

**Review Article**

Solid Waste Management in Urban India: An Overview

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Abstract: Government of India in recent past took a number of proactive initiatives in the form of changes in policies, institutions and management mechanisms to address the problem of municipal solid waste management. Despite these changes, results are believed to be less than expected ones. Increasing economic growth is bound to generate more wastes and managing these wastes needs both budgetary and technical resources. In view of scarcity of resources, there is thus a need for a paradigm shift in the approach to solid waste management in India. Among other things, this requires a thorough and dispassionate understanding of the gravity of the situation and a critical diagnosis of the response measures. Though underlying issues are to a large extent same across continents, countries, cities and municipalities, yet some issues are specific in this context. Thus, both commonalities and specificities have to be discerned and analyzed. It is against this background that the present paper is designed to present an overview of the existing municipal solid waste management practices from the global to national and national to local level perspectives in reference to the Indian cities. Particular emphasis has also been laid on to assess the overall solid waste generation and management services practiced by the Indian municipalities. Besides these, various legal, institutional and policy issues relating to urban solid waste management in the Indian context have also been reviewed to strengthen the argument in favour of the need for efficient solid waste management services for the Indian cities. It can be observed from the literature review that despite a number of positive initiatives taken by India in recent years, the state of the urban solid waste management is still far from a satisfactory level and there is thus an urgent need to address the issue by involving residents, private sector players and non-governmental organizations along with civic authorities.

Keywords: Solid Waste, Municipalities, Collection Efficiency, Management

1. Introduction

Solid waste management has emerged as a serious challenge for almost all municipalities across the continents. According to [5], solid wastes are the most visible forms of environmental bad. Lack of appropriate technology, inadequate financial resources, scarcity of land, mixed land users and absence of effective legal instruments as the main challenges faced by waste managers. Besides volume of wastes generated, composition, chemical characteristics and production of hazardous and toxic wastes also compounded the waste management challenges. Widespread incidences of waste-borne diseases and threats to urban public health due to inefficient waste and sewage management are regularly reported. Poor waste management is also adversely affecting cities' drainage systems and multiplying public sufferings. It

has also caused undervaluation of urban properties due to waste exposure. Presence of non-biodegradable waste components is irreversibly impacting both human and environmental health. Policy response has been far from satisfactory. Lack of awareness and ignorance about benefits of improved solid waste management services has further diluted the effectiveness of the existing policy instruments.

Things are, indeed, gradually changing. Studies in recent years have reported tangible changes in approaches to urban solid waste management services. Besides municipal authorities, residents too have started considering waste management an important civic priority. Increasing per capita income, education, easier flow of information, enhanced awareness about need for solid waste management and consequences of inaction have contributed a lot in motivating urban residents as well as civic authorities to think seriously

about waste management services.

Management of solid wastes in the urban India is gradually becoming a serious challenge for most municipal corporations across India. There are number of reasons behind this: scarcity of waste management fund and unavailability of required technology, technical manpower and effective management; corruption and mismanagement of allocated funds; collection of inefficiency and poor waste handling; lack of awareness and residents' habit of indiscriminate dumping of wastes, among others. Considering mismanagement or inefficiency in solid waste management not only causes degradation for urban environment, but also has clear economic, social and other types of environmental costs. It is thus important that India gives due importance to effective municipal solid wastes management as the cost of inaction or the business as usual situation is too high.

2. Solid Waste Management: A Global Perspective

Currently the world cities generate about 1.3 billion tons of solid waste/year, which is estimated to be about 1.2 kg/capita/day. It is projected that waste generation would be about 2.2 billion tons per year by the year 2025 [19]. The per capita waste generation by North America and the OECD countries are found to be at a higher side. On the other hand, most of the African and Asian cities have a lower waste generation rate, although experiencing some changes in recent years with changes in their level of income, increased urbanization and consumption habits.

Although, South Asian region compared to OECD, European Union and even South East Asian countries produces a lower amount of solid wastes, it is expected that waste generation by many Asian countries, including South Asian region (SAR), would keep on accelerating with changes in their level of income, faster GDP growth, and growth in urbanization and change in consumption pattern.

It is reported that by 2025 daily municipal solid waste generation by Asia alone would be 1.8 million tons/day. This may raise its per capita waste generation between 1.2 kg to 1.4 kg per day/person [19].

