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Enhanced composting of municipal solid waste using external microbial catalyst

Namasivayam Vasudevan, Sevu Natarajan, Odukkathil Greeshma*

Centre for Environmental Studies, Anna University, Chennai, Tamilnadu, (INDIA)

E-mail : greeshma.o@gmail.com

ABSTRACT

Composting of municipal solid waste is a common practice of managing MSW by which waste is converted into value added products. About 70 to 80 % of MSW consist of biodegradable waste, which makes them an efficient compostable material. However, the selection or development of a suitable composting system is vital for the production of high quality compost. The process of natural composting is a time consuming process and in view of the rapid increase in population and subsequent increase in production of waste, the composting of large volumes of Municipal Solid Waste by natural process requires a very large area. The focus of this study was on enhancing the composting process using external microbial catalysts (EM (A) & EM (B)). The study was carried out in three categories of waste namely, i) lower income group waste (LIG), ii) higher income group waste (HIG) and iii) food waste (FW) for a duration of 45 days. The nutrients in the compost were carbon 5.3 to 26%, organic nitrogen 0.54% to 2.3%, phosphorus 0.20% to 0.86 %, and potassium 0.64% to 1.1%. Composting using the microbial catalyst EM (B) showed a higher percentage of composting in LIG (97%), in HIG (95%), FW (98%) in 45 days. The study revealed that use of microbial catalyst can enhance the composting process.

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KEYWORDS

Municipal solid waste;
Composting;
Food waste;
External microbial catalyst;
Effective microorganism;
Municipal solid waste management.

INTRODUCTION

Municipal Solid Waste Management (MSWM) is a challenging problem in all the developing countries. Dumping the municipal solid waste (MSW) in open dumpsite is a common practice followed in all countries. Recently, due to land degradation and increase in per capita generation of municipal solid waste along with population explosion, conversion of municipal solid waste to value added products has become the focus of many developing countries. Composting helps in managing large quantities of organic wastes in a sustainable manner. It is one of the technologies of integrated waste management strategies, used for the recycling of organic materials into a useful product[1].

Composting may be defined as a method of solid waste treatment, whereby the organic component of the solid waste is biologically decomposed under controlled conditions to a state in which it can be handled, stored, and/or applied to land without adversely affecting the environment[2,8] defined composting as the biological decomposition and stabilization of organic substrates under conditions that allow development of thermophilic temperatures as a result of biologically produced heat, to produce a final product that is stable, free of pathogens, and plant seeds, and can be beneficially applied to land.

Composting is an efficient way of managing MSW but time consumption and area requirement are the major limitations. This is due to the fact that composting is dealing with a solid substrate, which needs a longer time to be degraded by microorganisms. In addition, the heterogeneous nature of MSW slows down the degradation process, since the easily biodegradable materials will be degraded at the beginning of the process, and after that the more complex organics will be assimilated[3]. Hence, for enhancing the composting process proper group of microbes which can survive and adapt to the varying conditions of the compost is very much essential.

In view of the above reason, a study was conducted on composting of MSW by using two different formulations of effective microorganisms (A&B). E. M solution is used as the microbial catalyst for enhancing the composting process. The investigation was also carried out to examine the effect of EM solution on composting of various categories of MSW.

EXPERIMENTAL

Collection and processing of MSW

Three categories of municipal solid waste were used in the present study namely, i) low income group (LIG), ii) high income group (HIG) and iii) food waste (FW). Low income group MSW was collected from Vysarpadi municipality of Chennai city, Perambur municipality of Chennai and food waste from a marriage hall in Vysarpadi municipality of Chennai city. The waste materials were air-dried and segregated from inorganic materials such as glasses, plastics, metal objects and other inerts etc. After segregation, the waste was shredded for composting process. Microbial catalysts used for the study are commercially available EM solutions of two different formulations (EM (A) & EM (B)).

Experimental set up

Composting was carried out in composting pit of size 1m x 0.5m x 0.75m constructed using bricks in a composting yard. About 27 Kg air dried shredded waste of each category (LIG, HIG and FW) was filled separately in the composting pits. The microbial catalyst was activated in the ratio of 1:1:20 (Microbial catalyst, Jaggery and water) on weight basis for 7 days. About 200 ml of activated microbial catalyst was sprayed over all the composting material and left for composting for duration of 45 days. One set in all three categories of MSW was kept for natural composting without spraying microbial catalyst and the other with microbial catalyst (TABLE 1). The composting material was periodically turned for proper mixing. Samples were collected from each composting pit on 15th, 30th and 45th day and were characterized for assessing the quality and rate of composting.

