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Municipal solid waste management in kolkata metropolitan areas - A case study

Anirban Das*, Moitrayee Sanyal, Pankaj Kumar Roy, Arunabha Majumder, Arun Kanti Biswas, Asis Mazumdar

School of Water Resources Engineering, Jadavpur University, Kolkata-700 032 (INDIA)

E-mail : anirban.evs@gmail.com; anirbanmll@gmail.com.

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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, creating problems to public health and the environment. In the present study, an attempt has been made to provide a comprehensive review of the characteristics, generation and collection of MSW practiced in Kolkata metropolitan area. 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.

KEYWORDS

MSW;
Open dumps;
Landfill;
Waste generation;
Waste collection;
KMA.

INTRODUCTION

Solid waste has been produced since the beginning of civilization. During the earliest periods, solid wastes were conveniently and unobtrusively disposed of in large open land spaces, as the density of the population was low. However, today, one of the consequences of global urbanization is an increased amount of solid waste. About 1.3 X 10^9 t of MSW was generated globally in 1990[4], and, at present, the annual generation is approximately 1.6 X 10^9 t. The urban population in Asia generates around 760 X 10^3 t of MSW per day, and this is expected to increase to 1.8 X 10^6 t by 2025[18]. The state of the economy influences waste generation[16]. Usually, greater economic prosperity and a larger urban population results in a larger amount of solid waste generation[1], which is a common feature in developing countries. Improper disposal of waste has huge social costs due to the spread of communicable diseases and increased treatment costs for pollutants, and is an issue of increasing concern[3].

MSWM is the major problem being faced by municipalities because it involves a huge expenditure and receives scant attention[7]. It is not only a technical problem but it also is strongly influenced by political, legal, socio-cultural, environmental and economic factors, as well as available resources. Moreover, these factors have interrelationships that are usually complex in waste management systems. Many cities in developing Asian countries face serious problems in managing their solid

waste. The annual waste generation increases in proportion to the rise in population and urbanization, and issues related to disposal have become challenging as more land is needed for the ultimate disposal of these solid wastes[10]. MSW is normally disposed of in an open dump in many Indian cities and towns, which is not the proper way of disposal because such crude dumps pose environmental hazards causing ecological imbalances with respect to land, water and air pollution[12]. Increasing population levels, rapid economic growth and rise in community living standards will accelerate the future MSW generation rate within Indian cities. The present annual quantity of solid waste generated in Indian cities has increased from 6 million tons in 1947 to 48 million tons in 1997 with an annual growth rate of 4.25%, and it is expected to increase to 300 million tons by 2047[8].

Improper management of MSW constitutes a growing concern for cities in developing nations. Proper management requires the construction and installation of essential facilities and machinery, based on a suitable management plan. More than 90% of MSW in India is directly disposed of on the land in an unsatisfactory manner[9]. The problem is already acute in cities and towns as the disposal facilities have not been able to keep space with the quantum of wastes being generated. It is common to find large heaps of garbage lying in a disorganized manner at every nook and corner in the cities[11]. Therefore, the present study aims at to determine the quantitative and qualitative characteristics of MSW along with basic information, which is desirable for MSWM, for Kolkata Metropolitan area.

STUDY AREA

Kolkata is one of the four metropolitan cities of India and is the capital of the state of West Bengal. The city is centered on latitude 22^0 34' North and longitude 88^0 24' East, is approximately 30 km from the Bay of Bengal, and the river tides at Kolkata range over 4m. In the absence of formalized waste segregation practices, recycling has emerged only as an informal sector using outdated technology, which causes serious health problems to waste–pickers[17]. Kolkata Municipal Corporation (KMC), the waste managing authority, has begun to analyze the existing waste management situation with the goal of improvement along with the help of financial assistance from different authorities. In the year 1998, the government of India asked the Asian Development Bank (ADB)[2] to provide financial assistance to ameliorate the environmental conditions in Kolkata. Since then, various improvement schemes have been undertaken under the Kolkata Environmental Improvement Project (KEIP)[13], of which solid waste management is a part.

