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Original Research Paper

Quantification, Characterization and Leachate Analysis of the Municipal Solid Waste From Erode Municipality, Tamilnadu, India

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ABSTRACT

The present study deals the sources, treatment and strategies for future management of municipal solid waste (MSW) in class I city Erode, Tamilnadu, India, which includes collection, segregation, transportation, treatment and disposal. The study also analysed and reported the existing waste treatment methods, which revealed the necessity for improvement and based on that suggested a suitable technology to improve the system thereby minimizing the associated environmental damage. Ground water samples were also collected in and around the solid waste dumping yard and analysed for their physico-chemical characteristics to ascertain the extent of groundwater pollution through leachate. The results revealed that concentration of most of the critical parameters (like hardness, BOD, COD, zinc, iron, etc.) exceeded the permissible limits, which requires the improvement of currently employed solid waste management system. The existing solid waste management practices such as open dumping and vermicomposting techniques are not only inefficient but also inadequate enough to manage huge amount of wastes generated daily. Hence, integrated solid waste management system comprising biomethanation, sanitary landfill, etc. is adopted.

INTRODUCTION

Municipal solid waste (MSW) generation, treatment and disposal are, both economic and environmental problem of concern, for the urban communities, especially in fast population exploding countries like India. Solid waste generation in Indian cities has been increased from 6 Tg in 1947 to 48 Tg in 1997 with per capita increase of 1-1.3 per year. The magnitude increases day by day due to fast growing population and migration of people from rural to urban areas. About three-forth of the MSW, generated from urban areas of India, is collected and disposed off in unscientifically managed dumping yards. Almost 70-80% of land-fills of India are open dump sites (Jha et al. 2008). The growth of MSW in our urban centres has outpaced the population growth in recent years. This trend can be ascribed for our changing lifestyles, food habits, and change in living standards. MSW in cities is collected by respective municipalities and transported to designated disposal sites, which are normally low lying areas on the outskirts of cities. The limited revenues earmarked for the municipalities make them ill-equipped to provide for high costs involved in collection, storage, treatment, and proper disposal of MSW. The insanitary methods adopted for disposal of solid wastes is, therefore, a serious health concern. The poorly maintained landfill sites are prone to groundwater contamination because of leachate production. Open dumping of garbage facilitates breeding of disease vectors such as flies, mosquitoes, cockroaches, rats and other pests (CPCB 2000). Municipal solid waste management is a part of public health and sanitation, and is entrusted to the municipal government for execution. Presently, the systems are assuming larger importance due to population explosion in municipal areas, legal intervention, emergence of newer technologies and rising public awareness towards cleanliness (Kumar & Gaikwad 2004). The municipalities in India, therefore, face the challenge of reinforcing their available infrastructure for efficient MSW management and ensuring the scientific disposal of MSW by generating enough revenues either from the generators or by identifying activities that generate resources from waste management (Singhal & Pandey 2001). MSW in India is increasing steadily during the recent years. Conventional handling of MSW poses serious environmental and public health concerns since large number of the landfills in India are not well-engineered. Due to these problems, sound and sustainable methods of solid waste management have been sought by central and regional policy makers. Waste-to-energy schemes, which provide energy in the forms of heat and/or electricity as by-products, are regarded sustainable.

Erode is one of the fastest growing cities in India, which is located in north-western part of Tamil Nadu, having a population of 1,51,274 (as per 2001 census) with 37,511 houses, about 5635 commercial buildings, 60 schools and two vegetable markets occupying an area of 8.44 sq. km. In addition, there is about 20,000 floating population in Erode town. This municipal city is situated at an elevation of 171.91m above mean sea level, between 10.36° and 11.58° north latitude and 76.49° and 77.58° east longitude. Erode town is divided into 45 wards and generating about 135 metric tons of solid waste per day from the households, vegetable markets and commercial activities, etc.

