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Sustainable Solid Waste Management with Special Reference to Controlled Composting in Puducherry and Cuddalore Towns, India

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Abstract: The study was aimed to compost of various substrates such as Theshpesia leaf litter, banana waste, Ipomoea, kitchen waste, paper waste and household waste. The various physical chemical parameters were monitored during the process of composting are temperature, moisture content, pH, carbon nitrogen ratio and the nutrient content of N, P and K. After laboratory experiment this composting program extended at village level in and around Puducherry region. The people cooperated when approached and showed interest in sustainable way of solid waste management.

Key words: Composting · Substrates · Temperature · C:N ratio · Decomposition · Moisture content

INTRODUCTION

Rapid increase in population and change in life style and consumption pattern in India have resulted in a dramatic increase in municipal solid waste (MSW). Municipal solid waste includes both domestic and commercial waste the characteristic of waste is heterogeneous of which biodegradable organic waste is higher [1]. Since the municipal solid waste contain higher degree of percentage of biodegradable organic it is suitable for microbial as well as vermicompost. The vermicompost has acceptable moisture content and C/N ratio in the waste [2]. However, the composting process and compost quality could further be improved by adding inoculating agent like cow manure, poultry manure, yard waste etc. in the municipal solid waste.

Reduction of waste by recycling at an affordable cost with locally available resources was a practical approach for waste management and environmental protection [3]. Vermicomposting is a sustainable way due to its high degree of macro nutrients [2] as N, P and K to recycle of the bio organic waste which is found largest content in municipal solid waste in urban areas.

Vermicompost has been shown to be richer in many nutrients than compost produced by other composting methods. It also has outperformed a commercial plant medium with nutrients added, but needed adjustment for magnesium and pH. vermicompost is rich in microbial life which converts nutrients already present in the soil into plant-available forms. Unlike other compost, worm castings also contain worm mucus which helps prevent nutrients from washing away with the first watering and holds moisture better than plain soil.

Composting is the process of converting organic residues of plant and animal origin into manure, rich in humus and plant nutrients. It is largely a microbiological process based upon the activities of several bacteria, actinomycetes and fungi [4]. The by-products are carbon dioxide, water and heat.

The micro organisms decompose the starting material progressively, breaking it down from complex to intermediate and then to simple compounds [5].

$$\underset{\text{Waste}}{\text{Fresh organic}} + O_2 \xrightarrow[\text{metabolism}]{\text{Microbial}} \text{Stabilized organic residue} + CO_2 + H_2O + \text{heat}$$

All kinds of organic residue amenable to the enzymatic activities of the micro organisms can be converted into compost by providing optimum conditions for biodegradation. Unless strictly controlled, composting employs the activities of both aerobic and anaerobic micro organisms.

Hence recycling of organic residues through composting is an ancient practice. In modern times the use of composting to turn organic wastes into a valuable resource is expanding in most of the countries, as landfill space becomes scarce and expensive. Municipal solid waste composting has been increasingly recognized as a promising alternative for solid waste management [6].

