Indian J. Edu. Inf. Manage., Vol. 1, No. 3 (Mar 2012) ISSN 2277 - 5374

Solid waste management in Chennai city

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Abstract

Human activities create waste, and the way these wastes are handled, stored, collected and disposed of, which can pose risks to the environment and to public health. Where intense human activities concentrate, such as in urban centers, appropriate and safe solid waste management (SWM) are of utmost importance to allow healthy living conditions for the population. Rapid increase in volume and types of solid and hazardous waste as a result of continuous economic growth, urbanization and industrialization, is becoming a burgeoning problem for national and local governments to ensure effective and sustainable management of waste. The environmental degradation caused by inadequate disposal of waste can be expressed by the contamination of surface and ground water through leach ate, soil contamination through direct waste contact or leach ate, air pollution by burning of wastes, spreading of diseases by different vectors like birds, insects and rodents, or uncontrolled release of methane by anaerobic decomposition of waste. This fact has been acknowledged by most governments, however many municipalities are struggling to provide even the most basic services. Typically one to two thirds of the solid waste generated is not collected (World Resources Institute, et al., 1996). Solid Waste (SW) generation in Chennai, the fourth largest metropolitan city in India, has increased from 600 to 3500 tons per day (tpd) within 20 years. The highest per capita solid waste generation rate in India is in Chennai (0.6 kg/d). Chennai is divided into 10 zones of 155 wards and collection of garbage is carried out using door-to-door collection and street bin systems. The collected wastes are disposed at open dump sites located at a distance of 15 km from the city. The community-based solid waste decomposition is an ideal and a safe disposal method, is more beneficial for solid waste management, as it easily converts waste to valuable fertilizer.

Keywords: Economic growth; Population; Solid waste; urban poverty; Environment problems.

Introduction

Solid waste can be classified into different types depending on their source: 1) Industrial waste as hazardous waste 2) Household waste is generally classified as municipal 3) Biomedical waste or hospital waste as infectious waste and 4) E-waste Electronic wastes such as TV's, refrigerators and computer waste.

Hazardous waste

Detection of traces of toxic chemicals in drinking water supplies, ground water sources and episodes have focused the attention of the public worldwide on the risks posed by the inappropriate disposal of hazardous waste and accidental release of toxic chemicals into the environment. Due to the liberalized policy the pace of industrialization has been accelerated, which has resulted in increasing amounts of hazardous wastes every year. This along with a growing amount of municipal solid waste due to rapid urbanization and hospital waste continues to remain a daunting issue of environmental concern to India.

Municipal solid waste

There has been a significant increase in the generation of MSW (Municipal Solid Wastes) in India over the last few decades. This is largely a result of rapid population growth in the country. The daily per capita generation of municipal solid waste in India ranges from about 100 g in small towns to 500 g in large towns. The solid waste generated in Indian cities has increased from 6 million tones in 1947 to 48 million tones in 1997 and is expected to increase to 300 million tones per annum by 2047 (Corporation of Chennai, 2012). The characteristics of MSW collected from any area depends on a number of factors such as food habits, cultural traditions of inhabitants, lifestyles, climate, etc1. At present most of the MSW in the country is disposed off unscientifically (i.e.) lack of 'sanitary landfill'. This has adverse impacts on not

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only the ecosystem but also on the human environment. Unscientific disposal practices leave waste unattended at the disposal sites, which attract birds, rodents, fleas etc., to the waste and create unhygienic conditions like odour, release of airborne pathogens, etc. The plastic content of the municipal waste is picked up by the rag pickers for recycling either at primary collection centers or at dumpsites. Plastic are recycled mostly in factories, which do not have adequate technologies to process them in a safe manner. This exposes the workers to toxic fumes and unhygienic conditions. Moreover, since the rag picking sector is not organised, not all the recyclables, particularly plastic bags, get picked up and are found littered everywhere, reaching the drains and water bodies ultimately and choking them (Esakku, 2007).

