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Barrel Composting of Domestic Solid Waste in Bangladesh: A Case Study

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Abstract: The solid waste in most of the urban centres in Bangladesh contains a very high proportion of biodegradable organic fraction. Thus the management of this organic fraction of solid waste is becoming a very important strategic option to minimize severe environmental pollution resulting from mismanagement of solid waste in many urban areas. The organic fraction of solid waste can be composted to reduce the volume of the waste and the compost can be used as soil conditioner. This paper summarizes one year long applied research on barrel composting plants undertaken to design an efficient small-scale plant for composting biodegradable portion of solid waste in Bangladesh. Selected environmental parameters were measured to assess the environmental conditions of digestion processes during composting of solid waste in these barrel-composting plants. The study included determination of chemical and microbial quality of compost produced of these composting plants for the effective use of compost as soil conditioner.

Key words: Barrel composting, domestic solid waste, food waste.

Introduction

Composting is the microbial decomposition of biodegradable solid waste, under aerobic condition, where microorganisms convert waste into a stable end-product (compost). The term co-composting is also used to describe the composting process of two or more substances together. The main objectives of composting are to decompose organic fraction of waste to: reduce its volume, weight and moisture content; minimise potential odour; decrease pathogens; and, increase potential nutrients for agricultural application. The composting process may minimise the spread of diseases because of the destruction of some pathogens and parasites at elevated temperature (Table 1).

Presently the composting is emerging to be a popular waste management alternative both in developed and developing countries. It diverts a significant portion of organic waste from municipal collection services and from final disposal site, and therefore, enhances both economic and environmental sustainability of waste management system. The use of compost as soil conditioner, minimising the use of chemical fertilisers, has significant environmental benefits. But one should not consider compost as an alternative to chemical fertilisers. It is a very good soil conditioner enriched with nutrients. Unless properly maintained, during composting process, the problems may arise (Rahman, 2004): odour nuisances; contaminated runoff; air (mostly dust) pollution; and, growth of pathogens in the surrounding area of the plants.

The solid wastes generated in developing countries contain higher percentage of organic matters compared with the solid waste generated in developed countries (Table 2). So the management of organic fraction of solid waste is becoming a very important strategic option to minimize severe environmental pollution in many urban centres. Thus the implementation of the composting technology has a great potential for mitigating several problems related to ecological imbalance due to loss of

Table 1: Destruction of some common pathogens and parasite at elevated temperatures

Organisms	*Observations*
Salmonella typhosa	No growth beyond 46°C; death in 30 min. at 55-60°C and 20 min. at 60°C; destroyed in a short time in compost environment
Salmonella sp.	Destruction within 1 h at 55°C and 15-20 min. at 60°C
Shigella sp.	Destruction within 1 h at 55°C
Escherichia coli	Destruction within 1 h at 55°C and 15-20 min. at 60°C
Entamoeba histolytica cysts	Destruction within a few minutes (mins.) at 45°C and within a few seconds at 55°C
Taenia saginata	Destruction within a few mins. at 55°C
Trichinella spiralis larvae	Quickly killed at 55°C, instantly at 60°C
Brucella abortus or Br. Suis	Destruction within1 hour at 55°C and within 3 mins. at 62-63°C
Micrococcus pyogenes var. aureus	Destruction within 10 mins. at 50°C
Streptococcus pyogenes	Destruction within 10 mins. at 54°C
Mycobacterium tuberculosis var. hominis	Destruction within 15-20 mins. at 66°C or after momentary heating at 67°C
Corynebacterium diptheriae	Destruction within 45 mins. at 55°C
Necator americanus	Destruction within 50 mins. at 45°C
Ascaris lumbricoides eggs	Destruction within 1 hour at 50°C

Source: Bhide and Sundaresan (1983); Vesilind and Rimer (1981) and Golueke (1972).

