



Effect of passive and forced aeration on composting of market solid waste

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Abstract

This study aimed to determine the effect of passive and forced aeration on composting of market wastes. Suitable vegetable waste, waste paper and sawdust as bulking agent were mixed with the proportion 75:10:15. Temperature inside composting reactors was measured daily time to time. Total sample and volatile solids were determined before and after composting of waste mixture with both passive and forced aeration. Temperature increased to maximum 52 °C for passive aeration and 54 °C for forced aeration. The percentage reduction in total sample was found to be greater for forced aeration than passive aeration. The volatile solids decreased with time at the end of both processes. The extent of volatile solids degradation of waste mixture with time was determined through forced aeration for a series of composting process. Total sample and volatile solids were determined at 2, 3 or 4 days interval. The percentage reductions in total sample and volatile solids were found to be varied from 3 to 68 % and 4 to 55% respectively. The percentage reduction in volatile solids increased with time. There is a possibility of recycling the waste mixture in the form of composting.

Keywords: Composting; Forced Aeration; Passive Aeration; Recycling; Volatile Solids Degradation.

1. Introduction

The increasing quantity of municipal solid waste, decreasing landfill capacity, increasing waste management cost, public opposition to waste management facilities, and concerns for risks associated with solid waste management, etc. led to the concept of integrated solid waste management [1]. In developing countries, the increasing quantity of organic waste is one of the most environmental problems. Environmental and health problems such as disease transmission, fire hazards, odor nuisance, aesthetic nuisance, air pollution, water pollution, and economic losses, etc. arise due to mismanagement of solid waste [2]. Solid waste management is an enormous task due to poverty, population explosion, urbanization, and lack of fund, etc. There are some waste disposal methods such as incineration, landfill, pyrolysis and gasification, etc., which are efficient but have negative impacts on environment as well as public health. Composting when properly managed is a sustainable method with various advantages such as production of biofertilizer, relatively low air and water pollution, low operational cost, and income generation [3]. Environmental degradation and ecological imbalance occur continuously due to poor planning and management of solid waste. Composting is a sustainable and environment friendly way of managing the waste [4].

Composting is a biological transformation of organic content of municipal solid waste to reduce the volume and weight of material and produce compost that can be used as a soil conditioner. Aerobic and anaerobic processes both have a place in solid waste management [5]. Organic materials undergo biological degradation to a stable end product [6]. The end product remaining after bacterial activity in composting of organic waste is called compost or humus [7]. Aerobic composting is the most common in the waste treatment because of simplicity and effective treatment and needs diffusion of air through waste [8]. High microbial activity accelerates the degradation of organic matter in the thermophilic phase [9]. A minimal level of oxygen is maintained constantly to ensure high biological quality [10]. Temperature, pH, moisture content and carbon nitrogen ratio (C: N) are the main parameters that affect the composting process, contributing to the efficiency of composting process [11]. The high content of organic matter and macronutrients in waste has high potentiality in the production of organic fertilizers [12].

Composting is very effective way to treat organic wastes and produce a good soil conditioner. Market wastes consume various nutrients such as nitrogen, phosphorus, potassium, which help to grow different plants. Keeping this in mind the present study experimented with market wastes to determine the temperature variation in both passive and forced aeration composting processes, to determine the extent of volatile solids degradation of the waste mixture and to study the possibility of recycling the waste mixture in the form of composting.

2. Materials and methods

2.1. Waste materials

Vegetable wastes, waste paper and sawdust were selected for the waste mixture. Vegetable waste, waste paper and sawdust were collected from local market of Khulna. The large pieces of vegetable wastes and waste paper were cut into small pieces of size less than 10 mm. Vegetable wastes, waste paper and sawdust as bulking agent were mixed thoroughly with a proportion of 75:10:15.

2.2. Reactor and aerator type

Twenty flasks were used as composting reactors. The diameter, height and capacity of each reactor were 100 mm, 270 mm and 1 litre respectively. Small pieces of polyurethane sheet were placed over reactor to protect the total system from leakage of self-generated heat of organic waste mixture during composting. Five aerators (Super Pump SP-780) were used for aeration. Air pipes of 5 mm diameter and 1000 mm length were used to connect aerator with reactors. Four air pipes from each aerator were connected with four reactors.