Components of municipal solid waste

Table 1. The type of litter generated and the approximate time it takes to degenerate

Type of litter	Approximate time it takes to degenerate
Organic waste such as vegetable and fruit peels, leftover foodstuff, etc.	a week or two.
Paper	10 - 30 days
Cotton cloth	2 - 5 months
Wood	10 - 15 years
Woolen items	1 year
Tin, aluminium, and other metal items such as cans	100 - 500 years
Plastic bags	One million years?
Glass bottles	Undetermined

Municipal solid waste consists of household waste, construction and demolition debris, sanitation residue, and waste from streets. This garbage is generated mainly from residential and commercial complexes. In Tamil Nadu due to urbanization and change in lifestyle and food habits, the amount of municipal solid waste has been increasing rapidly and its composition changing. Table.1 predicts the type of litter generated and the approximate time it takes to degenerate. The general composition of solid wastes is as follows (Table.2)

Table 2. General composition of the municipal solid wastes

Biodegradable matter	50%
Glass	4%
Plastics	3%
Paper	5%
Metals	1%
Leather and rubber	1%
Rags	5%
Household hazardous	1%
Inert materials	30%

Biomedical waste

Hospital waste is generated during the diagnosis, treatment, or immunization of human beings or animals or in research activities in these fields or in the production or testing of biologicals. This waste is highly infectious and can be a serious threat to human health if not managed in a scientific and discriminate manner. It has been roughly estimated that of the 4 kg of waste generated in a hospital at least 1 kg would be infectious1.

E-Waste

Electronic waste or E-waste as it is popularly called is a collective terminology for the entire stream of electronic. Computer waste is the most significant of all waste due to the gigantic amounts as well as the rate at which it is generated. In addition, its recycling is a complex process that involves many hazardous materials and poses significant environmental and health hazard.

Impact

Hazardous Waste

Improper storage, handling, transportation, treatment and disposal of hazardous waste results in adverse impact on ecosystems including the human environment.

Biomedical Waste

Most biomedical waste generated from health care facilities are at present, collected without segregation into infectious and non-infectious categories and are disposed in municipal bins located either inside or outside the facility premises. The infectious waste gets mixed with

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municipal solid waste, it has potential to make the whole lot infectious in adverse environmental conditions. The disposal of which poses a risk of injury and exposure to infection to sanitary workers and rag pickers working at these dumpsites. Since most of these dumpsites are unscientifically managed, the chances of pathogens contained in infectious waste becoming airborne and getting released to nearby water bodies or affecting the local resident population.

Objective of the study

1. To show the status of solid waste in Chennai City.
2. To show the distribution of dustbin/container for solid waste in Chennai City.
3. To identify the demand and gap assessment for the solid waste management in Chennai City.

Methodology

Based on the objectives of the present study the secondary and perceptional data has been adopted in the form of qualitative techniques for the study area of Chennai City.

Study area

For the present study the study area has been chosen is Chennai city – a special group of slums in Chennai city.

Solid waste management in Chennai city

The Corporation of Chennai is the largest generator of solid waste estimated at 3000 tonnes per day. It has a network of transfer stations and two landfill sites at Kodungaiyur and Perungudi. The following Table .3 provides an estimate of current daily generation of various types of waste.

Government bodies at all levels (central, state and municipal) are taking proactive steps to improve the municipal solid waste scene in India. The Government of India issued new rules that regulate the MSWM (MoEF, 2000) at the local level. The mandatory requirements of the rule are,

- Source segregation and storage at source
- Door to door collection
- Abolition of open storage
- Daily sweeping of the street
- Transportation of waste in covered vehicles
- Waste processing by composting or energy recovery
- Disposal of inerts by sanitary landfilling

The current solid waste management system in the Corporation needs to be improved and the management in the rest of CMA requires immediate attention. State governments are involved through the State Pollution Control Boards (SPCBs) which enforce pollution control laws and local municipalities to comply with the new rules. Chennai (formerly Madras), is the fourth largest metropolitan city in India. It is the capital of the State of Tamil Nadu and located on the eastern coast (Latitude 13^{o} 07' N and Longitude 80^{o} 16' E). Total area of the city is 174 sq.km with a current population nearing 6 million. The city has also attained the status of Mega city (NPC, 2005). MSW generation in Chennai has increased from 600 to 3500 tpd within 20 years. The per capita generation rate is 0.6 kg/day. MSWM is the

Table 3. Solid Waste Generated Daily in CMA (in tonnes)