Kolkata Metropolitan Area (KMA) (Plate1) is the urban agglomeration of the city of Kolkata, West Bengal, India. KMA consists of 3 Municipal corporations (Kolkata Municipal Corporation (KMC), Howrah Municipal Corporation and Chandannagore Municipal Corporation, also it consists of 38 Municipalities, 72 cities and 527 towns and villages According to the 2001 census data, the total population of KMA is 13,216,546. The total area is 1,026 km², making the population density 12,883 per km². According to a KMDA report of 2003, the approximate population is 14,000,000. The area is 1785 km², thus reducing the population density to 7843 per km². According to 2005 KMDA reports, the population has crossed 15 million and the area covered by KMA now is more than 1854 km². In KMA the cleaning and collection process involves collection of MSW from the street in wheelbarrows and thereafter, it is dumped into waste depots. MSW is then loaded into the transportation vehicles, which transport the waste to different disposal sites. Every year KMA spends on average 18% of its total budget on solid waste management.

METHODOLOGY

In the first phase of the study, a questionnaire survey was carried out on 41 municipal towns in the Kolkata Metropolitan Area. The questionnaire was pretested in a municipality for validation. Further, the per capita generation rate was evaluated from the population taken into account during survey work. Also population density were carried out from the area of the municipality and population.

In the second phase of the study, samples of MSW from different municipal towns were collected to determine its characteristics. The sampling and analysis of MSW were carried out as per standard procedures.

