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SHORT COMMUNICATION

An integrated approach of composting methodologies for solid waste management

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ABSTRACT: Organic fraction of solid waste, which upon degradation produces foul smell and generates pathogens, if not properly managed. Composting is not a method of waste disposal but it is a method of waste recycling and used for agricultural purposes. An integrated approach of composting methodology was tested for municipal solid waste management. Solid waste first was composted and after 22 days, was further processed by vermicomposting. Samples were routinely taken for analysis of carbon, nitrogen, moisture content, pH and temperature to determine the quality of composting. Decrease in moisture content to 32.1 %, relative decrease in carbon and nitrogen content were also observed. Among the different types of treatment, municipal solid waste + activated sludge integration showed promising results, followed by vermicomposting municipal solid waste + activated sludge combination, compared to the combinations of dried activated sludge, municipal solid waste + activated sludge semisolid and municipal solid waste + sewage water. Thus, windrow composting followed by vermicomposting gave a better result than other methods. Thus this method would serve as a potential alternative for solid waste management.

KEYWORDS: *Aerobic decomposition; Composting; Municipal solid waste (MSW); Sewage sludge; Vermi pits*

INTRODUCTION

Solid waste management is gaining importance all over the developed and developing nations. In India due to increasing population, economic growth and urbanization has impacted generation of municipal solid waste (MSW). The inefficient handling and improper disposal of solid waste pose hazards to the public health and environment deterioration (Kumar *et al*., 2011). In India traditionally the disposal process of MSW has been through burial, burning and ocean dumping (CPCB, 2014). Burning leads to toxic dioxins emissions, more carbon dioxide and particulate matter leading to severe air pollution, also disrupting aquatic environment hence landfill has now become the main waste management method, but due to scarcity of land and also because of various contaminates such leachate emission has rendered landfill as no longer, a sustainable option of solid waste disposal method (Soobhany *et al*., 2015a; Soobhany *et al*., 2015b). In the year 2014, 55 million tonnes per year solid waste was generated across India. (Singh *et al*., 2014a). Among the total solid waste generated, around 70% was collected and only 12.45% was either processed or treated (Lee *et al*., 2009).

Efficient management of solid waste impacts positively on the environment and it plays a vital role in the improvement of human health and quality of life (Hill and Baldwin, 2012). A number of processes have been explored for effective management of solid waste and composting is one potential method in managing the organic nutrient residues originating from agricultural residues, as it is biodegradable (Lalander

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et al., 2015; Hussain et al., 2015; Vig et al., 2011). Further, hybrid process of aerobic and anaerobic treatment of wastewater has been proven effective. (Omid et al., 2015). It is now accepted that no single solution exists for the management of MSW, and only integrated approaches are most likely to succeed (Blanka et al., 2014; Fu et al., 2015). Thus we are proposing here an integrated approach by combining windrow composting and vermicomposting to achieve maximum decomposition. This study has been performed in Kumaraguru College of Technology during 2013.

MATERIALS AND METHODS

Collection and classification of solid wastes

The fresh solid waste was collected from the municipal waste yard located at Vellalur, Coimbatore, Tamilnadu, India. The collected solid waste was then classified based on its size (above and below 100 mm) by trammel. The materials which are above 100 mm materials are used for reuse / recycling purposes. Larger inert objects (plastic, metal and glass) in the sorted organic fraction municipal solid waste were removed by hand. Inorganic matter was below 100 mm was used for composting purposes as it contains most of the organic materials.

Estimation of microbial population in different inoculum

The activated sludge which are aggregates left after the treatment of waste water was obtained from the sewage treatment plant (STP) located at KCT, Coimbatore, Tamilnadu- India. The samples were serially diluted and the bacterial isolates were screened on Luria Bertani (LB) agar plates by the standard pour plate method. Plates were incubated at 60 °C for 24 h and were subjected to colony counting to analyze the growth of thermophilic bacteria in the activated sludge sample (Fu et al., 2015). The number of microbial colonies grown was calculated using the Equation 1:

$$\text{Viable Cell Count} = \frac{\text{Number of colonies}}{\text{Volume plated (ml)} \times \text{Total dilution Used}} \quad (1)$$

Aerobic composting (windrow)

The aerobic treatment is to be done in the presence of oxygen. The solid wastes were piled up into five different types of windrows as per Table 1 (height of 50 cm and length of 4 m). Once in 4 days, the windrows were wetted and mixed for proper aeration. When the microorganisms utilize the carbon source from the waste, they produce acids which may lead to decrease in the pH of the compost. To avoid it, turning of the compost was done once in three days. This process may also reduce greenhouse gases emission. (Su et al., 2015). The moisture content was maintained in a range of 40% - 60% throughout the process.

