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Solid Waste Management in Delhi- Challenges and Problems of Landfill Sites

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Abstract—*Urbanizations in India has led to phenomenal shifts in the urban population and demography due to large migration of rural population to metropolitan cities like Delhi, Mumbai, Kolkata and Chennai. Ppopulation in Delhi grew from 2.3 Mn in 1961 to 16.75 Mn in 2011[1]. This change has resulted in tremendous growth in solid waste, overburdening the municipalities for its management. Municipalities in Delhi are dumping the Solid Waste in 3 landfill sites which have already overreached their capacity and are, therefore, prone to frequent accidents. Delhi is now at a juncture where it needs to find a solution for effective disposal of Solid Waste. World over it is a common practice to dump the solid waste in the landfill sites. This paper will review the current practices of treatment and dumping methods of Solid Waste in Delhi; challenges and problems associated with the existing Landfill sites. This paper will also attempt to find the best practices in landfill site design and their relevance for Delhi.*

INTRODUCTION

India is the second most populated country in the world having a population of 1.21 Bn (Census 2011) which is 17.5% of the world's population. The annual rate of growth of urban population in India is 3.35% (Census of India, 2011). The proportion of population living in urban areas has increased from 17.35% in 1951 to 31.2% in 2011(Census, 2011). Declining opportunities in the rural areas and shift from stagnant and low paying agricultural sector to higher paying urban occupations has largely contributed to this shift. It is interesting to note that currently 1 out of 3 people is living in an urban area and it is projected that as much as 50% of India's population will live in cites in the next 10 years (Khurshid and Sethuraman, 2011). Management of Municipal Solid Wastes (MSW) continues to remain one of the most neglected areas of urban development in India. Piles of garbage and wastes of all kinds littered everywhere have become common sight in urban life.

The Union Territory of Delhi has Haryana on the North, West and South and Uttar Pradesh on the East and is spread over an area of 1,484.46 square kilometres (0.04 percent of total geographical area of India). Approximately 94 percent of this area which caters to 97 percent of the population of Delhi is under the jurisdiction of Municipal Corporation of Delhi (MCD) and New Delhi Municipal Council(NDMC). The remaining 6 percent area comes under the jurisdiction of Delhi Cantonment Board (DCB) [2].

Delhi generates approximately 11,558 tonnes of municipal solid waste daily [2]. 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% [3].The management of MSW is in a challenging phase, because of unavailability of appropriate technique for treatment and disposing off the major portion of MSW generated daily. Disposing off the Solid Waste in low-lying areas in Major Cities without using proper dumping methodology is a common practice. Therefore, Management of Waste is one of the critical environmental challenges in metropolitan cities. SWM must have various processes associated with Collection, storage, transfer and transport, processing and disposal of solid waste. But, in most cities, the MSWM system comprises of only four activities, i.e., waste generation, collection, transportation, and disposal. Landfills are not designed with international best practices of Solid Waste Management.. The management of municipal solid waste requires proper maintenance, infrastructure and up gradation of all processes.

OBJECTIVE

The purpose of the current research study is to understand and analyse the municipal solid waste management in Delhi. The current paper has the following objectives:

- To study the quantity and characteristics of solid waste in Delhi
- To understand the ways of disposing of Solid Waste in Delhi
- To trace the problem related to disposal, landfill sites and give some suggestions for better management in Delhi

SOLID WASTE IN DELHI

Delhi is one of the largest cities in the world and also one of the most polluted. The Environmental Protection Training and Research Institute (EPTRI) estimates place MSW generation in Delhi at 4,000 tonnes per day whereas National Environmental Engineering Research Institute (NEERI) study estimates the present solid waste generation in MCD area of Delhi 6000-7000 tonnes per day. A study was carried out by MCD for estimating the quantity and characteristics of MSW during the year 2005 and it has indicated that Delhi generates about 8567 tonnes of waste every day. The waste generation in MCD areas, NDMC areas, and Delhi Cantonment Board area is about 6300 tonnes, 900 tonnes, and 100 tonnes daily respectively (IL and FS Eco smart Report, 2005). According to CPCB, 2010-11, Delhi is generating the highest quantity of municipal solid waste with 6800 tonnes per day (TPD) followed by Greater Mumbai and Chennai. A study carried out by WTERI (Waste-to-Energy Research and Technology, 2012) has estimated that Delhi generates 11,500 TPD or 4.2 million tonnes per year (TPY), the highest waste among union territories. The per capita generation of MSW in Delhi is approximately 0.5 Kg/capita/day (Ahmad, 2012).

