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Influence of the Molasses and Office Paper as Carbonic Amendments in Municipal Compost Production

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Abstract: The aim of this study was to investigate the effect of cane molasses and office paper (carbohydrate and cellulose sources, respectively) on total nitrogen and C/N ratio of municipal wastes compost. Each of treatments with 20 kg fresh organic wastes (decomposable municipal) in three replicates as a completely randomized design was done. Treatments including different amounts of molasses and office paper with municipal decomposable wastes that were added to organic wastes in 2 and 4 weeks after composting start (first and second stages). Treatments in free space weekly twice to turn upside down for aeration, while exercising some treatments and adding water for adjusting moisture of organic wastes were also done. After 50 days, a 100 g sample of every treatment was taken to measure total nitrogen, organic carbon, C/N ratio, EC and pH in 1:6 dry organic matter/water. Results indicated that the molasses is a suitable amendment for reclamation of compost quality properties. It held nitrogen in compost caused to reduce C/N ratio. The best time for the use of molasses was 4 weeks after composting process (first stage) that is accompanied with increase in microorganisms' activity and temperature. In this stage, using 8% molasses had a more effect in increasing total nitrogen; on the contrary, the most effect of 4% office paper was at the first stage. Application of 4% paper at the second stage because of the increase in C/N ration than control amounted 2.64 times is not proposed.

Key words: Municipal wastes compost, molasses, office paper, ammonia volatilization

INTRODUCTION

There is several sugar mills located in the sugar cane cultivation areas of Iran. On an annual basis, the sugar production process releases molasses by-products amounted 30000 tones, in Haft Tappeh sugar factory. Sugar extraction from the cane stalks and sugar production provides molasses as a by-product of the plant fresh weight. The utilization of this by-product is important for the economy of the global use of the crop. There is a market for molasses as a matter for domesticated meal, organic acid production and as soil amendment. Currently, an option for molasses utilization is as an amendment for production of organic wastes compost (Liang *et al*., 2006). It is a well known fact that composting is one of the most suitable ways of converting organic wastes into more stable products which are safe and beneficial to plant growth, as well as an environmentally friendly and economical alternative method for treating solid waste.

Composting is a biochemical process converting various components in organic wastes into relatively stable humus-like substances that can be used as a soil amendment or organic fertilizer. Even though composting is a proven-technology that can be applied on the spot, there are many aspects that should be improved in the performance of current composting facilities. One of these areas is the conservation and enhancement of the nutrients value of the product by reducing the loss of nitrogen (Jeong and Kim, 2001). The decreased ammonia loss may lead to an alleviation of the odor problem that is usually encountered in full-scale composting facilities (Switzenbaum *et al*., 1994).

Several factors such as C/N ratio, temperature, mixing and turning and aeration rate can influence the volatilization of ammonia during composting (Morisaki *et al*., 1989). Gaseous nitrogen losses during composting occur mainly as ammonia, but may also occur as nitrogen and NO_x (Eklind and Kirckman, 2000). Witter and Lopez-Real (1988) reported that total nitrogen loss could amount to 50% of the initial nitrogen in up to 33% of the initial nitrogen during composting of poultry manure (Hansen *et al*., 1989).

Ammonia (NH_3) is generated from decomposition of nitrogenous material, i.e. proteins and amino acids. Its emission frequently occurs during the thermophilic stage of aerobic decomposition and tends to be high with low C/N ratio. However, when different types of organic materials are composted, a higher C/N ratio does not necessarily indicate an effective solution for preventing N loss (Baca *et al*., 1992; Brink, 1995; Eklind and Kirchmann, 2000; Mahimairaja *et al*., 1994). Both chemical form and particle size of carbon (C) source affect the availability of C to microorganisms. Glucose, a readily available C source, appeared to cause immediate immobilization of N when an appreciable amount was added to soils (Liang *et al*., 2006). Subair (1995) found that glucose was effective in reducing NH_3 volatilization from liquid hog manure, whereas material resistant to decomposition (sawdust) was not. Meyer and Sticher (1983) showed that N loss during composting of cattle manure and straw could be reduced by increasing the proportion of ground straw to chopped straw whilst maintaining a C/N ratio of 31.6.

