of minimum daily air temperatures as cold as -26^{o} C. We concluded that the cold winter temperatures did not affect the composting process in the Phase 1 study. Temperatures measured over time during the composting process in both the compost with digester effluent and without digester effluent were very similar, indicating that the digester waste had not inhibited the composting process.

Quality of both finished composts was acceptable. The results are summarized in Table 2. The pH of the finished compost without digester waste was 8.6; the pH of the compost to which digester waste was added was 8.4. Carbon to nitrogen ratios of the compost and compost with digester waste were 15 and 17, respectively, which indicates a finished product that is suitable for general use (A-1 Organics, 2006).

The digester effluent had a very strong, unpleasant odor when it was delivered to the composting site. However, after it was incorporated into the other feedstocks, the odor was not detectible except while the pile was being turned. During the first two turnings, some digester effluent odor was detectible in the steam that escaped from the windrow. At the end of the composting process, both finished composts had an earthy smell. Composting this material appeared to mitigate the odor problem early in the composting process.

This preliminary study showed that the high pH digester waste did not inhibit the composting process. It also showed that no objectionable odor persisted during the composting process nor remained in the finished compost. As a result of this preliminary study, a second replicated composting study was designed to provide more information about remediating digester waste through the composting.

Table 2. Analysis of composts from the Phase 1 compost study.

Phase 1 Compost study: January – May, 2004*		
	pH	**C:N**
Compost	8.6	15
Compost with Digester Effluent Added	8.4	17

Phase 2

There were no statistical differences in pH, EC, or C:N between any of the treatments in the compost produced in the Phase 2 study. Results are summarized in Table 3. The pH and EC were acceptable for plant growth. However, the C:N of almost 40:1 indicated that this compost was not suitable for many uses on campus, which is important for the success of this composting research. The high C:N also indicates that the initial feedstock mix was above the recommended initial C:N of about 40:1. The principle feedstock, wood waste mixed with animal manure was analyzed at the beginning of the study. Laboratory test results showed its C:N was about 42:1. However, this analysis probably significantly underestimated the amount of carbon due to the heterogeneity of the material. This wood waste and manure mix was extremely heterogeneous due to the varying particle sizes of wood material, it was difficult to grind and mix, and an extremely small sample was utilized to obtain total carbon. In this case values from a table in On-Farm Composting (Rynk, 1992), which lists a C:N of above 100:1 for wood shavings, would have probably been more accurate to use.

The C:N ratios of the finished compost from the Phase 1 study were 15 and 17, well below the C:N measured in the compost from the Phase 2 study. In the Phase 1 study, the windrows were constructed with an initial C:N of about 40:1 in order to optimize all conditions for the composting process. Only enough wood shavings mixed with manure were used to absorb the effluent. In the Phase 2 study, the actual stall waste material generated at the Equine Center was used as a feedstock to better study what quality of compost could be made from the actual waste materials generated at CSU. The difference in the initial feedstock mixes explains why the composts from Phase 1 and Phase 2 had very different ratios of carbon to nitrogen (C:N).

A subsequent composting trial is planned in which the feedstock mixes will be adjusted based on the results of the first trial. More accurate testing methods will be used to determine the C:N of the stall waste feedstock. All the feedstock mixes will contain more nitrogen from either digester effluent or food wastes, resulting in lower initial C:N's in the range of 25 – 30 40:1. While the digester effluent is a good source of nitrogen for the composting process, if it is used as the sole source of the additional N that seems to be required, the EC or pH of the finished compost could be high enough to limit the usefulness of the compost.

Another approach to decreasing the C:N of the initial feedstock mix is to change the bedding material used at the Equine Center from wood shavings to an alternative bedding, such as pelleted wood bedding (Moon, 2006), which results in less carbon in the waste. A student-led study of alternative bedding materials is planned for2006.

Table 3. Comparison of target compost quality (Class I or Class II Compost) with actual quality of compost from Phase 2.

	Class I Compost	Class II Compost	ETRC Compost
pH	6.0 – 8.0	6.0 – 8.2	8.4
EC (mmhos cm^{-1}	0 - 5	5 - 10	3.0
C:N	<12	<18	38
NH_4/NO_3	<4	<6	2

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