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Experimental Studies on Co-composting of Municipal Solid Waste with Paper Mill Sludge

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In this study, a series of experimental studies were conducted with regard to bioconversion of organic fraction of municipal solid waste along with paper mill sludge at different C/N ratios. About 10 kg of shredded waste containing paper mill sludge, saw dust and municipal solid waste was placed in reactors in different proportions and 100 mL of effective microorganisms was added to it. The variation in physical and chemical parameters was monitored throughout the process. The results indicate that co-composting of paper mill sludge with municipal solid waste produces compost that is more stable and homogenous and can be effectively used as soil conditioner.

Key words: *Municipal solid waste, effective microorganisms, reactor composting*

Introduction

Since the early 1970s, Solid Waste Management (SWM) has received increasing attention from researchers and policy makers concerned to establish a sustainable management system.[1] Rapid urbanization has led to overstressing urban infrastructure services including municipal solid waste management because of limited resources available with the municipality.[2] Tamil Nadu in India is one among most urbanized states in India with its 43.86% of population living in urban areas. Composting is considered one of the most suitable approaches for disposing of solid waste and for increasing the amount of organic matter that can be used to restore and preserve the environment [3]. It may be defined 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 [4].

Composting is a broad term that includes co-composting. While composting generally refers to the decomposition of solid wastes, co-composting is the composting of two or more wastes with different characteristics. For example composting of sewage sludge with municipal solid waste is co-composting. The aim of co-composting organic fraction of municipal solid waste with paper mill sludge and saw dust as bulking agent was to provide indications whether a mixed organic waste could be composted effectively in reactors. If successful, it would obviate the need for supplementary nitrogen additions such as urea in the final compost.

Materials and methods

In this study, Drum made of PVC were used as reactors as indicated in **Fig.1**. Reactor consisted of 2 aeration tubes of 1" diameter (2.45cm) at a height of 15cm below the top level and 10 cm above the bottom to provide sufficient aeration. A mesh was provided at 10 cm height from the bottom of the reactor above the aeration tube to provide uniform air distribution in the reactor. It also helped to prevent rodent and insects from entering the reactor.

Aerator tubes consisted of small perforations of 3mm diameter throughout the tube at a uniform interval of 3cm. The organic fraction of MSW was collected from Vellalore Municipal composting yard and saw dust from saw mills near Kinathukadavu, Coimbatore. Paper and pulp mills sludge was

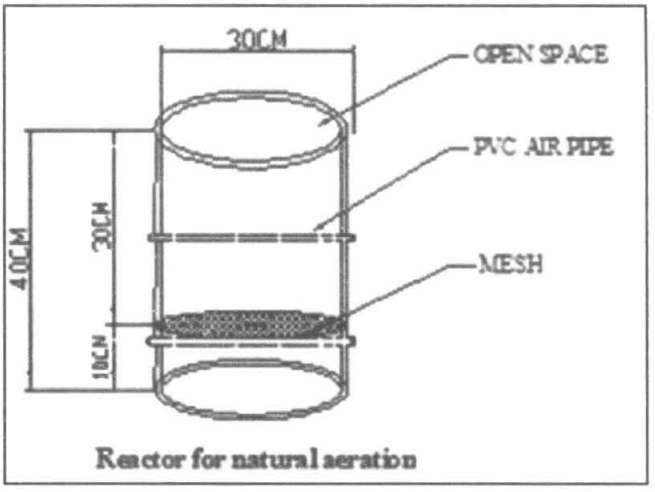

Fig 1: Reactor diagram

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Table 1: Mixture specifications

Reactor	Mix Ratio*	Saw Dust(kg)	OFMSW(kg)	Paper and pulp mill sludge(kg)	EM(mL)
1A	1:3	2.5	5	2.5	100
1B	1:6	1.4	5	3.6	100
1C	1:9	1	5	4	100

*Saw dust: (OFMSW+ paper and pulp mill sludge)

obtained from Amaravathy paper and pulp mills, Udumalpet. Effective microorganisms were obtained from Ramky Energy and Environment Limited located at Vellalore compost yard, Coimbatore. The materials were mixed in different proportions manually with the addition of 100 mL of effective microorganisms as indicated in **Table 1** and loaded into the reactors. Turning was done with the help of a wooden rod uniformly on alternate days to provide air for the microbes digesting the organics[5]. The major composition of the waste included vegetable and fruit waste. 400 mL of deionized water was also added initially and these reactors were watered on alternate days to keep the moisture level at an optimum range between 55% and 60%.