Table 1: Types of windrows based on their content

Types	Particulars
Windrow 1	MSW + Activated sludge
Windrow 2	MSW + processed sludge
Windrow 3	MSW + Raw sewage
Windrow 4	Dried activated sludge
Windrow 5	MSW + Filtrate

Vermicomposting

Earthworms belonging to species *Eudrilus eugeniae, Perionyx excavatus* were used in this study (Yadav et al., 2012). About half kg of earth worm was used. The wastes which were partially degraded by windrow composting (around 20 days) were transferred to vermi pits. The vermi pits are kept away from sunlight and rain since it will affect the growth of the worms. The favorable conditions for the earthworms were: temperature less than 30 °C and pH in the range of 7 – 8.5. In order to maintain these conditions, the vermi pits was watered for 3 days such that the temperature will be reduced. The pH and temperature changes were monitored once in 5 days (Amossé et al., 2013; Suthar, 2009).

Biological and chemical analyses

This involves the estimation of pH, temperature, carbon content, C: N ratio, phosphorus, potassium and moisture content in the sample after it got composted (Javed et al., 2012). The composted samples were drawn after 22 days and analyzed.

RESULTS AND DISCUSSION

Estimation of microbial population

The microbial populations were characterized from samples from the sludge and sewage. Two isolates are dominant among the samples and were subjected to MALDI-TOF analysis, it has been confirmed that the two cultures were *Lactobacillus delbrueckii* and *Bacillus badius.* These two organisms are identified as Gram positive bacteria and non-motile in nature (Xing et al., 2012 and Moreno et al., 2009).

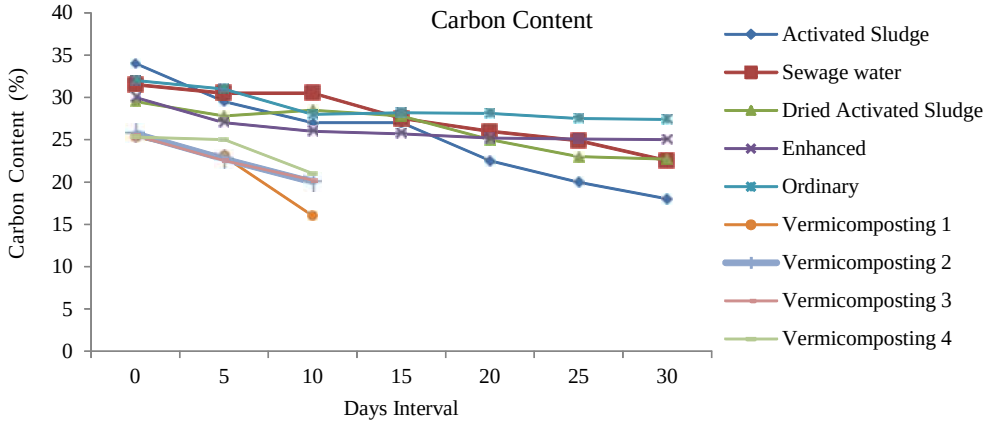

Fig. 1: Comparison between the carbon content of initial and final samples of the compost