Table 2: Physical characteristics of solid waste in developed and developing countries

City/Country	*Organic/ putrescible*	*Paper*	*Metal*	*Glass*	*Plastic, rubber*	*Textiles*	*Miscellaneous*
Banglore, India[1]	75.2	1.5	0.1	0.2	0.9	3.1	19.0
Kathmandu, Nepal[2]	65.6	7.4	2.2	3.1	5.4	1.7	
Manila, Philippines[3]	45.5	14.5	4.9	2.7	8.6	1.3	27.5
Abu Dhabi[4]	49.0	6.0	8.0	9.0	12.0	-	16.0
Qatar[4]	53.3	17.0	4.3	3.1	15.0	-	6.6
Ibadan, Nigeria[5]	76.0	6.6	2.5	0.6	4.0	1.4	8.9
Asuncion, Paraguay[3]	60.8	12.2	2.3	4.6	4.4	2.5	13.2
Mexico City, Mexico[6]	59.8	11.9	1.1	3.3	3.5	0.4	20.0
United Kingdom[7]	28.0	37.0	9.0	9.0	2.0	3.0	12.0
United States[8]	22.9	38.5	7.7	5.5	9.9	6.8	8.6
Japan[9]	32.0	38.0	6.0	7.0	11.0	-	6.0
France[9]	25.0	31.0	6.0	12.0	10.0	-	16.0
Switzerland[9]	27.0	28.0	3.0	3.0	14.0	-	25.0

Sources: [1]Nath(1993); [2]Thapa & Devkota (1999) [3]Diaz & Golueke (1985); [4]Qdais et al. (1997); [5]Diaz (1999); [6]Diaz et al. (1996); [7]Holmes (1984); [8]Warmer (1999); [9]WHO (1995).

nutrients from the ecosystem, the disposal of organic wastes, which cause water, soil and air pollution and health hazards of surrounding populations particularly in the low income areas, which are often deprived of the municipal waste collection services in Bangladesh (Rahman, 2004). The present composting practices in Bangladesh mostly involve implementation of prototype small scale composting plants in few urban centres especially in the medium- and low-income communities without proper attention to their design modification in the context of Bangladesh environment. This includes small-centralized windrow composting system and composting plants using perforated barrels. This study is aimed to assess the performance of barrel type composting plants analyzing the project “Solid Waste Management and Composting” with collaboration of International Center for Development and Research (ICDR) of Stamford University, Bangladesh (ICDR, 2005).

Barrel Composting Plant at Gazipur

Two-hundred litre capacity perforated barrels with a cover on the top and an opening in the bottom are used as a composting barrel. The height and diameter of the barrel are 34 inch and 21 inch respectively. The half inch diameter opening in the surrounding of the barrel is provided and one inch diameter perforated pipe is attached to the base of the barrel to maintain aerobic condition. The conical shaped cover protects the waste from sunlight and rain water. The base is six inch above from the earth to save the barrel from water during rainy season. The 10 inch by 12 inch opening is provided to harvest the compost from the barrel and to make it continuous process. Figures 1 and 2 show the details of barrel type composting plant at Gazipur.

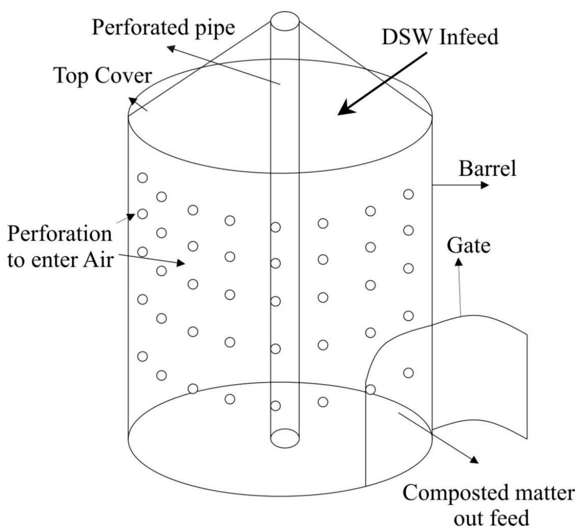

Figure 1: Schematic diagram of barrel-type composting plant.

Figure 2: Barrel-type composting plant at DUET, Gazipur.

Materials of Composting

To investigate the controlling parameters of composting, a small sized barrel composting plant is set in Dhaka University of Engineering & Technology (DUET), Gazipur campus. The total solid waste generated in Gazipur area is mainly organic when compared to small amount of inorganic. Among the organic waste the vegetables waste are dominant. The various types of solid waste generated are shown in Figure 3.