It is postulated that solid waste generation has a strong and positive relationship with family income level as income largely determines people's consumption pattern. Based on this understanding, generation of solid waste by different income earning countries (i.e. high income, upper middle income, lower middle income and lower income earning countries) has also been analyzed. Estimated current/day/capita average solid waste generations by the four income earning country groups are found to be 2.1, 1.2, 0.79 and 0.60 kg, respectively (*table 1*). Solid waste management through proper waste collection, segregation, transportation, land-filling or recycling services depend much on a country's economic and technological capabilities. It also depends on relevant policy and legal frameworks and their implementation efficiency. A high waste collection efficiency can be observed across the developed and upper income earning countries, while a lower efficiency is recorded by most of the low and lower middle income earning countries like India, although things are expected to be changed with time in many countries. Evidences show that waste collection efficiency ranges from 46 percent in African region (AFR) to 98 percent by OECD countries. In case of waste composition, low income earning regions like AFR, EAP and SAR are found to have lower inorganic waste components in their daily wastes generations compared to the high income earning OECD countries. This ranges from 38 percent in EAP region to 73 percent for OECD countries. A similar trend is thought to be followed by these income earning groups even until 2025 [19]. Furthermore, an increasing ratio of inorganic to organic solid wastes by most municipal corporations across the lower and lower middle income countries is expected to increase in Asia and Africa.

Table 1. Solid waste generation projections for different regions.

Income Earning Country Group	Current Data			Projections for 2025			
	Total Urban Population (millions)	Urban Solid Waste Generation Per Capita (kg/capita/day)	Total Generation (tons/day)	Projected Population (millions)	Urban Population (millions)	Projected Solid Waste Generation Per Capita (kg/capita/day)	Total Generation (tons/day)
Lower Income	343	0.60	204,802	1,637	676	0.86	584,272
Lower Middle Income	1,293	0.78	1,012,321	4,010	2,080	1.3	2,618,804
Upper Middle Income	572	1.16	665,586	888	619	1.6	987,039
High Income	774	2.13	1,649,547	1,112	912	2.1	1,879,590
Total	2,982	1.19	3,532,256	7,647	4,287	1.4	6,069,705

Source: [19]

Most mega-cities in Asia still produce lower/capita municipal wastes compared to most other regions [OECD, MENA and Latin American regions (LCR)]. But with changes in level of income, availability of consumer goods, consumption habits and people's lifestyles, generation of solid wastes are expected to amplify with time across the Asian cities (*table 2*).

The pace of urbanization in the Indian mega-cities over the last several decades is also found to be quite significant [20]. It is expected that the pace will continue in near future too. This may turn many Indian cities into large urban agglomerations with little basic amenities if proper initiatives are not taken in time. According to [6], about 31 percent Indians live in urban areas. Although the pace of

urbanizations in many large and aging cities (e.g. Kolkata) have shown either decreasing or very slow increasing trends in recent years, most smaller cities are expected to play a key role in India's urbanization process in the coming decades. Besides, number of large cities like Delhi (and its adjoining satellite cities of Gurgaon, Faridabad and NOIDA) are expected to continue further urbanization. This will accommodate more urban dwellers in the decades to come, mainly because of better economic opportunities the cities offer, and to enjoy modern urban services like better education and healthcare facilities.

Table 2. Rates of solid waste generation by major Asian cities.

Name of City (Country)	Generation Rate in 2007 (kg/per capita/day)
Delhi (India)	0.47
Dhaka (Bangladesh)	0.50
Urban (Iran)	0.80
Penang (Malaysia)	0.98
Kathmandu (Nepal)	0.30
Manila (Philippines)	0.66
Singapore (Singapore)	0.94
Colombo (Sri Lanka)	0.62
Taipei (Taiwan)	0.95
Bangkok (Thailand)	0.88
Hanoi (Vietnam)	0.63

Source: [3]

