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Rapid Composting Through Enzymatic Application in Organic Fraction of Municipal Solid Waste during Aerobic Composting Process

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***Abstract* – This paper describes the windrow composting of municipal solid waste in large scale composting reactor where solid waste was converted into matured manure with short span of time. Municipal Solid Waste (MSW) consists of organic (Biodegradable) and inorganic (Non-Biodegradable) wastes, in which the organic waste degrades naturally in 50-60 days. The addition of prepared inoculums into the composting reactor fastens the composting process rapidly by the action of enzymatic hydrolysis which reduced the time span and the volume of municipal solid waste to lower extent. Initially, higher organic carbon was observed in the reactor which was reduced into 50% of the initial organic carbon content, confirms the reduced volume of municipal solid waste in the reactor to 75% of initial volume. Eventually, the nutrient (NPK) evaluation confirms that the organic waste was converted into matured manure. Moreover, the C/N ratio of initial and final phase of composting reactor was analyzed for the confirmation of matured manure.**

***Keywords*— Municipal Solid Waste (MSW), Windrow composting, microbial growth rate and C/N ratio.**

I. INTRODUCTION

MSW is an inhomogeneous waste comprising of digestible organic, combustible and inert fraction. In general, MSW consists of 50% of organic content which states the importance the source separation in MSW management (Maria et al., 2007). Solid wastes are those organic and inorganic waste materials produced by various activities of the society, which have lost their value to the first user. Improper disposal of solid wastes pollutes all the vital components of the living environment (i.e., air, land and water) at local and global levels. The problem is more acute in developing nations than in developed nations, as their economic growth as well as urbanization is more rapid.

There has been a significant increase in MSW (municipal solid waste) generation in India in the last few decades. This is largely because of rapid population growth and economic development in the country. Due to rapid growth of urban population, as well as constraint in resources, the management of solid waste poses a difficult and complex problem for the society and its improper management gravely affects the public health and degrades environment. Municipal solid waste (MSW) management poses a challenge to all developing countries, which substantially increases the environmental pollution day-by-day.

For developing countries, the per capita waste generation rate ranges from 0.4 to 1.1 kg per day which makes more urge for identifying the optimum technique for managing MSW preferably with more advantages. MSW can be possibly disposed by sanitary landfill, composting, incineration and anaerobic digestion. Sanitary landfill is a traditional engineered tool for managing MSW in which infiltration of rain water to leachate adversely affects the groundwater system in the vicinity. Incineration brings threat in the form of air pollution and consumes more energy for combustion process. Composting is successful because it is a low cost and low infrastructure set-up and also produces manure, which is a marketable byproduct. In addition to making a positive contribution to agriculture, the sale of organic wastes reduces the amount of waste to be collected and disposed of by municipal authorities. Composting of MSW is undertaken by either of the two methods – Windrow composting or Vermi-composting. Landfill mining and bio-remediation are other ways of extracting compost among other resources from landfills. With all modern waste treatment technologies there are problems relating to the complexity of waste which need to be addressed (Maria et al., 2007).

Windrow composting facilities can efficiently handle large quantities of waste in comparison to vermin-composting. Composting depends many factor especially windrow composting depends oxygen supply and temperature. There was limited diffusion of oxygen to the bottom of the reactor, with a granule diameter of <40 mm, the volume of air supplied to all the reactors exceeded the microorganisms' theoretical demand (Maria et al., 2007).The problem with oxygen diffusion may have been caused by the high bulk density of the waste, and could be solved by installing a ventilation system in the bottom of the reactor, which is a promising subject for further research at a technical scale (Maria et al., 2007). In addition to this Kasinski et al., (2014) stated that with passive aeration, it is possible to effectively stabilize the organic fraction of mechanically separated municipal solid waste within 25 days (Maria et al., 2007; Rynket al., 1992). The thermophilic phase was reached within 2–3 days (Kasinski et al., 2014). The variation of compost properties implies management issues for their sustainable utilization in agriculture. Thus, compost management should depend on, and adjust according to the specific characteristics of each compost type and batch produced. (Maria et al., 2007). This present study deals to find the optimum method to decompose the organic solid waste rapidly, optimize the time taken for composting using a windrow composting method through laboratory arrangements and monitor the overall volumetric reduction & the total weight reduction of the waste on a daily basis

II. MATERIAL S AND METHODS

2.1 Study Area and Sample Collection

Avadi, a special grade municipal town in Tiruvallur district was selected for the study. Stratified random sampling technique was followed in order to eliminate the areas of non-uniform properties or concentrations which was identified and stratified. Thereafter, simple random technique was followed so as to obtain a representative sample (CPCB, 2013) and these was carried out at the study area of Avadi Municipality located adjacent to in Chennai city of Tamil Nadu province in India. The random sampling was carried out in different sources of segregated organic waste viz., residential colonies, vegetable market, flower shops, fruit shops, hotels, restaurants etc., restaurants and the same was pooled further into a composite homogenized sample for composting processes.