Area	Residential & Commercial	Hospital	Total	e-waste	Construction Debris
Chennai City	2620	80	2700	5	500
Municipalities	1073	11	1084	2	50
Town Panchayats	207	1	208	1	NA
Panchayat Union	255	1	256	2	-
Total	4155	93	4248	10	550

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primary function for CoC. This includes the street sweeping, collection, transportation and disposal of MSW from the city limit. Chennai is divided in to ten zones (Fig.1). The City Corporation has privatized (contracted) solid waste collection in a few zones. There are three different organizations namely the CoC, ONYX and CBOs such as Civic Exnora are involved in the MSWM of the city. This has improved the quantity collected but no progress has been made in respect of total solid waste management.

The Corporation maintains two solid waste dumping yards one at Kodungaiyur in the north and the other at Perungudi in the south. Both are over loaded and cause serious health problems to nearby residents. Besides the sites and surroundings are environmentally highly degraded. The municipalities of Alandur, Ambattur, Avadi and Thiruvottiyur have small sites of about 5 to 6 ha., being used as dumping grounds. Out of 16 municipal bodes in the CMA, 8 do not have any designated disposal facilities.

Solid waste management is an obligatory function of Municipal Corporations, Municipalities, Town Panchayats and Village local bodies.

The Tamil Nadu Pollution Control Board is responsible for enforcing the following rules in the Chennai Metropolitan Area

i) Municipal Solid Waste (Management & Handling) Rules 2000

ii) Hospital Waste (Management & Handling) Rules.

EXNORA through its several civic associations and several other resident associations have been active in door-to-door collection of solid waste in their neighbourhoods. This has been a significant feature for several years and Chennai City has a good standard of awareness and action for solid waste management at local levels.

Estimates of generation of solid waste

Based on the per capita generation of solid waste it is estimated that by 2026 about 6590 tonnes of solid waste will be generated in the local body areas of CMA including Chennai City (Table.4)

Table 4. estimation of generation of solid waste

Local Body	Tonnes
Chennai Corporation	3400
Municipalities	2050
Town Panchayats	550
Panchayat Unions	540
All Local Bodies	6590

The ERM study of 1996 had recommended solid waste management coverage in the City to be increased from 90% (1996-2000) to 100% (2001-2005). In respect of municipalities from 50% (1996-2000) to 70% (2001-2006) and 100% (2005-2011). In respect of Town Panchayat it was to be 10%, 30% and 70% respectively.

Population growth and rising income have resulted in a rapid growth in MSW generation rate of the city. Figure 2 presents the increase in average quantity of waste collected per day for the period of 1996 to 2006. Waste generation per day has been doubled during the last decade.

Graph and charts

MSW generated in Chennai includes 68 % of residential waste, 16 % commercial waste, 14 % institutional waste and 2 % industrial waste (Figure 3). The physico-chemical properties of the MSW generated in Chennai, showed that the majority of the waste is composed of green waste (32.3%) and inert materials (34.7%) *viz.*, stones and glass (CPCB, 2000 and Damodaran *et al*., 2003).

There is urgent need to institute a study to assess the quantities of the following categories of wastes to plan for their management.

- Domestic and commercial waste – Compostable, recyclable
- Industrial waste – non-hazardous and hazardous
- Hospital/biomedical waste – non-hazardous and hazardous

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- E-waste – recyclable and non-recyclable
- Construction debris – reusable as building material

Solid waste management by corporation of Chennai

The CoC is undertaking MSWM for the seven zones (1, 2, 3, 4, 5, 7 and 9). The management of solid waste as stated in schedule II of the MSWM & Handling Rules (MoEF, 2000) has listed collection of MSW with emphasis on segregation at source and door to door collection. In compliance with the above rules, several attempts are underway to improve the MSWM in Chennai city. The initiatives include the following.

Source Segregation*:* It is introduced with a view to setting aside of biodegradable and recyclable materials from the waste stream before these are collected with the other MSW, to facilitate reuse, recycling and composting. Initially source segregation was introduced in a few zones by January 2004, and the facility was further extended to other zones. It was initiated with a public awareness campaign on source segregation of MSW during 2003. Corporation workers, zonal officers, revenue officers technical staff, teachers and school children were involved in this program. Non Governmental Organisations (NGO's) and members of local welfare associations (Civic Exnora) started their own campaign and helped in distributing the pamphlets prepared by the CoC. The awareness program comprised of public rallies, meetings, distribution of pamphlets, street plays and advertisements.