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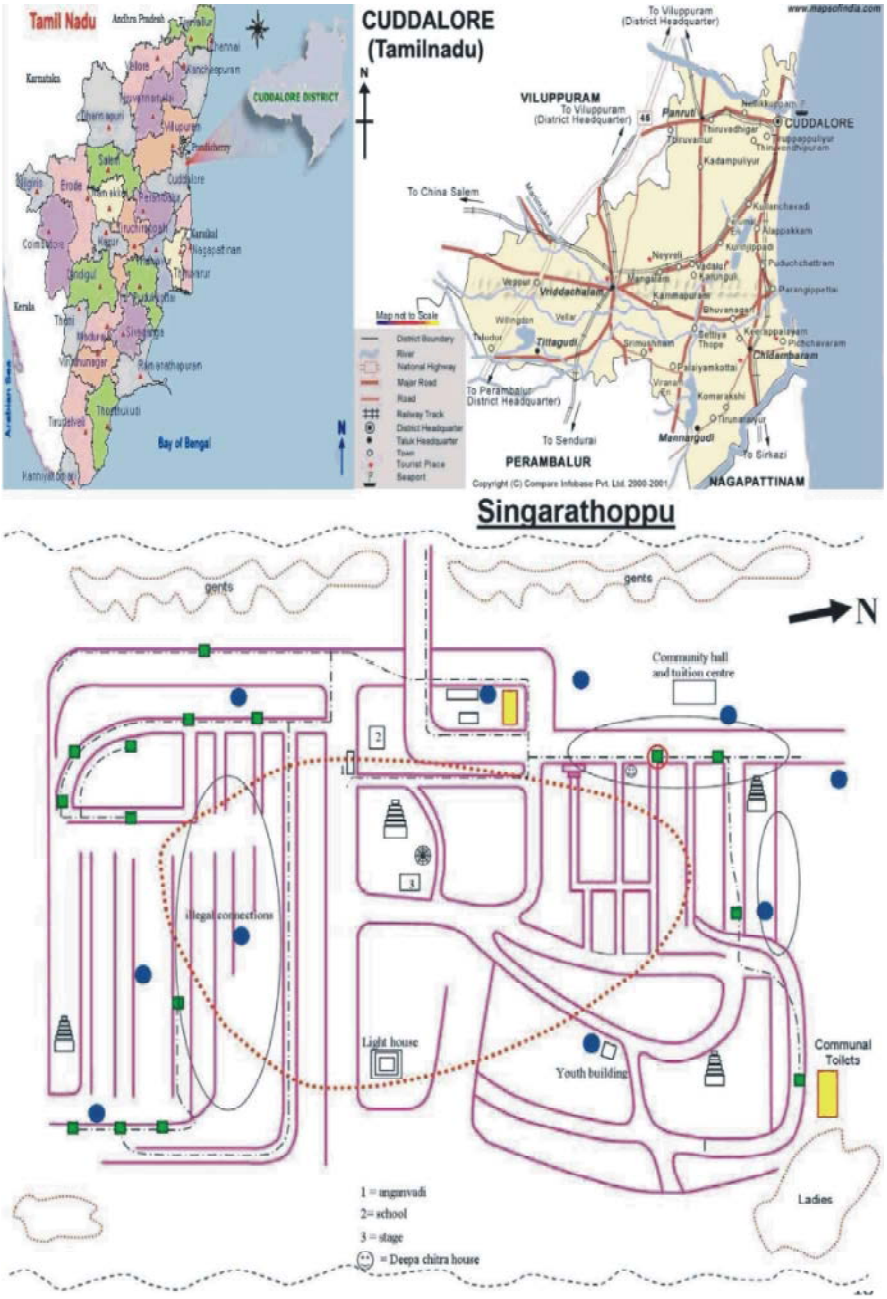

Fig. 1: Study area Map the location of Cuddalore district in the Tamil Nadu map

Study Area Description: Singarathope, a village situated in Cuddalore Old Town, coastal Tamil Nadu, India (Fig. 1). The people are mainly dependent on fisheries and this village comprises of nine hundred households was also affected by the tsunami 2004. The Kadaperikuppam village is belongs to Villupuram district of Tamil Nadu, India, located in 15 km north of Puducherry town.

MATERIALS AND METHODS

The substrates setting up successive layers, 10 cm and 5 cm thick respectively, of leaf litters and cow dung slurry in 50: l wooden boxes. The cow dung was drawn from the near by villages. The organic solids (waste) were topped with a 1 cm layer of garden soil. The entire contents were sprinkled with adequate water to generate

