

Municipal Solid Waste Management in Delhi – the Capital of India

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ABSTRACT: Solid waste management is one of the most challenging issues in urban cities, which are facing a serious pollution problem due to the generation of huge quantities of solid waste. This paper presents a review of the existing situation of municipal solid waste management (MSWM) in Delhi, the capital of India. Also, an insight to the landfills in the city and the leachate generated from them has been provided. Delhi being the most densely populated and urbanized city of India, generates about 9000 tonnes/day of MSW, which is projected to rise to 17,000–25,000 tonnes/day by the year 2021. An attempt has been made to provide a comprehensive review about the characteristics, generation, collection and transportation, disposal and treatment technologies of MSW practiced in Delhi.

KEYWORDS: Delhi, environment conservation, landfills, leachate, municipal solid waste management

I. INTRODUCTION

India is the second fastest growing economy and the second most populated country in the world. The population of India is expected to increase from 1029 million to 1400 million during the period 2001–2026, an increase of 36% in 26 years, at the rate of 3.35% annually [1]. The level of urbanization of the country has increased from 17.35% to 31.2% in the last 60 years and is expected that as much as 50% of Indian population will live in cities in next 10 years [2]. Rapid industrialization and population explosion in India has led to the migration of people from villages to cities, which generate thousands of tons of municipal solid waste (MSW) daily. The MSW amount is expected to increase significantly in the near future as the country strives to attain an industrialized nation status by the year 2020 [3]. An important feature of India's urbanization is the phenomenal concentration of the population in Class I cities (metropolitan cities), urban agglomerations/cities having a population of more than 1 million, as depicted by the increase in the number of metropolitans from 35 to 46 in the last decade [1]. Among these metropolitans, Greater Mumbai is India's largest city with a population of 18.4 million, followed by Delhi and Kolkata.

It has been estimated that urban India is generating approximately 1,88,500 tonnes of municipal solid waste per day (68.8 million tonnes per year). The capital of India, Delhi generates approximately 11,558 tonnes of municipal solid waste daily [4]. The generation rate is about 700 gm/person/day, which is almost five times the national average. Poor collection and inadequate transportation are responsible for the accumulation of MSW at every nook and corner. The collection efficiency ranges between 70% and 90% in the major metro cities in India, whereas in several smaller cities collection efficiency is below 50% [5]. The management of MSW is going through a critical phase, due to the unavailability of suitable facilities to treat and dispose off the larger amount of MSW generated daily in metropolitan cities. Generally, MSW is disposed off in low-lying areas without taking any precautions or operational controls. Therefore, municipal solid waste management is one of the major environmental problems of Indian megacities. It involves activities associated with generation, storage, collection, transfer and transport, processing and disposal of solid wastes. But, in most cities, the MSWM system comprises only four activities, i.e., waste generation, collection, transportation, and disposal. Landfills have not been designed with liners or leachate collection and treatment systems. Leachate is the liquid that leaches from a landfill. Any precipitation or external source of water contributes to leachate

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generation. The amount of leachate generated is dependent on the available water, landfill constituents, its surface and the foundation soils.

The management of municipal solid waste requires proper infrastructure, maintenance and upgradation for all activities. This becomes increasingly expensive and complex due to the continuous and unplanned growth of the city. The difficulties in providing the desired level of public service in the urban centres are often attributed to the poor financial status of the municipal corporations.

II. LITERATURE SURVEY

Kumar *et al.* (2001) talked about daily municipal waste generated and ways of its disposal. The most common method of disposal being land filling, the various shortcomings of the landfills were discussed like lack of proper liner and leachate collection and treatment systems. The authors also calculated the leachate generated in New Delhi yearly, by taking the average of the precipitation and pan evaporation data collected during the period 1987-1999, by applying the water balance method. The various leachate generation parameters have been shown in Fig.1.