2.3. Measurement of temperature

Thermometers were used for monitoring temperature generated in waste mixture inside reactors during composting. Thermometers were inserted into reactors and temperature readings were taken daily time to time.

2.4. Determination of moisture content and volatile solids

The weight of can (w_1) was measured using a digital balance. A small amount of waste mixture was taken into can. The weight of wet sample with can (w_2) was measured. The wet sample with can was kept in Oven at $105 \pm 5^\circ\text{C}$ for 24 hours. The weight of dry sample with can (w_3) was measured. Desiccator was used to control moisture content of the waste mixture. The moisture content (MC) was calculated using the following formula:

$$\text{MC (\%)} = (w_3 - w_2)/(w_2 - w_1) \quad (1)$$

Oven dried sample with can was kept in Muffle Furnace at $550 \pm 15^\circ\text{C}$ for 5 hours. The weight of fixed sample with can (w_4) was measured. The volatile solid (VS) was calculated using the following formula:

$$\text{VS (\%)} = (w_3 - w_4)/(w_3 - w_1) \quad (2)$$

2.5. Determination of temperature variation

2.5.1. Temperature variation in passive aeration composting

The first run was carried out using three reactors with passive aeration composting. Vegetable wastes (75%) after cutting into small pieces were mixed thoroughly with sawdust (15%) and waste paper (10%) and put into three reactors. The reactors were filled and shaken with the waste mixture. The openings of reactors were closed by small pieces of polyurethane sheet and thermometers were inserted into reactors for monitoring the temperature. The experimental setup for temperature variation during passive aeration composting is shown in Fig. 1. The total sample weight, moisture content and volatile solids of the waste mixture were determined before and after composting. The temperature readings were taken daily time to time for 29 days.



Fig. 1: Experimental Setup for Temperature Variation during Passive Aeration Composting.

2.5.2. Temperature variation in forced aeration composting

The second run was carried out using three reactors with forced aeration composting. Vegetable wastes (75%) after cutting into small pieces were mixed thoroughly with sawdust (15%) and waste paper (10%). Before filling the reactors with the waste mixture, air pipes of diameter 5 mm from air pump were inserted inside of each reactor. The reactors were filled and shaken with the waste mixture. The openings of reactors were closed by small pieces of polyurethane sheet and thermometers were inserted into reactors for monitoring the temperature. The experimental setup for temperature variation during forced aeration composting is shown in Fig. 2. Air was passed daily at the rate of 500 ml/min through waste mixture inside reactor for 8 hours in day time. The total sample weight, moisture content and volatile solids of the waste mixture were determined before and after composting. The temperature readings were taken daily time to time for 29 days.



Fig. 2: Experimental Setup for Temperature Variation during Forced Aeration Composting.

2.6. Determination of volatile solids degradation

The third run was carried out using twenty reactors with forced aeration composting following the procedure as described in section 2.5.2. The experimental setup for determination of volatile solids degradation is shown in Fig. 3. The temperature readings were taken daily time to time for 49 days. The total sample weight, moisture content and volatile solids of the waste mixture were determined at 2, 3 or 4 days interval.



Fig. 3: Experimental Setup for Determination of Volatile Solids Degradation.

3. Results and discussion

3.1. Passive aeration composting

The temperature inside reactor-1 increased from 26 to 42 °C within 7 days and maximum temperature was 52 °C. After 29 days the temperature decreased to 32 °C. The temperature inside reactor-2 increased from 26 to 44 °C within 7 days and maximum temperature was 49 °C. After 29 days the temperature decreased to 28 °C. The temperature inside reactor-3 increased from 26 to 40 °C within 7 days and maximum temperature was 51 °C. After 29 days the temperature decreased to 30 °C. The temperature variation during passive aeration composting is shown in Fig. 4. Initially the temperature inside reactors increased rapidly for few days and then decreased slowly.