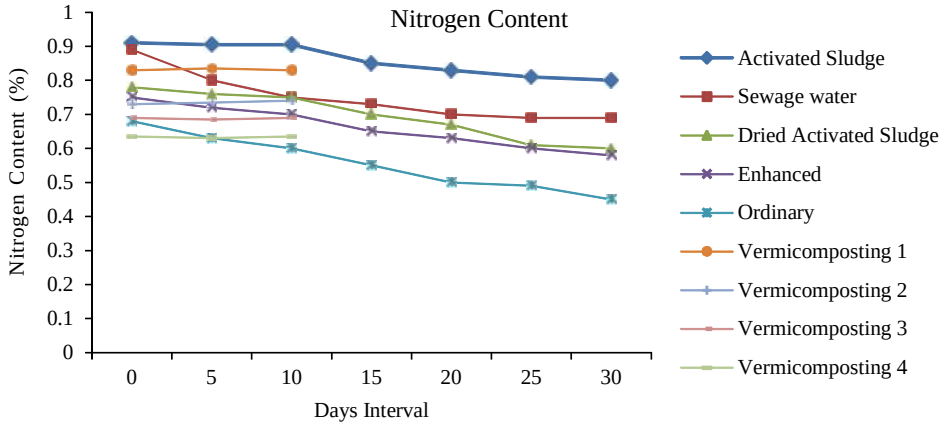

Fig. 2: Comparison of nitrogen levels in compost samples

Biological and chemical analyses

The samples were collected at an interval of four days for monitoring the chemical and biological changes that were formed during the composting. Carbon content, nitrogen content, moisture content, pH and temperature of the samples serve as a pointer on the efficiency of each solid waste management approach (Joo *et al.*, 2015; Xing *et al.*, 2012).

Analysis of parameters

Important parameters like Carbon, nitrogen, pH, moisture content, and temperature were analyzed. It was observed that there is decrease in the carbon content in the final sample when compared to the initial (Varma *et al.*, 2015); (Fig. 1). This is because the microorganisms utilized carbon for their growth, the decrease in the carbon content also indicate better decomposition of the organic compounds. Similar results were reported by others (Singh *et al.*, 2011a). Initial C: N ratio for enhanced sludge is 38.96. Final C: N ratio is 41.93 indicating relative decrease in nitrogen content. As the activity of microbes increases, nitrogen consumption is increased for metabolic activates. Nitrogen is also lost due to ammonification, which occurred due to high moisture content at active degradation stage. After the death of microbes, they undergo decomposition and nitrogen content increases slightly at the final stage. Nitrogen content is high in vermicomposting compared to windrow compost due to the addition of mucus and nitrogenous excrements from the earthworms. The results obtained coincide with the results obtained from other studies (Singh *et al.*, 2011b). The comparison between the nitrogen content of initial and final samples of the compost are shown in Fig. 2.

Analysis of moisture content

The moisture content lies between 58.6% and 32.1% due to the bio- degradation of organic material and