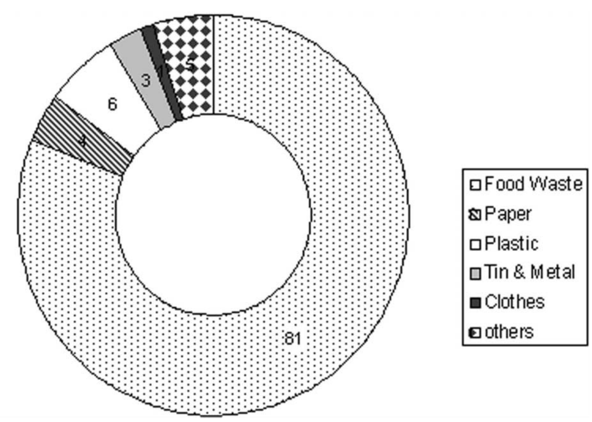

Figure 3: Physical composition of domestic solid waste at Gazipur.

Composting Process

The domestic waste is sorted and organic part is then separated from the inorganic part. Then the organic portion of the waste is deposited in the composting barrel. Before deposition in the barrel the waste is sorted and pulverized into small pieces for quick composting process. .After three to four weeks, the decomposing organic wastes are harvested from the bottom opening of the barrel. To observe the seasonal variations of various parameters of composting process the samples are collected in different seasons of the year.

Experimental Results and Discussions

Barrel type composting experiment was first carried out to identify the proper range of operating conditions for thermophilic composting of domestic waste. Particular emphasis has been given on the various controlling parameters which are generally affecting the composting process of solid waste in this study. The change of various physical parameters during composting is observed. The seasonal variations of different parameters are shown in Figures 4 to 7. These figures include the test results of five set of experiments conducted during January–March (Sample 1); March–May (Sample 2); May–July (Sample 3); July–September (Sample 4); and, October–December

(Sample 5) in the year 2004. Each set (sample) consists of average of three test data obtained from three composting barrels. The exothermic reactions in composting process release heat resulting in an increase in temperature within the composting materials (Figure 4). It is evident from Figure 4 that composing at the end of nearly three weeks, after charging the raw materials into the composting barrels, takes place in the composting barrels at a temperature range of 50–60°C. This appears to be more suitable environment for thermophilic microorganisms and results in a significant reduction of pathogens and parasites in composting process. This is in agreement with the results of the microbial quality of the compost as shown in Table 3. It is apparent from test results of environmental parameters of composting processes that composting takes place in experimental barrels in a suitable composting environment. Table 3 shows that most of the pathogenic substances cannot survive in the final marketable product after proper maturation of the compost, and therefore, the product is safe to use by the farmer. Table 4 shows the quality of the compost obtained from these barrel composting plants as well as the quality of the compost in international market (Rahman, 2004). It is evident from Table 4 that the composts produced from solid wastes in barrel composting plants have very good NPK values and hence can effectively be used as soil conditioner. Again, it is evident from Figure 7 that the pH of the raw materials during digestion are in the range of 5.5-8.5, which is the more desirable pH range for better composting. At the beginning of composting process, acid-producing bacteria becomes more active and converts complex materials to organic acid intermediates and hence reduces pH level. These organic acids are soon utilized by succeeding microorganisms resulting in increase in pH value (Figure 7).

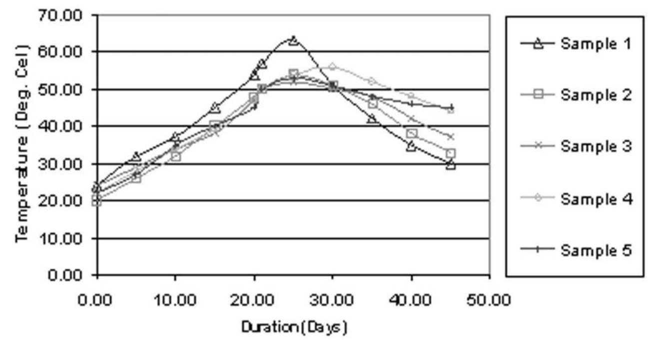

Figure 4: Comparison of seasonal variations of temperature during composting.

