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Domestic Organic Waste Composting in Madhyapur Thimi, Bhaktapur

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Abstract

Organic waste composting is an important waste management practice that can reduce the volume of municipal solid waste and increase crop productivity. A study was carried out in Madhyapur Thimi, Bhaktapur in order to develop understanding of different methods of composting for sustainable solid waste management practices. Solid waste was collected randomly from 50 households in the area and segregated manually. The biodegradable waste was composted through pile (aerobic), aerobic bin, anaerobic (pit) and vermicomposting process. The physico-chemical and microbial analysis of composts were carried out in laboratory whereas significance of composts on crop productivity was tested in the study area. The study showed that 81.4% of the waste generated was biodegradable. The physico-chemical and microbial analyses of the compost samples showed pH range of 7.6 to 8.2 and moisture content of 54.5% to 69.5% for different composts. The maximum temperature (62^{o}C) was observed in aerobic (pile) composting. The nutrient analysis (oganic matter, nitrogen, phosphorus, potassium and C: N ratio) of different composts showed that vermicompost was the most among all the composts. The total bacterial and fungal count varied from 3.91 x 10^4 to 8.05 x 10^6 cfu/g and 1.30 x 10^3 to 3.25 x 10^4 cfu/g respectively. The vermicompost was found rich in microbial population too. The application of vermicompost at 6.25 mt/ha in the study area resulted in increasing in height, diameter and yield of cauliflower by 15.62%, 37.58% and 38.95% respectively over farm yard manure. The height, diameter and yield of cauliflower grown in different composts was found to be significantly different ($P<0.05$).

Key words: Biodegradable waste, vermicompost, vegetable production

Introduction

Composting is the controlled biological decomposition of organic substance by successive microbial populations (mesophilic and thermophilic). The product obtained is sufficiently stable for storage and application on land without adverse environmental effects. In recent years, composting has been known as an environmental friendly and sustainable alternative to manage and recycle organic solid wastes with the aim of obtaining a quality organic product, known as compost, to be used as organic amendment in agriculture. By nature of decomposition, composting process may be anaerobic and aerobic. Sir Albert Howard made the first major advance in the history of modern composting (Howard 1935). In anaerobic composting, decomposition occurs in absence of the oxygen or its limited supply. Under this method, anaerobic micro-organisms dominate and develop intermediate compounds including methane, organic acids, hydrogen sulphide and other substances. On the other hand, aerobic composting takes place in presence of ample oxygen. In this process, the aerobic micro-organisms break down organic matter and produce carbon dioxide, ammonia, water, heat and humus, the relatively stable organic end product. Despite higher nutrients loss from materials in aerobic composting, it is considered more efficient and useful than anaerobic composting for the agricultural production (Chamle 2007).

Recently, vermicomposting has been emerged as an environment friendly technology that uses the earthworms as versatile natural bioreactors for effective recycling of organic wastes to the soils. It is thus an environmentally acceptable means of converting waste into nutritious composts for crop production (Edwards *et al.* 1985). The technology uses certain epigeic earthworm species such as *Eisenia foetida, Perionyx excavatus* and *Eudrillus eugineae* that are voracious feeders of organic wastes (Senapathi 1994). Organic waste composting can thus help in both managing the solid waste problem and replacing chemical fertilizer for sustainable agricultural system. The aim of this study was sustainable management of domestic organic wastes through different approaches of composting in Madhyapur Thimi, Bhaktapur. It also aimed to examine the significance and relevance of different compost types on vegetable production.

Methodology

Field study

This field study was conducted at Madhyapur Thimi Municipality in Bhaktapur from August 2005 to April 2006. The domestic waste (household waste) was collected randomly from 50 households in the study area and segregated manually. The composting site was selected in the periphery of the community from where the wastes were collected and the biodegradable wastes were used for preparing composts by i) aerobic (pile), ii) anaerobic (pit), iii) aerobic bin and iv) vermicomposting methods. The dimensions of pile and pit used for composting were 1.75 m x 1.25 m x 1 m and 1 m x 1 m x 1 m respectively. The aerobic bin composting was carried out in a polythene bin of 100 liter capacity while vermicomposting in five wooden boxes of 45 cm x 25 cm x 30 cm (l x b x h). Altogether 200 composting worms (mostly *Lampito mauritti and Eisenia foetida)* were placed over the bedding in each box. Organic waste used in this experiment was dried, chopped into small pieces and fed to the earthworms. Another common existing practice of manuring i.e farm yard manure was taken for the comparative purpose to other methods of composting.