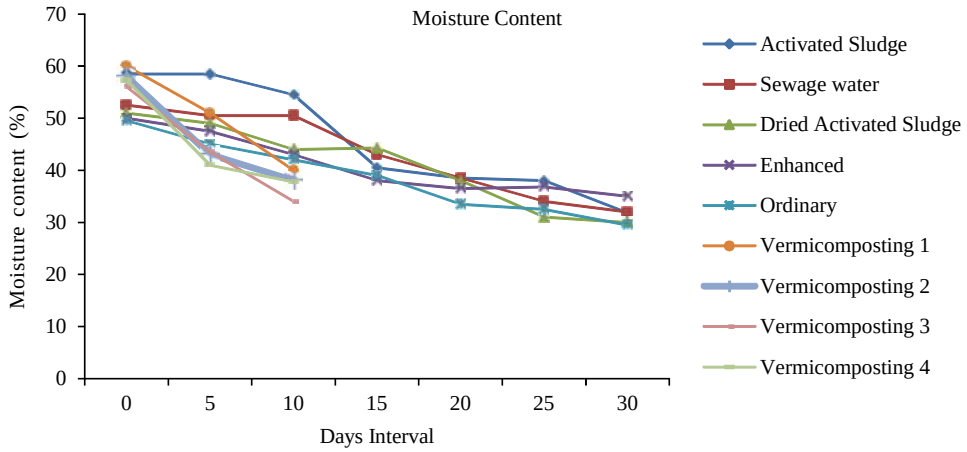

Fig. 3: Comparison of moisture content between various compost samples

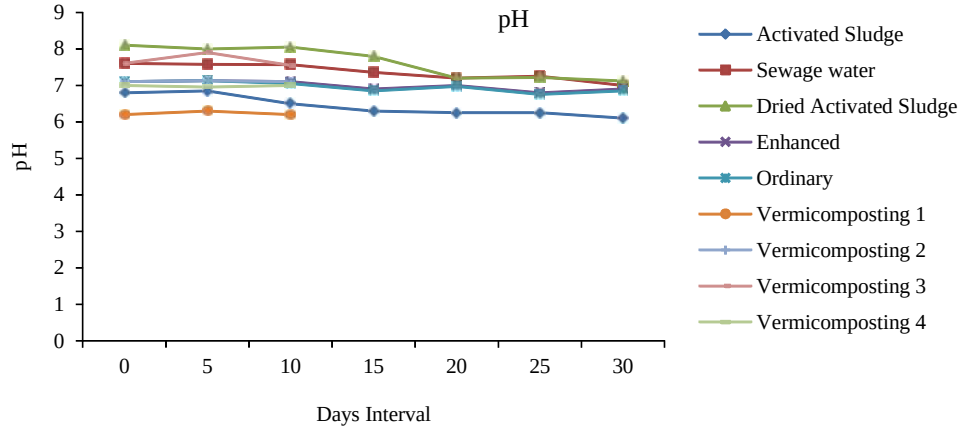

Fig. 4: Comparison of pH between the initial and final sample

maximum respiratory activity of the earthworm. During the initial period, the moisture content is high (>50%) 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 (Fig. 3). After the stabilization period, the moisture content was found to be reduced to 32.1% (Lleó *et al*., 2013).

Analysis of pH

Fig. 4 indicated that the pH was higher in the initial sample compared to the final sample. This change in pH from alkaline range to acidic range was due to the activity of fungi and other mesophilic organisms and also due to the formation of organic acids. Optimum pH range for most bacteria is 6-7.5 and fungi are 5.5-8. At lower pH in addition to bacteria, fungi acted upon the waste material and enhance the decomposition (Yadav *et al*., 2012).

Analysis of temperature

Initial temperature was around 33 °C in the wastes. As the composting process progressed the temperature rose to 62±3 °C (Fig. 5). This rise in temperature is necessary for the destruction of pathogenic microorganisms. The rise in temperature was due to the heat released by the microbial activity in conversion of organic matter. Favorable temperature for the earthworms to feed on waste is around 30 °C. Thus, the temperature was brought down from 44 °C – 45 °C to 33±2 °C by watering for three days. Further the temperature was maintained till the completion of the

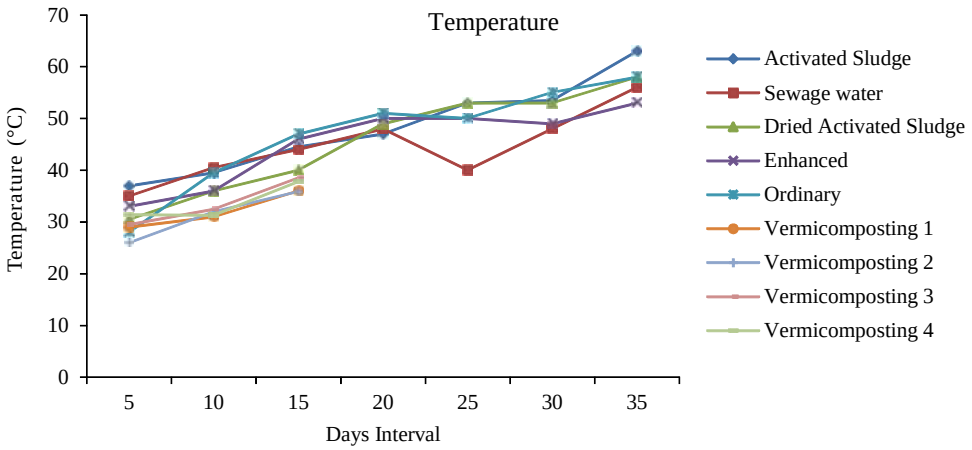

Fig. 5: Comparison of temperature between the initial and final samples

process. By proper watering 40-60% of moisture content was maintained throughout the process hence maintaining the temperature. This variation in temperature was also reported by Lleó *et al*., 2013.

CONCLUSION

Though various methods are available for treatment of municipal solid waste, the proposed method uses the waste from sewage treatment plants which has the advantage of treating two types of wastes under one method. Five different types of treatments were involved, among the MSW + Activated sludge integrated with vermicomposting was best among all the combination, followed by MSW + sewage integrated with vermicomposting. Of these, integrated methodologies gave a solution for solid waste disposal with minimal expenditure and the quantity of waste to be disposed of in landfill was minimized. Thus solid waste disposal can be reduced when integrated approach applied in larger scale and further conversion of waste to manure via vermicomposting serves as a value addition and can be a source of revenue for the agrarian sector.

CONFLICT OF INTEREST

The authors declare that there are no conflicts of interest regarding the publication of this manuscript.

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