3. State of Municipal Solid Waste Generation in India

With increase in urban population, generation of municipal solid wastes in India has also increased. According to [8], there are 5034 towns in India, wherein 4003 urban local bodies (ULBs) have been constituted. They play a crucial role in municipal solid waste management system. The average municipal solid waste generation in India, according to [3], was about 100,000 metric tons/day. India's daily municipal solid waste generation was 188,000 tons, according to [2], which was a sharp increase within a period of just five years. It is also expected that this might experience some further surge in the coming decades. A study on a comprehensive dataset of 366 Indian cities by [2] revealed that by the time period of 2001 to 2021, per capita solid waste generation in India would increase from 0.50 kg/day to 0.57 kg/day. Annual waste generation by the 366 Indian cities is expected to increase from 47.3 million tons in the year 2011 to 71.2 million tons in 2021. Similarly, for the same time period waste generation by entire urban India is expected to be from 1.85 lakh tons to 2.78 lakh tons daily, which comes out to be 67.6 million tons to 101.6 million tons annually, respectively. This implies that in between 2011 to 2021, total (cumulative) municipal solid waste generation by 366 Indian cities would be 643.5 million tons, while the entire urban India might experience producing a huge amount of 919.3 million tons of solid wastes by the same timeline (table 3).

Table 3. Expected solid waste generation by 366 selected Indian cities for the period of 2011 to 2025.

Year	Population of the 366 cities	Per Capita solid Waste Generation (kg/day)	Solid Waste Generated by 366 Cities		Solid Waste Generated by entire Urban India	
			Tons/day	Tons/year	Tons/day	Tons/year
2011	260,059,784	0.50	129,593	47,301,346	185,132	67,573,351
2012	267,341,458	0.51	134,993	49,272,506	192,847	70,389,295
2013	274,827,018	0.51	140,619	51,325,810	200,884	73,322,585
2014	282,522,175	0.52	146,479	53,464,680	209,255	76,378,114
2015	290,432,796	0.53	152,583	55,692,681	217,975	79,560,973
2016	298,564,914	0.53	158,941	58,013,529	227,059	82,876,470
2017	306,924,732	0.54	165,565	60,431,092	236,521	86,330,131
2018	315,518,624	0.55	172,464	62,949,400	246,377	89,927,715
2019	324,353,146	0.55	179,651	65,572,653	256,644	93,675,218
2020	333,435,034	0.56	187,138	68,305,223	267,339	97,578,890
2021	342,771,215	0.57	194,936	71,151,665	278,480	101,645,236
Cumulative Waste Generated			1,762,961	643,480,584	2,518,515	919,257,977

Source: [2]

Another study [13] reported that by 2031 urban India is projected to generate 165 million tons of waste annually and by 2050 it could reach 436 million tons. To accommodate this amount of waste generated by 2031, about 23.5×10^7 cubic meter of landfill space is required and in terms of area it would be 1,175 hectare of land per year. The area required from 2031 to 2050 would be 43,000 hectares for landfills piled in 20 meter height. These projections are based on 0.45 kg/capita/day waste generation.

It is also reported that only about 60 percent of wastes generated in the Indian cities are collected by concerned municipal corporations and councils and the rest are disposed in an unscientific manner [3]. Uncollected or openly dumped

wastes not only cause health hazards and direct (e.g. medicine costs, consultation fees, etc.) and indirect health costs (cost of lost labour hours), they affect property values as well as a city's aesthetic outlook. This speaks the volume of challenges the urban India is going to face in the coming years.

4. Type and Composition of Municipal Solid Wastes Generated in India

Main sources of municipal solid wastes in India are: residential, commercial, institutional and industrial areas.

Besides these, wastes are also generated from different municipal services (*table 4*). These include both biodegradable and non-biodegradable wastes like food, packaging and different types of electronic wastes. Composition of solid wastes in Indian municipalities is predominantly biodegradable in nature, while percentage of

non-biodegradable components is on an increasing trend. This is mainly because of changes in consumption behaviour by urban Indian residents and also the availability of numerous consumer products with increasing flow of information.

Table 4. Sources and types of municipal solid wastes in India.

Source of wastes	Type of wastes
Residential areas	Food waste, paper, cardboard, plastic, textiles, glass, metal and nonhazardous waste, batteries, construction debris, and demolition waste
Commercial areas (general store/restaurant/hotel)	Paper, cardboard, plastic waste, glass, metal, and e-waste
Institutional area (school, hospital, government offices)	Paper, cardboard, plastic waste, glass, metal, waste, hazardous waste, processing waste, ashes,
Industrial areas (light, medium and major plants)	Paper, cardboard, plastic, metal, e-waste, hazardous waste and non-hazardous waste
Municipal services (street cleaning, parks, water and wastewater treatments)	Green trash, silt/ashes, construction and demolition wastes and sludge

Source: [3]