TABLE 1 : Combination of MSW and microbial catalyst used in the study

Combination	Category of MSW	Microbial Catalyst
LIG Control	LIG[1]	Without Catalyst
HIG Control	HIG[2]	Without Catalyst
FW Control	FW[3]	Without Catalyst
EM (A)-LIG	LIG	EM (A)[4]
EM (A)-HIG	HIG	EM (A)
EM (A)-FW	FW	EM (A)
EM (B)-LIG	LIG	EM (B)[5]
EM (B)-HIG	HIG	EM (B)
EM (B)-FW	FW	EM (B)

[1]low income group,[2]high income group,[3]food waste, [4]effective microorganism, [5]effective microorganism

Physico-chemical analysis of the compost

Samples drawn from the composting pit were analyzed for physico-chemical parameters. pH of the compost was analysed by mixing compost in water in the ratio of 1:10. The organic carbon content of the compost was estimated by Walkley and Black method[4], total nitrogen by Kjeldahl method, total phosphorus by stannous chloride method[6,7], potassium by using flame photometer[5]. Volume reduction in the compost was also monitored during the period of composting. All the analysis were carried out in duplicates and the results are interpreted as the average of those values.

RESULTS AND DISCUSSION

Composition of the municipal solid waste

Municipal solid waste from low income group and high income group consisted of similar quantity of biodegradable waste. HIG waste had more cellulose based products such as cardboards and dry plant biomass whereas LIG waste had slightly more kitchen waste than HIG waste. Out 27 Kg of LIG MSW collected, 22.75 Kg of MSW consists of biodegradable waste, in HIG biodegradable waste was 22.67 Kg and food waste consisted of only biodegradable waste like rice, edible oil, vegetables, pulses etc. (TABLE 1). About 84% of MSW (LIG and HIG) used for the study consisted of biodegradable material. Higher the percentage of biodegradable organic waste in MSW, it is an excellent substrate for composting. Another quality for an excellent composting is C/N ratio, which was within the range of 30:1. It is one of the most important aspects of the total nutrient balance. This parameter is important in assessing the suitability of a given waste as a substrate for composting[10]. During active aerobic metabolism, microbes use about 15–30 parts of carbon for each part of nitrogen, i.e., C/N=15 to 30[3]. pH and moisture content of the MSW used for the study was in the range, 6.0 to 8.0 and 25 % to 30% respectively.

Variation in organic carbon content on composting

Organic carbon content in the nine composting pit is represented in Figure 1. In general, there was considerable decrease in organic content in all the composting pits. During LIG waste composting, the organic carbon reduced from 25.8% to 5.6% with EM (A)-LIG, to 5.3% with EM (B)-LIG and to 7.5% in LIG Control respectively. In HIG composting process, reduction of organic carbon was from 26.2% to 6.6% with EM (A)-HIG, 26.2% to 6.3% with EM (B)-HIG and 26.9% to 15.5% with HIG Control respectively. In the case of food waste, there was higher reduction in carbon in all the composting mixture, 66% to 5.9% in EM (A)-FW, to 6.9% in EM (B)-FW and to 26% in FW Control.

TABLE 2 : Composition of municipal solid waste

Composition	Low Income Group (Kg)	High Income Group (Kg)	Food Waste (Kg)
Plastics	3.50	3.13	-
Paper	2.00	2.25	-
Organic decomposable waste	17.50	14.25	27.00
Cardboards	1.50	2.40	-
Iron, Thermocoal & Glass Bottle	0.75	1.20	-
Fabric waste	0.75	0.53	-
Dry Leaves and coconut Shells	1.00	1.50	-
Total	27.00	27.00	27.00

Comparing the nine composting pits, the composting of MSW using microbial catalyst EM (A) and EM (B) showed higher reduction in organic carbon up to 85% in LIG, up to 81% HIG and up to 50% in FW from fifteenth day to 45th day. In the case of control, carbon reduction was comparatively less. Moreover, the composting by using the microbial catalyst was faster. Haug[2] defined composting as the biological decomposition and stabilization of organic substrates under conditions that allow development of thermophilic temperatures as a result of biologically produced heat, to produce a final product that is stable, free of pathogens, and plant seeds, and can be beneficially applied to land. Thus in the present study faster and higher reduction in the carbon proves proper stabilization of the organic content.