Improper disposal of municipal solid wastes causes huge social costs in terms of spreading communicable diseases, increased transition costs from pollution and is an issue of increasing concern, especially in the developing cities (John Paul & Daniel 2007). Much of society's solid waste is disposed in sanitary landfills, where it undergoes physical, chemical and biological transformations. The solubilization of organic and inorganic components in water produces a leachate, which can be difficult to treat (Daniole et al. 2004). The waste generation is likely to increase in the next few years due to the growing population and will become a challenge to the municipality unless the sustainable mitigation measures are taken. There is an urgent need to investigate the scientific and environmental sustainable solution for managing the solid waste in Erode city. Ministry of Non-conventional Energy Sources (MNES) Govt.of India provides fiscal and financial incentives under "National Program on Energy Recovery from urban, municipal and industrial wastes" to adopt technologies to improve our energy crisis, to create awareness among the public, the positive and negative impact and leaflets campaign, communication through mass media (Unni 2006). In this study an attempt has been made to analyse the proper management of municipal solid waste of Erode city. The source specific solid waste quantification and characterization will be helpful in predicting the waste quantity from various waste generating sources in city and this can be used as a basis for planning the solid waste management system. This will also facilitate to saving time, manpower and financial inputs required to be spent for the entire city. The objective of this study is to present an overview of the quantification, characterization and leachate analysis of municipal solid waste. A thorough analysis of all components of municipal solid waste was carried out and appropriate scientific management of MSW is suggested.

MATERIALS AND METHODS

Sources and generation of solid wastes: The solid waste generated in Erode city is managed by the public health department of the Erode Municipal Corporation. The list of staff members of public health section employed to manage the solid waste and vehicles used for transporting the generated wastes are given in Table 1. The solid waste was emanating from various residential areas, commercial centres, industries, hotels, commercial lodging facilities, schools and holy places (Table 2). The data pertaining to solid waste generation, collection, existing management strategies and disposal techniques were collected from the Commissioner of Erode Municipal Corporation. The data collection techniques include many approaches like service detail of vehicles engaged in transportation, interviews with persons involved in collection, transportation and Inspectors and Medical officers, were made to get a realistic estimation of the quality of wastes sources and quantity of generated wastes provide to the baseline data for proper solid waste management (Aji et al. 2007).

Sample collection: Ten representative samples weighing around 10 kg were collected from 10 different locations of dumping yard at Vendipalayam in Erode city. The solid waste, disposed off at dumping yard within 8 days of the date of collection, were considered for sampling and analysis. The physical components and chemical analysis of the samples were performed following the procedures given by ISI (1982) and the results are given in Tables 3 and 4. The samples were divided into biodegradable and nonbiodegradable components. The obtained nonbiodegradable fractions were discarded and only biodegradable components were further studied for their physico-chemical characteristics (APHA 1995).

Leachate analysis: Leachate samples were collected during the period from 2006 to 2007 at different places around the dumping site within a radius of 25m, 50m, 75m, and 100m. Four groundwater samples, collected from different distances (25m, 50m, 75m and 100m) from the fringe of the dumping sites, were selected for the study. The analyses of the different parameters like pH, volatile solids, iron, chlorides, phosphate, zinc and ammonia nitrogen were performed by the standard methods (APHA 1995). The total organic carbon was determined using the TOC analyser (Model: 5000A Shimadzu, Japan). The concentration of metals zinc and iron was determined by direct air acetylene flame method using the atomic absorption spectrophotometer Model: (SL 168 Elico, India).

RESULTS AND DISCUSSION

Design and operation of appropriate solid waste management systems are necessary for ensuring good sanitation and clean environment (Gawaikar & Deshpande 2006). Erode municipality on its own has taken certain initiatives for door to door collection and segregation of wastes from households, hotels, markets, business centres and commercial establishments. Out of all collected, about 50 metric tons of waste is being subjected to vermicomposting, and the remaining is dumped on an open site in an unscientific manner. The infectious and hazardous biomedical wastes are collected and treated by IMA (Indian Medical Association, Erode) separately and not included in this study. The present study indicated that the sources and quantity of generated wastes provides proper base line data for solid waste management. Here, the major solid wastes is produced from residential areas, hotels, commercial courses and vegetable markets. Presently estimated 135 metric tons of solid waste generation per day increases day by day due to indiscriminate growth of informal and illegal developed colonies. The mushrooming settlement colonies are developed in an unplanned way, thus, posing several constraints on city’s municipal services (Sharma et al. 2007). MSW generally includes degradable (paper, textiles, food waste, straw and yard waste), partially degradable (wood, disposable napkins, sludges) and nonbiodegradable (leather, plastics, rubbers, metals, glass, ash from fuel burning like coal, briquettes, wood, electronic waste). Generally, MSW is managed as collection from street and disposal at landfill (Jha et al. 2008).