In Delhi, there has been a tremendous increase in the generation of Solid Waste. Data collected on daily quantity of Municipal Solid Waste Generated (MSWG) in Delhi since (1993-2011) indicates that there has been considerable fluctuation in quantum during this period. There was continued rise in municipal solid waste in the years 1993, 1994, 1995, 1996 and 1997[4]. The trend clearly shows that there has been a significant increase in the generation of solid waste in the last few decades. Since 1993-2011 about 54 percent growth has been recorded in MSWG. In 2005 the MSWG was relatively higher than that of the year 2006. Further, in 2007 it was reduced to a considerable extent from the previous year. Subsequently, a steady growth was experienced. In the years 2008 and 2009, the waste generation rate increased due to hectic construction activity related to hosting of the Commonwealth Games in 2010. In 2012 NDMC area generated 82832.94 metric tonnes waste which was a substantial increased from 2011 (10731.45 MT.). The Central Pollution Control Board has reported that waste from India's cities has crossed 1,42,870 (1.43 lakh) tonnes per day, of which a substantial 12,858 tonnes is not even collected. Of the 91% (1.3 lakh tonnes) collected, around 65,000 tonnes is dumped or disposed off in the most unscientific and unhygienic manner. Only 23% is being treated while 27% is dumped in landfills [4].

TREATMENT OF MSW:

Composting

In Delhi, since a huge amount of biodegradable waste is generated, there exists a good potential for composting. Therefore, Delhi Government had initiated various composting plants (Table 8). The first composting plant was set up at Okhla in 1980. It was a semi–mechanised plant with a capacity of 150 tons per day for composting the waste. In 1985 this plant was expanded and presently processes 500 tons of MSW per day.

However, this plant was non-operational during 1991-1995 due to low quantity of waste material and high operating costs. In May 2007, Infrastructure Leasing and Financial Services Limited (IL and FS), an infrastructure development and finance company, signed a concession agreement with the MCD to rehabilitate the Okhla compost plant with carbon finance support. The project uses the technique of multi-treatment of municipal waste to avoid possible pollution. It involves mechanical sorting and composting of organic waste, recycling of materials like metals, plastics and paper and treating the residual organic waste using composting process. This plant converts approximately 1,82,500 tonnes of MSW into compost every year which is equivalent to 500 tonnes per day. Likewise, New Delhi Municipal Council (NDMC) had also set up a compost plant in Okhla. Then came two other compost plants in Bhalswa and Tikri Khurd. The plant in Bhalswa, however, has been shut down by Delhi Pollution Control Committee (DPCC) since March 28,2014 for violating pollution norms.

Recently MCD has installed a compost plant at Narela-Bawana with a capacity of 400 TPD and it is working since January 2012 (Table 8). The Compost facility processes approximately 400 TPD MSW (150 TPD from incoming solid waste, 150 TPD from MRF, and 100 TPD from screening section).

Incineration (Waste to Energy)

Waste to energy facilities may generate steam, electricity, super-heated water or a combination of these. Incineration is a good alternative for waste processing being used in India. The Government of Delhi also gave permission for 3 plants for conversion of solid waste into power:

Timarpur-Okhla Waste to Energy Plant:

The Timarpur Refuse Incineration-cum-Power Generation station was commissioned by the Ministry of Non-Conventional Energy Sources (MNES) in 1987 at a capital cost of Rs. 20 crores (US$ 4.4 million). Built by Volund Miljotecknik Ltd. of Denmark, the plant was designed to incinerate 300 tonnes of municipal solid waste per day to generate 3.75 MW of electricity. The plant ran for 21 days of trial operations, then was shut down due to the poor quality of incoming waste. In November 2007, the CDM Executive Board registered a project by the name Timarpur-Okhla Waste Management Company to build two facilities to handle 2050 tonnes per day of municipal waste.

Gazipur WTE Plant: The Gazipur project processes 1,300 tonnes per day of municipal waste generated in the Trans-

Yamuna area. The waste is collected to produce green electricity.

The Narela-Bawana Waste to Energy plant: Around 4000 TPD of Solid Waste will be treated in 2 phases; Phase-1 will process 1000 TPD of waste and Phase-II will be having a Mass-burn technology based power plant which will process 3000 TPD of waste.

DISPOSAL OF MSW

At present, Delhi has four active sanitary landfill sites (Bhalswa, Gazipur, Okhla and Narela-Bawana) having more than 200 acres of land, under different Local bodies of the city, in different directions. The Municipal Corporations of Delhi (NDMC, SDMC and EDMC) are responsible for the management of all four existing landfill sites. Other bodies like Delhi Metro Rail Corporation (DMRC) and Agricultural Produce Market Committee (APMC) etc. dispose off their waste on the landfill sites controlled by MCDs. New Delhi Municipal Council (NDMC) and Delhi Cantonment Board(DCB) do not have any provision for disposal of the waste produced in their area. Hence, MCD allows these bodies to use its Landfill sites for a fee. The three active landfill sites, namely, Bhalswa, Gazipur and Okhla have breached their limits but illegal dumping is prevalent by all the civic bodies, which has lead to many accidents and is hazardous to human health and environment.

Table 1 displays the status of the active landfill sites in Delhi.

Table 1: Status of landfill Sites in Delhi

S. No	Name of landfill Site	Status	Area	Leachate Collection System
1	Bhalswa	Exhausted	40	No
2	Okhla	Exhausted	32	No
3	Ghazipur	Exhausted	70	No
4	Narela-bawana	-	60	Yes

The above table clearly shows that currently, in SWM, disposal is the biggest concern as all landfill sites are now exhausted. New sites need to be designed incorporating international best practices otherwise it may lead to disasters and serious accidents like the Ghazipur landfill site accident (September 2017) in which 2 people died and 7 were injured [5].