Generation of hazardous and electronic wastes (e-waste, which means waste from electrical and electronic equipments, whole or in part included in, but not confined to equipments listed in the 'Schedule-I' or scraps or rejects from their manufacturing process, which is intended to be discarded) in India is increasing fast. This is gradually emerging as a serious threat to human health and urban environment. Total amount of hazardous wastes generated by India, according to a report [3], was estimated to be 4,415,954 metric tons/year from 13011 hazardous waste-generating units. Biomedical wastes are other types of highly hazardous wastes that are expected to increase with time considering the ever-expanding healthcare market in India. With increasing incidences of diseases due to poor food safety, unscientific practices of food consumption and environmental degradations that the country is facing, it is expected that biomedical wastes in coming decades would be multiplied in most Indian cities. Similarly, use of electronic devices and electrical products by the billion plus Indians are increasing day by day. Because of short lifespan, arrival of newer and handy models and aggressive advertisements, generation of electronic wastes in recent years has increased significantly. India produced over 100,000 tons of waste from refrigerators; 275,000 tons from TVs; 56,300 tons from personal computers; 4,700 tons from printers and 1,700 tons from mobile phones every year [20], whereas e-waste generates from obsolete or broken down electronic and electrical equipments was estimated to be in the tune of 146,000 tons per year [7]. This surely is going to be a serious challenge for most Indian municipal corporations in the years to come, unless proper attention is given in advance.

On the other hand, a substantive amount of organic wastes (like compostable wastes) are also produced by the 1 million plus populous cities in India. On an average, about 47.50 percent of total solid wastes generated by Indian cities are found to be compostable [19]. But the amount varies from city to city and region to region. Agartala, the capital of Tripura, is found to have produced the highest amount of compostable wastes by an Indian city of 1 million plus population (58.57 percent), while Daman has the lowest

percentage of compostable wastes (29.60 percent). Most cities in the State of Gujarat and Uttar Pradesh are found to have produced low compostable wastes, while cities from Eastern and North-eastern States of India like Pashchim Bangla (West Bengal), Bihar, Assam and Odisha (Orissa) produce substantive amount of compostable wastes. Similarly, wastes from paper and pulp constituted about 8 percent of the total wastes generated by these cities. About 10.80 percent of wastes from plastic, glass and metals are found to be recyclable. Wastes categorized as 'inert' constituted about one-fourth of the total municipal wastes, as the same time wastes from rubber and leather, rags, wooden matter, coconut and bones are some other common types of municipal solid wastes in India.

According to [2], of the total wastes produced in the Indian cities, 51 percent wastes are organic, 17.5 percent recyclable (paper, plastic, metal and glass) and remaining 31 percent are inert. Chemical contents in the form of 'hcv Kcal/kg' found in municipal solid waste in India is considered to be significantly high, which on an average is estimated to be 1606 hcv Kcal/kg of waste. Looking at average chemical contents in solid wastes generated by those cities in India, As per the estimation by [1], moisture content occupied 48 percent, while 38 was volatile matter, 26.50 'c/n ratio' and 22.17 'c percent'. Similarly, other contents like 'h range', 'n percent' and 'k percent', 'p percent' as P_2O_5 were also present in municipal solid wastes generated by these cities. On the contrary, findings by [2] reported 47 percent moisture content, while average calorific value was estimated to be 7.3 MJ/kg or 1745 Kcal/kg [1].

5. Waste Collection, Segregation, Transportation & Disposal Methods

Collecting, processing, transporting and disposing municipal solid wastes are the responsibility of urban local bodies (ULBs) in India [16]. ULBs need to spend quite a lot amount of their budgetary resources every year in this regard. Despite the most municipal corporations in India spend substantial amount of their annual budgetary resources for

solid waste and sewage management services, yet the apathy of waste management services continues to remain a common phenomenon for almost all Indian cities. In all areas of municipal solid waste management, most Indian cities are continued to be lingering in a poor state of management. Besides poor collection efficiency, wastes segregation, transportation, recycling and disposal methods practiced by most Indian cities are also not scientific in nature. It is important to have a careful analysis of each step followed in solid waste management for a better understanding and effective remedial measures to be taken for improving solid waste management services for Indian municipalities.

First of all, state-wise solid waste generation in India is on an increasing trend. In India the current daily solid waste generation is estimated to be about 141064 metric tons; a gigantic amount indeed to manage efficiently. Of the total wastes generated, about 90 percent are said to be collected (table 5), although there are different opinions by experts about the authenticity of such claim. The overall waste collection condition, particularly for smaller and less populated cities in India, is extremely in disrepute. Most of the mega-cities in the country have relatively better collection efficiency [3]. Only a smaller fraction of the collected wastes are treated and land-filled systematically.