Analysis of compost properties

Temperature of the composting process was regularly monitored by using a soil thermometer. The samples of matured composts collected from each composting method were further analyzed for moisture content (APHA, 1998), organic carbon (Walkley & Black 1965), total Kjeldahal nitrogen (TKN) (Jackson 1973), available phosphorus (APHA, 1998) and total potassium (Toth & Prince 1980) at Nepal Agriculture Research Council, Lalitpur. The C: N ratio was calculated from the measured values of C and N. The microbial analysis of compost sample was carried out by serial dilution method as described by Aneja (2003).

Field experimental design and treatments

The experimental design was a randomized block design (RBD) with four replications and five treatments. The treatments were: 1. pile compost, 2. pit compost, 3. aerobic bin compost, 4. vermicompost, and 5. farm yard manure. In each plot size of 3.2 m^2, 35 days old cauliflower seedlings were planted maintaining a plant to plant distance of 40 cm and row to row of 30 cm. A dose of 6.25 mt/ha of compost was applied for each compost type as per the usual practice of farmers. The height, diameter of curd and yield of cauliflower were measured at the time of harvesting. The data obtained

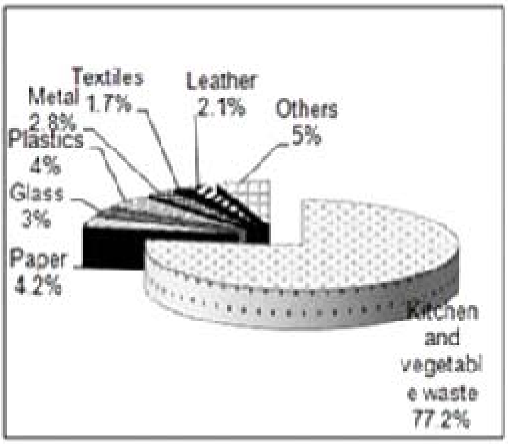

Fig. 1. Solid waste composition

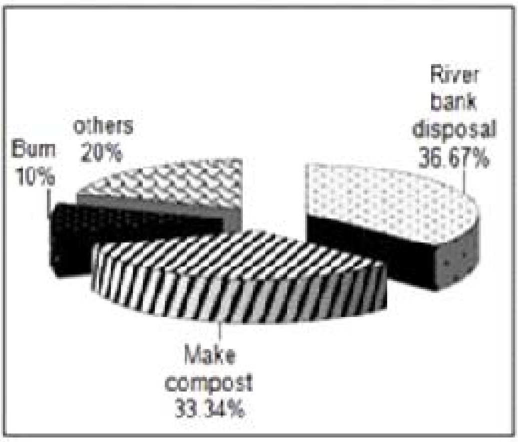

Fig. 2. Household waste disposal practice

were analyzed using statistical package for social sciences (SPSS 11.5) program. One way analysis of variance (ANOVA) was used for testing the statistical significance of variations of means at 5% level.

Results and Discussion

Waste generation and disposal practice

Total waste generation in the municipality was 79.4 kg per day with an average waste generation of 2.64 kg per household. Of the total 81.4% household waste was bio-degradable containing major proportion of paper and vegetable waste. The remaining 18.6% non-biodegradable waste that included plastic, glass, textiles, leather and metals as shown in Figure 1.

The composition of waste showed higher percentage occupied by organic wastes. A study on solid waste generation in Bhaktapur in 2001 had shown 89% of total waste as biodegradable (UNEP 2001). The present study however found 81.4% of total waste as biodegradable which is quite similar to the result observed by the municipality which indicated 81% as biodegradable (MTM 2004). Solid waste problem has been emerging as a critical issue in all urban areas of Nepal. It has also been growing as a major environmental problem. Majority of residents (36.67%) in the study area had been disposing the solid wastes into the banks of nearby Hanumante River where as only one-third households made compost fertilizer in the pit. Some households preferred to burn the wastes and some dispose in the streets. The household waste disposal practice as observed in the municipality is shown in Figure 2. The study also revealed that most of the residents did not segregate the waste before disposal.

Physical and chemical properties of composts

The temperature is an important indicator to observe the progress of aerobic decomposition and the basis for determining whether the pathogens should be killed at 55^{0}C (Gottas 1956). The temperature fluctuation observed during composting period of different types of composting process has been presented in Figure 3. Among all, pile composting attained the maximum temperature (62^{0}C) during the fifth week of composting period followed by pit composting (58^{0}C) during fourth week of composting. The maximum temperature of vermicomposting was recorded to be 24^{o}C (temperature ranged from 12 to 24^{o}C), which is comparatively lower than those recorded for other composting methods. Vermicomposting itself is a mesophilic process and has a general temperature range of 10-32^{o}C. The various observations performed by Domonguez *et al.* (1997) Maharjan (2004), Pandey (2004) and Shrestha (2005) had also found lack of thermophilic stage in vermicomposting process.