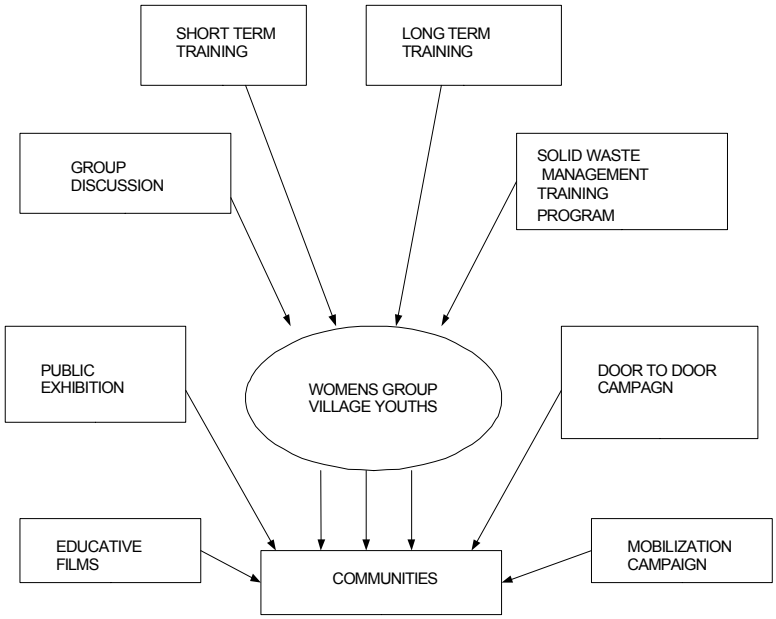

Fig. 2: The activities developed in the solid waste management program in the Singarathope Village, Cuddalore district of Tamil Nadu

average moisture content of 50% and were covered with cardboard and thick black plastic sheets. The temperature of the reactor contents was monitored with digital probes. After the initial setting, the compost boxes were left undisturbed as the aerobic process of composting started and gradually lifted the temperature of the reactor contents. When the temperature began to fall, the plastic covers were removed and the contents thoroughly mixed. The covers were removed and the contents thoroughly mixed. The covers were then replaced and the boxes left once again to continue the composting. In this manner, the leaf litters was turned into manure-like compost in 5 weeks.

In order to create awareness on sustainable solid waste issues and management at community level, various programs such as, film show, public meetings, door to door campaign, short term training programs, public exhibitions (Fig. 2) and pamphlets distribution were conducted on various issues of solid waste and its sustainable management methods such as composting and vermicomposting. Training programs were also conducted on making controlled composting and vermicomposting in order to manage household level waste for women's groups and village people.

The studies on solid waste management program extension work have conducted at different following locations in and around Puducherry.

Kadaperikuppam: This location is about 20 km of downtown of Pondicherry.

Abishegapakkam: This location is about 8 km south of downtown Puducherry.

Singarathope: This location is about 20 Km south of Puducherry.

Navarkulam: This location is about 4 Km downtown of Puducherry.

Methods of Composting and Vermincomposting at Community Level: Each household separates their wastes individually. Members of women's group have divided the area amongst them and do the house level collection themselves. Maintenance of the compost unit is done on a voluntary basis by the women's group. Women's group spends about 2 hours daily in checking the moisture, turning compost etc. The waste is then brought to the composting yard where wastes are composted and vermicomposted. During the compost and vermicompost process allowed to compost for at least 25 days with added catalysts such as cow dung and effective microorganisms (EM). After decomposition process is over the final product turns into a brownish colored soil-like material. This is then

transferred to the vermicompost pit were the African red worm Eisenia fetida has been introduced. After fifteen to twenty days all the material turns into nutrient rich vermicastings. These vermicastings are harvested manually and sieved using a 0.3 mm mesh by the members themselves. It is then dried under the shade of a tree in order to prevent loss of nutrients and vermi-castings moisture content. The group distributed vermi-compost to all members which they used in their kitchen gardens and flower beds. Apart from this the group also sells the earthworms at Rs 350/- per kg to those are interested to start vermi-composting programs in nearby villages.