C/N ratio of the compost

Change in the C/N ratio during the composting process in all the composting pits is represented in Figure

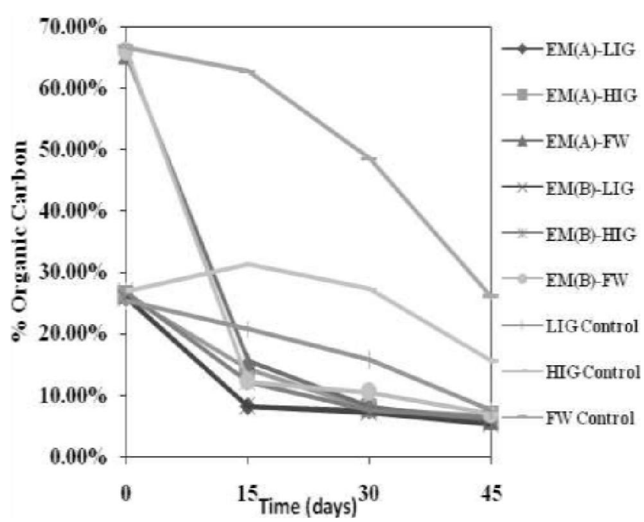

Figure 1 : Variation in the carbon content during composting of MSW

2. In general there was considerable decrease in the C/N ratio in all the composting process. Reduction in C/N ratio during LIG composting was from 31.5 to 9.8 in EM (A)-LIG, 31.3 to 9.7 in EM (B)-LIG, 31.9 to 13.5 in LIG Control. In HIG, the C/N reduction was from 32.6 to 10.5 in EM (A)-HIG, 32.4 to 9.5 in EM (B)-HIG, 33.2 to 10.6 in HIG Control. In the case of food waste composting, the C/N reduction was from 43.3 to 10.7 in EM (A)-FW, 43.4 to 10.5 in EM (B)-FW, 43.1 to 11.3 in FW Control.

In all composts, C/N ratio was below 20 which indicate the compost maturity. Similar result was re-

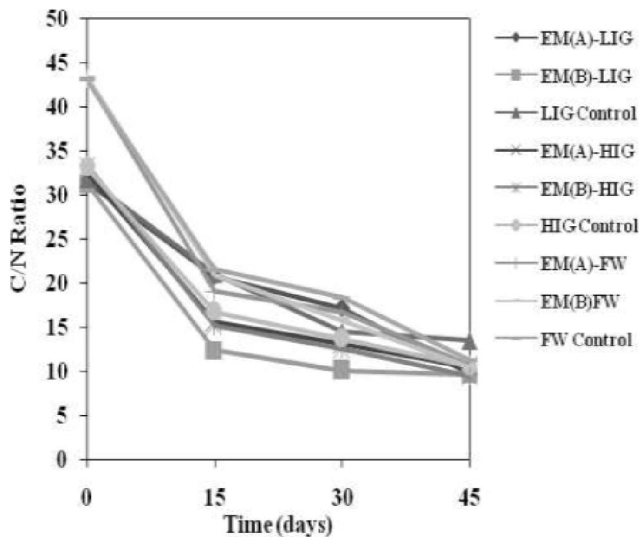

Figure 2 : Changes in the C/N ratio of MSW during composting process

ported during the composting of sugarcane and coffee byproducts, but in a longer duration of time[12]. Composting using microbial catalyst EM (B) attained compost maturity in a shorter period of time (15 days). It has been reported that during efficient composting, the C/N ratio is expected to decrease because of degradation of organic matter and mineralization[9]. Present study also shows a decrease in C/N ratio and EM (B) proved out to be an efficient microbial catalyst for enhancing the composting process. Carbon and nitrogen are the most important constituents of organic matter. Rather than the total concentration, the balance between organic and mineral forms will influence the agronomic use of the waste[11]. The low organic content in the composts of 45 days old were very low, which may be due to the maturity of the compost was attained by 15 days.