2.2 Mechanical Shredder For Carrying Out Size Reduction

The collected organic waste was subjected to shredding process and the waste sample break into manageable pieces approximately 1.5 to 2 cm. The shredded organic waste was stored in a tub constructed for carrying out further process at room temperature.

2.3 Tub/cubical Specifications

Tub/cubical having size of 3.60m×1.80m×1.00m (L×B×H) was constructed with brick work with pipes fitted in the side wall as openings for continuous aeration. The air enters the composting tubs through these openings provided at the side walls in order to achieve uniform distribution of air throughout the period.

Fig. 1 Large scale composter

2.4 Composting Process

The shredded waste contains organic fraction of MSW of weight 5.18 T, is mixed with fermented solution, seed inoculum with rice-husk media in the ratio of 1:16 was filled in the tub which has a volume of 6.48m3. To monitor the composting process, sample were collected on daily basis. The parameter such as TS, VS, and pH of the solid waste was noted at every 24 hrs. A continuous monitoring of the volumetric reduction of the vegetable waste and the temperature of the degrading waste was done.

III. RESULTS AND DISCUSSION

3.1 Effects of moisture and temperature

Initially degradation occurs due to mesophilic microorganisms. The moisture content is retained around 77% by fine grinding. The moisture content is reduced by adding bulking agent which also helps in the increase of surface area where the micro organisms grow. The moisture content decreases as the temperature increases with time. The growth of micro organisms is initially low due to lack of oxygen. As the temperature increases, moisture content decreases with time. After 2 days, activity of microbial organisms is high where the enzyme produced by this activity, disintegrates the substrate where very high of thermophilic bacteria was evolved during the peak of the degradation rate. Afterwards activity of microorganism gradually decreased where the temperature reduced to mesophilic condition.

3.2 Effects of pH on Composting

The pH of the finely shredded substrate is checked before feeded into the reactor. Result states that this pH could enhance the growth of micro organisms which results in matured compost. Since the moisture content is high, the system becomes anaerobic due to lack of oxygen supply (Michel et al., 1996; Brodie et al., 2000). This could be the reason for the acid accumulation which tends to reduce the pH value. However, the reactor recovers itself by high

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microbial activity which increases the temperature to thermophilic. Further, the accumulation of ammonia in the reactor could increases the pH with elapsed time where the alkaline condition of the reactor confirmed the maturity of compost (Gabhane et al., 2012).

3.3 Effects of Carbon-Nitrogen Ratio on Composting

The carbon to nitrogen ratio is major compound which decides the maturity of the composting period where the carbon is for growth and the nitrogen is for protein synthesis. Decreasing trend of C/N ratio was observed initially attributed to the high carbon degradation rate. Thereafter, sudden rise and fall in the C/N ratio was observed with days elapsed (Michel et al., 1996). Ammonia are converted into nitrite and nitrate so that decrease in nitrogen compounds makes increase in C/N ratio. This could be due to the accumulation and releasing of ammonia resulting from the nitrogenous compound degradation whereas the carbonaceous content was digested and released in the form of CO2. Eventually, nutrients formation/accumulation as NPK makes decreased C/N ratio which confirms the maturity (Kumar et al., 2011; Witter & Real 1987). For an efficient composting, C/N ratio 30 is preferable. For instance, Kumar et al., (2011) revealed that C/N ratio of 25-35 is appropriate for rapid and efficient composting.

3.4 Volume and organic strength reduction in compost

The volume reduction was depends on optimized enzyme and substrate concentration. No volume reduction was observed during initial day which was coincided with results reported by Michel et al., (1996); Witter & Real (1987). However, the increasing microbial activity increased the substrate hydrolysation and further conversion into gaseous state was observed as the days progress. This could lead to high reduction of volume (26%) in this slurry state within 2-5 days. Thereafter, the steady state of reduction was observed upto 7th day where the shrinkage limit of the volume reduction was achieved. Eventually no volume reduction was observed at the end of the experiment was attributed by the shrinkage limit.

IV. CONCLUSIONS

- Enzymatic composting enhanced the high microbial activity
- The composting period was shortened and rapid size and volume reduction was achieved.
- Enriched manure was obtained with short span
- High biological conversion rate was achieved even with the low initial C/N ratio

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