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Original Research Paper

Evaluating the Physico-Chemical Characteristics of Municipal Solid Waste in Coimbatore City, Tamilnadu

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ABSTRACT

Municipal solid waste management (MSWM) is one of the major environmental problems of Indian cities. Improper management of municipal solid waste (MSW) causes hazards to inhabitants. Various studies reveal that about 90% of MSW is disposed of unscientifically in open dumps and landfills, create problems to public health and the environment. This paper presents an assessment of the existing situation of municipal solid waste management (MSWM) in Coimbatore city. The quantity and composition of MSW vary from place to place, and bear a rather consistent correlation with the average standard of living. Field investigations were carried out for quantification, analysis of physico chemical composition, and characterization in disposal site. Studies carried out in these places have revealed that there are many shortcomings in the existing practices used in managing the MSW. These shortcomings pertain mainly to inadequate manpower, financial resources, implements and machinery required for effectively carrying out various activities for MSWM. Various adopted treatment technologies for MSW are critically reviewed, along with their advantages and limitations. The study is concluded with a few fruitful suggestions, which may be beneficial to encourage the competent authorities/researchers to work towards further improvement of the present system.

INTRODUCTION

Waste is the most visible environmental problem among many in urban areas. Increasing population, changing consumption patterns, economic development, changing income, urbanization and industrialization result in increased generation of solid waste and also a diversification of the types of the solid waste generated. Solid waste is often called the third pollution after air and water pollution. Solid waste consists of highly heterogeneous mass of discarded materials from residential, commercial and industrial activities (Kavita Kalayankumar et al. 2002). The impact of disposed waste is composed of (i) the contamination of surface and groundwater through leachate; (ii) soil contamination through direct waste contact or leachate; (iii) air pollution through burning of wastes; (iv) spreading of diseases by different vectors like birds, insects and rodents; (v) odour in landfills; and (vi) uncontrolled release of methane by anaerobic decomposition of organic matter in waste. Although some governments have formulated policies for environmental protection, these policies have been implemented only in the national capital cities. In rural areas, open dumping is still the most commonly used method of solid waste disposal.

Waste cannot be dumped without due concern and preparation, because not only is it unpleasant, unhygienic, and potentially disastrous to our environment, it also requires the allocation of space and incurs costs related to the consequences of the waste disposal. Moreover, suitable landfill sites are becoming more difficult to find as urban areas expand. Also, individuals are not willing to accept the implementation of a new landfill site near them because of concerns about smell, litter, pollution, pests and the reduction in the value of their homes. There are large costs involved in providing conveniently located and environmentally responsible landfill facilities.

In recent years, the notion of integrated waste management, applied to reduce waste at its source before it even enters the waste stream, has spread. It means that waste materials generated must be recovered for reuse and recycling, and the rest should be disposed at landfill sites. Unfortunately, disposal is not a sustainable solid waste management solution. Also, the zero emissions concept has arisen since the late 1990s. The amount of solid waste generated varies for different cities and towns. The concept is reflected by the phrase 'no time for waste' because the concept envisages all industrial outputs from processing being used as input process materials or converted into value added inputs for other processes, maximizing resource consumption and increasing eco-efficiency. In this way, the production process is reorganized into a closed loop system which emulates as an industrial metabolism of the sustainable cycles found in nature 'grown-use-waste-reuse'. Also, waste can be fully