RESULTS AND DISCUSSION

On average, about 0.83 kg of total waste per household was collected per day in the study area. The average daily quantity of waste per capita ranging from 0.08 to 0.37 kg/day on average, about 1.6 kg of biodegradable waste per household was collected per day in the study area. This makes up 63% of the total waste collected. The average percentage of biodegradable waste per household is 65%. Most of the non-food waste observed in the waste bags is plastic and nylon bags and small pieces of paper.

The result of the analysis showed that, the average solid waste generation observed was 1018, 820 and 974 kg /year high, middle and low income level in Singarathoppu village Cuddalore region. Of which, the solid waste generation per day at source was found 33.9±2.0, 32.5±3.5 and 27.3±2.9kg at high, low and middle income group in the village, of the fraction Low-income group households solid waste composition 25% food, 22% fish residue, 18% others, 12% inert materials and 7% paper. The biodegradable waste was 84 % and non biodegradable waste was 16% of which 9% plastic, 4% glass and metal was 3%.

Middle income group households solid waste composition 35 % food, 19 % fish residues, 12% others, 10 % inert materials and 8% paper among this fraction totally 84% biodegradable and non biodegradable waste was 16% of this 8% plastic, 5% glass and 3% metal from total waste generated.

High income group household's solid waste compositions found that highest waste generation 38% food, 18 % fish residues, 14% others, 9% inert materials and 8% paper. totally 87% biodegradable waste, 13 % are non biodegradable waste of which, plastic 7%, glass 4%, metal 2% from total waste generation. The annual waste generation in Singarathoppu 33,749 ton/year both biodegradable non biodegradable generated.

Temperature: The normal pattern after a composting unit is set up is that aerobic fermentation causes gradual degradation of the biodegradable portion of the carbonaceous organic compounds contained in the substrate. The process is exothermic and lifts the temperature of the contents to above ambient. In efficiently occurring composting process, the reactors may reach up to 60°C.

The temperature pattern during composting of different wastes at the different sites is given in Figure 1, 2. In Kadaperikuppam, the maximum temperature obtained was 56°C with Thespesia leaves, 58°C with banana leaves and Ipomoea leaves, 54°C with kitchen waste and 57°C with paper waste (Figure 3). In Abishegapakkam, 56°C was the maximum temperature obtained with leaves, 57°C with hay, vegetable waste and 58°C with MSW.

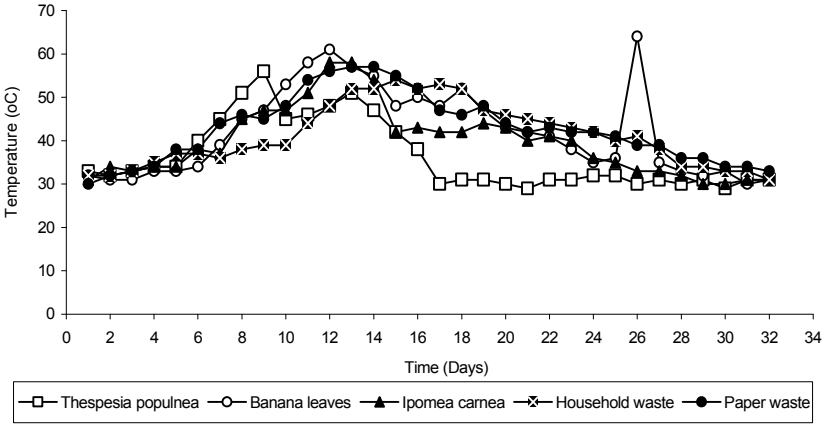

Fig. 3: Temperature pattern observed with different wastes in Kadaperikuppam

Table 1: Characteristics of the compost obtained form various wastes

Substrate	Moisture content (%)	pH	C/N ratio
Thespesia leaves	15.6	8.3	22.4
Banana leaves	24.8	8.0	23.1
Ipomoea	19.4	7.9	21.8
Kitchen waste	20.6	7.3	22.5
Paper waste	23.9	7.1	21.6
MSW	22.5	7.8	20.8