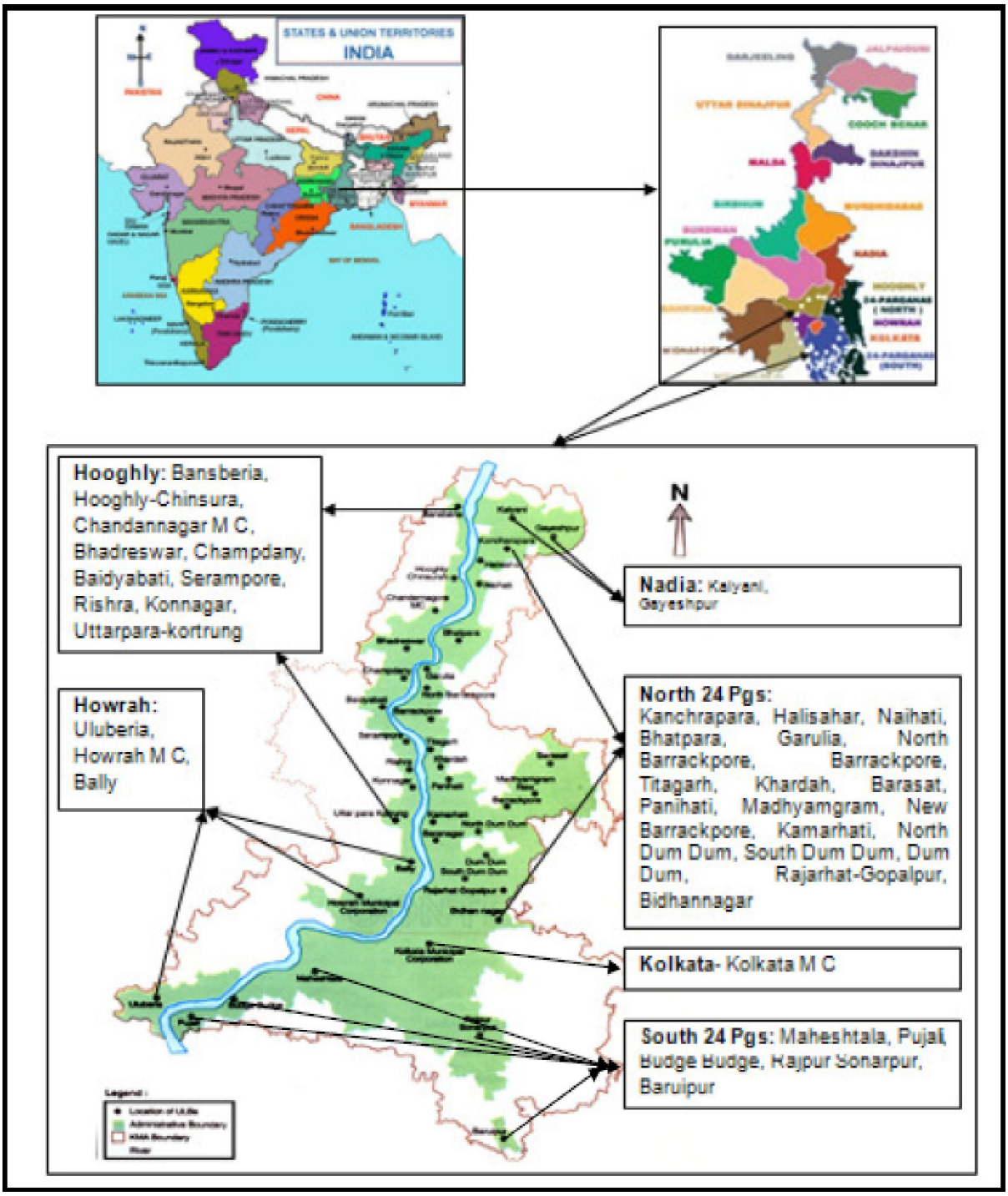

Plate 1 : Location map of Kolkata Metropolitan area

Five samples were randomly collected from different municipal towns (one sample/ward), and two samples were collected from the disposal sites. Critical analysis of existing MSWM systems comprising collection, storage, transportation, processing, and disposal was performed in keeping with the provisions made under MSW (Management and Handling) Rules, 2000, and shortcomings in the systems were identified. With a view to overcoming these shortcomings, indicative strategies and guidelines for action plan preparation were formulated. The methodology adopted for the present study is shown in Figure 1a.

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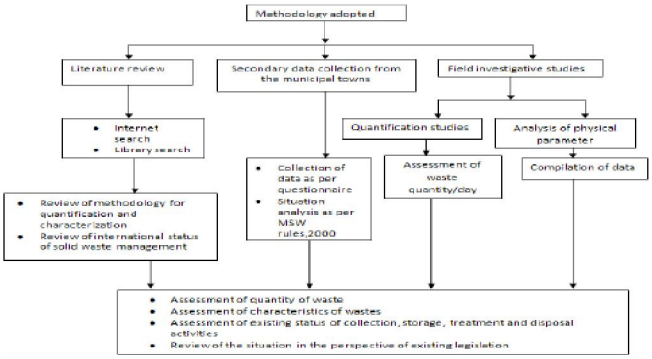

Figure 1a : Flow chart adopted for the study.

RESULTS

Assessment of waste generation is essential for formulating the solid waste management system . While per capita waste generation is a statistic, which is necessary for indicating trends in consumption and production, the total weight and volume of waste generated by the community served by the management system are of greater importance in planning and design. On the basis of the information furnished by the municipal towns in the given questionnaire and the surveys conducted in various municipal towns from time to time the per capita waste generation rates have been calculated based on the various population ranges. TABLE-I highlights quantity of solid waste generation in the 41 municipal towns under Kolkata metropolitan area. In most of the municipal bodies under Kolkata metropolitan area, collection of solid waste is less than generation of solid waste (Figure 1 - Figure 2), as a result

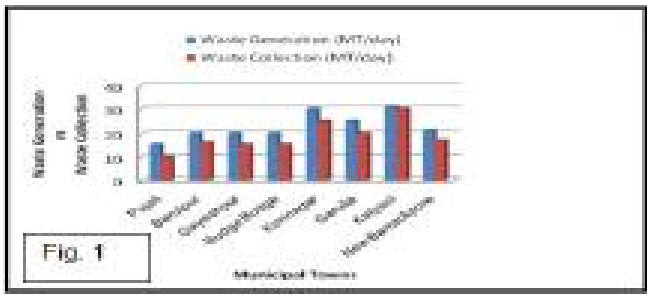

Figure 1 : Waste generation v/s collection in different municipal towns (Pupulation < 1 lakh)