The objective of this study is to evaluate the effectiveness of two types of C amendments in reducing N losses and increasing municipal compost quality.

MATERIALS AND METHODS

In this research, the effect of sugar cane molasses and office paper (carbohydrate and cellulosic sources, respectively) as municipal wastes compost amendment on total nitrogen and C/N ratio of compost have been investigated. Municipal wastes were collected from the compost factory of Rasht, Guilan province; while molasses was prepared from Haft Tappeh sugar factory, Khouzestan province, Iran. Used molasses and office paper had a C/N ratio equal 72.3 and 560.3, respectively. The C/N ratio difference of both materials is related to their nitrogen, because they have a similar carbon but the nitrogen amount of office paper is much more than molasses.

The material discharged from the rotary drum was passed through the trommel screen with the finer size fraction being collected through the screen and the coarser size fraction being collected on the screen. The finer fraction contains mainly biodegradable organic materials and was used for composting and the coarse fraction contains mainly non-biodegradable organic (e.g., plastics) and inorganic (e.g., metals, glass) materials was sent to a landfill. The fines account for 50-55% of the original weight of material and have a moisture content of 55-60%. Some properties of the used municipal wastes are observed in Table 1.

Table 1: Concentration of the some elements and pH in the used municipal wastes

Parameters	Amount	Parameters	Amount
pH (1:6 dry OM/water)	6.24	Cl (%)	0.51
N (%)	1.12	Na (%)	0.62
C (%)	16.27	S (%)	0.24
P (%)	0.29	Fe (%)	0.70
K (%)	0.24	Zn (ppm)	302.00
Ca (%)	1.86	Mn (ppm)	311.00
Mg (%)	0.22	Cu (ppm)	186.00

Each of treatments with 20 kg fresh organic wastes (decomposable municipal) in three replicates as a completely randomized design was done. Treatments included different amounts of molasses and office paper that were added to decomposable organic wastes in 2 and 4 weeks after composting start (first and second stages) as following:

- Control (M_0P_0): no amendment
- $M_{2\text{-}1}$ treatment i.e., 2% molasses at the first stage
- $M_{4\text{-}1}$ treatment i.e., 4% molasses at the first stage
- $M_{8\text{-}1}$ treatment i.e., 8% molasses at the first stage
- $M_{2\text{-}2}$ treatment i.e., 2% molasses at the second stage
- $M_{4\text{-}2}$ treatment i.e., 4% molasses at the second stage
- $M_{8\text{-}2}$ treatment i.e., 8% molasses at the second stage
- $P_{2\text{-}1}$ treatment i.e., 2% office paper at the first stage
- $P_{4\text{-}1}$ treatment i.e., 4% office paper at the first stage
- $P_{2\text{-}2}$ treatment i.e., 2% office paper at the second stage
- $P_{4\text{-}2}$ treatment i.e., 4% office paper at the second stage

Molasses, with a composition of mainly sucrose, was chosen as the readily available C source to be added into composting mixture. Increasing dosage of molasses were dissolved in the same amount of water and added in treatments. Office paper, consisting mainly of cellulose, was chosen as a less readily available C source. Standard 216×280 mm sheets of paper were shredded to approximately 10 mm in width prior to mixing with municipal wastes. Treatments in free space weekly twice to turn upside down for aeration, while exercising some treatments and adding water for adjusting moisture of organic wastes were also done. After 50 days, a 100 g sample of every treatment was taken. The samples were air dried and ground to pass through a 1 mm sieve. Total Kjeldahl Nitrogen (TKN) and Total Organic Carbon (TOC) of samples were estimated by using a micro-kjeldahl method (Randhir and Pradhan, 1981) and Walkey and Blacks Rapid (1934) titration method. The pH and EC were determined on a water extract from compost using compost to water ratio of 1:6 by weight. The pH and EC values were determined from three 5 g samples that for each sample, 30 mL of DD water was added and mixed to compost.