Table 5. State-wise solid daily solid waste generation, collection and treatment (in metric tons).

Sl No.	Sates	Generated	Collected	Treated	Land-filled
1	Andaman & Nicobar*	70	70	05	
2	Andhra Pradesh*	4760	4287	6402	
3	Arunachal Pradesh	116	70.5	0	
4	Assam	650	350	0	
5	Bihar	1670	-	-	
6	Chandigarh	370	360	250	
7	Chhattisgarh*	1896	1704	168	
8	Daman Diu & Dadra*	85	85	Nil	
9	Delhi	8370	8300	3240	
10	Goa	450	400	182	
11	Gujarat	9988	9882	2644	
12	Haryana	3103	3103	188	
13	Himachal Pradesh	276	207	125	150
14	Jammu & Kashmir*	1792	1322	320	375
15	Jharkhand*	3570	3570	65	
16	Karnataka	8697	7288	3000	
17	Kerala	1339	655	390	
18	Lakshadweep*	21	-	-	
19	Madhya Pradesh	6678	4351	-	
20	Maharashtra	22,570	22,570	5,927	
21	Manipur*	176	125	-	
22	Meghalaya	208	175	55	122
23	Mizoram*	552	276	Nil	
24	Nagaland	344	193	-	
25	Orissa	2374	2167	30	
26	Puducherry	495	485	Nil	
27	Punjab*	4105	3853	350	
28	Rajasthan*	5037	2491	490	
29	Sikkim*	49	49	0.3	
30	Tamil Nadu	14500	14234	1607	
31	Tripura	415	368	250	
32	Telangana	6740	6369	3016	3353
33	Uttar Pradesh	19180	19180	5197	
34	Uttrakhand	918	918	Nil	
35	West Bengal	9500	8075	851	515
Total		1,41,064	1,27,531 (90%)	34,752 (27%)	4,515

Source: [8]

Dumping of wastes near roadsides, in waterbodies or fallow lands is a common practice in the most Indian cities. Similarly, collection of garbage from dustbins and community *dhalao*s in many cases are not done on a regularly basis. This not only creates unhygienic environment around, but also serves as fertile ground for mosquito breeding and vector-borne diseases. Frequent blockage of city drainage systems because of careless throwing of poly-bags, plastic materials, etc. is a major cause of human sufferings for many underdeveloped localities, particularly

during rainy season when overflowing drains create water-logging for many cities in India. Exposure to wastes and poor sewage systems can also contribute in undervaluation of nearby properties and affect property rents.

Most Indian cities still enjoy a system of manual sweeping method, which is mostly done by municipal corporations-employed sweepers (table 6). Traditionally they have been working in this sector for generations. In recent years some private firms and NGOs have also been involved by municipal authorities in many cities of India, including

Delhi, to oversee solid waste management activities. This, if compared with earlier system, has definitely yielded positive results although inefficiency still remains as a major problem. Along with the organized methods of waste management, informal methods are increasingly being employed in many

cities of India. For example, rag-pickers for all Indian cities play a great role in waste collection, segregation and recycling. Although these people are not municipal appointed, they play a positive role in any city's waste management.

Table 6. Sweeping methods, types of laborer, and collection of solid wastes in India.

Population of Cities(in Millions)	Number of Cities	No. of Sweepers per 1000 population	Manual	Mechanical	Sweeping Labour		House--to-House Collection
					Government	Private	
Above 10	3	1.3-3.8	90-100%	0-10%	100%	0%	Private waste collector, municipal workers, and self-help groups
2-10	10	1.57-2.11	70-100%	0-30%	70-100%	0-30%	
1-2	22	0.15-3.51	100%	0%	100%	0%	

Source: [3]

According to the [8], segregation of municipal solid wastes is a compulsory process in waste management service. But in reality segregation is hardly done by waste producers (households or industries) or even by waste management agencies (municipal corporations). Despite legal provisions, formal waste segregation in most municipal corporations in India still is non-existent. In recent years, private waste management operators employed by municipal corporations are required to segregate waste in two separate bins (biodegradable and non-biodegradable). For example, the Municipal Corporations of Delhi (MCD) uses blue and green bins for non-biodegradable and biodegradable wastes, respectively.

