

Carbon and nitrogen mineralization of non-composted and composted municipal solid waste in sandy soils

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Abstract

A sterilized, but undecomposed, organic by-product of municipal waste processing was incubated in sandy soils to compare C and N mineralization with mature municipal waste compost. Waste products were added to two soils at rates of 17.9, 35.8, 71.6, and 143 Mg ha⁻¹ dry weight and incubated at 25 °C for 90 d. Every 30 d, nitrate and ammonium concentrations were analyzed and C mineralization was measured as total CO₂-C evolved and added total organic C. Carbon mineralization of the undecomposed waste decreased over time, was directly related to application rate and soil nutrient status, and was significantly higher than C mineralization of the compost, in which C evolution was relatively unaffected across time, soils, and application rates. Carbon mineralization, measured as percentage C added by the wastes, also indicated no differences between composted waste treatments. However, mineralization as a percentage of C added in the undecomposed waste treatments was inversely related to application rate in the more productive soil, and no rate differences were observed in the highly degraded soil. Total inorganic N concentrations were much higher in the compost- and un-amended soils than in undecomposed waste treatments. Significant N immobilization occurred in all undecomposed waste treatments. Because C mineralization of the undecomposed waste was dependant on soil nutrient status and led to significant immobilization of N, this material appears to be best suited for highly degraded soils low in organic matter where restoration of vegetation adapted to nutrient poor soils is desired.

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1. Introduction

When applying organic materials such as municipal waste (MW) compost to soil, care must be taken not to adversely influence the establishment and growth of vegetation. Undecomposed compost that is high in ammonium (NH₄⁺), organic acids, and other compounds can be phytotoxic (Zuconi et al., 1981b; Chanyasak et al., 1983a, b; Wong, 1985). Fortunately, these chemicals most often do not persist for long or induce lasting toxic effects in the environment (Zuconi et al., 1981a). Longer term effects can occur from unstabilized organic material with a high carbon/nitrogen (C/N) ratio, as microbial decomposition can immobilize significant amounts of N, making it unavailable for plant utilization and resulting in deficiency

problems (Bengston and Cornette, 1973; Terman et al., 1973). Composting organic matter will alleviate these potential problems, but only if the substrate is allowed to compost to maturity.

To date, there is no agreed upon test to determine whether or not compost is mature, or even what the definition of mature should be. Numerous tests and measurements have been developed to provide insight into changes that occur in decomposing organic matter, how these changes relate to maturity, and how these changes might affect plant growth (Jimenez and Garcia, 1989; Bernal et al., 1998; Cooperband et al., 2003). The general consensus is that a series of tests, encompassing several different aspects of decomposition, is the most reliable method of determining compost maturity. Two validated, simple, and widely used tests to predict the maturity of composting organic matter are the C evolution and N mineralization tests. By combining measurements of

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microbial respiration with nitrate (NO_3^-) and NH_4^+ concentrations, useful information regarding the phytotoxicity, nutrient immobilization, and maturity of decomposing materials can be obtained.

A new waste processing system has been developed that destroys pathogens, removes contaminants, and separates the organic fraction of garbage from the inorganic portions, producing Fluff®[®], an uncomposted MW (Bouldin & Lawson, Inc., 2000). While the bulk of this material is composted for use as a horticultural substrate, it has been successfully used in its undecomposed state to establish native grasses on damaged training lands at Fort Benning, Georgia, USA (Busby et al., 2006). Utilization of non-composted waste material such as Fluff provides significant benefits over composting when considering associated handling costs. However, because this MW is unstable, the effect that the microbial decomposition of this material has on nutrient availability when used as a soil amendment is unknown. The purpose of this research is to determine the rate of decomposition and N cycling transformations of this MW at increasing application rates in two distinct sandy soils and to compare it to mature commercial MW compost. Both waste derivatives have shown promise for soil amelioration.