Table 2: Macronutrients level in the compost from difficult wastes

Substrate	N (%)	P (%)	K (%)
Thespesia leaves	1.02	1.9	4.7
Banana leaves	0.91	2.2	5.5
Ipomoea	1.11	1.6	7.0
Kitchen waste	0.98	2.8	4.8
Paper waste	1.18	2.0	6.5
MSW	1.22	2.1	5.8

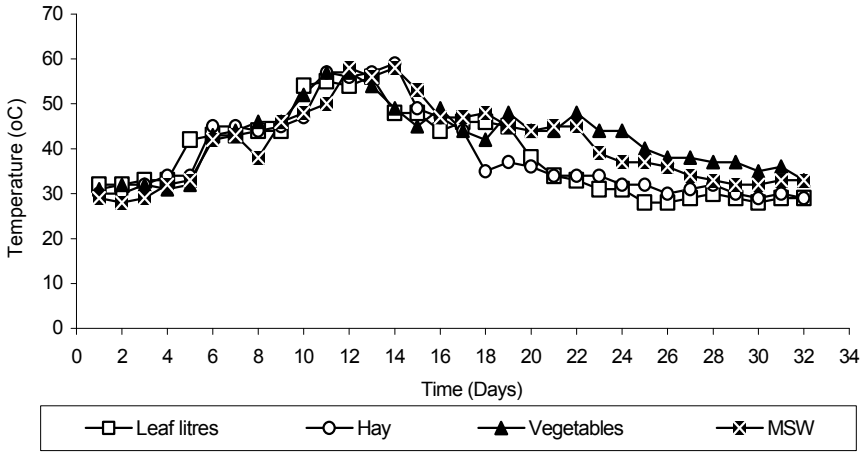

Fig. 4: Temperature pattern observed with different wastes in Abishegapakkam

PH: In general, pH did not follow any pattern. The pH values of different wastes during the composting process at various sites varied between 7.1 to 8.3 (Table 1). The contents of all the composting units showed alkaline pH not less than 5.9 throughout the process indicating that the contents had not undergone putrefaction and no appreciable amounts of troublesome organic acids were apparently produced.

Carbon-Nitrogen Ratio: The compost obtained with different leaf litters as substrate had the following C/N ratio: compost from Thespesia leaves had C/N ratio of 22.4, banana leaves compost had C:N 23.1, Ipomoea compost had a C/N ratio of 21.8. The compost from kitchen waste and paper waste had 22.5 and 21.6 respectively (Table 2).

In Abishegapakkam, the hay compost had C/N ratio of 24.1; leaf litter compost the kitchen waste and MSW compost showed C/N values of 23.4, 22.6 and 20.8 respectively. In the aerobic process, some of the carbon is lost to the atmosphere as carbon dioxide. On the other hand, the nitrogen present in the substrate remains bound. Due to these factors, C/N ratio of a substrate goes down during composting.

Moisture Content: The moisture content of the various compost fell within the range suggested [7], which gives that the moisture content should not exceed 15-25%.

Nutrient Status of the Compost: The N, P, K content of the various composts was analysed. The results are given in Table 2.

According to previous research suggested [8], the optimum composting temperatures were in the range of 52-60°C. The temperature attained with various wastes in the present study falls in this range both in Kadaperikuppam village (Fig. 3) and Abhishegapakkam village (Fig. 4). According to previous research suggested [9], mature compost generally has a pH value between 7 and 8. Most of compost fell in this range. All the values fell within the range (15-25) recommended by previous research report [10]. The moisture content of the compost fell within the range suggested by previous research report [11] the village people were done this composting program under close monitoring. People were monitored essential parameters of moisture content, volume reduction and temperature. The people cooperated when approached and showed interest.

The research concluded that the sustainable way of vermicompost with involvement of local community is one of the best ways to manage local municipal solid waste issues and environmental quality.

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