Transportation of wastes is another important operation in the process of municipal solid waste management. Overall state of waste transportation service across Indian cities is also found to be quite inefficient. Similarly, waste disposal/land-filling is another necessary step required in efficient solid waste management services. Disposal of wastes means specific measures to prevent contamination of ground-water, surface water and ambient air quality from wastes. Solid waste disposal in practice can broadly be of two types: scientific or unscientific disposal. Scientific disposal of municipal solid wastes can be in the form of waste recycle and re-use, sanitary land-filling, composting, vermi-composting or incineration. According to [2], "there cyclables collected are separated by rag-pickers and collectors on a daily basis and transferred to small, medium and large dealers. Usually, the pickers and collectors sell to small dealers in the slums, near their residence. The small dealers sell the waste to medium or large dealers and finally the waste will be sold to the recycling units. There are 1,777 known plastic recycling units in India. Most of these known units are located in Tamil Nadu (588), Gujarat (365), Karnataka (302), Kerala (193) and Madhya Pradesh (179). The total number of plastic recycling units (will be much higher) and the capacity of each of these units is unknown". It is also estimated that every ton per day of recyclables collected informally saves urban local body USD500 or about Rs. 24,500 per year and also avoids the emission of 721 kg of carbon dioxide/year. Similarly, land-filling, which is the controlled disposal of wastes on land in such a way that contact between wastes and the environment is significantly reduced and wastes are concentrated in a well-defined area.

Considering poor state of recycling and reuse of wastes in India and increasing awareness about open dumping practice, sanitary land-filling can be termed as the last resort of unused municipal solid wastes.

As per the *table 7* there are 34 land-fills which together occupy a total of about 1,895 hectares of land. [2] observed that based on a business as usual (BAU) scenario of 91 percent land-filling, the waste generated by 2021, it would require 590.1 sq.km of land which is even greater than the area of Hyderabad (583 sq.km), the largest Indian city in terms of its area. The Ministry of Finance, Government of India (2009), estimated a requirement of more than 1400 sq km of land for solid waste disposal by the end of 2047. This is equal to the area of Hyderabad, Mumbai and Chennai together.

Table 7. Number of land-fill sites in the Indian cities and total areas occupied.

Name of city	No. of landfill sites	Area of landfill (ha)
Chennai	2	465.5
Coimbatore	2	292
Surat	1	200
Greater Mumbai	3	140
Greater Hyderabad	1	121.5
Ahmadabad	1	84
Delhi	3	66.4
Jabalpur	1	60.7
Indore	1	59.5
Madurai	1	48.6
Greater Bengaluru	2	40.7
Greater Visakhapatnam	1	40.5
Ludhiana	1	40.4
Nashik	1	34.4
Jaipur	3	31.4
Srinagar	1	30.4
Kanpur	1	27
Kolkata	1	24.7
Chandigarh	1	18
Ranchi	1	15
Raipur	1	14.6
Meerut	2	14.2
Guwahati	1	13.2
Thiruvananthapuram	1	12.15
Total	34	1894.85

Source: [2]

6. Financing Municipal Solid Waste Management in India

Solid waste management is a costly affair as it requires municipal corporations to spend a substantial percentage of their annual budgetary resources for solid waste and sewage management services. Government of India in recent years has increasingly been allocating resources for municipal corporations for dealing with gigantic amount of wastes generated by Indian municipalities. The Twelfth Finance Commission (TFC) recommended grants amounting Rs.5,000 crore for municipalities in this regard.

Some recent initiatives taken by India would help us to understand how costly solid waste management affairs can be. In 2005, the Government of India launched a massive urban modernization scheme named *Jawaharlal Nehru National Urban Renewal Mission* (JnNURM) under the Ministry of Urban Development. It envisaged an amount of Rs.100,000 crores over a period of nine years until 2014 (initially for seven years and then extended by two more years). An amount of Rs.66,000 crores was committed for this scheme. Creating 'economically productive, efficient, equitable and responsive cities' by a strategy of upgrading social and economic infrastructure in cities with provision of basic services to urban poor and wide-ranging urban sector reforms to strengthen municipal governance in accordance with the 74th Constitutional Amendment Act, 1992 were the main objectives of the scheme.