2. Materials and methods

2.1. Incubation experiment

A 90 d incubation experiment was conducted to measure C and N mineralization of composted and non-composted MWs at application rates of 17.9, 35.8, 71.6, and 143 Mg ha^{-1} dry weight. Non-composted MW was obtained from WastAway, Inc. (McMinnville, TN), and mature compost was obtained from the Prairieland Compost Facility (Truman, MN). Standard quality assurance chemical analyses data for the compost were obtained from Minnesota Valley Testing Laboratory, New Ulm, MN, and similar analyses for the uncomposted MW were conducted by the ARS National Soil Dynamics Laboratory, Auburn, AL (Table 1). Total C and N of both organic additives, analyzed using a LECO CN 2000 (LECO Corp., Saint Joseph, MI), indicated that the MW had a much higher C content, but a similar N concentration compared with the compost (Table 1).

Two soils were collected in October 2003 at depths to 15 cm from study sites at Fort Benning, GA, where land application studies of MW were located. Moisture contents of the additives and soils were determined after oven drying at 105 °C for 24 h. Water holding capacity of sieved soils (2 mm screen) was determined by wetting soils to field capacity and oven drying. Analysis of the soils revealed considerable differences between the two (Table 2). Soils were analyzed for electrical conductivity (EC) and soluble salts (SS). Soils were also analyzed for total C and N using a LECO CN 2000 (LECO Corp., Saint Joseph, MI). The Dove Field (DF) soil, a Troup loamy fine sand (loamy,

Table 1
Chemical properties of organic additives^a

Property	Uncomposted municipal waste	Municipal waste compost
pH (water)	6.5	7.1
TOC (g kg^{-1})	371	165
Total N (g kg^{-1})	12.6	12.5
C:N ratio	32.0	12.9
P (mg kg^{-1})	1900	3880
K (mg kg^{-1})	2170	7070
As (mg kg^{-1})	<D.L. ^b	12.2
Cd (mg kg^{-1})	1.9	7.8
Cu (mg kg^{-1})	47.7	812
Ni (mg kg^{-1})	9.12	67.2
Pb (mg kg^{-1})	65.4	448
Se (mg kg^{-1})	9.67	1.25
Zn (mg kg^{-1})	234	1690

^aValues on a dry weight basis.

^bD.L., detection limit.

Table 2
Physical and chemical soil characteristics

Characteristic	Soil ^a	
	Borrow Pit (BP)	Dove Field (DF)
Sand (g kg^{-1})	920	840
Silt (g kg^{-1})	70	140
Clay (g kg^{-1})	10	20
Texture	Loamy sand	Loamy fine sand
pH	5.1	6.2
Electrical conductivity (EC, dS m^{-1})	0.011	0.057
Soluble salts (SS, mg kg^{-1})	14	73
Total organic carbon (TOC, g kg^{-1})	0.64	6.76
Total nitrogen (TN, g kg^{-1})	0.169	0.456
TOC/TN ratio	3.8	15

^aValues on a dry weight basis.

kaolinitic, thermic Grossarenic Kandiodults), which was considered to be the more productive soil based on site evaluations, had higher C and N concentrations than the Borrow Pit (BP) soil, a highly disturbed Orangeburg loamy sand (fine-loamy, kaolinitic, thermic Typic Kandiodults) (Soil Survey of Muscogee County, Georgia, 1983; Soil Series Classification Database, 2004).

2.2. Methods of incubation and measurements of carbon evolution

Methods of incubation follow techniques of Wood et al. (1994) and Torbert et al. (1998). Treatments consisted of 25 g dry weight of sieved soil samples placed in small plastic cups. Composted or non-composted MW was added to soils at desired application rates, mixed vigorously for