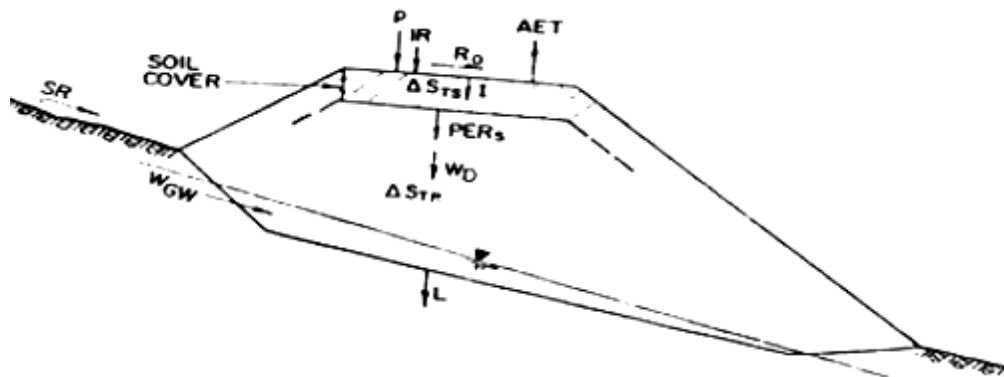


Fig. 1: Leachate generation parameters. [7]

where,

SR = Input water from surrounding surface runoff,

W_{GW} = Water from the groundwater underflow,

P = Input water from precipitation,

IR = Input water from irrigation,

I = Infiltration,

R_o = Surface runoff,

dS_{TS} = Change in moisture storage in soil,

PER_S = Portion of I that will percolate through the soil cover,

W_D = Water from decomposition of solid waste,

dS_{TR} = Change in moisture storage in refuse,

L = Amount of leachate generated, and

AET = Actual Evapotranspiration (i.e. the sum of water loss from evaporation and plant water use).

Using the parameters shown and explained in Fig. 1, the water balance method can be applied which allows the estimation of percolation based on one-dimensional flow, conservation of mass, and the retention and transmission characteristics of the soil cover and solid waste in the landfill.

Kumar and Alappat (2003) have put forward the results of the experimental work carried out by them at an active landfill site in Okhla Phase I in New Delhi, India, to ascertain the composition of leachate, and its effect to the ground water below the site. They also studied the variation in the leachate composition with the age of deposition of solid.

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This study indicated that it might be worthwhile to use different methods for the treatment of leachate from different parts of landfill, if collected separately. The study was concluded with a few suggestions for the flaws seen on the landfill site.

Table 1: Physical and Chemical Characteristics of MSW at Okhla landfill site. [9]

(A) Physical Characteristics (All values are in percent by wet weight)				
S. No.	Parameters	Minimum	Maximum	Average
1	Biodegradable	23.79	30.62	28.62
2	Paper	03.10	05.42	03.78
3	Plastic	03.57	06.14	04.45
4	Metal	00.03	01.10	00.10
5	Glass & Crockery	00.38	02.10	01.45
6	Bioresistant	17.00	23.36	19.73
7	Inert	30.75	41.80	32.70
(B) Chemical Characteristics (All values are in percent by dry weight)				
S. No.	Parameters	Minimum	Maximum	Average
1	Moisture	22.97	30.11	25.58
2	Organic Carbon	10.77	19.81	14.82
3	Nitrogen as N	00.52	00.74	00.65
4	Phosphorus as P ₂ O ₅	00.22	00.33	00.27
5	Potassium as K ₂ O	00.44	01.22	00.91
6	C/N Ratio	20.71	26.77	22.80
7	Lower Calorific Value (Kcal/Kg)	380.0	610.0	528.5

Table 1 lists out the physical and chemical characteristics of the municipal solid waste at the landfill site in Okhla Phase I. As it is evident, waste mostly comprises of inert and biodegradable materials, containing high calorific values and moisture content.

Kumar and Alappat (2005) described a concept of the leachate pollution index, a tool for quantifying the leachate's contamination potential of landfill sites. Table-2 gives the list of the pollutant parameters along with their respective weights that are included in the LPI. The system was developed by surveying 80 penalists, using Rand Corporation's Delphi Technique. The theoretical range of LPI is from 5 to 100.

Along with this, the authors also demonstrated its practical application by comparing the leachate contamination potential of two active and two closed landfill sites in Hong Kong. Through this study, it was found out that leachate generated from the closed landfills can have equal or even more contamination potential in comparison to the active landfill sites. Hence, the remediation measures and post-closure monitoring should be ensured at the closed landfills, till the leachate generated is stabilized and poses no further threat to the environment.