National or State-level infrastructure fund is another source of finance for municipal solid waste management in India. National level set up funds by financial institutions and banks, supplemented by State level Infrastructure Funds and Pooled Finance Funds are some other options for municipal solid waste management financing. Besides, there is an option of offering Municipal Bonds and Debentures by many municipal corporations in India (e.g. Ahmedabad) to generate funds. Loans from financial institutions like IDFC, ICICI, IDBI, and LIC of India also provide funds for infrastructure projects. The Ministry of Urban Development (MoUD) enjoys this Pooled Finance Development Fund (PFDF) scheme. An innovative development in this front in recent years is public-private partnership (PPP) as a source of funding for urban infrastructure development. Number of cities, including Delhi, has been exploring this option in providing municipal solid waste management services. Loans from bilateral and multilateral financial agencies like World Bank, Asian Development Bank, also provide soft loans on long terms and grants for infrastructure projects like development of landfills, etc. Short term loans from local banks are also available for such projects. Under these options, finance can be utilized for running waste management infrastructure projects.

Most municipal corporations in the country are not in a position to provide those services efficiently and the ultimate sufferers are residents who needed to face various waste-induced health hazards and other associated problems. Per capita expenditure on solid waste management varies

across cities (*table 8*).

Table 8. Per capita expenditure on solid waste management by selected Indian cities.

City	FICCI	NIUA	NSWAI
Delhi	Rs. 431	Rs. 135	Rs. 497
Mumbai	Rs. 428	Rs. 372	Rs. 392
Jaypur	Rs. 301	Rs. 185	Rs. 301
Chennai	Rs. 295	Rs. 150	Rs. 295
Ludhiana	Rs. 258	Rs. 73	Rs. 1

FICCI= Federation of Indian Chamber of Commerce and Industries (2007);

NIUA= National Institute of Urban Affairs (2005)

NSWAI= National Solid Waste Association of India (2001)

Source: Various sources; 2007, 2005, 2001

It varies not only city to city, but even colony to colony within a city. It also differs if a waste collector needs to collect wastes from a multi-storied building (i.e. from upper or top floor); the rate is expected to be higher than ground floor).

Against this backdrop, the 74th amendment of the Indian Constitution allows urban local bodies (ULBs) to raise resources by taxing or levying service charges on people to be used for public health, sanitation, conservancy and solid waste management. Imposition of service charges for improved waste management services thus can be a viable option for mobilizing resources for waste management.

7. Policies, Legal and Institutional Frameworks for Municipal Solid Waste Management in India

Under the Indian legal and policy frameworks, management of all types of wastes, including municipal solid wastes have been given high importance. The Indian Constitution, under *Article 21*, emphasizes on the *right to life*, which connotes 'quality of life' as interpreted by the higher judicial system of India. By ensuring right to quality of life, a person has been allowed to enjoy a pollution free environment. The *Article 48A* of the Indian Constitution requires a state to guard and preserve its environment, including waste related hazards. Similarly, there are two major criminal laws in India which deal with solid waste management: the *Indian Penal Code (IPC)*, 1980 under which *Chapter XIV* mentions 'of offences affecting the public health, safety, convenience, decency and morals', while the *Criminal Procedure Code (Cr. PC)*, 1973 deals with 'removal of nuisance'. With these objectives in mind, the *Municipal Solid Waste (Management and Handling) Rules, 2000* have clearly defined three different constituents and their specific responsibilities involving municipal solid wastes and associated other civic amenities management:

(a) *Municipal Authority*: According to the aforesaid rules, every municipal authority in India is responsible for collection, storage, segregation, transportation, processing and disposal of municipal solid wastes generated under its jurisdiction. Management of solid wastes is thus an important

duty of any municipal corporation along with other such duties. According to the 12th Schedule of the Indian Constitution, the Indian municipalities are required to perform the following duties: urban planning including town planning; regulation of land-use and construction of buildings; water supply for domestic, industrial and commercial and solid waste management; public health, sanitation conservancy and solid waste management; urban forestry, protection of the environment and promotion of ecological aspects; slum improvement and upgrade; provision of urban amenities and facilities such as parks, gardens, playgrounds; cattle pounds; prevention of cruelty to animals; and regulation of slaughter houses and tanneries.

For any developing country city like Delhi, managing these duties by the concerned civic authority is a real challenge.