2 min to ensure uniformity within and between samples, and deionized water was added to moisten soils to 85% of field capacity. Cups were then placed in 1.06 l wide-mouth glass jars and 10 ml deionized water was added to the jars to maintain humidity. Plastic vials containing 10 ml of 1 M NaOH were added and the jars were sealed and placed in an incubator in the dark at 25°C and 70% relative humidity. Five replications of each soil-additive-rate-time combination were used as well as blank soils and blank C traps. Carbon traps were replaced every 30 d for the compost and every 15 d for the MW due to its high C evolution and the development of anaerobic conditions during longer sampling intervals. Carbon evolution was determined by adding 1 ml of 1 M BaCl₂ to C traps and titrating to neutral pH with 1 M HCl. Soil samples were extracted every 30 d with 2 M KCl and analyzed for NH₄⁺ and NO₃⁻ by standard colorimetric procedures using a Technicon Autoanalyzer IIC (Seal Analytical, Inc., Buffalo Grove, IL) (Technicon Industrial Systems, 1973a,b). The percentage of added total organic carbon (TOC) mineralized was also determined by subtracting the evolved C for each control soil from each respective experimental unit and dividing the net added C evolved by the TOC added for each respective additive-rate treatment.

2.3. Analysis of data

Data were analyzed in 30 d increments as a completely randomized design with five replications. Additive effects exhibited a bimodal distribution and were tested using the Wilcoxon–Mann–Whitney two-group test. Soil, rate and time effects, and their interactions were transformed (square root for C and natural log for percentage TOC and N) and analyzed using analysis of variance in SAS Mixed Models (Littel et al., 1996; SAS Institute, 2001). All differences between treatments were considered statistically significant at the 0.05 probability level and mean separation of significant main effects was conducted using Fisher's LSD at the 0.05 probability level.

3. Results

3.1. Carbon mineralization

Carbon evolution data from the 15 d MW incubation intervals were summed into 30 d increments for a direct comparison to the compost, which was measured every 30 d. Carbon mineralization data are presented in Table 3. The additives had a significant effect on C evolution, as MW had a much higher C evolution rate than the compost treatments. The soil also had a significant effect on C evolution in both the MW and compost treatments, as mineralization rates were significantly higher in the DF soil than in the BP soil for both additives. Carbon evolution rates were significantly affected by time across additives, with rates in the MW treatments decreasing significantly over time for the duration of the study. The

compost treatments exhibited a significant decrease in C evolution from 30 to 60 d of incubation, but C evolution rates were statistically equal between 60 and 90 d of incubation (Table 3).

Application rate had a significant effect on C mineralization in both the MW and compost treatments. Increasing application rates resulted in large increases in C evolution rates in the MW treatments, but small increases in C evolution in the compost treatments (Table 3). In the MW treatments, C evolution rates were directly related to the MW application rate and all application rates were significantly different from each other. In the cases of the compost treatments, the 143 Mg ha⁻¹ treatment evolved significantly higher C than all other application rates. All MW treatments, but only the highest application rates of compost, evolved more C than the untreated control soils. Rates of C evolution remained higher in the MW treated soils than in the compost treated soils throughout the incubation, with the exception of the 17.9 Mg ha⁻¹ MW treatment in the BP soil. This indicates that the lower MW treatment had thoroughly decomposed to a level similar to that of the compost.

Carbon evolution data were also analyzed as percentage organic C mineralized as CO₂-C from the TOC added to each treatment (Table 4). Additive and soil effects were removed and analyzed separately using non-parametric methods and rate and time effects were natural log transformed for ANOVA. The additive had a significant effect on percentage additive TOC evolved, as the MW treatments evolved a much higher percentage of added TOC than the compost treatments. Soil type was also significant, as the DF treatments evolved a much higher percentage of added TOC than the BP treatments in both the MW and compost treatments.

In the MW treatments, time had a significant effect on the percentage of added TOC evolved in both the DF and BP soils. A significant increase in the percentage of added TOC evolved was observed over time for the first 60 d of incubation in both soils, and then the evolution remained unchanged for the duration of the incubation. Soils treated with compost showed only slight increases in the percentage of added TOC evolved over time. However, the time effect was significant in the DF soil which exhibited a significant increase in the percentage added TOC evolved for the first 60 d and remained unchanged thereafter. No effect of time was observed in the BP soil. Application rate had a significant effect on the percentage of added TOC mineralized in the MW treatments only in the case of the DF soil. In that case all mean rates of percentage added TOC evolved were significantly different and inversely related to application rate (Table 4). Application rate had no effect on the percentage of added TOC evolved in either the compost treated soils or in the MW treatments in the BP soil.