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Table 2: Weights of the pollutant parameters included in leachate pollution index (LPI). [10]

S. No.	Pollutant	Significance	Pollutant weight
1	pH	3.509	0.055
2	Total Dissolved Solids	3.196	0.050
3	BOD5	3.902	0.061
4	COD	3.963	0.062
5	Total Kjeldahl Nitrogen	3.367	0.053
6	Ammonia Nitrogen	3.250	0.051
7	Total Iron	2.830	0.045
8	Copper	3.170	0.050
9	Nickel	3.321	0.053
10	Zinc	3.585	0.056
11	Lead	4.019	0.063
12	Total Chromium	4.057	0.064
13	Mercury	3.923	0.062
14	Arsenic	3.885	0.061
15	Phenolic Compounds	3.627	0.057
16	Chlorides	3.078	0.048
17	Cyanide	3.694	0.058
18	Total Coliform Bacteria	3.289	0.052
	Total	63.165	1.000

Agarwal *et al* (2005) investigated and analyzed recycling of MSW in the Indian capital city of Delhi. Market mechanisms of the recycle trade in the city were studied and the details of the informal sector were revealed by carrying out extensive interviews and surveys with recyclists from various slums. The authors were also able to identify the complete hierarchy from recyclists to the final sellers of the recycled products (Fig. 2) and also the profits at each level were determined. The MSW sector is labor intensive and comprises a chain constituted by recyclists, recyclable dealers and finally the recycler units at the top. It has a hierarchical structure, with increasing specialization and decreasing numbers as we move upwards. At every stage of the transaction, waste is sorted more specifically and in bulk, to assort the most valuable components.

In the end, two models were also proposed to evaluate the possibility of formalizing the unorganized waste trade. Finally, the study was concluded by saying that it is possible to organize the sector but this would leave a huge number of recyclists unemployed, who mainly belong to the poorest strata of the society.

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Figure-2:Waste recycle hierarchy in Delhi. [11]

Sharholly *et al.* (2008) provided a comprehensive review of the characteristics, generation, collection and transportation, disposal and treatment technologies of MSW practised in India. The study pertaining to MSWM for Indian cities was carried out to evaluate the current status and identify the current problems. Also, various adopted treatment technologies for MSW like landfilling, recycling of organic waste, thermal treatment technologies and recovery of recyclable materials were critically reviewed, along with their advantages and limitations. The study was 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.

Talyan *et al.* (2008) discussed and evaluated the present state of municipal solid waste in Delhi. The paper also talked about the various Policies and legislative frameworks for MSWM in India along with the generation and composition of MSW in Delhi. The authors also talked about collection, storage, transportation and treatment of the MSW in Delhi, and also the various other initiatives of the government towards improvement of MSWM were described briefly. The study concluded that the existing facilities and policies for MSWM in Delhi are inadequate in dealing with the ever increasing population and the rapid pace of urbanization.

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Table 3: Summary of Acts & Rules on MSW in India. [14]

Acts and Rules	Brief Description	Issuer
Municipal Solid Waste (Management and Handling) Rules, 2000	Set criteria and procedure for municipal authorities for collection, segregation, storage, transportation, processing and disposal of MSW. The criteria and procedure for management and handling of MSW are specified in schedule II, specifications for landfill sites in schedule III and setting up of waste processing facilities with the adoption of appropriate technology in schedule IV.	MoEF*, Govt. Of India.
The Delhi plastic bag (Manufacture, Sales and Usage) And Non-Biodegradable Garbage (Control) Act, 2000	Prevents manufacturing, sale, etc of recycled plastic bags for food packaging and also prohibits throwing or depositing non-biodegradable garbage in public drains, roads and places open to public view. Act also defines that the placement of receptacles and places for deposit of garbage is the responsibility of MCD, NDMC or DCB.	Legislative Assembly of the National Capital Territory of Delhi.
Hazardous Wastes(Management and Handling) Rules, 1989 and Amendments Rules, 2000 and 2003	Specify the processes, hazardous wastes, constituents, concentration limits and waste applicable for import and export. The occupier should take responsibility for proper management and handling of waste either himself or through the operator of a facility. The different categories of the hazardous waste are specified in schedule I.	MoEF, Govt. Of India.
The Bio-Medical Waste (Management and Handling) Rules, 1998 and Amendment Rules, 2003	Recommended treatment and disposal options according to the 10 different categories of biomedical waste generated are defined in schedule I of the rules. Standards for the treatment technologies are given in schedule V.	MoEF, Govt. Of India.
Delhi Municipal Corporation Act, 1957	Early legislation, deals with the environment pollution caused by MSW. The provisions related to MSW are defined under chapter 3 'Functions of the Corporations' and chapter 7 'Sanitation and public health'.	Act of Parliament, Govt. Of India

*MoEF - Ministry of Environment and Forest

Table 3 lists the acts and rules drafted by the GoI and the state governments to deal with solid waste management. Besides these rules, a comprehensive manual on Municipal Solid Waste Management was published by the CPHEEO in 2000, under the Ministry of Urban Development for the guidance of urban local bodies to implement the MSW Rules 2000.