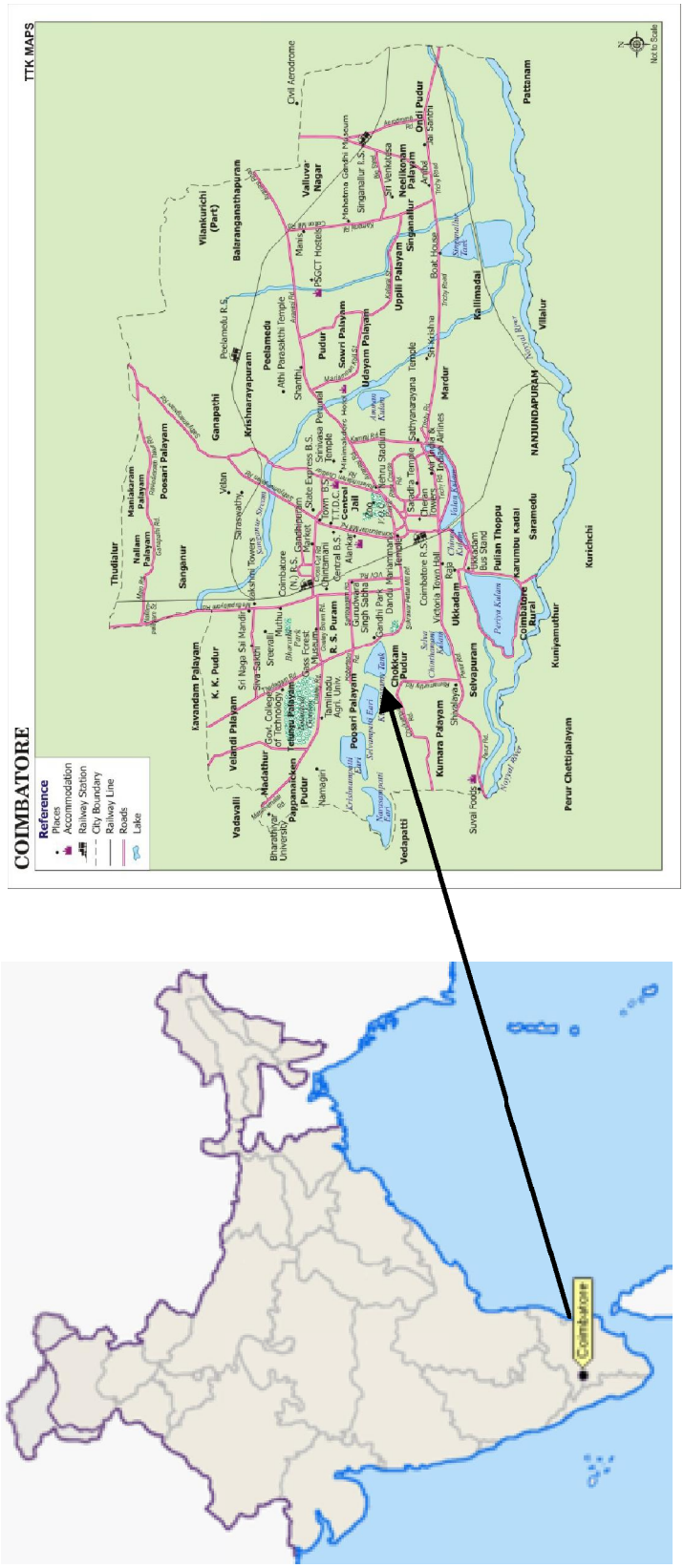

Fig. 1: Location map of the study area.

matched with the input requirements of any other processes. A perfectly integrated process management produces 'no waste' and it can be an innovative system of sustainable industry development, where reduction, minimization and utilization of waste are simultaneously realized.

Solid Waste Management in Coimbatore City

Coimbatore city: General information: Coimbatore is a one million plus city located between 12°57'03"N Latitude and 77°39'57"E Longitude in the state of Tamilnadu. It is the third largest city of the state and known for the textile industry. It is called as the "Manchester of South India". The city is well connected air, road and railway links. The city has a vibrant economy and reasonably good physical infrastructure as compared to many other one million plus cities in India. The city has grown over a period of years into a large industrial city. The city municipality was upgraded to Municipal Corporation in the year 1981 by merging some adjoining areas into municipal limit. Its area in 1981 became 105.6 sq.km and its population went up to 700923. The population as per 2001 census is 930882 and its present population is around 1026219 (December 2008) and in 2011 it was around 4271856 (www.coimbatorecity.com).

Climate and rainfall: The climate of Coimbatore city is salubrious with a pleasing landscape of hillocks and green vegetation surrounding the city. The summer months are hot and dry with average maximum temperature of 39.6°C. But, during the winter it is cool and pleasant with average minimum temperature of 17.3°C. The average rainfall is only 494.6mm.

Table 1: Sample location and period of selection.

S.No.	Sample	Period of study	Climate
1	Sample I	June 2011 to	Rainy season
2	Sample II	August 2011	
3	Sample III		
4	Sample IV		
5	Sample V		
6	Sample VI	September 2011 to	Winter season
7	Sample VII	November 2011	
8	Sample VIII		
9	Sample IX		
10	Sample X		

Soil and vegetation: The geological formation in the area mostly belongs to great gneissic series with abundant of limestone found in extensive beds of grey, pink and white colours hinter banded with gneissic matter. The soil belongs to Irugur series is moderately well drained with rapid surface run off and is mainly used for the cultivation of millet, paddy, cotton, tea, oil seeds and tobacco, where the water supply facilities are available. The flora mainly consists of palmyra, tamarind and xerophytes. Groundwater in these areas occur

Table 2: Physico-chemical characteristics of solid waste (June to August 2011).

