Appendix D

Nitrogen Mineralization Study: Biosolids, Manures, Composts

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Abstract

A study of the yearly nitrogen mineralization rates of various products derived from municipal wastewater treatment plants, composting facilities and farms in Washington State was conducted. Results indicated that manures and uncomposted biosolids products had greater mineralization rates and lower variability than composts. Additionally, aerobically treated biosolids showed higher mineralization rates than anaerobically treated biosolids; this result is attributed to the more complete stabilization of carbon-nitrogen organic complexes by the anaerobic digestion process. It is suggested that the greater variability of the composts was likely due to the varying levels of maturity and varying types of carbonaceous materials present. It is further suggested that the lower mineralization rate of composted products was due to the existence of greater levels of woody, high carbon materials as well as the greater level of stabilization achieved by the composting process relative to other treatment methods.

Introduction

This report summarizes an examination of the nitrogen (N) mineralization rates of various biosolids, manures and composts. In 1995 an investigation of the yearly mineralization rates of different biosolids, manures and compost products from Washington State wastewater treatment facilities, farms and composting facilities was begun. The research was conducted at Washington State University's Research and Extension Center in Puyallup, WA (Puyallup). The objectives of the study were to determine the mineralization rates of the various products to gain a more thorough understanding of N mineralization dynamics and to develop a more comprehensive knowledge of the most appropriate utilization of the various product types.

Methods and Materials

Study Initiation

Initial installations were made in October 1995. Additional biosolids and composts received from Tacoma, Pierce County Utilities and Cowlitz County treatment plants after the trial was commenced were applied in late November 1995; these chambers were removed 11 months later in late October—at the same time as the initial chambers.

Organic N Mineralization Method

The standard residual technique was used for determination of the organic N mineralization rate. The residuals method used ceramic tubes with 5 grams of biosolids, manure or compost. Biosolids and compost products were oven dried at 70° C. Initial N concentration and mineral N concentration of dried product were analyzed. The chambers were inoculated, capped and then

buried. Chambers were removed after either 11 or 12 months—depending on the installation time. After removal, the chambers were oven-dried, weighed, and the samples were removed for total and mineral N analysis.

The percent organic N mineralized was calculated as follows:

$$\frac{(\text{Initial organic N concentration} * \text{Initial wt.}) - (\text{Final organic N concentration} * \text{Final wt.})}{(\text{Initial organic N concentration} * \text{Initial wt.})} * 100$$

Biosolids, Manures and Compost Characteristics

Biosolids, manures and composts examined are summarized by type in Table 1. Specific carbon (C) and N characteristics of the product samples utilized are summarized in Table 2.

Table 1. Biosolids, manures and composts used in mineralization study and treatment type.

Product	*Treatment Type*
Birch Bay	Aerobic
Brewster	Lime-stabilized
Centralia	Drying Bed
Centralia Digested	Anaerobic
Centralia Liquid	Anaerobic (liquid)
Cowlitz County 1	CoCompost
Cowlitz County 2	CoCompost
Cowlitz County 3	CoCompost
GroCo	CoCompost
Kennewick	Lagooned
Land Recovery, Inc.	Yard Compost
Northwest Cascade	CoCompost
Pierce County Utilities	Anaerobic
Port Townsend	CoCompost
Renton	Anaerobic
Smith Brothers-Dairy	Manure
Tacoma	Anaerobic
Tacoma Liquid	Anaerobic (liquid)
Tagro	Soil Mix
Vashon	Oxidation Ditch
Wilcox Farm-Chicken	Manure

Table 2. Carbon and organic nitrogen of biosolids, manures and composts used in mineralization study.

Product	*C%*	*Organic N%*
Birch Bay	30	5.3
Birch Bay	33	4.2
Brewster	31	3.9
Centralia Digested	34	3.6
Centralia Drying Bed	12	1.6
Centralia Drying Bed	11	1.4
Centralia Liquid	28	3.6
Cowlitz County 1	44	2.3
Cowlitz County 1	27	1.8
Cowlitz County 2	31	1.4
Cowlitz County 3	32	1.1
GroCo-Fine	43	0.84
Kennewick	19	1.9
Land Recovery, Inc.	21	1.6
NW Cascade	32	1.3
Pierce County Utilities	35	4.7
Port Townsend	20	1.6
Renton 6/27/95	33	5.1
Renton 9/5/95	33	5.2
Smith Brothers-Dairy	na	na
Tacoma Cake	31	3.3
Tacoma Liquid	29	3.2
Tagro	6.2	0.34
Vashon	43	6.7
Vashon	37	5.0
Wilcox Farm-Chicken	34	3.0

Results

Yearly N mineralization rates of the various products showed that biosolids products and manures had less variability and higher mineralization rates than composts. Some of the chambers containing composts even indicated N immobilization. Annual mean mineralization rates are shown in Table 3 and Figure 1.

Table 3. Average N mineralization of biosolids, composts and manure types.