Despite consistent efforts of different regulatory bodies and directives from Honourable Supreme Court of India, the implementation of these rules is still a distant dream. As shown in Fig. 3, there has been insignificant progress in the matter of processing of waste and construction of sanitary landfills, and only about one-third compliance in the remaining five steps.

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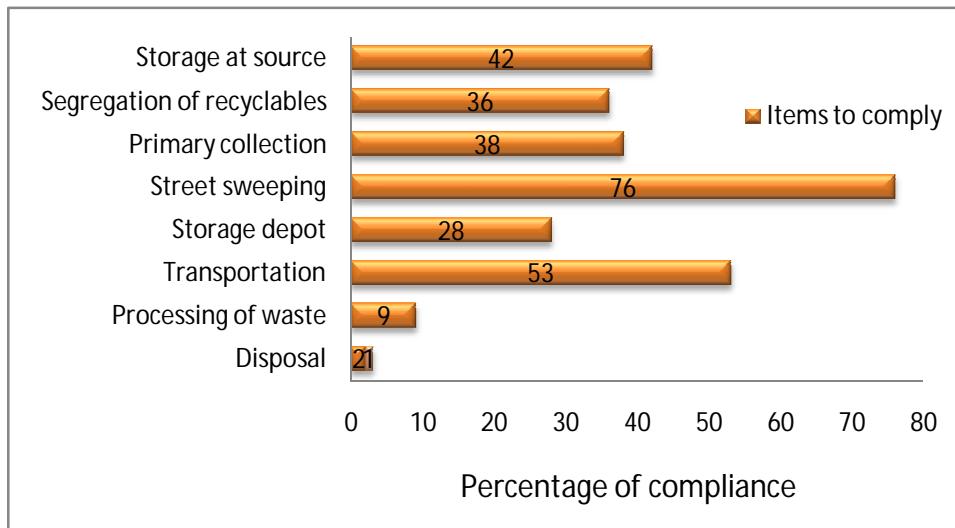


Figure-3: Status of compliance of MSW Rules 2000 by Class-1 cities. [14]

Kumar *et al.* (2009) presented an assessment of the existing situation of the MSWM of major cities in India. Quantification, analysis of physical composition, and characterization of MSW was done by extensive field investigation in each of the 59 identified cities. Fig. 4 shows the salient findings with respect to different components such as waste quantity, waste generation rate, and different categories of waste of MSWM systems in all 59 cities, based on the data collected and extensive field investigations.

The MSW management status (as per MSW Rules, 2000) has also been assessed, and an action plan for better management has been formulated. The study shows that there are various shortcomings in the existing practises pertaining mainly to inadequate manpower, financial resources, implements, and machinery required for effectively carrying out various activities for MSWM.