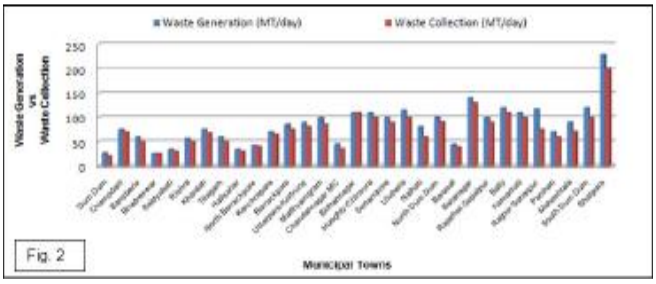

Figure 2 : Waste generation v/s collection in different municipal towns (Pupulation 1 lakh – 5 lakh)

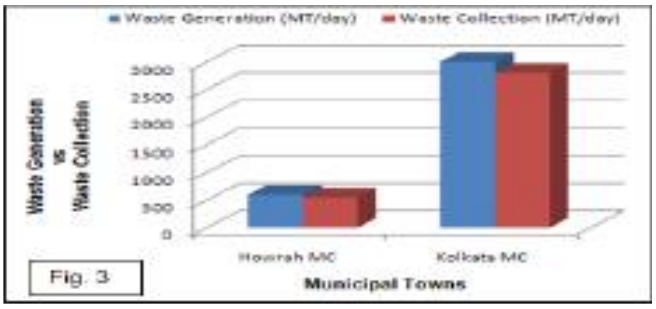

Figure 3 : Waste generation v/s collection in different municipal towns (Pupulation > 5 lakh)

TABLE 1 : Solid waste generation in different municipal towns under KMA.

Sl. No.	Name of the Municipal Towns	Latitude & Longitude	Population (as per 2001 Census) (Lakh)	Area (km^2)	Waste Generation (MT/day)	Waste Collection (MT/day)	Per capita waste generation (gm/day)	Average per capita waste generation (gm/day)
			Population less than 1 lakh					
1	Pujali	$22^0$28' N & 88^0 09' E	0.34	8.50	15.0	10	441.1	
2	Baruipur	$22^0$21' N & 88^0 25' E	0.45	9.07	20.0	16	444.4	
3	Gayeshpur	$22^0$57' N & 88^0 29' E	0.55	30.00	20.0	15	363.6	
4	Budge Budge	$22^0$42' N & 88^0 20' E	0.75	9.06	20.0	15	266.6	
5	Konnagar	$22^0$49' N & 88^0 22' E	0.72	4.33	30.0	25	416.6	352.3
6	Garulia	$22^0$29' N & 88^0 11' E	0.72	6.48	25.0	20	347.2	
7	Kalyani	$22^0$58' N & 88^0 26' E	0.82	21.91	31.0	30	378.0	
8	New Barrackpore	$22^0$45' N & 88^0 22' E	0.83	17.17	21.5	17	259.0	
	Total		5.18		182.5			