Non-composted MW treatments mineralized a considerably higher percentage of added TOC than did the compost treatments. Compost treatments remained little changed

Table 3

Carbon evolution rates ($\text{mg CO}_2\text{-C kg-soil}^{-1}\text{ d}^{-1}$) for non-composted and composted municipal waste for application rates, additives, soils, and incubation duration

Day	Blank soil	Waste product application rate (Mg ha^{-1})							
		17.9		35.8		71.6		143	
		MW ^a	MWC ^b	MW	MWC	MW	MWC	MW	MWC
<i>Dove Field soil</i>									
30	3.15 ± 0.86^c	24.74 ± 1.90	3.50 ± 0.55	34.02 ± 1.47	4.20 ± 0.89	56.12 ± 2.67	6.65 ± 0.66	80.85 ± 3.19	9.81 ± 0.70
60	0.35 ± 0.21	9.94 ± 0.74	0.53 ± 0.35	17.76 ± 1.49	1.93 ± 0.64	24.74 ± 0.39	1.93 ± 0.93	35.10 ± 1.62	2.98 ± 1.45
90	1.05 ± 0.51	5.98 ± 0.76	1.58 ± 0.58	9.64 ± 0.47	2.10 ± 0.86	13.97 ± 1.67	2.45 ± 1.09	17.63 ± 2.32	4.90 ± 1.53
<i>Borrow Pit soil</i>									
30	2.80 ± 0.43	8.72 ± 1.14	2.80 ± 0.70	21.54 ± 1.28	2.80 ± 0.70	36.30 ± 1.51	4.90 ± 1.70	76.08 ± 3.03	7.70 ± 0.43
60	0.53 ± 0.53	4.22 ± 0.77	1.05 ± 0.64	6.61 ± 1.06	2.10 ± 1.13	13.57 ± 1.19	0.18 ± 0.18	26.39 ± 2.70	2.63 ± 1.07
90	0.35 ± 0.35	0.11 ± 0.11	0.00 ± 0.00	3.07 ± 2.05	0.00 ± 0.00	4.65 ± 1.63	2.28 ± 1.40	16.85 ± 3.02	3.68 ± 1.60

^aMW, non-composted municipal waste.

^bMWC, municipal waste compost.

^cValues represent means of five samples \pm standard error.

Table 4

Comparison of percentage carbon mineralization of additive TOC for non-composted and composted municipal waste between application rates, additives, soils, and incubation duration

Day	Waste product application rate (Mg ha^{-1})							
	17.9		35.8		71.6		143	
	MW ^a	MWC ^b	MW	MWC	MW	MWC	MW	MWC
<i>Dove Field soil</i>								
30	15.5 ± 1.2^c	1.1 ± 0.6	11.7 ± 0.5	1.1 ± 0.6	9.6 ± 0.4	1.5 ± 0.3	7.4 ± 0.2	1.4 ± 0.1
60	26.7 ± 1.9	1.7 ± 0.6	19.3 ± 0.8	2.6 ± 0.2	15.1 ± 0.9	2.2 ± 0.4	11.3 ± 0.4	2.0 ± 0.2
90	25.8 ± 3.5	3.3 ± 1.4	19.9 ± 0.5	3.1 ± 0.4	17.8 ± 0.5	2.6 ± 0.4	12.4 ± 0.9	2.6 ± 0.2
<i>Borrow Pit soil</i>								
30	4.8 ± 0.8	0.9 ± 0.2	6.5 ± 0.4	0.5 ± 0.4	6.0 ± 0.2	1.1 ± 0.6	6.5 ± 0.2	1.0 ± 0.1
60	9.7 ± 1.3	2.2 ± 0.7	10.3 ± 0.6	2.1 ± 0.9	9.2 ± 0.3	1.2 ± 0.6	9.2 ± 0.4	1.5 ± 0.2
90	8.9 ± 1.7	2.2 ± 0.7	11.3 ± 1.0	2.1 ± 0.9	10.3 ± 0.5	2.1 ± 0.4	10.3 ± 0.7	2.2 ± 0.2

^aMW, non-composted municipal waste.