Door to door collection: Door to door collection is introduced to replace the street bin collection system with a view to reduce the environmental effects. Tricycles fitted with bells were used for MSW collection from doorsteps. The scheme was introduced in June 2003 and expanded throughout the city during January 2004.

Abolition of open storage*:* It is partially achieved by the removal of community bins from the streets. The number of street bins were reduced from 14,000 to 1,300 during November 2004. Due to the lack of financial resources, non co-operation of the population and inaccessible area/narrow lanes it is difficult to achieve 100% abolition of open storage.

Daily sweeping of the street: Corporation employees are engaged in sweeping the streets at least once in a day using brooms, brushes, rotomould wheeled bins, wheel barrow and long brooms. The major constraints in implementing daily street sweepings are shortage of sanitary workers, public holidays and lack of financial support.

Transportation in covered vehicles*:* CoC has initiated the transportation of MSW in vehicles covered with fishnets to avoid spillage. Difficulties in using the covered vehicles for transportations are financial resource, insufficient number of vehicles and attitude of workers.

Wastes processing by energy recovery or composting*:* Ward level composting units were introduced in 106 places to reduce the transportation cost of MSW and the amount of waste reaching dumpsite. The segregated waste is collected and the organic fraction is subjected to composting in ward level composting units, whereas the non recyclable fraction is transported to the dumpsites for disposal. There were proposals to recover energy from the waste and composting of organic fractions in centralized mechanical composting units. These projects are yet to be implemented.

Sanitary landfilling*:* According to Environmental Resource Management suggestions (ERM 1996), the open dump sites are in operation for the past 20 years and their lifetime is expected to last up to 2011, which can be extended to a further period by upgrading the existing sites. Based on the recent investigations CoC has initiated the upgradation process of Kodungaiyur dumpsite. The approach is a phase wise conversion of open dumpsite into a sanitary landfill as per the recommendation of the National Productivity Council (NPC, 2005).

It is difficult to fulfill the requirements of all the above aspects in developing countries like India,

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Table 5. Service Indicators for the Assessment of Solid Waste Management		
Sl. No.	**Particulars**	**Service Indicators**
1	*Service levels*	Daily per capita waste generation (grams/day) based on the normative standards
		Total temporary waste storage collection capacity with respect to waste generation
3	*Service coverage*	Average spacing between dustbins

due to practical problems such as lack skilled personal for MSWM, administrative difficulties and public coordination.

Solid Wastes Status Assessment

Solid waste management is also one of the grossly neglected sectors in city, impacting severely on the health and hygiene. Solid waste management is also one of the obligatory services of the local body. The service levels in case of solid waste management has been assessed in terms of generation waste (based on normative standards), availability of temporary waste storage points / dustbins and spacing between them. Following are some select service indicators used to assess the performance on the solid waste management aspect (Table 5)

For any strategy for effective solid waste management, an estimate on the quantity of waste generation is a key input. Since the scientific calculation of solid waste generation can be estimated based on various parameters at city level. It is difficult to ascertain the quantity of waste generation accurately for a slum or a pocket of area within the city. In practice, the estimate of solid waste generation for a pocket of area is ascertained based on the per capita waste generation at the city level.

Table 6. Zone-wise Break-up of Estimated Solid Waste Generation

Sl. No.	**Zones**	**Slum Population**	**Estimated Solid Waste Generation** (Expressed in MT per Day)
1.	Zone I	33799	20.28
2.	Zone II	17342	10.41
3.	Zone III	34854	20.91
4.	Zone IV	27327	16.40
5.	Zone V	17418	10.45
6.	Zone VI	43482	26.09
7.	Zone VII	16140	9.68
8.	Zone VIII	12688	7.61
9.	Zone IX	48111	28.87
10.	Zone X	78663	47.20
	Total	**329824**	**197.89**

It may be noted that the rate of per capita waste generation of solid waste depends on various socio-economic characteristics and consumption pattern of the population. In general, it is observed that the per capita waste generation is directly proportional to the city size and the income of the population. The zone-wise break-up of quantity of waste generation in for a pocket of area in Chennai city is given in Table 6.