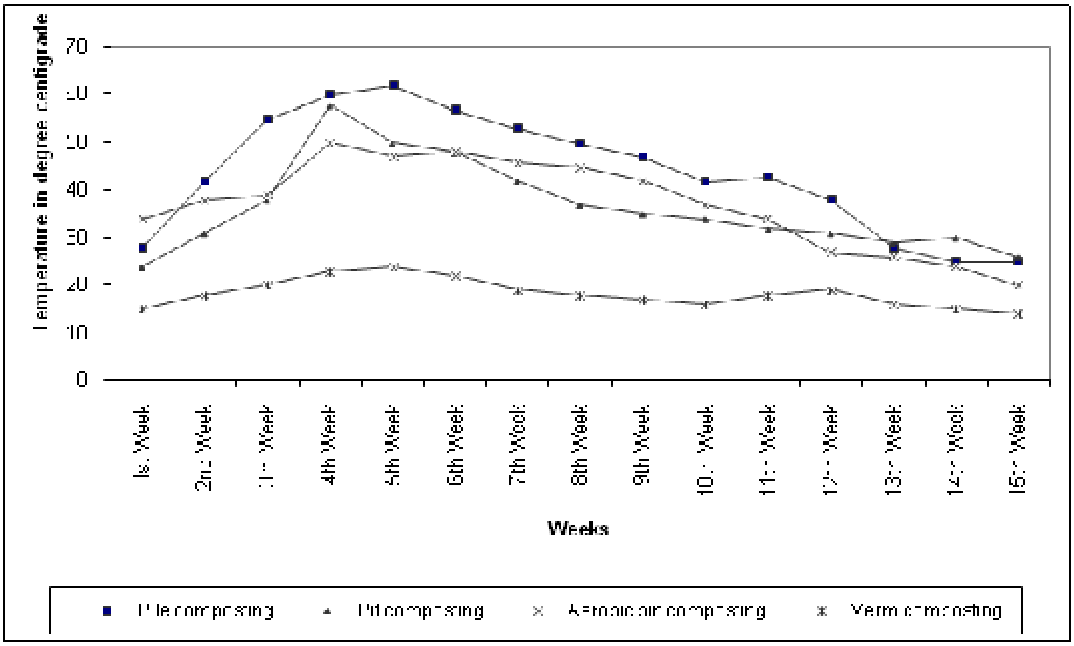

Fig. 3. Weekly temperature records for different composting methods

Similarly, pH value of matured composts ranged from 7.4 to 8.2, highest being observed in the pit compost. The higher pH in pit compost might be due to CO_2 evolution associated with the decarboxylation of organic anions. The pH of vermicompost was 7.6 which is slightly lower than that observed by (Pandey 2004) and (Shrestha 2005). Lunt & Jacobson (1944) had also found neutral pH of earthworm casts while Pradhan (1996) had recorded pH value of 6.8 for matured vermicompost.

The moisture content of matured composts ranged from 54.5% to 69.5%. The moisture content of aerobic bin composting was found comparatively higher than other composts. This might be due to the penetration of rain water and addition of excess water to the bin. Moisture content of organic materials is important as it determines its decomposition rate. Microorganisms require moisture to assimilate nutrients, metabolize new cells, and reproduce. Water is the key ingredient that transports substances within the composting mass and makes the nutrients physically and chemically accessible to the microbes. So higher the moisture content, greater the chance of growth of microorganisms, but excessive moisture above 60% can lower internal temperature inhibiting oxygen flow that results anoxic condition (Sharma 2001).

The organic matter improves the soil structure and thus enables the soil to resist erosion holding more water without water logging (FAO 1987). An important potential use of compost in the agricultural industry is its application as a soil amendment to eroded soils. This study also determined the organic matter of matured composts that ranged from 14.07% to 31.49% similar to the value obtained by Shrestha (2005). The high organic matter content in the vermicompost thus suggests that it is rich in nutrient content. Zucconi & Bertoldi (1991) suggested that at least 10% organic matter is beneficial for plant growth while Anthonis (1994) suggested 20% as the standard. Thus the obtained values for all composts were acceptable as per Zucconi & Bertoldi standard but less than the standards (except, vermicompost) as per suggested by Anthonis (1994).