^bMWC, municipal waste compost.

^cValues represent means of five samples \pm standard error.

across soils, rates, and time, and all treatments mineralized less than 5% of their respective added TOC. Additionally, a significantly higher percentage of MW TOC was mineralized in the DF soil compared to the BP soil, whereas only marginal differences in additive TOC mineralization occurred between soils for the compost treatments.

The DF soil contained 10 times the native soil C relative to the BP soil. This difference in native C may have contributed to differences in C evolution rates between the soil types, as previous research has shown that when immature organic matter is added to soil, it also promotes decomposition of the native soil C through a priming effect (Jenkinson, 1966). However, this effect was assumed to be minimal, and given the low C concentrations in both soils, probably did not significantly impact on C evolution rates.

A similar study conducted by Bernal et al. (1998) incubated several composts at varying degrees of maturity

at a rate of 48 Mg ha^{-1} for 70 d in a calcareous soil equally as infertile as those used here. The percentage of added TOC mineralized for the mature municipal solid waste compost was 9%. This compares reasonably well with the 2–3% estimated for the same application rate and incubation duration for this study, taking into account the differences in soil type. However, the value obtained for the untransformed municipal solid waste of 80.1% in the Bernal study is considerably higher than the estimated 10–14% obtained for the MW in this study. The major difference between the organic materials is the processing used to produce MW, as both materials began as household waste. Because the MW had such a low rate of C mineralization relative to the raw waste, the processing must have had a significant effect on the degradation rate of the material. If the soluble C and other easily decomposed fractions are removed or transformed by this process leaving only humic and other recalcitrant organic

compounds, then the carbonaceous material produced by this process may have a higher residence time in the soil, which is a significant benefit.

3.2. Nitrogen mineralization

Nitrate concentrations were higher for both additives in the DF soil than in the BP soil (data not shown). Nitrate concentrations were significantly higher in all compost treatments and blank soils than in all MW treatments. Non-composted MW treatments indicated significant immobilization of N, as NO_3^- was either not detected or occurred at very low concentrations ($<20 \text{ mg kg}^{-1}$). MW compost application rate was directly related to NO_3^- concentration in both soils. However, the MW application rate was inversely related to NO_3^- concentration in the DF soil and the rate did not affect the NO_3^- concentration in the BP soil. Nitrate was not detected in any MW treatments in the BP soil for any time interval. However, because the blank BP soil contained no detectable NO_3^- , except in the case of the 30 d sampling interval (mean of 1.23 mg kg^{-1}), the extent of N immobilization in the soil due to MW decomposition is difficult to assess. In the DF soil, concentrations generally increased over time for all treatments, but remained relatively constant across all BP treatments. Differences in NH_4^+ concentrations between all treatments were minimal, with a range of mean NH_4^+ concentrations across all soils, rates, additives, and time intervals from 0 to 10.35 mg kg^{-1} (data not shown). Soil type exhibited a significant control over NH_4^+ concentrations, especially in the MW treatments. Because of the low mean concentrations obtained for both NO_3^- and NH_4^+ , these data were combined to yield total inorganic N for statistical analysis.

Total inorganic N concentration was significantly affected by additive, with the compost treated soils

exhibiting a much higher total inorganic N concentration than the MW treated soils. Inorganic N concentrations were significantly higher in all compost treatments and blank soils than in all MW treatments (Table 5). The MW treatments indicated significant immobilization of N, as it was either undetectable or occurred at concentrations less than 23 mg kg^{-1} (Table 5). Soil also had a significant effect on total inorganic N concentration for both additives, with the DF soil mineralizing significantly higher N concentrations than the BP soil in both MW and compost treatments.