From the field visits and the discussion with the officials of the Chennai Municipal Corporation, the Consultants understand that the temporary waste storage points are located outside the slums irrespective of the road length inside a slum, due to the paucity of space inside. Accordingly, the analysis and demand-gap assessment has been made assuming that there were no temporary waste storage points / dustbins within the slums as the same need to be designed separately suiting to the space requirements of the slums.

Demand Assessment

Disposal of Solid Waste from the Source of Generation

Based on the Demand Assessment Surveys, a majority of the households (about 54.5 percent) have found the easy way out of throwing the solid waste at road side/ open spaces. About 33.3 percent of the respondents reported that they deposit the waste generated in the municipal bins. Others (about 12 percent) revealed that they throw into the drains. Only 0.2 percent of the households got it collected on payment, as indicated in the

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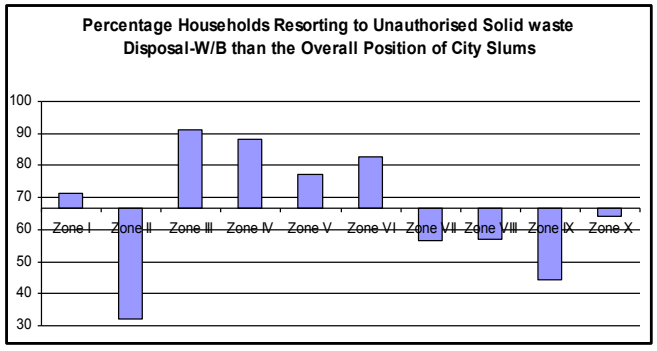
Table 7. Zone-wise Break-up of Mode of Disposal of Waste Generated at Source
All Figures in Percentage

Sl. No.	Zones	Dumped at Municipal Bins	Thrown at Road Side/ Open Spaces	Thrown into Drains	Collected by Payment	Total
1.	Zone I	28.8	59.8	11.4	0.0	100.0
2.	Zone II	66.8	12.1	19.8	1.3	100.0
3.	Zone III	8.7	83.6	7.7	0.0	100.0
4.	Zone IV	11.6	84.4	4.0	0.0	100.0
5.	Zone V	22.6	68.3	9.1	0.0	100.0
6.	Zone VI	17.1	48.1	34.8	0.0	100.0
7.	Zone VII	43.4	51.3	5.3	0.0	100.0
8.	Zone VIII	43.2	49.5	7.4	0.0	100.0
9.	Zone IX	55.4	33.6	10.9	0.2	100.0
10.	Zone X	35.8	54.0	10.1	0.2	100.0
	Total	**33.3**	**54.5**	**12.0**	**0.2**	**100.0**

Source: *Demand Assessment Surveys; 2004*



Source: *Demand Assessment Surveys; 2004*

Chart 1. Zone-wise Rating of Slums Resorted to Unorganized Disposal of Solid Waste Generated at Source

table below. The zone wise rating based on the habits of the respondents to throw waste on road / open space and in drains is shown in the chart below.

It is shocking to note that about three-fourth of the respondents were not following scientific method of depositing the waste in designated temporary waste storage point/ dustbin. One of the prime reasons for this habit was also non-availability of dustbins in the vicinity (Table 7 & Chart 1).

Frequency of Collection of Waste

For a query on the frequency of collection of waste by the municipal authorities, a majority of respondents (about 54.3 percent) revealed that the solid waste generated was collected on daily basis. However, about 7.5 percent reported that the collection was carried out alternative days, while another 10.5 percent reported that the collection was done on weekly basis. About one-fifth of the respondents did not respond to this query, as given in the Table 8.