Methodology for preparation of EM solution

The mother culture was developed by adding two solvents namely Agar Bacterial Dextrose and Agar Agar and mixed with 20 mL distilled water in a conical flask. It was then shaken well and introduced into a test tube where it settled in the form of strips.

Bacterial Nutrient Broth medium was prepared by adding ingredients such as Peptone (100 g), Beef extract (60 g), Dextrose (sodium chloride) (19 g) in 20 litres of distilled water. Mother culture was introduced into the medium after a day. For the Fungal nutrient broth medium the potatoes dextrose agar was used. These were allowed to settle for a week and thus effective microbes including Phospobacteria, *Azospirillum lipoferum, Acetobacter aerogens,* and *Trichodema viridi* were developed.

Results and discussion

Initial characteristics and variation of characteristics of biodegradable portion of municipal solid waste obtained from Vellalore yard, Coimbatore are given in **Table 2**. Initial values of phosphorus and potassium were high, indicating high initial nutrient values in the waste. The micronutrients and heavy metals were also high for the waste. The heavy metals exceeded the permissible limits for compost specified by Municipal Solid Wastes (Management and Handling) Rules; 1999. Initial C/N ratio of 40.31 was suitable to carry out the composting process [6]. High levels of EC indicate presence of soluble salts and initial pH indicates alkaline conditions due to the alkaline nature of municipal refuse. Initial characteristics

Table 2: Initial characteristics of biodegradable municipal solid waste

Parameters	Value	Parameters	Value
P-ppm	2113	Cu-ppm	11.52
K-ppm	30500	pH	9.43
Ca-ppm	853	% Organic Carbon	30
Mg-ppm	301	% Total Nitrogen	0.74
Zn-ppm	82.69	C/N	40.31
Fe-ppm	783.38	EC mhos/cm	1.550
Mn-ppm	133.38		

of the secondary paper and pulp mill sludge are listed in **Table 3**. The organic matter in the sludge indicates that it is highly biodegradable. The presence of micronutrients in the organic wastes indicates its possible conversion into high quality compost.

The biodegradation levels of parameters during the composting process are indicated in **Fig.2, Fig.3** and **Fig.4**. Initially, due to the rapid breakdown of the available organic matter and nitrogenous compounds by microbial activities, the temperature of the three composting mixtures rapidly increased and reached their maximal values of 40, 46 and 52 ^{0}C for composting mixture 1A, 1B, 1C respectively. As the organic matter became more stabilized, the microbial activity and the decomposition rate slowed down, and the temperature in the three composting mixtures gradually decreased to reach ambient temperature. The composting mixture with mix ratio

Table 3: Initial characteristics of paper and pulp mill secondary sludge

Parameters	Value
Temp ^{0}C	29.3
Moisture content %	49.64
EC mhos/cm	1.8
% organic carbon	23.28
% Total Nitrogen	1.06
% P	0.256
% K	0.368
% Ca	3.00
% Mg	0.11
% Na	0.13