Time had a significant effect on inorganic N concentrations in both non-composted and composted waste treatments. In both additive treatments, inorganic N increased significantly for the first 60 d but remained constant thereafter (Table 5). The rate also had a significant effect on total inorganic N concentrations in the compost treated soils, as inorganic N concentrations in the compost treatments increased significantly with increasing rates of compost application (Table 5). Compost application rate was directly related to N mineralization in both soils. Non-composted MW treatments were unaffected by the application rate. Both the MW and compost treatments exhibited significant time \times soil and soil \times rate interaction effects as well.

The DF soil had almost three times the native N concentration as the BP soil, and NO_3^- was virtually non-existent in the blank BP soil during the incubation. This difference in soil N most likely had a profound effect on the rate of decomposition of the MW in both soils. Initially, all MW treatments across soil types contained no NO_3^- ; however, NO_3^- did begin to appear in small but increasing amounts in the DF soil as the incubation progressed. The C:N ratio of the MW would indicate net N immobilization initially, which is supported by the data. However, if there is no N supply available in the soil to

Table 5

Total inorganic N concentration (mg kg^{-1}) for non-composted and composted municipal waste for application rates, additives, soils, and incubation duration

Day	Blank soil	Waste product application rate (Mg ha^{-1})							
		17.9		35.8		71.6		143	
		MW ^a	MWC ^b	MW	MWC	MW	MWC	MW	MWC
<i>Dove Field soil (10.14)^c</i>									
30	23.39 ± 2.98^d	2.60 ± 0.94	38.51 ± 1.18	3.71 ± 0.96	59.65 ± 1.69	4.17 ± 1.19	85.22 ± 3.03	3.78 ± 0.83	117.68 ± 2.54
60	33.98 ± 1.39	14.89 ± 3.70	51.83 ± 2.36	12.16 ± 3.42	67.34 ± 2.18	10.13 ± 1.97	108.06 ± 8.69	6.59 ± 2.38	139.94 ± 2.53
90	36.71 ± 3.34	22.93 ± 1.88	56.19 ± 4.84	15.35 ± 3.12	68.78 ± 5.44	7.47 ± 1.86	101.57 ± 6.18	5.22 ± 2.92	132.69 ± 4.36
<i>Borrow Pit (BP) soil (0.24)^e</i>									
30	1.23 ± 0.15	0.00 ± 0.00	18.53 ± 0.81	0.00 ± 0.00	29.11 ± 0.69	0.00 ± 0.00	55.93 ± 2.38	0.50 ± 0.22	112.92 ± 1.84
60	0.00 ± 0.00	0.43 ± 0.32	17.30 ± 1.03	0.93 ± 0.48	30.61 ± 1.40	1.08 ± 0.59	64.55 ± 3.01	1.01 ± 0.40	123.58 ± 1.25
90	0.08 ± 0.08	0.00 ± 0.00	14.64 ± 1.86	0.30 ± 0.17	31.68 ± 2.94	0.11 ± 0.11	61.86 ± 3.99	0.63 ± 0.21	123.79 ± 1.85

^aMW, non-composted municipal waste.

^bMWC, municipal waste compost.

^cInitial total inorganic nitrogen concentration of DF soil at onset of incubation.

^dValues represent means of five samples \pm standard error.

^eInitial total inorganic nitrogen concentration of BP soil at onset of incubation.

promote decomposition, the process will occur much more slowly. That is probably why C evolution was much lower in the BP soil than the DF soil, and would explain the differences in C evolution per unit of MW between the soils.