Sl. No.	Name of the Municipal Towns	Latitude & Longitude	Population (as per 2001 Census) (Lakh)	Area (km^2)	Waste Generation (MT/day)	Waste Collection (MT/day)	Per capita waste generation (gm/day)	Average per capita waste generation (gm/day)
			Population 1 to 5 lakhs					
1	Dum Dum	22^0 37' N & 88^0 25' E	1.01	8.81	26.0	20.0	257.4	
2	Champdani	22^0 48' N & 88^0 20' E	1.03	6.47	75.0	70.0	728.1	
3	Bansberia	22^0 57' N & 88^0 24' E	1.04	9.07	60.0	50.0	576.9	
4	Bhadreswar	22^0 49' N & 88^0 20' E	1.06	6.48	24.7	24.7	245.3	
5	Baidyabati	22^0 47' N & 88^0 19' E	1.08	9.06	35.0	30.0	324.0	
6	Rishra	22^0 43' N & 88^0 20' E	1.13	6.48	57.0	50.0	504.4	
7	Khardah	22^0 38' N & 88^0 22' E	1.16	6.87	75.0	68.0	646.5	
8	Titagarh	22^0 38' N & 88^0 22' E	1.24	3.24	60.0	50.0	483.8	
9	Halisahar	22^0 57' N & 88^0 25' E	1.24	8.28	35.0	30.0	282.2	
10	North Barrackpore	22^0 45' N & 88^0 22' E	1.24	8.42	43.0	41.0	346.7	
11	Kanchrapara	22^0 49' N & 88^0 30' E	1.26	9.07	70.0	65.0	555.5	
12	Barrackpore	22^0 45' N & 88^0 22' E	1.44	11.65	85.0	75.0	590.2	
13	Uttarpara-ortrung	232 37' N & 88^0 25' E	1.50	18.15	90.0	80.0	600.0	
14	Madhyamgram	22^0 41' N & 88^0 27' E	1.56	21.32	100.0	85.0	641.0	
15	Chandannagar MC	22^0 51' N & 88^0 22' E	1.62	22.03	45.5	36.4	280.8	
16	Bidhannagar	22^0 40' N & 88^0 28' E	1.68	33.50	110.0	110.0	654.7	413.4
17	Hooghly-Chinsura	22^0 49' N & 88^0 26' E	1.70	21.52	110.0	100.0	647.0	
18	Serampore	22^0 45' N & 88^0 20' E	1.98	5.88	100.0	90.0	505.0	
19	Uluberia	22^0 28' N & 88^0 06' E	2.02	33.72	115.0	100.0	569.3	
20	Naihati	22^0 53' N & 88^0 25' E	2.15	11.55	80.0	60.0	372.0	
21	North Dum Dum	22^0 37' N & 88^0 23' E	2.20	26.45	102.0	92.0	463.6	
22	Barasat	22^0 42' N & 88^0 28' E	2.32	31.41	45.0	40.0	193.9	
23	Baranagar	22^0 38' N & 88^0 22' E	2.50	7.12	140.0	130.0	560.0	
24	Rajarhat Gopalpur	22^0 37' N & 88^0 25' E	2.71	28.00	100.0	90.0	369.0	
25	Bally	22^0 38' N & 88^0 21' E	2.82	11.81	120.0	110.0	425.5	
26	Kamarhati	22^0 39' N & 88^0 22' E	3.14	10.96	110.0	100.0	350.3	
27	Rajpur-Sonarpur	22^0 28' N & 88^0 21' E	3.36	57.90	117.0	75.0	348.2	
28	Panihati	22^0 42' N & 88^0 22' E	3.48	19.40	70.0	60.0	201.1	
29	Maheshtala	22^0 29' N & 88^0 15' E	3.89	44.17	90.5	70.8	232.6	
30	South Dum Dum	22^0 35' N & 88^0 23' E	3.92	15.49	120.0	100.0	306.1	
31	Bhatpara	22^0 52' N & 88^0 24' E	4.42	34.49	230.0	200.0	520.3	
	Total		62.9		2600.3			
			Population > 5 lakh					
1	Howrah MC	22^0 35' N & 88^0 20' E	10.09	51.74	600	550	654.8	
2	Kolkata MC	22^0 33' N & 88^0 21' E	45.81	197.54	3000	2800	873.1	644
	Total		55.9		3600			

good amount of solid wastes are remaining accumulated at various places in the towns creating problems to public health and the environment.