Further the nitrogen contents of the composts were determined and the values ranged from 0.57 in aerobic bin compost to 1.17% in vermicompost. The values are lower than those observed by Maharjan (2004), Pandey (2004) and Shrestha (2005). Nitrogen is important for microbial activity as well as for adjusting the C: N ratio of the composting materials. It is an essential constituent of amino acids, nucleic acids and chlorophyll which increases the growth and development of living tissues. For the compatible agricultural use, the total level of nitrogen should not be less than 0.6% (Zucconi & Bertoldi 1991). Among the composts, nitrogen content of vermicompost was relatively higher than other. This could be due to the initial feeding materials of earthworms like cow dung and vegetables rich in nitrogen. The nitrogen content of farm yard manure (FYM) and composts depends on not only its storage and handling conditions but also kinds of raw materials used. There is a wide variation in the nitrogen contents of the compost prepared by Nepalese farmers normally being 0.5% (Maskey *et.al*. 2001). But the study showed nitrogen content of FYM was 1.01% which may be due to the addition of nutrient rich poultry waste.

From this study, the phosphorous contents of the matured compost were found to range from 0.21% to 1.15%. These values are relatively lower than the values observed by Maharjan (2004), Pandey (2004) and Shrestha (2005). The result also revealed that farm yard manure has maximum phosphorous content as compared to others. This may be due to the residual nutrient content in residue of the farm yard wastes. The normal range of phosphorus as stated by Zucconi & Bertoldi (1991), is 0.5 to 0.9 %.

Potassium is an activator of enzymes involved in the photosynthesis as well as carbohydrate metabolism. It provides strength to plants and cell wall and plays an important role in cell reproduction and metabolism. The present study also revealed that farm yard manure has maximum potassium contents as compared to other composts which might be due to the mixing of ashes rich in potassium content to the farm yard manure. The potassium contents of other composts were also found to be relatively higher than those observed by Maharjan (2004), Pandey (2004) and Shrestha (2005).

Finally, the C: N ratio, a common indicator of the availability of compounds for microbial use, was also determined during the study. The C: N ratios of the matured composts ranged from 8.09 to 16.40 in the study. The C: N ratio within the range of 10:1 to 15:1 is considered to be the desired ratio in matured compost (Anthonis 1994).

Table 1. Physical and chemical properties of different composts

Parameter	Pit compost	Pile compost	Anaerobic bin compost	Vermi compost	Farm yard manure
Moisture content (%)	65.5	54.5	69.5	62.5	55.25
pH	8.2	8.1	7.9	7.6	7.4
Organic Matter	15.41	15.41	16.08	31.49	14.07
Nitrogen (%)	0.91	0.82	0.57	1.17	1.01
Phosphorous (%)	0.23	0.30	0.21	0.70	1.15
Potassium (%)	3.51	5.40	4.99	4.99	6.07
C: N ratio	9.84	10.92	16.40	15.64	8.09

Microbial analysis

The bacterial count from different compost samples varied from 3.91×10^4 to 8.05×10^6 cfu/g. Similarly, the fungal count of the compost varied from 1.30×10^3 to 3.25×10^4 cfu/g. The result also showed rich in microbial population in vermicompost as shown in Table 2. It is because earthworms are believed not only to decompose the organic matter but also stimulate and increase the number of microorganisms in the soil (Parle 1963).

Table 2. Total bacterial and fungal colony count from different samples of compost

S.N	Compost type	Total bacterial count (cfu/g)	Total fungal count (cfu/g)
1	Pit (Anaerobic) compost	3.91×10^4	2.12×10^3
2	Pile (Aerobic) compost	5.50 x 10	1.30×10^3
3	Aerobic bin compost	4.40×10^4	1.60×10^3
4	Vermicompost	8.05×10^6	3.25×10^4
5	Farm yard manure	2.50×10^6	2.81×10^4

Experimental results

The effects of different composts on overall growth of plant have been depicted in Figure 4. The statistical analysis regarding effects of different composts on vegetable production revealed that there is a highly significant difference at $P<0.05$ in height, diameter and yield of cauliflower grown in different composts under same dose. The summery of the statistical analysis is presented in the following table.