NPK content in the compost

Nitrogen, phosphorus and potassium (NPK) content in the compost is represented in the Figure 3. Nitrogen content in the compost ranged from 546 mg/Kg to 2300 mg/Kg. Among the nine composts, nitrogen content in all the control compost was high; moreover FW control showed a higher nitrogen content of about 2300 mg/Kg. In the other composts with EM (B) and A, the nitrogen was minimum of about 546 and a maximum of about 854 mg/Kg. Relatively high nitrogen content in the FW control could be attributed to the difference in the composting material used. High nitrogen in the FW control was due to the presence of highly nitrogen rich components in the food waste. Higher nitrogen content in all the control composting process was due to the slow composting process. Phosphorus content in the compost ranged from 161 mg/Kg to 812 mg/Kg. Phosphorus also showed a similar trend as nitrogen. NPK ratio were found within the acceptable limits as prescribed for soil conditioning similar observation have also made by several other workers[14-17]. Potassium ranged from 360 mg/Kg to 1090 mg/Kg with FW control showing higher potassium content. NPK ratio in the control compost was higher, whereas with EM (B) and EM (A) it was almost similar. Higher NPK in all the control can be attributed to the slow mineralization process.

Percentage of composting

Composting of MSW by three different methods was

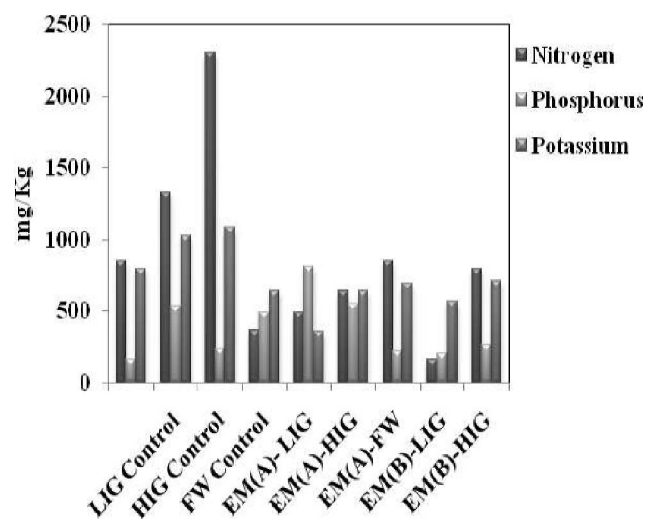

Figure 3 : NPK concentration of the compost

compared on the basis of sieve analysis performed on 45th day of composting. Percentage of composting for all the composting process is represented in Figure 4. In general, there was an enhancement in composting process by using microbial catalyst in comparison with the control. Among the two microbial catalysts used EM (B) proved out be slightly better than EM (A) in enhancing the composting process reaching 95 to 98%. Moreover among the different waste used there was a higher volume reduction for food waste in which microbial catalyst was added for composting. The reduction (98%) on a dry weight basis achieved in this study during food waste composting was significantly higher than reported for conventional solid-state decomposition of food wastes (37%)[13]. Volume reduction while the composting of MSW was also reported in many other studies[17]. Comparing with other studies volume reduction during composting was higher and was achieved in a shorter period of time. This may be due to the enhanced degradation of MSW by effective microorganism.

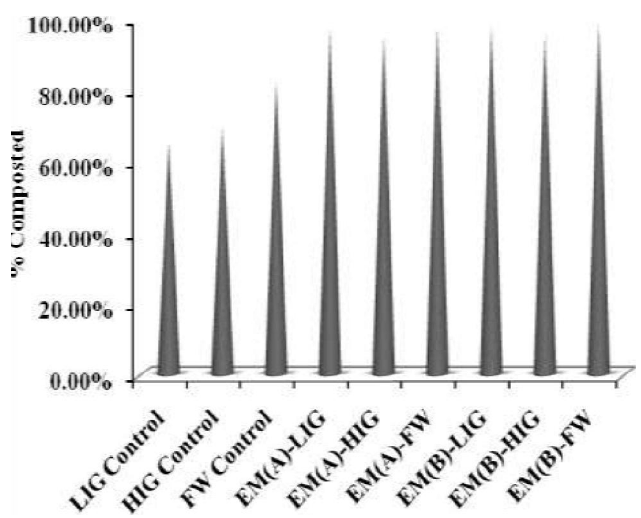

Figure 4 : Percentage of composts produced after four weeks

CONCLUSION

Composting of solid waste in a shorter period of time is necessary for proper management of solid waste produced in a city. Time lag for composting process is one of constraints in MSW composting. In present study, microbial catalysts were used for enhancing the composting process. The study revealed that microbial catalyst can bring compost maturity in a shorter period of time. It is evident from the study that the degradation of organic matter in MSW was rapid in case of enhanced composting using microbial catalyst. It was observed that there was an appreciable reduction in volume in microbial composting of solid waste.

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