INTERNATIONAL JOURNAL OF APPLIED BIOLOGY AND PHARMACEUTICAL TECHNOLOGY

www.ijabpt.com Volume-3, Issue-3, July-Sept-2012 Coden : IJABPT Copyrights@2012 ISSN : 0976-4550

Received: 18th June-2012 *Revised: 22nd June-2012* *Accepted: 25th June-2012*

Research article

STATUS OF HEAVY METALS DISTRIBUTION IN MUNICIPAL SOLID WASTE IN TIRUCHIRAPPALLI CITY, INDIA

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ABSTRACT: Urbanization and rapid growth of population in India has led to drastic increase in municipal solid waste. Unscientific disposal of municipal solid waste is one of the main reasons attributed for environmental degradation. The present work concentrates on municipal solid waste management in Tiruchirappalli City which comprises of four zones namely Srirangam, Goldenrock, Araiyamangalam and Abishekapuram. This study also attempted to assess the physical composition, characteristics and the heavy metals content in municipal solid waste. It can be observed that the bio-degradable fraction of municipal solid waste is found to be 74 percent of the total solid waste generated from the city. Hence composting could be the best option for the treatment of municipal solid waste.

Key words: Municipal solid waste, land filling, compost, heavy metals, pyrolysis

INTRODUCTION

Solid waste management has become one of the major environmental issues in India. In India there has been a significant increase in the municipal solid waste generation during the past years. This increase in waste generation is due to rapid population, industrialization and fast economic development in the country. The population of India as per 2001 census was 1027 million, of which 285.3 million people lived in 5161 urban area (Sahu, 2007). Annual production of solid waste in India has been estimated to be 2,000 million tonnes (MOWR 2000). The problem of waste management is important not only because the quantity of waste generation is large but also due to the land space required by the local bodies for treatment grasps the concentration of environmentalist in this area. In India the major five metropolitan cities alone together contribute a total of 21275 ton of waste in a day (Table 1). The quantity of municipal solid waste that is generated depends upon the size of the urban population and the per capita income. The increase in the quantity of solid waste due to urban growth is obvious. However, the per-capita waste generation also increases with income because there is more demand for packed goods and less for recycling of lower value products. Larger cities will generally have higher incomes and a higher quality of life. Changes in lifestyle determine the quantity and the composition of solid waste generated. In Tamilnadu, there are six municipal corporations namely - Chennai, Coimbatore, Madurai, Tiruchirappalli, Salem and Tirunelveli. These six cities together generate 5869 MT/day, of which Chennai alone accounts for 3500 MT/day or 60 percent (Table 2). Even though there are number of technological developments such as land filling, composting, incineration and pyrolysis, among these composting is supposed to be the feasible techno-economic method for proper disposal of solid waste. According to environmental report it is clear that about seventy percent of the heavy metals found in landfills come from electronic wastes (Toxics Link, 2003). Small scale industries located near urban areas often dispose of their wastes along with municipal solid wastes (Esakku et al. 2003). Heavy metals are gaining scientific interest due to its characteristics such as high reactivity, lithophilic nature, toxicity and non-biodegradability (Duruibe et al. 2007).

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Heavy metals composition in municipal solid wastes varies widely depending on the sources, composting process and geographical location (He et al.1992; Krogmann 1999).

Earlier studies also conformed heavy metal contents exceed the specified limits in municipal solid wastes (Merian 1991; Cebula et al. 1995; Pascal et al. 1997; Ciba et al. 1999). For example, Ciba et al. (1999) found the occurrence of cadmium, cobalt, manganese, nickel, lead and zinc in municipal solid waste compost. These elements remain unaffected during degradation of organic waste and have toxic effects on living organisms when exceeding a certain concentration. While the compost from municipal solid wastes is used as manure with some heavy metals, it may transferred to the food chain by the process of bioaccumulation and subsequently lead to human health risk to the exposed population. Since, high exposure of heavy metals may cause serious health impacts include carcinogenic, non-carcinogenic and endocrine disruptions (NIEHS, 2002). Hence, severe attention should be envisaged before the application of compost made from municipal solid waste. In this context, a preliminary investigation was carried out to characterize and extent of select heavy metals (Cu, Cr and Pb) distribution in the municipal solid waste.