Table 3. Analysis of variances (ANOVA) of different parameters

Parameters	**Source of Variation**	**Sum of Squares**	**d f**	**Mean square**	**F-cal**	**F-tab at 0.05 level**	**Sig.**
Height	Between treatments	2478.95	(4,15)	619.38	51.16*	3.06	0.000
Diameter	Between treatments	87.37	(4,15)	21.84	52.31*	3.06	0.000
Yield	Between treatments	41705.78	(4,15)	10426.44	23.54*	3.06	0.000

In terms of height, diameter of curd and yield of cauliflower, vermicompost seemed superior over the pit, pile, bin and farm yard manure. This might be due to high level of nutrient content in the vermicompost as compared to other composts. Bhattarai (2001) had also reported higher yield of maize and wheat by vermicompost use. Several studies have indicated significant role of the application of organic manure on vegetable production. Khadka (1996), Pradhan (1996), Sharma (1996) and Pandey (2004) found the supremacy of organic manure in agricultural practices. A study conducted by Karki (2002) in Lalitpur found higher yield of maize and cabbage through application of farm yard manure (FYM) compared to inorganic fertilizers. There have also been studies to see the effect of single or combined application of organic manures and fertilizers on the yield of various crops in the country. Most of the results have shown better results of crop yields when organic manures are applied in combination with mineral fertilizers (Maskey *et al.* 2001). The present study, however presents the farm yard manure as second potential after vermicompost in its role in the cauliflower production.

The application of vermicompost at 6.25 mt/ha resulted in increase in height, diameter and yield of cauliflower by 15.62%, 37.58% and 38.95% respectively over the control (FYM) showing the superiority to other composts and the application of FYM at the same dose also showed its superiority over the pit, pile, and bin composts. The difference in vegetable production using different composts was statistically significant, vermicompost being the superior.

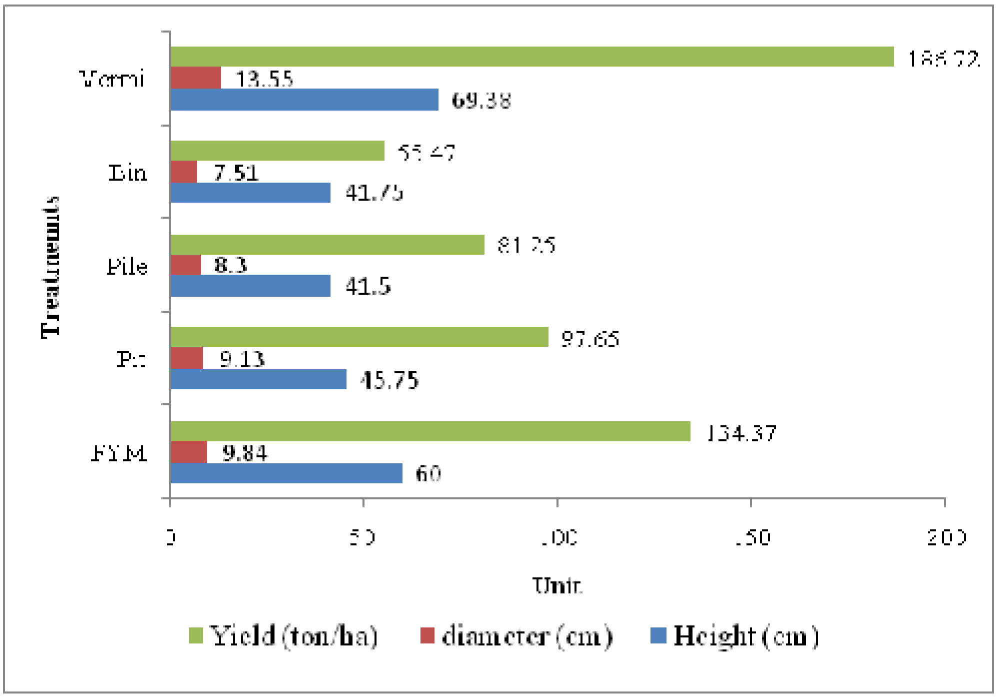

Fig. 4. Effects of different composts on vegetable production

Composting is a cost effective and environmental friendly way of waste recycling. It is a process in which organic waste materials are biologically converted into amorphous and stable humus like substances (under conditions of optimum temperature, moisture and aeration) that can be handled, stored and applied without any hazardous environmental impacts. The organic waste if treated properly can turn out to be a valuable resource. The novelty of the approach being used in this study is application of organic fertilizer, thus increasing crop yield by applying raw and composted organic material. Composting of organic materials may reduce dependence on chemical fertilizer and helps to maintain nutrients in soil. Moreover, it is an economical and safe way of the disposal of organic wastes generated in urban/ metropolitan centers. So the reduction of huge piling of organic wastes in cities by this technology can be an extra benefit. Further the use of organic manure ensures stability of soil structure improves soil organic matter status, nutrients availability and high crop yield. The organic waste generated in the community can thus be managed locally, which will also be beneficial in several ways such as management of wastes at source and generation of income through compost production. The organic waste composting can therefore be the best option for sustainable solid waste management in the urban area.

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