Parameters	Sample I	Sample II	Sample III	Sample IV	Sample V
Physical parameters (in %)					
Colour	Pale grey	Pale grey	Pale grey	Pale grey	Pale grey
Texture	Mixed	Mixed	Mixed	Mixed	Mixed
Leaves	0.07	12.30	4.95	5.94	8.84
Food wastes	18.12	14.09	39.40	42.36	12.65
Fruit residue	9.20	8.39	23.20	20.20	0.09
Ash & fine earth	62.78	42.28	12.89	8.92	26.70
Paper	1.03	9.80	7.65	2.56	9.78
Plastics	1.60	13.11	0.64	8.65	18.60
Wood Scraps	3.42	0.01	4.95	2.89	9.32
Textile	1.80	0.005	2.32	6.99	6.99
Metal	1.76	0.01	0.66	1.49	4.78
Rubber	0.22	0.003	3.34	0	2.25
Moisture Content	60.79	62.34	60.12	64.76	61.00
Chemical parameters					
pH	7.1	7.3	7.4	7.1	7.2
EC	3.55 mho/cm	3.79 mho/cm	3.52 mho/cm	3.52 mho/cm	3.12 mho/cm
Total Carbon	23.76 %	32.56 %	34.70 %	43.78 %	45.25 %
Total Nitrogen	0.80 %	0.89 %	0.81 %	0.96 %	1.23 %
Phosphorus	0.58 %	0.67 %	1.20 %	0.61 %	1.20 %
Potassium	0.93 %	0.87 %	0.98 %	0.43 %	0.99 %
C/N Ratio	29.70	36.58	42.84	45.60	36.79
Calorific Value	810 kcal/kg	825 kcal/kg	845 kcal/kg	810 kcal/kg	813 kcal/kg

*EC – Electrical Conductivity

Table 3: Physico-chemical characteristics of solid waste (September to November 2011).

Parameters	Sample VI	Sample VII	Sample VIII	Sample IX	Sample X
Physical parameters (in %)					
Colour	Pale grey	Pale grey	Pale grey	Pale grey	Pale grey
Texture	Mixed	Mixed	Mixed	Mixed	Mixed
Leaves	8.86	9.12	8.92	7.50	10.63
Food wastes	20.12	25.69	25.0	26.08	26.66
Fruit residue	2.16	2.25	1.50	2.00	1.69
Ash & fine earth	26.89	21.96	35.96	42.23	34.26
Paper	35.80	33.65	20.81	13.50	20.96
Plastics	3.12	2.21	1.09	1.69	1.85
Wood Scraps	2.09	3.86	4.66	4.50	1.73
Textile	0.96	0.05	1.12	1.00	1.05
Metal	0.00	0.96	0.43	0.00	0.96
Rubber	0.00	0.25	0.51	1.50	0.21
Moisture Content	64.20	66.8	68.2	68.6	69.25
Chemical parameters					
pH	7.2	7.1	7.4	7.1	7.1
EC	3.42 mho/cm	3.85 mho/cm	4.36 mho/cm	3.55 mho/cm	3.53 mho/cm
Total Carbon	26.42 %	22.35 %	26.70 %	39.07 %	33.56 %
Total Nitrogen	0.78 %	0.76 %	0.76 %	1.22 %	0.95 %
Phosphorus	0.52 %	0.77 %	0.428 %	0.46 %	0.40 %
Potassium	0.85 %	0.52 %	0.55 %	0.42 %	0.38 %
C/N Ratio	33.87	31.81	35.13	32.02	35.33
Calorific Value	892 kcal/kg	810 kcal/kg	892 kcal/kg	896 kcal/kg	828 kcal/kg

*EC – Electrical Conductivity

in limited quantities in the pores available in the weathered material overlying in the crystalline-rocks and also in the joints, fissures and other openings in the rocks below.

Infrastructure: The town has been well connected with road network system. Round the clock bus facilities are available. The administrative boundary of Coimbatore city extends and covers area of 182.98 sq. km for urban use.

MATERIALS AND METHODS

The solid waste of Coimbatore city was collected from the Vellalore dumping yard. The sampling procedure adopted for collection was Quartering Technique (Lakshminarasimaiah et al. 2010). In this method representative samples of 10kg were obtained from several parts of the heaps of the wastes and well mixed and during this it is ensured that equal amounts are taken from all parts so that a true representative sample can be obtained. Steps involved are:

Step 1: Apart from other operations, a truck load waste was unloaded.
Step 2: Quartering the waste load was done.
Step 3: One of the quarters was selected and quartered that quarter.
Step 4: The individual components of the waste were taken into preselected components from the selected quarter.
Step 5: Separated components were placed in a container of known volume. The volume and mass of each component was measured. The separated components were compacted tightly to simulate the conditions in the storage containers from which they were collected.
Step 6: The percentage distribution of each component by mass was obtained.