Municipal solid waste generation may be depen-

TABLE 2 : Population density in different municipal towns

Sl. No.	Name of the Municipal Towns	Population (as per 2001 Census) (Lakh)	Area (sq. Km)	Population Density (no. of person/sq. km)	Waste Generation (MT/day)
	Population less than 1 lakh				
1	Pujali	0.34	8.50	4000.0	15.0
2	Baruipur	0.45	9.07	4961.0	20.0
3	Gayeshpur	0.55	30.00	1833.3	20.0
4	Konnagar	0.72	4.33	16628.0	30.0
5	Garulia	0.72	6.48	11111.0	25.0
6	Budge Budge	0.75	9.06	8278.1	20.0
7	Kalyani	0.82	21.91	3742.5	31.0
8	New Barrackpore	0.83	17.17	4834.0	21.5
	Population 1 to 5 lakhs				
1	Dum Dum	1.01	8.81	11464.2	26.0
2	Champdani	1.03	6.47	15919.6	75.0
3	Bansberia	1.04	9.07	11466.3	60.0
4	Bhadreswar	1.06	6.48	16358.0	24.7
5	Baidyabati	1.08	9.06	11920.5	35.0
6	Rishra	1.13	6.48	17348.0	57.0
7	Khardah	1.16	6.87	16885.0	75.0
8	Titagarh	1.24	3.24	38271.6	60.0
9	Halisahar	1.24	8.28	14975.8	35.0
10	North Barrackpore	1.24	8.42	14726.8	43.0
11	Kanchrapara	1.26	9.07	13891.0	70.0
12	Barrackpore	1.44	11.65	12360.5	85.0
13	Uttarpara-Kortrung	1.50	18.15	8264.4	90.0
14	Madhyamgram	1.56	21.32	7317.0	100.0
15	Chandannagar MC	1.62	22.03	7353.6	45.5
16	Bidhannagar	1.68	33.5	5014.9	110.0
17	Hooghly-Chinsura	1.70	21.52	7899.6	110.0
18	Sertampore	1.98	5.88	33673.4	100.0
19	Uluberia	2.02	33.72	5990.5	115.0
20	Naihati	2.15	11.55	18614.7	80.0
21	North Dum Dum	2.20	26.45	8317.5	102.0
22	Barasat	2.32	31.41	7386.1	45.0
23	Baranagar	2.50	7.12	35112.3	140.0
24	Rajarhat Gopalpur	2.71	28.00	9678.5	100.0
25	Bally	2.82	11.81	23878.0	120.0
26	Kamarhati	3.14	10.96	28649.6	110.0
27	Rajpur-Sonarpur	3.36	57.90	5803.1	117.0
28	Panihati	3.48	19.40	17938.1	70.0
29	Maheshtala	3.89	44.17	8806.8	90.5
30	South Dum Dum	3.92	15.49	25306.6	120.0
31	Bhatpara	4.42	34.49	12815.3	230.0

Sl. No.	Name of the Municipal Towns	Population (as per 2001 Census) (Lakh)	Area (sq. Km)	Population Density (no. of person/sq. km)	Waste Generation (MT/day)
		Population > 5 lakh			
1	Howrah MC	10.09	51.74	19501.3	600
2	Kolkata MC	45.81	197.54	23190.2	3000

dent on the population density. In order to assess dependency of municipal solid waste generation on population density, data analysis were undertaken for the 41 municipal towns under Kolkata metropolitan area. The outcome of the data analysis have been presented in TABLE 2. The study on population density vis-à-vis municipal waste generation indicate the following:

The final component in the solid waste management system(SWMS) is disposal. Today the disposal of wastes by land filling or uncontrolled dumping is the ultimate fate of all solid wastes, whether they are residential wastes collected and transported directly to a landfill site, residual materials from Materials Recovery Facilities, residue from the combustion of solid waste, rejects of composting, or other substances from various solid waste-processing facilities. A summarized form of the disposal options followed by the different municipal towns are given in TABLE 3.

TABLE 3 : Disposal Options in the Municipalities.