Soil Amendment	*Average N Mineralization Rate (St.Dev.)*
Soil Mixes, e.g. Tagro	2% (15%)
Yard Compost, e.g. Land Recovery, Inc.	10% (9%)
Cocomposts, e.g. GroCo, Cowlitz	11% (12%)
Lagooned Biosolids, e.g. Kennewick	20% (3%)
Anaerobic Liquid, e.g. Centralia, Tacoma	27% (4%)
Drying Bed, e.g. Centralia	37% (8%)
Anaerobic, e.g. Renton, Pierce, Tacoma	39% (7%)
Oxidation Ditch, e.g. Vashon	45% (1%)
Aerobic, e.g. Birch Bay	49% (7%)
Lime-stabilized, e.g. Brewster	55% (3%)
Manure, e.g. Dairy Cows, Chicken	62% (6%)

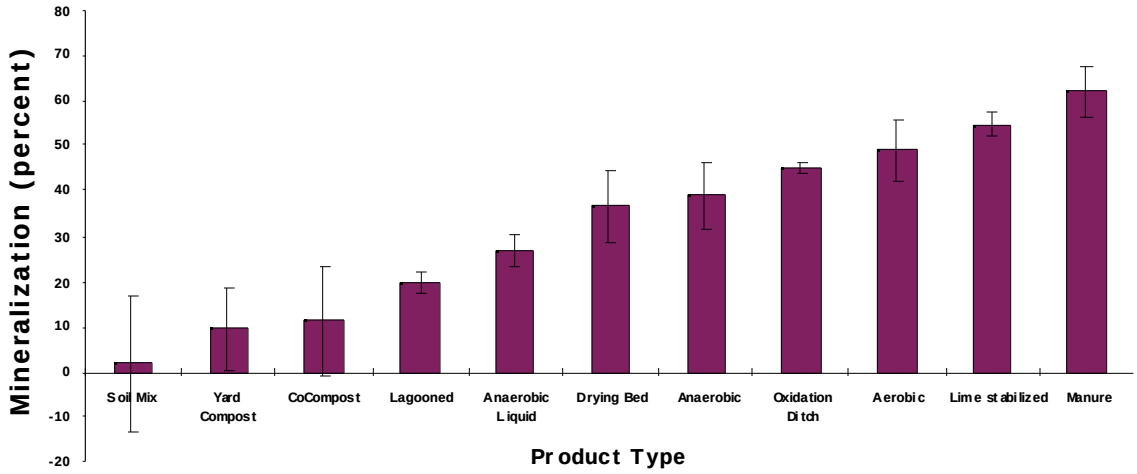

Figure 1. Average N mineralization rate of biosolids, composts and manure types.

Biosolids and Manures

The two manures had the highest average mineralization rates of approximately 60 percent. The aerobically treated product from Birch Bay and the lime-stabilized aerobically treated product from Brewster were next highest, ranging between 49 and 55 percent. The Vashon oxidation ditch (which had the highest concentration of organic N for all samples) mineralized 45 percent in the year. The dewatered anaerobic biosolids from Pierce County Utilities, Renton, Centralia and Tacoma had mineralization rates ranging between 32 and 43 percent. The drying bed product from Centralia had a mineralization rate of approximately 37 percent. The anaerobic liquid biosolids from Tacoma and Centralia had rates ranging between 26 and 27 percent. The lowest mineralization rate among biosolids and manures, 19 percent, was from the Kennewick lagooned material.

Composts

Composts were much more variable in results and generally had much lower N mineralization rates than the manures or biosolids products. The co-composts, had an average yearly mineralization rate of approximately 11 percent, but the standard deviation for this rate was 12 percent, so it may range greatly according the results of this study. The yard compost (produced by the Land Recovery, Inc.) had an average rate of 10 percent (SD =9 percent). The soil mix (produced by Tagro) had the lowest average yearly mineralization rate among all the product types examined, but also the greatest variability; it's mineralization rate was <2 percent ± 15 percent.

Discussion

Previous work has indicated that the rate of organic N mineralization depends upon all of the following: 1) the nature of the initial N compounds (for example, the percentage of initial organic N), 2) the type of treatment or stabilization method, 3) the length of the stabilization period and 4) the type of organics. The results of this study suggested that each of the four factors—individually and/or in combination—likely played some role in determining the annual N mineralization rates of the products tested.

The results indicated that mineralization was likely affected by the initial organic N concentration. The soil mix (Tagro) had the lowest level of organic N and showed the lowest annual N mineralization rate. Likewise, the cocomposts and yard waste compost possessed low levels of initial organic N, and this N was mineralized at relatively low rates. The aerobically treated product from Birch Bay, the lime-stabilized product from Brewster and the oxidation ditch product from Vashon had relatively high levels of initial organic N and showed very high rates of N mineralization. Similarly, the anaerobically treated biosolids products all began with moderate to high organic N levels, and moderate to high rates of mineralization occurred over the course of the study.