(b) *State Governments and the Union Territory Administrations*: Like municipal authorities, all States and Union Territories (UTs) in India are also required to take care and oversee the management of solid wastes. For all metropolitan cities, Secretary-in-Charge of the Department of Urban Development of the concerned State or UT is responsible for the enforcement of the rules, while for a District Magistrate or Deputy Commissioner (DC) is the person responsible for the same duty [17].

(c) *Central Pollution Control Board (CPCB) and State Boards or Committees*: According to the Rule 6(5) of the *Municipal Solid Waste (Management and Handling) Rules, 2000*, “the Central Pollution Control Board shall coordinate with the State Boards and the Committees with particular reference to implementation and review of standards and guidelines and compilation of monitoring data”, while the Rule 8(2) emphasizes the need for preparing a consolidated annual report on the status of management of municipal solid wastes by the concerned municipal corporation and forward it to the Central Government. All the 34 State Pollution Control Boards (SPCBs) in coordination with the CPCB are responsible for ensuring solid waste management compliance issues in their respective States. Another important duty of the CPCB is to lay down standards of state of the art technologies proposed by any municipal authority or operator of the facilities through its ‘Technology Appraisal

Committee’.

Other policy instruments which directly deal with municipal solid waste management in India are: the *Environment (Protection) Act, 1986*; the *Recycled Plastics Manufactures and Usage Rules, 1999* (amended in 2003); *Bio-medical waste (Management and Handling) Rules, 1998*; the *Hazardous Waste (Management, Handling and Transboundary Movement) Rules, 2008*.

8. Stakeholders’ Participation in Solid Waste Management in Indian Municipalities

Though *Municipal Solid Waste (Management and Handling) Rules, 2000* make respective urban local bodies responsible for waste management. However, the provision of teaming up with other stakeholders like private sector players, NGOs and people’s organizations is allowed under the Rules. Economic rationale behind participation of non-state stakeholders in municipal solid waste management is clear and this can also turn out to be a win-win situation for all stakeholders involved.

Different types of partnerships among municipal corporations (ULBs), private sector, NGOs and community organizations have been formed in India in recent years. According to [4], there are four kinds of partnership that are engagements in municipal solid waste management in India.

It can be observed from table 9 that quite a few large as well as medium sized municipal corporations in India in recent years have formed partnership with other important stakeholders for providing better waste management services. Participation of non-state stakeholders in municipal solid waste management services needs to be explored further. This may pave the way for developing a stakeholders’ participation-based management mechanism, where stakeholders may not only be partners of business possibilities, but their vary engagement itself may ensure higher level of satisfaction. Although in Delhi, non-state stakeholders’ engagement has now been explored, the possibility of community engagement also needs to be explored.

Table 9. Types of partnership in municipal solid waste management in India.

ULB (on their own)	ULB +Private Sector Player	ULB +Community	ULB+Private Sector Player +Community
Bokaro, Trichy, Munger, Patna	Hyderabad, Rajkot, Chennai (1995 onwards), Bengaluru, Ahmedabad	Chennai (1989-1995) Namakkal Trivandrum	Guwahati

Source: [4]

9. Conclusion

It is understood that the state of municipal solid waste management services in most Indian cities remains substandard and there is an ample scope to improve them. Because of exposure to uncollected solid wastes dumping, people have to bear both direct and indirect costs and ultimate

sufferers are the residents themselves. Number of policy instruments has indeed been put in place and have definitely yielded dividends. However, given the magnitude of solid wastes generated and the severity of their impacts on human and environmental health more efforts needs to be given to solve the problem of municipal solid waste in India. In this context this paper proposes a number of initiatives that can be taken to address the challenge of solid waste management by

the urban India: (i) there is a need to take a holistic approach in waste management by the urban India; (ii) it is important to assess the possible impacts of municipal solid waste mismanagement to create more awareness among residents, municipal authorities, and other stakeholders associated in the process of waste generation, collection, transportation, segregation and disposal system. The costs of inaction can also be understood through this process; (iii) more investment on technology used for waste management is an urgent step that needs to be taken immediately; (iv) the question of stakeholders' participation in the overall waste management process may make significant differences in urban waste management in India. In this context awareness generation, effective utilization of people's networks and voices and creation of business opportunities for private sector players should be given due importance in waste management; (v) the issue of waste reduction, reuse and recycling (the 3 R's) needs to be given due importance; (vi) local-level initiatives to educate people about the need to maintain cleanliness and follow municipal waste management guidelines need to be taken by involving socio-political and cultural platforms to make them more effective.

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