Disposal Options	No. of Municipalities where the disposal options are available	% of Municipalities where the disposal options are available
Uncontrolled open dumping	41	100
Sanitary/Secured land filling	Nil	Nil
Composting	9	22

During the study quantitative and qualitative assessment of MSW were carried out for three municipal towns, namely Bidhannagar (Adjacent to Kolkata; North 24 Parganas), Titagarh (North 24 Parganas) and Chandannagar (Hooghly). In each of the towns quantitative and qualitative analysis of MSW were carried out at five different locations including the disposal ground. Characteristics of the waste were studied at the field as per standard method and quantifications were assessed for garbage, ash, paper, plastic, ceramic, glass, rags, etc. The results of quantitative

TABLE 4 : Physical characteristics of solid waste samples

Sl. No.	Components of the solid waste sample	Name of the Municipal towns visited			
		Bidhannagar	Titagarh	Chandannagar	Average in %
		Percentage Composition			
1	Garbage(Putrefactive part/organic)	68.93%	37.02%	40.99%	48.98
2	Ash/Earth(Inorganic)	3.5%	40.72%	21.50%	21.91
3	Paper/Cardboard box	4.96%	3.40%	9.16%	5.84
4	Plastic/PVC/HDPE	7.61%	2.70%	6.70%	5.67
5	Rags/Cotton/Textile	0.75%	1.10%	1.76%	1.20
6	Rubber	0.02%	-	0.09%	0.06
7	Leather	-	0.22%	-	0.002
8	Wood	-	-	0.15%	0.0015
9	Earthenware	3.80%	5.30%	3.12%	4.07
10	Ceramics	-	0.11%	0.11%	0.001
11	Glass	2.60%	0.68%	0.87%	1.38
12	Hay/Straw/Thermocol	0.10%	0.02%	0.10%	0.07
13	Leaves	0.27%	2.50%	12.50%	5.09
14	Metals	0.36%	0.09%	0.30%	0.25
15	Others	7.10%	6.15%	2.65%	5.30

analysis as average assessment of three samples, have been presented in TABLE 4.

DISCUSSION

The existing SWMS studied for the Kolkata metropolitan areas indicate the estimated waste generation rates in gm/day for various population ranges as under:

- In cities having population less than 1 lakh, the waste generation ranges between 259 gm/capita/day and 444.4 gm/capita/day. Average generation of solid waste is therefore, 352.3 gm/capita/day.
- In cities having population between 1 lakh-5 lakhs, the waste generation ranges between 193.9.67 and 728.1 gm/capita/day. Average generation of solid waste is therefore, 444.56 gm/capita/day.
- In cities with population more than 5 lakhs, the waste generation ranges between 654.8 and 873.1 gm/capita/day.

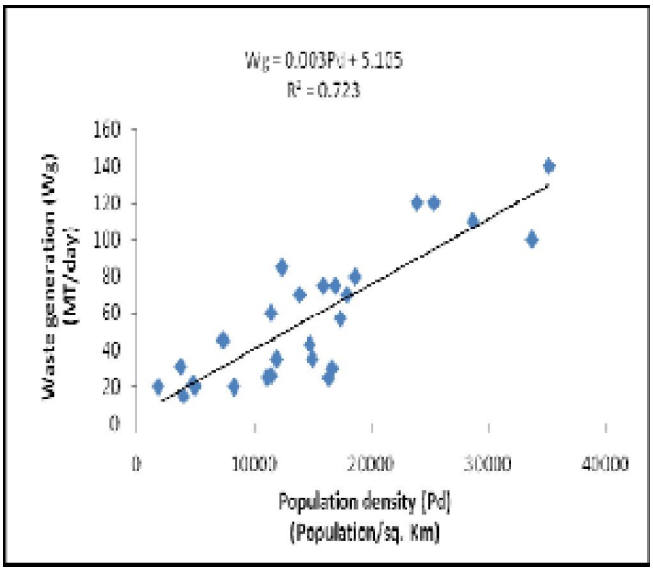

Figure 4 : Correlation between population density and waste generation
Wg = 0.003Pd + 5.105 R^2 = 0.723

The graphical presentation (Figure 5) of population density and solid waste generation for different municipalities indicated a straight line relationship. The graph depicted increasing generation of solid waste with the increase in population density in the municipal towns. The increase in population density in a city or town normally results with lesser vacant areas. The residents in densely populated areas will have no other alternative but to keep all solid wastes in the household or community containers. So, chances of waste thrown in vacant plots will get reduced considerably in densely populated areas. Further in densely populated towns the socio-economic conditions are comparatively better and accordingly generation of solid waste are comparatively higher. The present study has reflected the above phenomenon. We know that population density cannot be maintained but waste generation can be maintained through source minimization of the Kolkata metropolitan area.