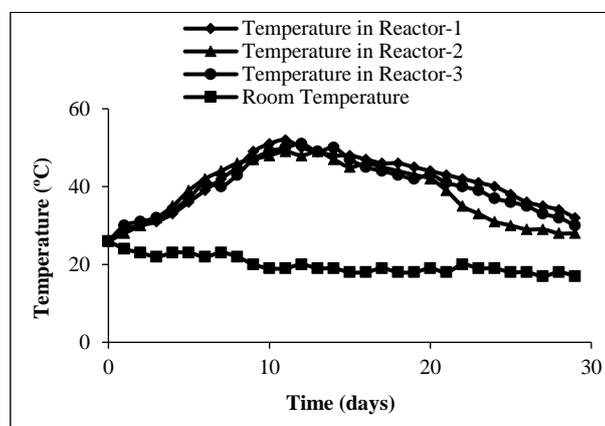


Fig. 4: Temperature Variation during Passive Aeration Composting.

Initial weight of waste mixture in reactor-1, 2 and 3 were 450, 455 and 435 g respectively and final weight were 370, 380 and 355 g respectively after 29 days of composting. The moisture content of the waste mixture was 69.4% initially and increased to 77.9%. The volatile solid of the waste mixture was 94.4% initially and decreased to 90.3%. The percentage reductions in total sample, moisture, dry solids and volatile solids in reactor-1 were found as 17.78%, 7.72%, 40.60% and 43.15% respectively.

3.2. Forced aeration composting

The temperature inside reactor-4 increased from 26 to 42 °C within 7 days and maximum temperature was 50 °C. After 29 days the temperature decreased to 19 °C, near to room temperature 17 °C. The temperature inside reactor-5 increased from 26 to 39 °C within 7 days and maximum temperature was 53 °C. After 29 days the temperature decreased to 20 °C. The temperature inside reactor-6 increased from 26 to 43 °C within 7 days and maximum temperature was 54 °C. After 29 days the temperature decreased to 19 °C. The temperature variation during forced aeration composting is shown in Fig. 5. Initially the temperature inside reactors increased rapidly for few days and then decreased rapidly for few days and slowly for forced aeration composting.

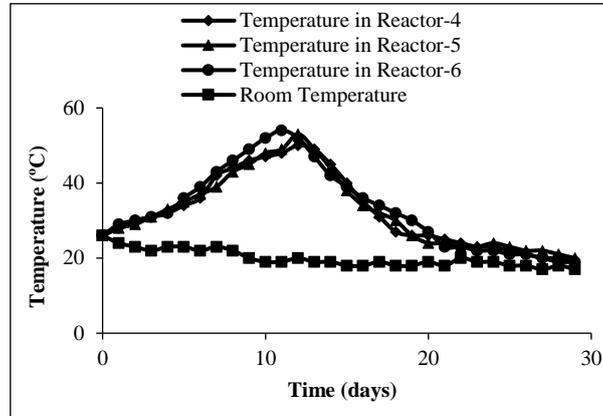


Fig. 5: Temperature Variation during Forced Aeration Composting.

Initial weight of waste mixture in reactor-4, 5 and 6 were 450, 455 and 465 g respectively and final weight were 235, 265 and 270 g respectively after 29 days of composting. The moisture content of the waste mixture was 69.4% initially and decreased to 66.1%. The volatile solid of the waste mixture was 94.4% initially and decreased to 88.2%. The percentage reductions in total sample, moisture, dry solids and volatile solids in reactor-4 were found as 47.78%, 50.27%, 42.12% and 45.15% respectively.

3.3. Volatile solids degradation

The maximum temperature was in the range of composting process (below 60 °C) in both passive and forced aeration composting processes. The percentage reduction in total sample was greater for forced aeration than passive aeration. Forced aeration composting of the waste mixture was selected to determine the volatile solids degradation with time. The temperature increased from 30 to 52 °C. The moisture content of the waste mixture was 68% initially and increased to 69.9% and decreased to 41.7%. The volatile solid of the waste mixture was 93.4% initially and decreased to 87.4%. The volatile solids decreased with time at the end of composting process. The percentage reductions in total sample, moisture, dry solids and volatile solids in reactor-1 were found as 3.85%, 2.43%, 6.99% and 7.23% respectively. The percentage reductions in total sample, moisture, dry solids and volatile solids with time are shown in Fig. 6. The percentage reductions in total sample, moisture, total solids and volatile solids increased with time.