The N-mineralization rate also appeared to be significantly impacted by the treatment/stabilization method. The manures received no treatment after production, and it was theorized that the organic fraction thus had a higher concentration of more easily mineralized organic C and N complexes. Given the very high N mineralization rates for the manures, the results provide evidence that, indeed, this was correct. Aerobic digestion (typically performed at smaller treatment plants) is generally not as complete as the anaerobic digestion typical of larger treatment plant operations. The aerobically treated biosolids showed a higher mineralization rate relative to the anaerobically treated biosolids. This was likely the case due to the greater level of more easily decomposed C-N organic complexes present in the aerobically treated products. The composting process generally stabilizes the C-N organic complexes beyond that of other treatment methods, and the results of this study clearly showed that composting decreased the mineralization rate.

Figure 2 shows the decomposition rate. The decomposition rate of the products provides further evidence that those products containing higher concentrations of the more recalcitrant C-fractions (the more stabilized products), have slower decomposition rates with a resulting reduction of the N mineralization rate. With only three exceptions (the lime-stabilized biosolids,

the drying bed biosolids and the lagooned biosolids) the decomposition rate indicated the N mineralization rate. Compared to the other biosolids products, the three exceptions were thought to possess relatively more stable organic matter (OM), and, thus, one would not expect the materials to decompose rapidly. Among these three, the lime-stabilized biosolids had a very high N mineralization rate, the drying bed biosolids had a moderate rate, and the lagooned biosolids showed a relatively low N mineralization rate. The lagooned and the drying bed biosolids had the lowest percentage of organic C of all the products examined except for the Tagro soil mix product. With such a low organic C percentage and stable OM, it wasn't expected that these products would decompose rapidly. It was expected that the N mineralization rate for these two product types would be lower than the results indicated. That the N mineralization rate of these two product types was not lower may be the result of the initial low carbon:nitrogen (C:N) ratios of the products. A low C:N tends to lead to greater mineralization of N. The lime-stabilized product was not expected to show such a high N mineralization rate either. However, this product possessed a high initial organic N concentration and, this may account for its high N mineralization rate despite the low decomposition rate.

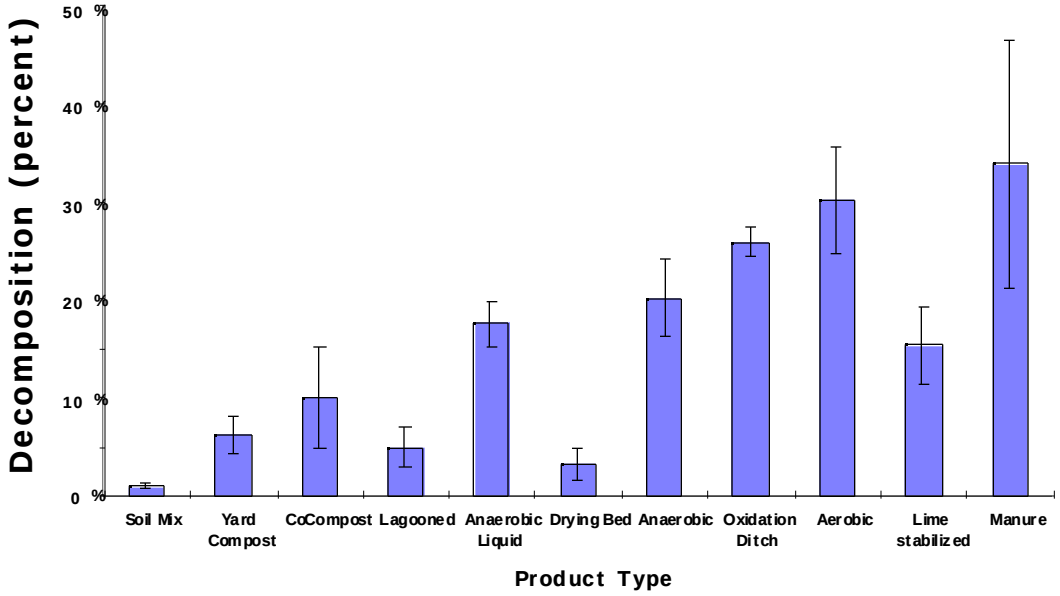

Figure 2. Average decomposition rate of biosolids, composts and manure types.

The length of the stabilization period and the type of organic material likely resulted in the great variability associated with the composted products samples. Specifically, the variability of the compost products was likely due to the variable ages and types of material as well as the heterogeneity within the product; this heterogeneity was due to the variable particle size of woody materials in the composts. The fact that some chambers with composts actually indicated N immobilization provided further evidence that the type of C material and maturity of the compost is very important; an immature compost with difficult to decompose woody material may lead to N immobilization.

Conclusions

Initial product characteristics, treatment/stabilization technique, length of treatment/stabilization, and type of carbonaceous material present all affected the yearly N mineralization rate.

Specifically:

- The higher the initial concentration of organic N, the greater the N mineralization rate.
- The more thorough and lengthy the treatment/stabilization method, the lower the N mineralization rate.
- The more recalcitrant the carbonaceous materials, the lower the N mineralization rate—unless offset by a high initial organic N concentration.
- The following N mineralization rate trends were found: soil mix < yard compost < co-compost < lagooned biosolids < anaerobically treated liquid biosolids < drying bed biosolids < anaerobically treated dewatered biosolids < oxidation ditch biosolids < aerobically treated biosolids < lime-stabilized biosolids<manure.