Data were analyzed by standard ANOVA procedures using MSTATC and SAS software and significant differences was determined based on $p<0.05$ level for the Least Significant Difference (LSD) Test.

RESULTS

Table 2 shows the temperature of the organic wastes during 7 weeks of composting process. In molasses treatments at the first stage, organic wastes temperature was maximum at the fourth week increased to more than 50°C. Temperature in M_{8-2} treatment at the fifth week has reached to maximum. This trend more or less exists for paper treatments.

Figure 1 shows the effect of the molasses on the total nitrogen of final compost. Although at the first stage, application of 2 and 4% of molasses have increased the total nitrogen than in the control, but this increase in 2% treatment not significant. The greatest increase in total nitrogen is related to M_{8-2} treatment that the total nitrogen 2.82 times has increased than in control. Table 3 shows the effect of treatments on final compost carbon. In all molasses treatment excluding M_{2-1} and M_{8-2}, carbon has decreased compared with control, but changes not significant. Thus, C/N ratios in molasses treatments have decreased than in the control. Decrease in C/N ratio between 2, 4 and 8% of molasses is also observed, but not significant.

A result of the Table 3 indicated that the use of the 2 and 4% molasses in both stages did not significantly affect on the pH than in control. Only using 8% molasses in both stages decreased the pH of compost. In these treatments (M_{8-1} and M_{8-2}), we had the greatest total nitrogen. Increase in electrical conductivity of the compost is significant in all molasses treatments excluding M_{2-2} treatment. This increase is 0.15-1.41 times than in the control.

Figure 2 shows that the application of 2 and 4% office paper at the first stage caused to increase the total nitrogen of compost. Effect of 4% paper on total nitrogen is more than 2% paper. A comparison of the 2 and 4% office paper treatments with these amounts of the molasses at the first stage indicated that the effect of paper on stopping ammonia and increasing total nitrogen is more than in molasses. Off course, Effect of paper has decreased at the second stage, so that; the total nitrogen has significantly decreased by the application of 4% paper than in the control. A significant decrease in total nitrogen is observed in the P_{2-2} treatment than in the P_{2-1}, but not significant than in the control.

According to the results of the Table 3, significant change in the carbon percent between paper treatments were not observed, but there is a considerable difference for C/N ratios. In all paper treatments excluding 4% paper at the second stage, C/N ratio is less than in the control. In recent treatment (P_{4-2}), the C/N ratio is much more than in the control (41.13% versus 15.56%). The pH of the

Table 2: Organic wastes temperature (°C) during the composting time in different treatments

	Time after composting start (week)						
Treatments	1	2	3	4	5	6	7
M_0	32	37	42	51	48	39	28
M_{2-1}	30	33	44	52	50	41	27
M_{4-1}	27	37	42	50	47	38	30
M_{8-1}	27	32	49	58	48	37	29
M_{2-2}	29	28	38	49	54	43	32
M_{4-2}	30	37	39	54	58	41	30
M_{8-2}	32	35	42	56	57	42	31
P_{2-1}	25	28	37	52	48	33	26
P_{4-1}	29	35	46	48	46	36	27
P_{2-2}	35	42	48	48	42	34	27
P_{4-2}	32	45	49	51	43	32	26

Table 3: Effect of the treatments on the C, C/N ration, pH and EC of produced compost

