AEROBIC- THERMOPHILIC COMPOSTING OF MUNICIPAL SOLID WASTES USING SOLAR ENERGY

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Received December 10, 2012 Accepted March 15, 2013

ABSTRACT

Aerobic composting is the creation of compost that depends on bacteria that thrive in an oxygen rich environment. Thermophilic composting is breaking down biological waste with thermophilic bacteria. In this study a cylindrical Aerobic-Thermophilic Bio-reactor (ATB) was made where aeration was continuously provided with the help of a fan attached to pipe arrangement in such a way that air reached all corners of the reactor. A solar panel was connected to the fan for its working. Organic waste included dry vegetable waste collected from Municipal Solid Waste (MSW) ramp, Koregaon Park, Pune, India. * Bacillus megatherium and Pseudomonas fluorescens bacteria cultures were used as they accelerate the composting process. The characteristics of compost like pH, moisture content, temperature, C/N ratio and volume reduction were studied for the period of composting 35 days (5 weeks) which was low as compare to conventional composting period (40 to 90 days). The results showed that the mature organic compost having pH near to neutral, moisture content (22.36%), volume reduction (45.43%), C/N ratio (16.5–20%) and phosphorous (2.2 to 2.5%). It can be concluded that these values are within the desired limits and compost is suitable for ornamental plants. The setup of ATB reactor is eco-friendly, effective and economical.

Key Words: Aerobic, Thermophilic, Organic waste, Bio-reactor, Composting, Solar energy, Koregaon Park, Pune

INTRODUCTION

Compost is particularly useful as organic manure which contains plant nutrients (Nitrogen, Phosphorous and Potassium) as well as micro-nutrients which can be utilized for the growth of plants. Composting can be carried out in two ways i.e., aerobically and anaerobically. During aerobic composting aerobic micro-organisms oxidise organic compounds to carbon dioxide, nitrite and nitrate. Carbon from organic compounds is used as a source of energy while nitrogen is recycled. Due to exothermic reaction, temperature of the mass rises. During anaerobic process, the anaerobic microorganisms, while metabolising the nutrients, break down the organic compounds through a process of reduction.1 A very small amount of energy is released during the process and the temperature of composting mass does not rise much. Aerobic composting is a dynamic system where in bacteria, actinomycetes, fungi and other biological forms are actively involved. Thermophilic bacteria are mainly responsible for the breakdown of proteins and other readily biodegradable organic matter.2

Solid waste management is gaining importance all over the developed and developing nations as the nuisance, pollution potential, unsightly, unhygienic conditions and the resources it is associated with are demanding more and more attention. In India increasing population levels, rapid economic growth and rise in community living standard accelerates the generation rate of MSW. The inefficient and improper methods of disposal of solid waste create serious hazards to the public health, cause pollution of air and water resources, lead to accident hazards and increase in rodent and insect vectors of diseases which interfere with community life and development. The adverse effect of solid waste on environment emphasises the need to develop new and improved methods for proper and economic solid waste management.3 From the quality analysis of the compost available in the market, it can be

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seen that unless value addition is done, the compost derived from just biodegradable waste or municipal solid waste does not have the required nutrients to be used as a fertilizer. Hence, unless properly sorted organic waste is ensured and additives to increase the nutrient content such as cow dung and other organic manure are added. Composting at 37°C also exhibited high microbial activities probably due to degradation of complex organic compounds. Microbial biomass was found to be high at 20°C and 37°C, indicating larger microbial communities at lower compost temperatures. Organic matter degradation analysis revealed no large differences in the final solid degradation rate at 55°C and 37°C. The study suggests the importance of a thermophilic–mesophilic sequence in composting to maximize the extent of organic matter degradation.

In other treatment methods like incineration and pyrolysis, air pollution problems are predominant and also initial investments are very high.

AIMS AND OBJECTIVES

To develop eco-friendly, effective and economical ATB for composting. The objectives of this study were:
1. To reduce maturation time of compost,
2. Use of renewable source of energy- solar energy for aeration purpose and
3. To generate nutrients rich compost

MATERIAL AND METHODS

The ATB was covered by wire mesh on all four sides so that air circulation is convenient. The ATB was at 0.3 m height from the ground level. The cylindrical ATB of wire mesh of diameter 0.38 m and height 0.6 m was prepared as shown in Fig. 1. It was kept in the open air with protection on the sides from birds and rain.

Municipal solid waste was collected from MSW ramp, Koregaon park, Pune metropolitan city. The collection of MSW was done using crap sampling method. In the initial stage of composting, waste was segregated to get organic waste by hand sorting method. The ATB was loaded with raw organic waste by shredding the material to approximately 5–10 cm size. A layer of dried leaves was laid at the base of ATB. Then organic waste was laid in layers, each layer being approximately 10 cm thick. The bio-degrader, Bacillus megatherium and Pseudomonas fleurescens collected from National Chemical Laboratory, Pune, India was introduced in equal proportion at every 30 cm height of the ATB. The main purpose of using these bacteria was to accelerate the process of composting. Then aeration assembly was installed. Aeration was continuously provided with the help of a fan attached to pipe arrangement in such a way that air reached all corners of the ATB. A solar panel was connected to the fan for its working having specifications as given in Table 1. In the intermediate stage of composting, mixing was done every four days. Mixing was useful to spread bacteria throughout the waste. When temperature of the waste rises to 35 °C to 40°C, it gives rise to thermophilic bacteria. This growth of bacteria goes on until the temperature