Uncontrolled dumping of MSW is practiced in majority of the municipal bodies. This practice causes aesthetic pollution and also degrades the environmental quality. Composting, an environmentally friendly way of disposal is practiced in a handful of ULBs, for e.g. at Kalyani, Chandannagar, KMC(Kolkata Municipal Corporation) New Barrackpore, Bhadreswar, Titagarh, Kanchrapara, North Dum Dum, Maheshtala, etc. TABLE 3 indicates that out of the 41 municipal bodies taken as study area, each of them practice uncontrolled dumping and only nine of them employ composting. Although the area available for uncontrolled dumping is limited in most of the cases but still it is the most widely used disposal option.

The quantitative analysis of MSW (TABLE 4) revealed that 48.98% waste was comprised of garbage i.e., organic part. Around 21.91 % of MSW consisted ash/earth/silt (inert matter). The rest 29.031% wastes were found to be the mixture of several components i.e., paper, plastic, rags, cotton, leather, rubber, glass etc. The study also indicated the organic part of MSW ranged between 37.02% and 68.93%. The ash contents of MSW have been found to be in higher proportion (40.72% to 21.50%) except in one municipal town (Bidhannagar) where the ash content was found to be 3.5 %. Such lower quantum of ash in MSW in Bidhannagar town was relevant because the town was found to be free from slum and residents mostly use LPG for domestic cooking purpose. The percentage of recyclable materials (glass, paper, plastic, metals) has been found to be very low. This may be due to rag pickers, who collect and segregate recyclable materials from collection points and disposal sites.

CONCLUSION

The generation of large quantities of MSW in Kolkata metropolitan areas has become a serious environmental issue. Urban local bodies, though committed to their services, are finding this issue difficult to manage properly due to the growing magnitude of problems.

The major problems in MSW management at KMA are due to lack of waste segregation at source, low percentage of house-to house collection, large number of open vats, low operational efficiency of waste transport system with old vehicles, low collection efficiency in newly added areas, and an inefficient informal recycling system.

Moreover, house-to-house collection of MSW should be organized through methods like collection on regular pre-informed timing and scheduling. The collection bins must be appropriately designed with features like metallic containers with lids, and to have a large enough capacity to accommodate 20% more than the expected waste generation in the area, with a design for mechanical loading and un-loading, placement at appropriate locations, etc. Municipal authorities should maintain the storage facilities in such a manner that they do not create unhygienic and unsanitary conditions. Proper maintenance of the MSW transportation vehicles must be conducted, and the Dumper Placer should replace the old transportation vehicles in a phased manner.

Recyclables could be straightway transported to recycling units that in turn would pay a certain amount to the corporations, thereby adding to their income. This would help in formalizing the existing informal set up of recycling units. Recycling of solid waste needs to be encouraged by the ULBs. Rag pickers and scavengers involved in salvaging recyclable inorganic solid waste could be involved in the organized process of recycling of solid waste. Such involvement would improve the socio-economic conditions of the scavengers/rag pickers.

Private sector has so far not been attracted in this important area of municipal service. However, private sector participation is being attempted by a few local bodies in the country for the past few years, which has remained restricted in the area of awarding contract for transportation of waste from waste storage depots/road side vats to the disposal ground.

Management of solid waste in ULBs depends on joint initiatives of Municipal Authority and citizens. The ward committees could play a vital role for effective segregation, containerized collection and efficient transportation system. A considerable fund could be generated from citizen's contribution for house to house collection services, sale of inorganic recyclables, sale of compost and other by-products.

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