4. Discussion

Carbon mineralization of the MW was much higher than in the mature compost. The higher rates of MW application still had significantly higher C evolution rates than the compost even after 90 d of incubation, indicating that this material was still not completely stabilized at a level similar to that of the compost. Further, the percentage of additive TOC mineralized indicates that the compost was much more stable, although the percentage of MW TOC mineralized did stabilize after 60 d. Soil type greatly influenced C evolution of the decomposing MW, as the soil with higher initial C and N concentrations had significantly higher rates of C evolution across the application rates. This difference was most likely due to the differences in available soil N. Nitrogen was extremely limited in the BP soil and slightly less so in the DF soil, and that could have significantly reduced microbial activity. The inverse relationship between the MW application rate and the percentage of MW TOC mineralized in the DF soil further demonstrates this effect, as the N limitation would have increased with increasing MW application.

Total inorganic N and NO_3^- concentrations were considerably higher in the compost treatments than in the MW treatments, indicating that decomposition of the MW was resulting in significant N immobilization. No changes in inorganic N concentration were observed in the BP MW treatments through 90 d, but the DF MW treatments did increase over time at the lower application rates. The DF MW treatments also exhibited an inverse relationship between MW rate and inorganic N concentration. Ammonium amounts did not differ in the same magnitude. Ammonium concentrations in the compost treatments remained very low and relatively constant across rates and soils, but decreased slightly over time. Ammonium concentrations in the DF MW treatments peaked at day 60 and decreased to their initial amounts by day 90, indicating that there had been net ammonification during the incubation. Net nitrification had begun by the end of the 90 d. Even at the peak, however, NH_4^+ levels still remained at low concentrations ($<11 \text{ mg kg}^{-1}$). The low concentrations of NH_4^+ indicate that potential toxicity from NH_4^+ buildup would not be a problem in these soils even at rates of 143 Mg ha^{-1} . In the BP soil, neither net ammonification nor nitrification was ever indicated throughout the incubation as both NH_4^+ and NO_3^- concentrations stayed consistently low. This consistency indicates a severe N deficiency in this soil and was probably responsible for the slower decomposition of the MW.

4.1. Conclusions

Because both soils were relatively infertile, and both C and N mineralization of the MW were closely tied to the fertility status of the soils, it is likely that MW decomposition will occur at a faster rate in more fertile soils. When used in infertile soils, N immobilization will occur for an extended period due to incorporation into microbial biomass, with potential negative consequences for vegetation initially. Fertilization with a readily available N source may alleviate the period of this immobilization. On the other hand, slower degradation of the material may provide the best long term benefit as leaching losses would be minimized and N inputs would more closely resemble that in natural soils, as was found with yard waste composts that led to net immobilization initially (Claassen and Carey, 2004). The mature compost would work well for vegetation that requires significant N inputs as it provided a steady and significant amount of N throughout the 90 d. In settings where available N could be detrimental, such as native plant restorations, or in other instances where weed pressure is undesirable, MW application could be a simple way to decrease available N in the short term, but it would most likely provide a slowly available source over the longer term. Restoration of native perennial plant communities has been achieved through a high C/N ratio of organic soil amendments, such as sucrose and sawdust that limit available N (McLendon and Redente, 1992; Morgan, 1994; Paschke et al., 2000). Additionally, any increase in the organic C content of soil can provide significant benefits, especially in degraded soils where vegetative cover is minimal. Soil organic matter reduces compactibility (Zhang et al., 1997), increases water holding capacity (Hudson, 1994), increases particle aggregation (McDowell and Sharpley, 2003), and reduces erodibility (Barthes et al., 1999; Gilley and Risse, 2000).

The comparison between these data and the study using raw household waste (Bernal et al., 1998) indicates that the MW used here had a much lower rate of C mineralization relative to the unprocessed waste in the previous study. The only major difference between the organic materials was the processing used to produce MW. Because the MW had such a low rate of C mineralization relative to the raw waste, the processing must have had a significant effect on the degradation rate of the material. If the carbonaceous material resulting from this process should increase the residence time of added C in soil, then this could have a significant benefit for increasing organic matter in soils. The increase in soil C and the decrease in soil N from the uncomposted MSW indicate that it would be best suited for highly degraded soils where establishment of native perennial communities adapted to N limitation is desired.

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