Table 1. Generation of solid waste and recyclables

City	Generation of solid waste (Metric ton/day)
Delhi	6000
Mumbai	5800
Kolkata	4000
Bangalore	2800
Chennai	2675
Total	21275

Source: The Hindu dated 07/03/2007

Table 2. Solid waste generation in cities in Tamilnadu

Cities	Solid waste generation (Metric ton/day)	Total (percent)
Chennai	3500	60
Madurai	711	12
Coimbatore	710	12
Tiruchirappalli	408	7
Salem	330	6
Tirunelveli	210	4
Total	5869	100

Source: Computed from Corporations Website, 2008. www.tnulbs.in

MATERIALS AND METHODS

Study area description

Tiruchirappalli City Corporation owns 47.70 acres of land in Ariyamangalam situated along Trichy – Thanjavur Main road at a distance of 10-km away from the city centre and these lands are used for dumping the solid wastes (Figure 1). This site is provided with a compound wall all around. Details of the existing disposal sites are furnished in Table 1. There is no proper management and planning for the disposal of municipal sewage at Tiruchirappalli. The city generates the organic and inorganic wastes of about 250-300 tones per day and the municipal corporation are dumping them in the Dump yard at Ariyamangalam.

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Figure 1. Study area Ariyamangalam solid waste dumping yard

Municipal solid waste collection and characterization

Municipal solid waste comprises waste that is generated from all sources, such as residential sector, commercial sector, and market area etc. In order to represent the overall composition of municipal solid waste, samples were collected from the existing dumping yard at Ariyamangalam. To accomplish the data on the composition of municipal solid waste random sampling method was adopted. Waste was sampled from all the four zones of the corporation limits to frame a waste composition profile for each zone of the Tiruchirappalli City. All types of waste were thoroughly mixed together with the help of the rag pickers and a total of 25 kg of mixed waste from each zone was taken continuously for a week and segregated and again it was weighted.

Depth sample collection

Municipal solid waste samples were collected as per the Guidelines for environmental monitoring at Municipal Solid Waste Landfills of Ministry of water, land and Air protection, Government of British Columbia (1996). Three sampling points were selected to represent the surface solid waste characteristics and samples were collected at intervals of 6 cm (0-6, 6-12, 12-18, 18-24, 24-30 and 30-36 cm) up to 36 cm during April 2010. Samples were properly labeled and brought to the laboratory for analyses.

Solid waste acid digestion

For the determination of total metal content, aqua regia extract of MSW fine fractions was prepared by digesting 3 g of sample with 25 ml of aqua regia (HCl + HNO_3 3:1 v/v) at 100° C using a hotplate. Each digested sample was made up to 25 ml with de-ionized water and analyzed for heavy metals in an Atomic Absorption Spectrophotometer.

RESULTS AND DISCUSSION

Composition of Municipal Solid Waste in Tiruchirappalli City

The composition of municipal solid waste varies throughout the world. Sometimes in the same country waste changes from place to place depending upon climate, demographic location, standard of living etc. In Tiruchirappalli city, it can be observed that the bio-degradable fraction of municipal solid waste is found to be 74%. In Ariyamangalam zone, the degradable fraction of waste is observed to be 19.3 kg out of the sampled 25 kg. The percentage of organic component is greater in the dumping site since vegetable waste from the market area, restaurant and hotels is also dumped.

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The bio-degradable fraction is quite high in the samples that were collected at the disposal site. As per the CPHEE (Central Public Health and Environmental Engineering Organization) manual of solid waste management (2000), the percentage of bio-degradable matter is greater for low income countries than with that of middle income and high income countries. However, the composition of biodegradable is significant which could benefit the city while considering land filling requirements.