Table 8. Zone-wise Break-up Indicating Frequency of Collection of Solid Waste
All Figures in Percentage

Sl. No.	Zones	Daily	Alternate Day	Twice a Week	Weekly	No Response	Total
1.	Zone I	25.8	7.3	0.4	15.6	50.9	100.0
2.	Zone II	47.4	16.8	1.3	15.9	18.5	100.0
3.	Zone III	53.3	5.3	0.2	6.9	34.3	100.0
4.	Zone IV	52.5	7.8	0.0	3.8	35.9	100.0
5.	Zone V	57.7	9.1	0.0	2.4	30.8	100.0
6.	Zone VI	46.3	1.2	0.0	0.4	52.1	100.0
7.	Zone VII	77.4	6.2	0.0	8.0	8.4	100.0
8.	Zone VIII	85.3	3.7	0.0	0.0	11.1	100.0
9.	Zone IX	37.0	8.0	0.2	44.2	10.7	100.0
10.	Zone X	60.7	10.0	0.2	7.4	21.7	100.0
	Total	**54.3**	**7.5**	**0.2**	**10.5**	**27.4**	**100.0**

Source: *Demand Assessment Surveys; 2004*

Availability and Distance of the Temporary Waste Storage Point / Dustbin

The distance between two temporary waste storage points/ dustbins is one of the most important aspects in solid waste management. About 26.4 percent of the respondents reported that the temporary waste storage point/ dustbin were available within 50 m of distance. However, a majority of about 52 percent did not respond to

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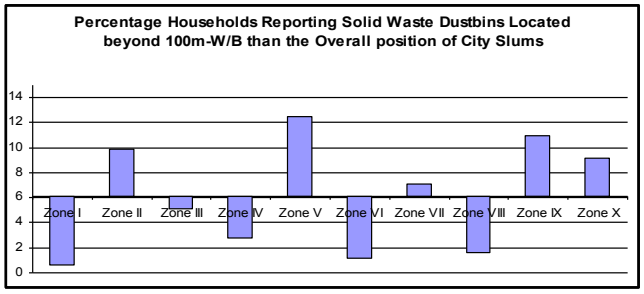
Table 9. Zone-wise Break-up of Availability of Dustbin and Distance between them
All Figures in Percentage

Sl. No.	Zones	Less than 50 m	51 m -100 m	101 m -250 m	More than 250 m	No Response	Total	More than 100 m
1.	Zone I	23.1	15.8	0.2	0.4	60.4	100.0	0.6
2.	Zone II	30.2	33.2	7.8	2.2	26.7	100.0	9.9
3.	Zone III	5.9	3.8	1.0	4.2	85.1	100.0	5.1
4.	Zone IV	22.9	3.8	2.8	0.0	70.4	100.0	2.8
5.	Zone V	37.0	16.3	6.3	6.3	34.1	100.0	12.5
6.	Zone VI	16.7	3.9	0.8	0.4	78.2	100.0	1.2
7.	Zone VII	37.6	4.9	4.9	2.2	50.4	100.0	7.1
8.	Zone VIII	40.5	6.8	0.0	1.6	51.1	100.0	1.6
9.	Zone IX	19.0	47.7	1.5	9.5	22.3	100.0	11.0
10.	Zone X	31.2	18.7	5.8	3.3	41.0	100.0	9.2
	Total	**26.4**	**15.5**	**3.1**	**3.0**	**52.0**	**100.0**	**6.1**

Source: *Demand Assessment Surveys; 2004*

his query, as they have not seen temporary waste storage point/ dustbin in the vicinity. About 6.1 percent of the respondents reported that the bins were located more than 100 m distance, as given in the table below. Further, zone-wise rating of response for temporary waste storage point/ dustbin location beyond 100 m distance is presented in the Table 9 and Chart 2.



Source: *Demand Assessment Surveys; 2004*

Chart 2. Zone-wise Rating of Slums having Dustbin Located at more than 100 m Distance

Willingness-to-Pay for Improved Solid Waste Management

For the query on the willingness-to-pay for the improved solid waste management, a majority of the respondents (about 78.2 percent) responded unfavorably while about 9.2 percent were willing to pay less than Rs. 10 per month. About 1.8 percent was willing to pay Rs. 11-25 per month for improved solid waste management, while about 0.7 percent was willing to pay more than Rs. 25 per month for the improved solid waste management, as presented in the table below. The chart below presents the zone wise rating of the slums in terms of respondents' willingness-to-pay up to Rs. 10 per month on the improved solid waste management (Table 10 & Chart 3).