Fig. 1 : Set-up of ATB for composting
reaches 55°C to 60°C. Also, water was sprinkled on the waste to maintain its moisture content. In the last stage of composting, waste particles falling out were collected in a tub kept at the bottom of the ATB. It was seen that the particle size of waste reduced considerably. This stage was completed by the fifth week (35 days). The final composting material should be grey black to brown in colour and should have an earthy odour.9,10

Table 1 : Specifications of solar panel and exhaust fan

<table>
<thead>
<tr>
<th>Solar Panel</th>
<th>Exhaust Fan</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>Pressure</td>
</tr>
<tr>
<td>Amorphus</td>
<td>8.4 mm H₂O</td>
</tr>
<tr>
<td>Model</td>
<td>Size</td>
</tr>
<tr>
<td>HYA-02.5 A</td>
<td>80x80x24 mm</td>
</tr>
<tr>
<td>Dimension</td>
<td>Power</td>
</tr>
<tr>
<td>127x410x18mm</td>
<td>12 W DC</td>
</tr>
<tr>
<td>Peak power</td>
<td>Current</td>
</tr>
<tr>
<td>3 W</td>
<td>120 MA</td>
</tr>
<tr>
<td>Max. power current</td>
<td>RPM</td>
</tr>
<tr>
<td>0.27A</td>
<td>2200</td>
</tr>
<tr>
<td>Open circuit voltage</td>
<td>Noise</td>
</tr>
<tr>
<td>9.2V</td>
<td>32 dBA</td>
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<tr>
<td>Short circuit voltage</td>
<td>Weight</td>
</tr>
<tr>
<td>12.2V</td>
<td>320 gm</td>
</tr>
</tbody>
</table>

RESULTS AND DISCUSSION
The temperatures at the bottom and middle, on all four sides of the ATB were measured before mixing. Whereas, moisture content, organic matter content, pH, total solids, volatile solids, nitrogen content (N-Kjeldhal) of the ATB compost were measured once in a week. It was found from the study that all the organic MSW was converted to composting material in mere 35 days by using ATB as against approximately 90 days (3 months) for conventional method. All the parameters were measured for the examination of water and wastewater using standard methods. Fig. 2 shows the pH drop of the composting material due to the formation of organic acids caused by microbes degrading the organic material.

![Fig. 2 : Variation of pH of compost with time](image)

After some period, the pH tends to move towards neutral when these acids are converted to carbon dioxide by microbial action. The pH of compost at the end of fifth week is 6.7. The availability of nutrients is directly affected by the soil pH. Plants have specific pH requirements for normal growth. Fig. 3 shows the variation of moisture content versus the number of days. The moisture content lies between 57.6% and 22.36% due to the bio-
degradation of organic material and maximum respiratory activity of the organism. During the initial period, the moisture content is high (>60%) and the physical structure of the compost mixture is poor. As manure dries, the nutrients not only concentrate on a weight-basis but also on a volume-basis due to structural changes of the manure. After the stabilization period, the moisture content is reduced to 22.36%. Fig. 4 shows the variation of temperature versus number of days. The ATB is operated in the thermophilic range up to the stabilization period. Due to high temperature all the pathogenic organisms are eliminated. Also heat generation results from microbial activities, and hence the composting process experiences an initial rise in temperature followed by declining and stable temperature attained as microbial activities decreases due to lower levels of available organic matter.

Fig. 3 : Variation of moisture content of compost with time

Fig. 4 : Variation of temperature of compost with time

Fig. 5 shows the volume reduction versus number of days. The volume reduction was observed from the 14th day onwards. The final volume reduction was observed to be 45.43%. Fig. 6 shows the nutrient values of compost versus time of days. C/N ratio decomposition of
organic matter is brought about by microorganisms that use carbon as a source of energy and nitrogen for building cell structure. The more stabilized final product is indicated by the matured compost value (16.5–20%) and this value is within the allowable limit of organic compost. It was achieved by a proper mixing process using exhaust fan and maintaining pH (7.2–6.7) and Fig.7 shows analysis parameter of compost versus time of days.

Fig. 5 : Variation of volume reduction of compost with time

Fig. 6 : Variation of constituents in compost with time
Fig. 7: Analysis parameter of compost v/s time in days

CONCLUSION
The physicochemical analysis showed that the compost from the ATB provides good compost to build up poor physical soil properties and gives basic plant nutrients. The results of the investigations enable one to prove the usefulness of the ATB composting method for utilizing MSW. Due to the addition of bacteria culture, the composting process was accelerated. The maturation period was 35 days (five weeks). Aeration provided with the help of solar energy which increased the efficiency of process. Proper mixing and adequate aeration in composting process reduces odour emissions and composting period. All these helped to keep various parameters like pH, temperature, moisture content, C/N ratio within desired limits. The final compost obtained is suitable for ornamental plants like azaleas, gardenias, camellias, etc. The cost of setup is approximately INR 4000 only. Thus it can be concluded that the adopted composting method is found to be effective and economical.

REFERENCES
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