The composition of non biodegradable percentage obtained through sampling is 25.3%. According to CPHEE (2000) manual of solid waste indicates that paper content generally varies between 2.9 to 6.5% and increases with increase in population. The plastic, rubber, and leather contents are generally lower than the paper content, and do not exceed 1 percent in metropolitan cities. The recyclable fraction of the domestic solid waste includes paper, glass and metals, which amounts to about 24.8%. Stone and sand form inert components of the waste stream and constitute about 0.5 % of the waste from the dumping area, which is due to the inclusion of street sweeping, drain silt, and construction and demolition debris.

Table 3. Composition of Municipal Solid Waste

Parameters	Percentage composition				
	Srirangam	Ariyamangalam	Golden rock	K. Abishekapuram	Average
Biodegradable (Food Waste, Garden Waste)	18.0	19.3	18.2	19.2	74.7
Paper	4.0	3.9	4.1	3.9	15.9
Plastic	2.0	1.1	1.8	1.2	6.1
Textile	0.7	0.5	0.6	0.3	2.1
Glass and metals	0.2	0.1	0.2	0.2	0.7
Inert	0.1	0.1	0.1	0.2	0.5
Total	25	25	25	25	100

Physico-chemical characteristics and heavy metals concentration in municipal solid waste

Physico-chemical characteristics of municipal solid waste are shown in Table 4. In the surface samples pH was ranged between 7.32 and 8.24. However, in the depth samples not followed any gradually decreasing trend it ranged from 7.1 to 9.38. Total dissolved content of surface and depth samples ranged between 275 and 1870 mg/kg and 67.2 and 789 mg/kg, respectively. Higher level of moisture in the refuse is mainly attributed to cooked waste material from hotels, restaurants and household kitchen waste (Sharma and Gupta 2006). The moisture is also contributed by slaughter house waste (Sivapalan et al. 2002). Earlier study conducted by Gurijala and Suflita (1993) reported higher landfill gas emission at pH 6.8–7.4 and at higher moisture contents in landfill areas.

Table 4 Characteristics of municipal solid waste

Particulars	Moisture (%)	pH	Conductivity (mS/cm)	Total dissolved solids (mg/kg)	Oxidation reduction potential (mv)
S1	35	8.24	1.33	478	-48
S2	39	7.32	3.11	1870	-33
S3	37	7.81	2.70	275	-38
Depth samples (cm)					
0-6	41	9.21	0.315	193	-63
6-12	39	8.25	0.205	720	-87
12-18	42	9.38	0.315	115	-64
18-24	36	7.39	0.60	789	-73
24-30	38	7.89	1.69	67.2	-82
30-36	39	7.10	0.171	145	-45

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The heavy metal content of the municipal solid waste fine fraction is presented in Table 5. The concentration of Cr is comparatively less than that of other metals (Cu and Pb). Comparison of the metal contents with Indian standards for compost shows that the concentrations of Cr and Pb exceeded their limits. However, according to USEPA regulation limits the present levels are falls under the specified limits prescribed for composts. The concentration of heavy metals in municipal solid wastes compost obtained from several US composting facilities are 2.6, 2.9, 34.8, 154, 215, 248 and 503 mg/kg for As, Cd, Cr, Cu, Pb, Ni and Zn, respectively (Epstein et al. 1992).