Table 1: Man power and vehicle facilities used for MSW management of Erode municipal corporation.

Sl.No.	Staff Members Available in the Public Health Section	Vehicle Facilities
1.	Chief Health Officer-1	Automatic refuse collector vehicle-6
2.	Assistant Health Officer-1	Mini lorry-6
3.	Sanitary Inspector-15	Sewage container lorry-3
4.	Sanitary Supervisors-24	Hand corts-275
5.	Sanitary workers-579	Bins-180
6.	Private employees-30	Plastic containers-37

(Source: Erode Municipal Corporation)

Table 2: Existing solid waste generation system.

				Commercial Establishment						School		Religious and Holy places		
Sl. NO.	No.of Wards	No.of Houses	Popul-ation	Hotel Lodges	Comm-unity centers	Hosp-itals	Indu-stries	The-atres	Oth ers	Pri-vate	Govt.	Tem-ples	Chu-rches	Mos-ques
1	1,2,3,4,9	4511	17989	-	3	5	1	-	94	7	2	18	1	1
2	5,6,7,8,	4132	16111	-	6	-	2	-	82	3	2	6	-	1
3	10,11,17	2608	10872	-	-	-	-	-	69	1	1	4	-	-
4	Market 16	581	2919	3	-	1	-	1	345	2	-	2	-	2
5	18,19,20	3181	13243	-	1	2	1	-	247	3	1	2	-	-
6	30,31,32	2290	9316	-	1	1	-	1	53	2	1	-	-	1
7	34,35,33	2046	8304	-	-	2	-	-	10	1	-	12	3	2
8	36,42,43,44	2657	10066	-	3	7	-	2	132	1	4	2	-	2
9	39,40,41,45	3406	12670	-	2	4	-	2	112	5	-	-	2	-
10	28,29,37,38	3700	14653	1	8	-	-	-	159	-	-	6	1	-
11	13,24	1704	6380	9	-	18	10	3	174	3	1	4	-	-
12	21,22	1261	6451	7	-	1	-	-	1647	3	2	11	1	1
13	15,23,	1253	5490	3	3	12	-	-	749	8	-	6	-	-
14	25,26,27	2553	10174	1	3	41	-	-	350	5	2	-	2	-
15	12,14	1628	6636	19	7	3	-	5	1207	-	-	7	-	1
16	Malaria Ward													
17	Vehicle division													
18	Fertilized stock rooms													
	Total	37511	1,51,274	43	37	97	14	14	5430	44	16	80	10	11

(Source: Erode Municipal Corporation)

The physical segregation of samples showed that an average 60 percent by weight is vegetable matter (Table 3). A significant portion of MSW of Erode city comprises 60% biodegradable organic fraction, which include vegetables, fruits and food wastes. The weight percentage of paper, plastics, garden trimmings, jute, wood pieces, construction debris, glass, metal, cloth, rubber and miscellaneous were in least values. In Erode municipality certain amount of biodegradable waste is (about 50 metric tons) converted in to manure using vermicomposting technique and the remaining waste is dumped in the site. Sanitary landfills are widely used for the disposal of municipal solid waste (MSW) due to their economical and convenient advantages. However, leachate and gas generated from landfills may pollute the environment if not properly managed (Hao et al. 2008).

The moisture content was found to be between 51 and 68 percent. The organic carbon ranged from 22 to 30 percent with an average value of 25.98 percent. The organic matter varied from 54.66

Table 3: Physical components of municipal solid waste.