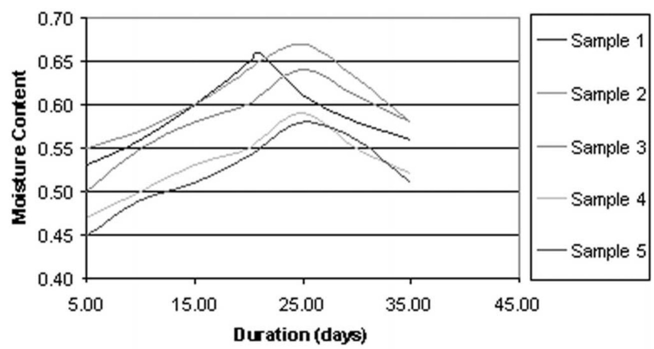

Figure 5: Moisture content variations composting.

Table 3: Result of microbial quality of compost samples

Sample No.	*Total bacterial count c.f.u/g*	*Total coliform c.f.u/g*	*Salmonella* spp. *c.f.u/g*	*Pseudomonas* spp. *c.f.u/g*	*Fecal coliform c.f.u/g*
Sample 1	4.5 × 1000000	1.1 × 1000	Nil	Nil	Nil
Sample 2	7 × 1000000	4.5 × 1000	Nil	Nil	Nil
Sample 3	6.2 × 1000000	5.1 × 1000	Nil	Nil	Nil
Sample 4	5.5 × 1000000	Nil	Nil	Nil	Nil
Sample 5	5.5 × 1000000	Nil	Nil	Nil	Nil

Table 4: Nutrient content of solid waste compost

Nutrients	*Sample 1*	*Sample 2*	*Sample 3*	*Sample 4*	*Sample 5*	*International market*
Nitrogen (N)	0.92	1.12	1.02	0.87	1.22	1.10
Phosphorus (P)	0.17	0.18	0.17	0.20	0.58	0.40
Potassium (K)	0.90	0.95	0.90	0.71	0.88	0.50

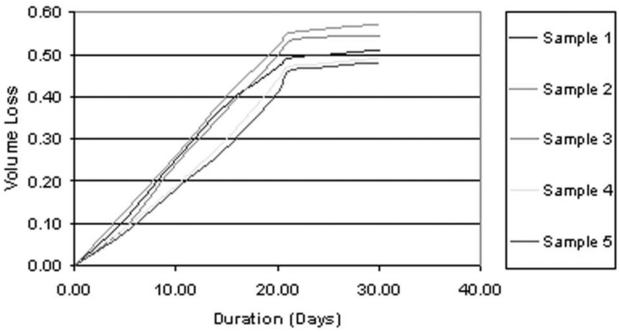

Figure 6: Moisture content variations composting.

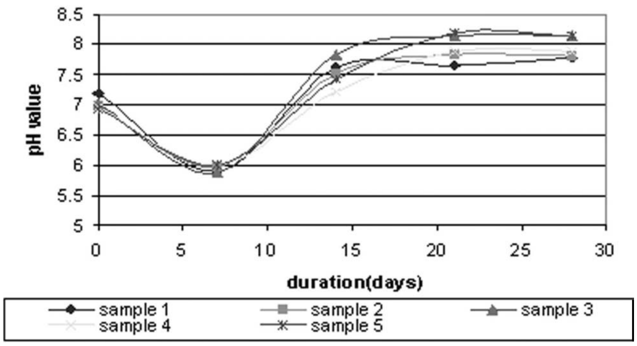

Figure 7: pH of the waste content of the composting barrel during composting.

Conclusion

On a critical examination of the experimental results of this study, the following observations and conclusion can be drawn:

- It is evident that after nearly three weeks, the variation of volume loss in the composting process is insignificant which can be used as retention time for digester design in composting process in Bangladesh in general and Gazipur in particular.
- The moisture content of the domestic waste of Gazipur area is suitable for composting and, hence without further treatment, the waste can be composted aerobically.
- The variation of temperature within the barrel during composting does not vary more than 20% at the same duration during different season whereas the natural temperature outside the barrel is varied 75% at the same duration during different season. So the variation of external temperature is insignificant in composting process.
- The composts produced from solid waste in barrel composting plants have very good NPK values (Table 4) and can effectively be used as soil conditioner.
- This study revealed that most of the pathogenic substances cannot survive in the final marketable product after proper maturation of the compost (Table 3), and therefore, the product is safe to use by the farmer.

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