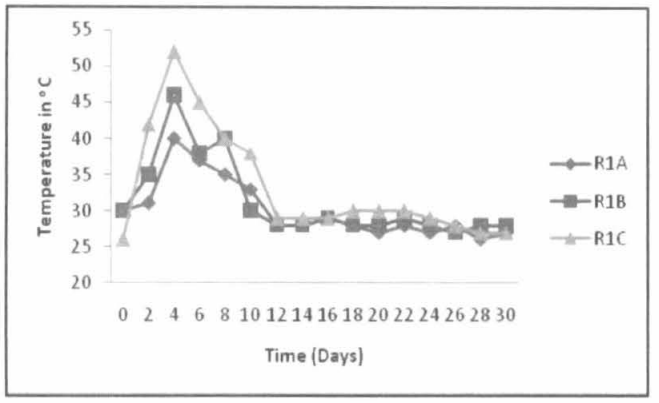

Fig 2: Variation of temperature in Reactor 1A, 1B and 1C

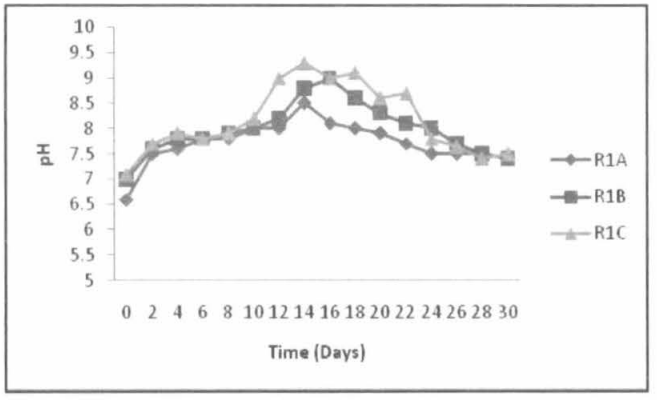

Fig 3: Variation of pH in Reactor 1A, 1B and 1C

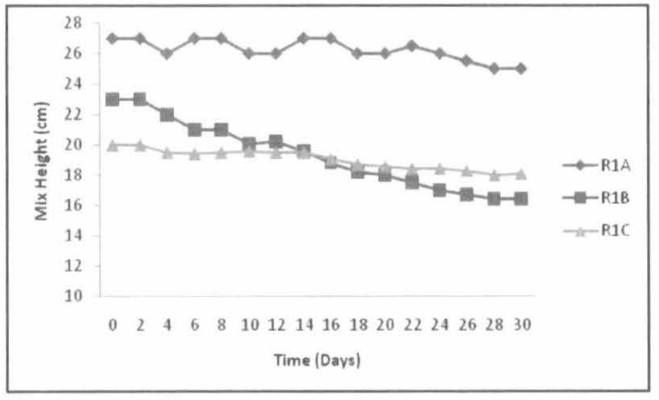

Fig 4: Variation of mix height in Reactor 1A, 1B and 1C

of 1:9 maintained a temperature exceeding 45 ^{0}C for 4 days which ensured the maximum pathogen reduction. The relatively low levels of rise in temperature was due to the fact that high amount of moisture content (65% to 75%) was present initially in the wastes and the moisture content also increased due to the hydrolysis reactions.

An increase in pH was observed in all the reactors during the initial stages of composting. The pH values shifted from acidic to alkaline conditions before dropping to neutral values. The production of ammonia from nitrogenous compounds is reflected by increase in pH. The reduction in the height of the composting mix was observed to be higher in the second reactor. **Table 4** presents the final characteristics of the compost after the process is over. C/N values stabilized to less than 20 at the end of the composting process. It indicates the stability of the compost and it is within the standard limits for compost [7]. The values indicate that the product can be effectively used as soil fertilizer [8].

Table 4: Final characteristics of compost

Parameters	**1A**	**1B**	**1C**
Total organic carbon %	21.2	18.03	18
Total nitrogen %	0.874	0.89	1.07
C/N	24.26	20.26	16.82

Conclusion

Paper mill sludge, which is the inevitable by-product of the papermaking process, has been composted successfully around the world for over 30 years, in relatively small quantities. Most paper mill sludge is relatively low in plant nutrients and its direct application to soils can lead to short term nitrogen sequestration in those soils. Direct land spreading of paper-mill sludge can also give rise to local management issues concerning storage capacity, material handling, transportation costs, visual impact, odours and nuisance. Composting the sludge ahead of land application can alleviate many of those issues. In addition, structural amendments are usually necessary to allow a sufficient air passage through the compost. The co-composting of paper and pulp mill sludge with organic fraction of municipal solid waste is found to be beneficial for land application. The chemical and physical characteristics of solid wastes (constituents, pH and moisture) and operating conditions of solid waste composting (carbon-to-nitrogen ratio, reaction temperature and time) impose significant effects on the ecological succession of microorganisms and the rate of biodegradation. The in-vessel composting method can also be applied to domestic wastes, with some alterations in the process such as source segregation of organic and inorganic fractions of domestic waste.

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