Treatments	Carbon (%)	C/N	pH (1:6)	EC (1:6)
M_0P_0	11.80cd	15.56cd	8.11abcd	6.65hi
M_{2-1}	11.03e	11.16def	8.02cde	7.56abcde
M_{4-1}	11.36cde	10.40defg	8.04cde	7.93abc
M_{8-1}	11.26de	8.80efg	7.90ef	8.06a
M_{2-2}	11.26de	11.00def	8.02cde	6.80ghi
M_{4-2}	11.20de	9.96efg	8.10abcd	7.50cdef
M_{8-2}	12.03c	5.46g	7.76f	8.03ab
P_{2-1}	11.50cde	6.36fg	8.10abcd	7.01fgh
P_{4-1}	11.73cd	5.86fg	8.11abcd	7.10defgh
P_{2-2}	11.46cde	11.30def	8.10abcd	7.20defg
P_{4-2}	11.80cd	41.30a	8.11abcd	7.06efgh

LSD (least significant difference) shows the significant difference ($p<0.05$) among the means of treatments, Values followed by the same letter(s) in each column are not significantly different at the 0.05 level (least significant difference)

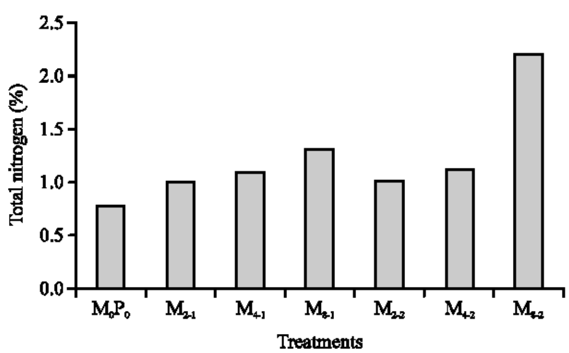

Fig. 1: Effect of the molasses treatments on total nitrogen of produced compost

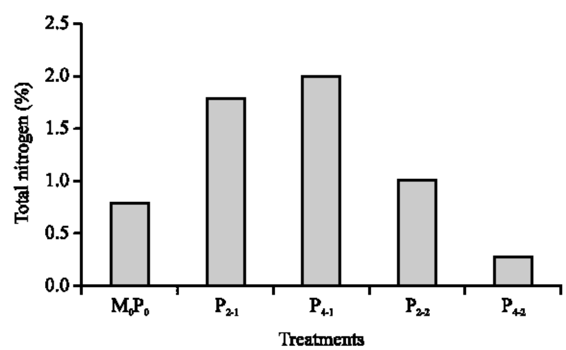

Fig. 2: Effect of the paper treatments on total nitrogen of produced compost

paper treatments did not change significantly than in control, but EC of P_{2-2} increased than in the control, significantly.

DISCUSSION

Regarding treatments temperature, it seems that the use of molasses and paper at the first stage caused to occur thermophilic stage in the fourth week after composting, but with the use of molasses at the second stage, microorganism activities has increased until the fifth week, consequently, we observe the temperature pick in this week.

Low C/N ratio-organic wastes are easily decomposed by the exo-cellulitic enzymes of microbial groups and their nitrogen are converted to new compounds. Ammonia (NH_3) is generated from decomposition of nitrogenous materials, i.e., proteins and amino acids (Liang *et al*., 2006). Ammonia Loss of the great N-compounds decomposition is led to decrease in the total nitrogen. Xi *et al*. (2004) reported that the ammonia volatilization is the most important reason nitrogen loss of the chicken manure compost. Therefore, it would be desirable if N is retained and converted to organic forms during composting. Ammonia emission frequently occurs during the thermophilic stage of aerobic decomposition and tends to be high with low C/N ratio. During the composting process, aerobic, thermophilic bacteria break down organic materials and utilize available nutrients to produce microbial biomass.

Using molasses have promoted microorganisms' activity, consequently they have decomposed organic wastes to obtain carbon for production of microbial biomass, which contributed to the nitrogen immobilization by microorganisms and a resultant reduced N loss. This is in agreement with the results of Liang *et al*. (2006). They reported that addition of the molasses, a readily available form of carbon, has reduced cumulative ammonia emissions substantially, so that nitrogen loss of the most-molasses (10% of initial DM) was the lowest (12.1%), while the highest N loss (24.6%) occurred with no amendment. The more increase in total nitrogen of 8% molasses treatment-second stage can be due to use of the more molasses and also aeration. Numerous reports indicated that NH_3 volatilization increased remarkably with the increase of air supply (Beck *et al*., 1997; Osada *et al*., 1997). Maeda and Matsuda (1977) also reported a linear relationship between NH_3 collected in acid trap an aeration rate when composting swine, dairy and poultry manure with varying C/N ratios from 15-45 under various levels of constant aeration.