Sl.No	Components	S_1	S_2	S_3	S_4	S_5	S_6	S_7	S_8	S_9	S_{10}	Av. & SD
1.	Paper	3.20	2.58	5.80	4.42	3.30	4.10	4.41	3.10	4.15	3.35	3.841±0.92
2.	Plastics	5.26	6.50	7.28	4.96	5.50	6.60	4.97	5.36	6.55	5.35	5.833±0.81
3.	Garden trimmings	4.31	3.86	5.25	6.58	4.25	4.00	6.60	4.21	3.95	5.25	4.826±1.05
4.	Organic fraction	45.20	65.80	49.00	76.00	63.00	62.15	59.20	63.29	62.20	61.00	60.68±8.53
5.	Jute	1.75	1.92	1.85	2.48	1.80	1.82	1.50	2.00	1.72	2.15	1.89±0.267
6.	Wood pieces	1.98	2.74	3.98	3.30	2.00	2.90	2.49	2.40	3.11	3.15	2.80±0.61
7.	Construction debris	3.24	8.76	4.58	1.45	1.30	1.64	0.70	1.30	0.65	0.95	5.43±1.92
8.	Glass	1.27	0.70	0.58	1.45	1.30	1.64	0.70	1.30	0.65	0.95	1.05±0.38
9.	Metals	1.30	0.96	0.76	0.98	1.20	1.98	1.81	1.25	0.90	0.98	1.21±0.39
10.	Cloth	3.48	4.62	6.79	5.11	6.50	5.50	4.50	4.00	4.40	5.21	5.01±1.04
11.	Rubber	2.64	3.58	1.26	0.52	2.50	1.00	1.98	2.50	1.26	2.10	1.93±0.92
12.	Miscellaneous	4.28	5.89	6.32	7.51	5.15	5.30	6.34	5.35	4.01	4.51	5.56±1.02

Table 4: Chemical characteristics of solid waste samples (%).

Sl.No.	Characteristics	S_1	S_2	S_3	S_4	S_5	S_6	S_7	S_8	S_9	S_{10}	Av. & SD
1.	Moisture content	51	62.25	65.30	56.75	63.95	55.65	52.60	67.45	61.63	68	60.558±6.01
2.	Organic carbon	22	25.2	23.4	24.8	28	30	23.7	26.3	27.4	29	25.98± 2.60
3.	Organic matter	56	57.29	63.23	54.66	61.79	64.98	62.28	61.23	59.62	65	60.608±3.62
4.	Nitrogen	0.74	0.84	0.80	0.88	0.90	0.93	0.81	0.94	0.87	0.93	0.864± 0.06
5.	Phosphates	0.60	0.85	0.82	0.75	0.70	0.96	0.86	0.78	0.98	0.72	802.802± 0.11
6.	Potassium	0.45	0.48	0.56	0.62	0.60	0.64	0.61	0.47	0.54	0.68	0.565± 0.07
7.	Sodium	0.35	0.67	0.45	0.40	0.62	0.48	0.61	0.55	0.60	0.58	0.531±0.10
8.	C/N ratio	29.72	30	29.25	28.18	31.11	32.25	29.25	27.97	31.49	31.18	30.04±1.43

Table 5: Physico-chemical analysis of MSW leachate (groundwater samples) near dumping site.

Sl.No	Characteristics	Sample 1 (25 m)	Sample 2 (50 m)	Sample 3 (75 m)	Sample 4 (100 m)
1	Colour	Less	Less	Less	Less
2	Odour	Less	Less	Less	Less
3	Elec. conductivity	4650	3120	3080	3050
4	Hardness	2650	1890	1320	1060
5	TDS	2670	2490	1910	1620
6	Turbidity	3	2	1	0
7	pH	7.5	7.4	7.2	7.1
8	Total organic carbon	1.90	1.70	1.33	1.13
9	Total nitrogen	Nil	Nil	Nil	Nil
10	Total phosphorus	<1mg/L	<1mg/L	<1mg/L	<1mg/L
11	Ammonia nitrogen	4.5	3.9	3.8	3.7
12	Chlorides	1329.58	1079.66	649.76	609.81
13	Sulphates	0.047	0.039	0.017	0.013
14	Volatile solids	1030	990	890	740
15	COD	1680	910	640	420
16	BOD	180	120	90	70
17	Zinc	1.45	1.21	1.0	0.92
18	Iron	4.01	3.69	2.09	1.80

All the values are in mg/L, except pH, turbidity (NTU) and electrical conductivity (μmhos/cm).

to 65 percent with an average of 60.6 percent. The nitrogen content ranged from 0.74 to 0.94 percent with an average value of 0.86.% High nitrogen content of 0.94% might be due to huge quantity of food wastes. The phosphate content in solid waste ranged from 0.60 to 0.98 percent. The potassium content ranged from 0.45 to 0.68 percent, and sodium from 0.35 to 0.67. The C/N ratio values shown that the MSW predicted to be suitable for biomethanation or composting.