Table 10. Zone-wise Break-up of Respondents' Willingness to Pay for Improved Solid Waste Management
All Figures in Percentage

Sl. No.	Zones	Less than Rs. 10	Rs. 11 to Rs. 25	More than Rs. 25	None	No Response	Total
1.	Zone I	7.7	0.6	0.2	49.3	42.2	100.0
2.	Zone II	12.5	2.6	0.4	62.1	22.4	100.0
3.	Zone III	2.0	0.4	0.0	91.7	5.9	100.0
4.	Zone IV	14.4	0.5	0.0	72.8	12.3	100.0
5.	Zone V	24.0	4.8	3.8	65.4	1.9	100.0
6.	Zone VI	0.6	0.6	0.6	97.7	0.6	100.0
7.	Zone VII	1.8	4.9	0.9	86.7	5.8	100.0
8.	Zone VIII	6.3	0.0	0.5	92.1	1.1	100.0
9.	Zone IX	6.4	0.2	0.0	90.1	3.4	100.0
10.	Zone X	16.3	3.5	0.6	74.6	5.0	100.0
	Total	**9.2**	**1.8**	**0.7**	**78.2**	**10.1**	**100.0**

Source: *Demand Assessment Surveys; 2004*

Problems in Solid Waste

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Management

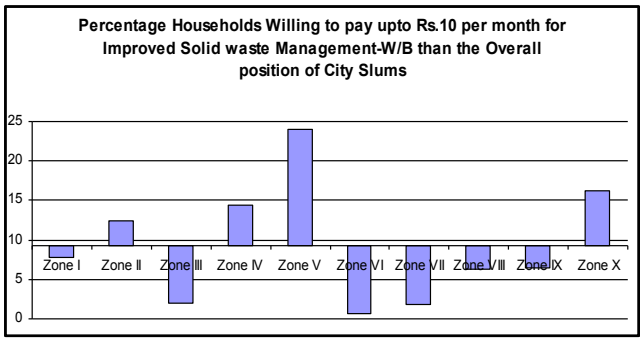
With regard to problems of solid waste management, an overwhelming majority of households (60.4 percent) indicated that there were no problems. About 21.4 percent of the households indicated that the dustbins were inadequate while about 12.2 percent complained about irregular collection, as given in the table below. The zone wise variation in this aspect is presented in the chart below. It may be noted that about one-third of the respondents in Zone 1 did not answer for this query (Table 11 & Chart 4).

Solid waste management

Summary on Status Assessment

As stated earlier, the solid waste generation in the surveyed slums has been estimated assuming a per capita waste generation of 600 grams per day and as a whole the slums located within the administrative jurisdiction of Chennai Municipal Corporation were generating about 134.21 MT per day. From the field visits and the discussion with the officials of the Chennai Municipal Corporation, the Consultants understand that the temporary waste storage points are located outside the slums

irrespective of the road length inside a slum, due to the paucity of space inside. Accordingly, it is assumed that there were no temporary waste storage points / dustbins within the slums as the same need to be designed separately suiting to the space requirements of the slums.



Source: *Demand Assessment Surveys; 2004*

Chart 3. Zone-wise Rating for up to Rs. 10 Willingness-to-Pay for the Improved Solid Waste Management

Service and Cost Norms

The service norms for solid waste management have been fixed for the temporary waste storage points/dustbins only with respect to their capacity and spacing between them, as per the following. Further, a broad cost norm for the provision of dustbin has been evolved and presented below (Table 12):

Demand and Gap Assessment

Based on the existing status and in comparison with the above indicated service norms for solid waste management, a demand and gap assessment has been carried out and is presented in the table below zone-wise. It may be noted that the size of

Table 11. Zone-wise Break-up of Problems in Solid Waste Management
All Figures in Percentage

Sl. No.	Zones	Inadequate Dustbins	Irregular Collection	Others	None	No Response	Total
1.	Zone I	20.9	12.8	1.0	37.7	27.6	100.0
2.	Zone II	17.2	37.5	0.9	42.2	2.2	100.0
3.	Zone III	14.3	4.0	0.2	79.4	2.2	100.0
4.	Zone IV	32.9	1.7	0.7	63.1	1.7	100.0
5.	Zone V	3.8	11.5	0.5	83.2	1.0	100.0
6.	Zone VI	55.8	0.6	1.0	42.4	0.2	100.0
7.	Zone VII	26.1	6.2	4.4	62.8	0.4	100.0
8.	Zone VIII	11.6	2.1	6.8	76.8	2.6	100.0
9.	Zone IX	12.2	37.9	0.5	47.4	2.0	100.0
10.	Zone X	19.5	8.1	1.6	68.4	2.4	100.0
	Total	**21.4**	**12.2**	**1.8**	**60.4**	**4.2**	**100.0**