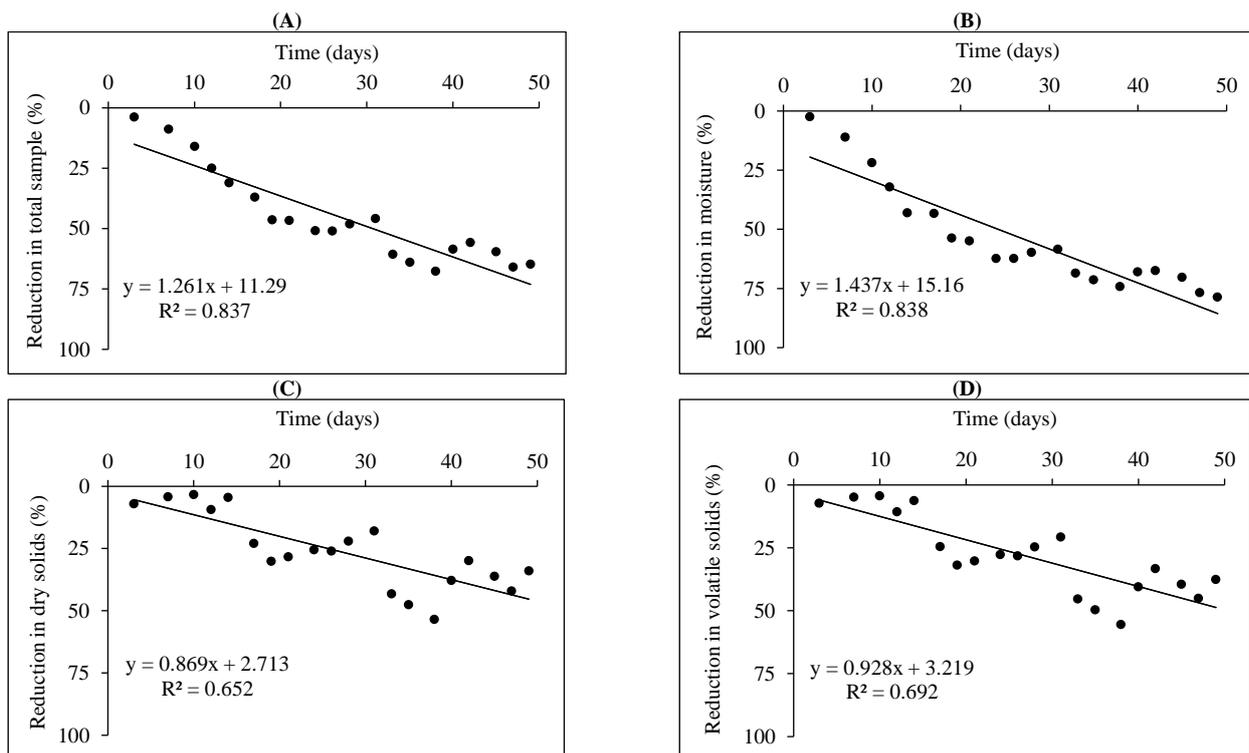


Fig. 6: Reductions in Total Sample, Moisture, Total Solids and Volatile Solids during Forced Aeration Composting. (A) Reductions in Total Sample. (B) Reductions in Moisture. (C) Reductions in Dry Solids. (D) Reductions in Volatile Solids.

4. Conclusions

In this study the first run was carried out with passive aeration and second run with forced aeration to determine the temperature variation with time during composting. The third run was carried out with forced aeration to determine the volatile solids degradation with time for a series of composting process. Initially the temperatures inside reactors increased rapidly from 26 to 52 °C for few days and then decreased slowly to 28 °C for passive aeration composting. Initially the temperatures inside reactors increased rapidly from 26 to 54 °C for few days and then decreased rapidly to 26 °C for few days and slowly to 19 °C for forced aeration composting. During composting chemical reaction in the waste mixture generates heat, thus increasing the temperature inside reactors. The percentage reductions in total sample and volatile solids were found to be varied from 3 to 68 % and 4 to 55 % respectively. The percentage reductions in total sample, moisture, total solids and volatile solids increased with time. Vegetable waste and paper waste are degraded during composting. There is a possibility of recycling the organic waste in the form of composting.

Acknowledgments

The experimental work was conducted in the Environmental Engineering Laboratory of Department of Civil Engineering at Khulna University of Engineering and Technology, Khulna, Bangladesh. The authors would like to express thanks to the Staffs of Environmental Engineering Laboratory for their co-operation during the study.

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