Leachate means liquid that seeps through solid wastes or other medium and have extracts with dissolved or suspended materials from it (Goswami & Sarma 2007). The dumping site at Erode does not possess any channels for leachate collection. The present study of leachate analysis indicated that the quality of groundwater due to disposal of municipal solid waste at dumping yard in Vendipalayam, Erode city that all samples are odourless, colourless and slightly alkaline in nature with the pH ranging from 7.5 to 7.1 (Table 5). The hardness in the groundwater samples ranged from 2650-1060 mg/L. The hardness is above the prescribed limit of 300 mg/L (IS: 10500 1991-1993) in all samples (Karthikeyan & Murugesan 2007). The EC (electrical conductivity) varied from 4650 to 3120 μmho/cm. The EC was found to be higher in the water samples analysed (Naik et al. 2007). COD values ranged from 1680 to 420 mg/L, and the BOD values from 180 to 70 mg/L. High COD values were obtained in the samples indicating contamination of groundwater by oxidizable organic matter. Leachate COD is a measure of all oxidizable matter in the leachate, while BOD is a measure of the biodegradable organic mass (El-Fadel et al. 2002). The variation in heavy metal concentration like zinc and iron is high. These are varied from 1.45-0.92 and 4.01-1.08. It is interesting to know that as the radial distance from the dumping yard increased, the contamination and magnitude of pollution decreased. The higher ranges of the physico-chemical parameters are due to the discharge of salts and minerals from the waste, which is landfilled in the dumping yard. However, the physico-chemical characteristics of the leachate samples exceed the limits of drinking water standards (John Paul & Daniel 2007). Therefore, it is necessary to treat the solid waste in a scientific manner, otherwise it poses to serious environmental problems like groundwater contamination and affect the soil characteristics. Organic solids are present in very large quantities as products or waste from agriculture, food industry and market waste. The composition of the organic fraction of municipal solid waste (OFMSW) is influenced by various factors, including regional differences, climate, collection frequency, season, cultural practices and changes in composition. The removal and alternative treatment of the organic fraction from landfill sites is likely to have an impact by increasing the methane yields. Anaerobic digestion has several advantages over traditional solutions (landfill, incineration and aerobic composting) and these include better handling of wet wastes and the production of useful digester gas. Anaerobic digestion has proven to be a viable option for the management and stabilization of the OFMSW. Conventional anaerobic digesters require feed material with total solids content below 10% (Forster-Carneiro et al. 2007). It could be feasible to use biomethanation technologies and convert the same into the fuel energy and electrical energy (Jeyapriya & Saseetharan 2007).

CONCLUSION

The investigation gives field data about the quantity and characteristics of solid waste, and projects future implications of currently employed treatment techniques at Erode municipality. In addition, it revealed the solid waste leachate characteristics collected near the dumping yard. It is evidenced from the results that organic matter content, generated in the city, is about 60% of the total solid waste generated. Hence, it could be recommended that biodegradable fraction of MSW can be utilized as bioenergy source and converted into bioorganic fertilizer. But as a prerequisite from the waste generated, inorganic waste (nonbiodegradable) should be segregated and recyclable wastes separated properly, only then it should be disposed into sanitary landfill. It can be suggested that the integrated solid waste management approach will fulfil the future demands of Erode city. Public education, involvement, participation, awareness, cooperation among the businessmen, service providers of municipality and application of suitable methods, sustainable solutions and low cost technologies will facilitate the integrated solid waste management. It not only brings the remedial measures to the present environmental scenario but also revenue to the Erode municipality.

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