Source: *Demand Assessment Surveys; 2004*

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Table 12. Service and Cost Norms for Solid Waste Management

Sl. No.	Particulars	Unit	Norm	Basis
A.	**Service Norms**			
1.	Spacing of Temporary Waste Storage Points / Dustbins	Metres	300	Manual
2.	Capacity of Dustbins with respect to Waste Generation	Times	1.5	Manual
3.	Size of each Dustbin/Container	cu. m	0.30	Proposed
B.	**Cost Norms**			
1.	Dustbin/Container	Rs. / Unit	3,800	Proposed

Table 13. Zone-wise Requirement of Dustbins/Containers for Solid Waste Management

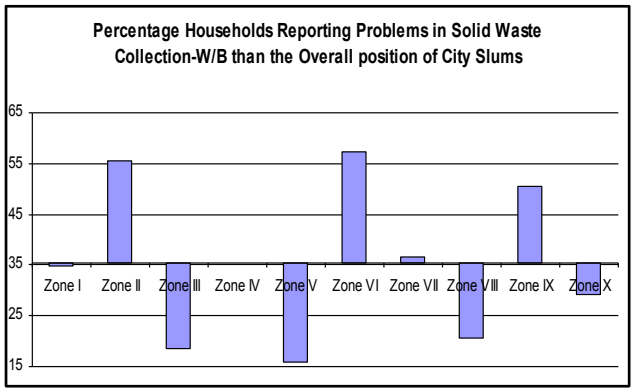
Sl. No.	Zone	Dustbins/Containers (Nos.)		
		Based on Waste Generation (1.5 times waste generated)	**Based on Spacing between the Bins** (300 m apart)	**Suggestion** (Maximum of 1 and 2)
		1	**2**	**3**
1.	Zone I	203	36	203
2.	Zone II	104	18	104
3.	Zone III	209	66	209
4.	Zone IV	164	39	164
5.	Zone V	105	60	105
6.	Zone VI	261	32	261
7.	Zone VII	97	45	97
8.	Zone VIII	76	21	76
9.	Zone IX	289	41	289
10.	Zone X	474	70	474
	Total	**1982**	**428**	**1982**

each dustbin/container is envisaged as 0.30 cu. m (approximately 150 kg of solid waste) as larger dustbin or containers are not possible to place due to paucity of space. Accordingly, the numbers of dustbins/containers have been estimated taking the maximum figure out of requirement of dustbins or containers based on quantity of waste generated (1.5 times) or spacing between the dustbins/container (300m), (Table 13).

Based on the above table, it is estimated that about 1982 Nos. of dustbins/containers, each of capacity 0.30 cu. m (approximately about 150 kg) is required to improve the solid waste management system in these slums.

Table 14. Zone-wise Estimate of Capital Investment Requirement for Solid Waste Management

Sl. No.	Zone	Capital Investment Estimate (Rs. in Lakhs)	Percentage Contribution
1.	Zone I	7.73	10.27
2.	Zone II	3.95	5.25
3.	Zone III	7.95	10.56
4.	Zone IV	6.23	8.27
5.	Zone V	3.97	5.27
6.	Zone VI	9.91	13.16
7.	Zone VII	3.68	4.89
8.	Zone VIII	2.89	3.84
9.	Zone IX	10.99	14.59
10.	Zone X	18.00	23.90
	Total	**75.30**	**100.00**



Source: *Demand Assessment Surveys; 2004*

Chart 4. Zone-wise Rating Indicating the Problems in Solid Waste Management

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Capital Investment Estimate

Based on the norms proposed for the solid waste management and the estimated number of dustbins/containers, and the cost norms proposed, the capital investment estimate has been prepared and presented zone-wise in the Table14.

Based on the above, it is estimated that a capital investment of Rs. 0.75 crores is required to improve the solid waste management in Chennai City.

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