When adding organic amendments to compost, acidic intermediate compounds of metabolism could be produced and pH value of the compost mixture may be lowered so that NH_3 loss can be reduced. Witter (1986) reported that composting process halted at 40°C and pH fell from 7.5-4.5, when adding 4% sucrose (dry weight) to an initial sewage sludge-straw mixture. In our experiment, 2 and 4% molasses at two stages significantly did not increase pH, but the use of 8% molasses in both stages led to decrease in pH than in the control, remarkably. Using 8% molasses caused to the more increase in microbial activity led to the production of the more acidic intermediate compounds. These acidic intermediate compounds with the acidic pH of the molasses (pH = 5.5) caused to decrease in pH of the 8% molasses treatment.

Carbon variations are approximately similar in molasses treatments, but to differentiate their C/N ratios that is related to the total nitrogen differences. The greatest decrease in C/N ratio is related to 8% molasses treatment amounted 3 times than in the control. Molasses has increased treatments electrical conductivity compared with the control, but it should be regarded that this increase in EC can be adjusted by the soil EC, when it is mixed in the soil, because increase in EC was not considerable than in the control.

Regarding derived results, show that the office paper as a carbon resource has increased total nitrogen that can be due to the increase in microbial biomass and stopping ammonia. Off course, the effect of 4% paper on nitrogen was more than 2% paper. When 2 and 4% paper are compared with 2 and 4% molasses, it indicates that the office paper effect on total nitrogen is more than molasses. Liang *et al*. (2006) studied indicated that the effect of the office paper as an ammonia suppressant was less than molasses, but in the present study, paper with stopping ammonia has more increased total nitrogen than molasses at the first stage. In some studies, application of cellulosic organic matter such as maize and rice straw affect on nitrogen loss. Xi (2004) concluded that the addition of 1% rice straw in the chicken manure could reduce the loss by 2.52%. Pilot composting experiments of swine manure with corncob by Nengwu (2006) showed that the composting system could destroy pathogens, converted nitrogen from unstable ammonia to stable organic forms and reduced the volume of waste.

Total nitrogen of the 4% paper treatment had decreased than in the control. This can be due to the use of paper at the second stage. During the time, microbial activity increase to decompose organic wastes, consequently it is needed to available carbon. Since paper is a cellulosic compound, microorganisms decompose it during the time gradually; and available carbon is prepared for increasing microbial biomass, but in the second stage that is accompanied with the highest activity of microorganisms, paper has still been decomposed to prepare available carbon for this aim; therefore, the great part of nitrogen is lost as ammonia. Molasses as a carbohydrate compound is a readily resource of carbon to prepare necessary carbon for microorganisms in both stages.

Significant change in carbon, pH and EC of the paper treatments is not observed than in the control. The best paper treatments with the view of C/N ratio are related to 2 and 4% treatments at the first stage, although use of the 2% paper is also suitable at the second stage. Application of 4% paper at the second stage because of the increase in C/N ration than control amounted 2.64 times is not proposed.

CONCLUSION

With regard to derived results, molasses as a readily carbon resource is a suitable ammonia suppressant for municipal compost production to increase the total nitrogen of the final compost. Influence of office paper on total nitrogen and C/N ration of compost is more than molasses, but use of the office paper at the second stage is not proposed, because it is a cellulosic compound and its carbon easily is not available for microorganisms' growth in thermophilic stage. Application of 8% molasses and 4% office paper respectively at the first and second stages decrease C/N ratio below 6 while the use of 4% office paper at the second stage increase it to about 46.

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