In this study, the daily waste quantity was computed and waste generation in kg/capita/day was calculated based on the urban population. The waste from identified trucks was thoroughly mixed and grab samples were collected from various trucks located in Vellalore site, Coimbatore Corporation. About 100 kg of sample was collected, thoroughly mixed and reduced to 10 kg by quartering technique. Using the quartering technique, the total waste mass was divided into four parts and waste from two diagonally opposite portions was taken and mixed. The other two portions were discarded. This procedure was repeated until a waste sample of approximately 10 kg weight was obtained. Characterization studies were conducted to assess the recycling and pollution potential of MSW (Bhide & Sundersan 1983, Jeevan Rao & Shantaram 1993, Ingle & Mali 2000, Nanda et al. 2003).

Various components from the 10 kg sample, such as plastics, paper, metal, organic fractions, etc. were segregated and

weighed and these were expressed as a percentage of the total weight. To determine the moisture content, the entire sample was weighed to obtain the wet weight (W_w). It was then dried in an oven at 105°C till its mass becomes constant. After drying, the dry weight (W_d) was measured. Moisture content (Bhattacharjee & Gupta 2009) is an important parameter affecting various processing operations e.g., composting, incineration, etc. of municipal solid wastes. It is expressed by the equation given below:

$$\text{Moisture Content} = (W_w - W_d)/W_w$$

The organic fraction was taken to the laboratory for chemical analysis. Chemical analysis was performed as per standard methods (BIS No. 9234/1979) (Bhide & Sundersan 1983). The parameters studied were pH, electrical conductivity, carbon (C), total nitrogen (N), phosphorus (P), potassium (K) and C/N ratio.

RESULTS AND DISCUSSION

The physical and chemical characteristics of the MSW were analysed and presented in Tables 2 and 3. The characteristics of MSW were analysed for two seasons during the period of June to August (Season 1) and September to November (Season 2) in 2011.

Table 1 shows the sample location and period of collection of all the samples I to X. Table 2 gives the physical and chemical characteristics of five samples of MSW of Coimbatore city for season 1. Table 3 shows the physical and chemical characteristics of five samples of MSW of Coimbatore city for season 2.

Organic and inorganic contents: Analysis of the results revealed that organic contents were 12.52% in the first season and 15.14% in the second season. Inorganic wastes were 8.31% in first season and 6.55% in second season on an average weekly disposal of five samples in two different seasons. From the results it can be concluded that the organic waste can be converted into organic manure by composting method. For the inorganic contents it can be concluded that after recovery and reuse they can be used instead of disposing into environment.

pH and electrical conductivity: pH was found to vary between 7.1 and 7.4 in both the seasons. Electrical conductivity varied from 3.12 to 4.36 mho/cm and it was maximum in the second season. This indicates the greater degree of mineralization (Hogarh et al. 2008).

Total carbon, phosphorus and potassium: Higher percentage of carbon of 45.25 in the first season and 36.07 in the second season concluded that waste can be controlled by composting successfully.

Phosphorus and potassium were found to be approximately 1% in both the seasons. In both the seasons C/N ratio was above 30% indicating that the organic manure of solid waste is rich in nutrients.

Calorific value: MSW samples from Season 1 have a maximum calorific value of 845 kcal/kg and 896 kcal/kg in season 2. This may be due to addition of waste materials from other sources (Chaoton Meetei & Ibotombi Singh 2011).

Based on the studies, it is observed that solid waste is not being segregated and hence the energy that can be recovered from the waste by using suitable technology is not presently possible. Recently compost yard and landfill site has been developed and it will commence its operation very soon. The organic fractions can be either composted or used as organic manure or it should be biomethanated for generation of energy and the less organic fractions can be used for sanitary landfilling. The study is concluded with few fruitful suggestions, which may be beneficial to encourage the competent authorities/researchers to work towards further improvement of the present system.

CONCLUSION

From the results the following conclusions can be drawn:

- All the samples are grey in colour.
- All the samples contain food wastes, wood scraps, plastic, ash and fine earth, paper, textile, metal, rubber, etc.
- Moisture content was found to be above 60%, which is required for the process of composting.
- A conclusion can be made that the amount of organic waste is high. Proper awareness regarding segregation of waste must be created among the people with the help of NGOs to reduce the cost of transportation and to reduce the volume of waste. Masks and gloves should be provided by the government to the labourers working at disposal site. As given in the report, proper management of waste will include collection, segregation, storage, transportation, processing and disposal. This will lead to integrated solid waste management in Coimbatore Corporation. The integrated waste management will provide salubrious environment to the town making it green and clean town, environmental friendly, garbage and dust free and also to implement vision plan with full commitment.

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