Indiscriminate dumping of industrial wastes is probably source of Cr and Pb in the soild wastes in Tiruchirappalli City. Earlier studies conducted by Rawat et al. (2003) and Moturi et al. (2004) also found elevated level of heavy metals in municipal solid wastes of Delhi city, India. Although solid waste composts are rich in plant nutrients, these composts often have high concentrations of metals like Cu, Zn, Pb, Cd, Ni, Cr, etc. Continuous application of metal contaminated compost leads to the accumulation of toxic concentrations of these metals in soils and get transferred to plants grown on them, rendering the edible portion of plants unfit for animal or human consumption. Hence, the fine fraction of the composted waste material can perhaps be applied to other than food crops and it may be used as cover material in geographically suitable area. Further, metal content in the solid waste may increase in response to volume reduction during biodegradation (Das et al. 2002). Therefore the final composted materials must be tested for its metal content. Comparison of these values with Table 5 shows that all the three studied metals are recorded higher concentration in Ariyamangalam. This may be attributed to the dumping of Cr containing wastes with municipal solid waste. According to Saha et al. (2010), heavy metal contents in municipal solid waste composts from bigger Indian cities (>1 million population) were higher by about 86% for Zn, 155% for Cu, 194% for Cd, 105% for Pb, 43% for Ni and 132% for Cr as compared to those from smaller cities (<1 million population).

Table 5 Heavy metals content in municipal solid waste fine fractions (all values are in mg/kg).

Particulars	Cu	Cr	Pb
Minimum	155.4	56.0	151.7
Maximum	225.6	92.5	184.3
Mean ±	201.5	75.5	172.9
Standard deviation	40	18.2	18.4
Indian Compost standards [a]	300	50	100
USEPA compost standards [b]	1500	1200	300

[a] Municipal solid waste (Management and handling) Rules (2000).
[b] US composting council (1997).

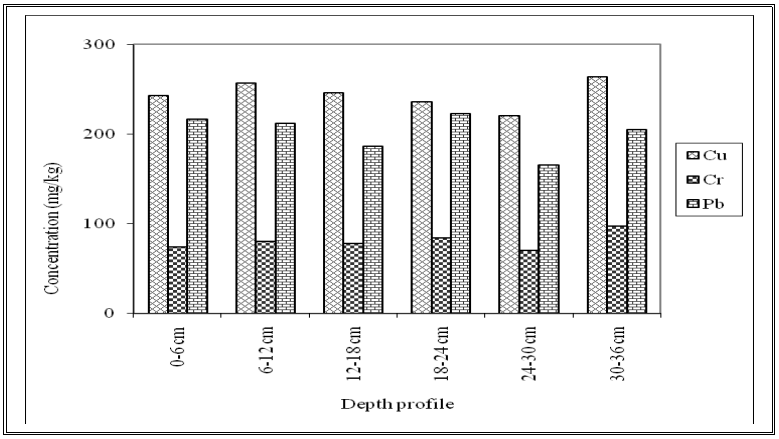

Figure 2. Depth-wise variation of heavy metals in municipal solid waste

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The depth wise variation of heavy metal content of municipal solid waste fine fraction for Tiruchirappalli city is shown in Figure 2. Mean concentration of Cu, Cr and Pb was recorded as 244, 80.5 and 201 mg/kg, respectively. There is no significant variation in the heavy metal distribution in various depths suggests unsaturation of surface and sub-surface layers of municipal solid waste with leachates. Slightly high concentrations of Pb observed at the middle layer (18-24 cm) may be due the downward migration of leachates (Esakku et al. 2003). Further, the low concentrations of Cr at the top layer (0-6 cm) can be attributed to phytoextraction of metals by natural vegetation (Esakku et al. 2003). The heavy metal distribution in the depth samples was observed in the order of Cu>Pb>Cr.

CONCLUSION

High proportion of bio-degradable fraction of municipal solid waste (74%) generated from the city can be used for methane generation and composting. Engineered landfill yard should be planned and constructed in the dumping yard, from where methane gas can be trapped and used as green energy as practiced in the developed countries. Comparison of metal contents in solid wastes of Tiruchirappalli with Indian standards for compost shows that the concentrations of Cr and Pb exceed the limits. Therefore, fine fraction of the composted waste suitable for non-edible crops only.

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