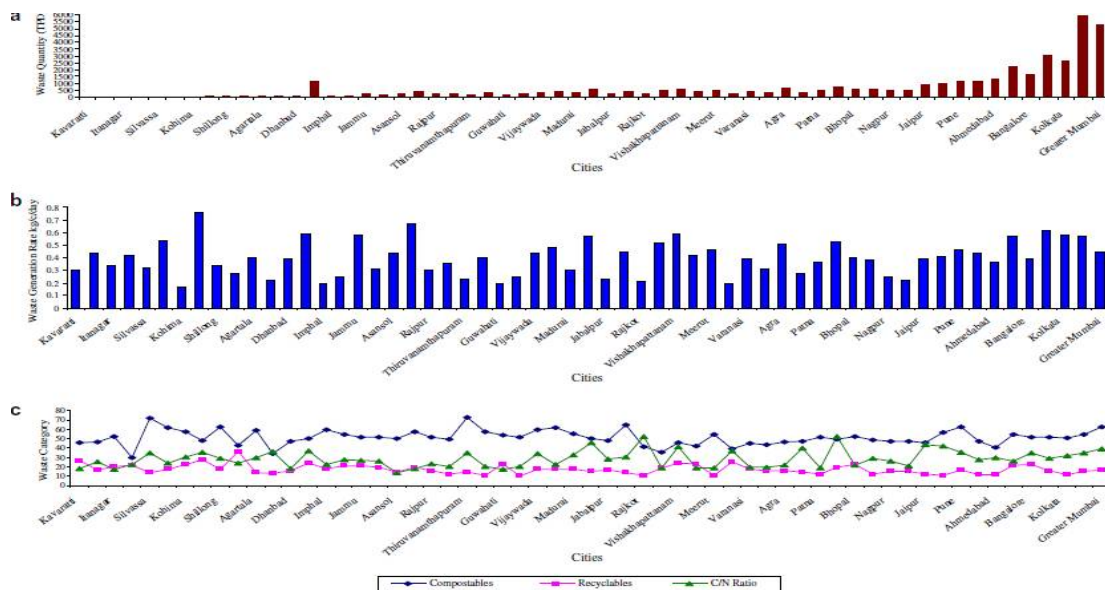


Figure-4: Waste quantity generation rates, and waste category for cities in India. (a) Waste quantity (TPD) vs. cities, (b) Waste generation rates (kg/c/day) vs. cities, and (c) Waste category vs. Cities. [15]

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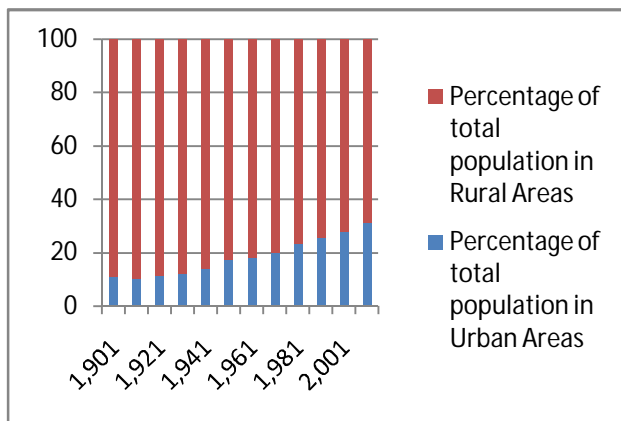


Figure 5: Level of Urbanization. [4]

Year	Per capita waste generation (g/day)	Total urban municipal waste generation (MT/yr)
1971	375	14.9
1981	430	25.1
1991	460	43.5
1997	490	48.5
2025	700	Double the amt. Of 1997

Table-4:Waste generation trends in India. [4]

Vij (2012) presented a report on urbanization and solid waste management in India. The report focused on the upcoming trends of urbanization in India and accordingly the changes in waste generation. Fig. 5 clearly depicts that the percentage of population living in urban areas has increased from 17.9% in 1951 to 31.16% in 2011. Urbanization directly contributes to waste generation, as modern urban living brings on the problem of waste because of everything in packaging and fast food products which increases the quantity of waste and changes its composition with each passing day, which is prominent from Table 4.

The paper also evaluated the current practices prevalent in India to deal with solid waste and problems associated with it, along with the measures to deal with the waste in healthy and environment friendly manner so that it may prove a resource instead of waste.

III. CONCLUSION

Solid waste management has become acute in Delhi, the capital of India. With an ever increasing population and a rapid pace of urbanization, the effects of poor waste management practices on human health and the environment have never been more pronounced. Municipal Corporation of Delhi and the Government of Delhi have realized the seriousness of the situation and framed guidelines in the form of the Master Plan (2005–2021) for disposal and treatment of MSW for the entire state of Delhi. MCD took a big step towards improving municipal solid waste management practices, by privatizing the collection, segregation, transportation and disposal of waste. Non-government organisations, with the assistance from resident welfare associations (RWAs), have played an important role in establishing an infrastructure for Door To Door Collection (DTDC) services and segregation of waste at the source in certain areas of Delhi; this kind of cooperation needs to be replicated at a larger scale. Public co-operation is essential for successful operation of an effective and well-founded system. The Bhagidari scheme initiated by the Government of Delhi has been instrumental in promoting civil partnership in local governance, in the field of MSWM. More such initiatives need to be taken towards educating people about correct practices of solid waste disposal. Initiatives taken by policy makers never yield results unless matched by proper implementation at every level. It is clear that any substantial change in the present scenario is not possible without a three-way partnership of the government, the private sector and the citizens. Finally, there is also a need to develop a methodology of research for developing interactive techniques for system's design and operational control.

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