New landfill sites and waste-to-energy plants are frequently stopped from being set up by protesting locals which leads to delay in implementing a long term plan to close the existing sites and switch to alternate sites.

International Best Practices for landfill sites

Delhi now requires a complete switchover to a new Solid Waste Disposal (SWD) site design as per international best practices as well as identification of new sites since existing sites are exhausted. Scientific and well-engineered design of landfill sites will lead to improved public health and less pollution to nearby environment as frequent fires in these sites is also one of the reasons for rising pollution levels in Delhi. Properly designed landfill sites will enhance the generation of Landfill Gas which will further enhance the efficiency of Landfill Gas-Energy (LFGE) plants.

SWD sites can be categorised into three groups depending on the main characteristics of the sites: (1) Open dump; (2) Controlled landfill/dump; (3) Sanitary landfill. Their basic difference can be summarised in Table 2 [6].

Table 2: Comparison of Solid Waste Disposal Sites [6]

Factor	Open Dump	Controlled Landfill/Dump	Sanitary
Environmental Factors			
Atmosphere			
Fires	Intentional burning common	Limited, may be present	Unlikely
Release of hazardous gases	Yes, if no collection exists	Yes, if no collection exists	Yes, if no collection exists
Unpleasant odours	Yes	Possible, depending on site conditions and whether LFG is controlled	Minimal, if the right measures are taken to cover waste and control LFG
Ground/Soil			
Topographical Modification	Yes	Yes	Yes
Contamination (leachate)	Yes	Possible, depending on base or liner conditions	No
Gas Migration	Yes	Possible, depending on site conditions	No
Water (surface and ground water)			
Channeling runoff	No	Possible, depending on site conditions	Yes
Contamination	Likely underground and surface water	Possible if low-permeability liners are not used	Minimal

Monitoring system present	No	No	Yes
Flora			
Vegetative cover alteration	Yes	Yes	Yes
Fauna			
Changes in diversity	Likely	Yes	No
Vector control	No	Potentially, depending on site conditions	No
Socioeconomic Factors			
Landscape			
Alteration of Condition	Yes	Yes, can be mitigated with visual buffer (for example, a forest buffer)	Yes, can be mitigated with visual buffer (for example, a forest buffer)
Humans			
Health hazards	Yes	Potentially, depending on site conditions	Potentially, depending on site conditions
Negative image	Yes	Yes	Yes, improved if there is post-closure utilization of land
Environmental education	No	Yes, in some cases	Yes, with careful planning
Economics			
Decline of land value	Yes	Yes	Yes
Formal employment	No	Yes	Yes
Changes in land use	Yes	Yes	Yes
Social			
Waste pickers	Yes	Yes, in some cases	No

From the comparison given in Table 2, it can be inferred that Sanitary Landfill is better than the other two methods. In the long run, Sanitary landfill design is more cost effective, as it is a preventive measure, than the poorly designed sites which need more efforts later on.

Sanitary Landfill designs are continuously evolving with better research and engineering techniques being employed and its technology varies from country to country. Most developing countries do not have stringent laid down regulations pertaining to the Sanitary Landfill design. A few countries have mentioned in their laws the need for a bottom liner, LFG venting, final cover and leachate management.

Bottom Liner Systems:

The objective of the bottom liner is to protect the soil and ground water from the pollution that originates within the waste mass. The bottom liner creates an impermeable barrier between the waste mass and underlying soils and ground water and is applied to the entire surface of the landfill to prevent both horizontal and vertical migration. Liners also serves as a barrier to LFG migration to surrounding soils[6].

Descriptions of the different materials used in liners and information on the different types of bottom liner systems can be found in various reference materials, including Solid Waste Landfill Engineering and Design by McBean et al. and the Landfill Types and Liner Systems Fact Sheet produced by Ohio State University[7].

Cost of the liner systems are dependent on many factors such as source of clay soil proximity and its transportation cost etc..

Leachate Collection and Management Systems [6]

Leachate is a wastewater formed when water percolates through or comes in contact with the waste mass. Leachate contains high concentrations of organic and inorganic constituents that can be toxic[6].

In an SWD site, leachate can originate from two sources: moisture contained in the solid waste when it is disposed of; and external sources of water such as rain.

The major concerns of leachate have to do with its migration to and contamination of surface and ground water and its impediment to LFG collection when it accumulates and floods LFG collection wells.

A Leachate Collection and Removal System (LCRS) is designed to collect, conduct and store the leachate for its treatment on site or off site.

An LCRS normally consists of a drainage layer above the liner system. This drainage layer provides a means for the leachate to flow above the liner system. Typically, a network of pipes is installed within the drainage layer to transport leachate to a collection point (such as a lagoon or storage tank)[8].A typical layout of an LCRS can be seen in Figure 2-1. Note the bottom slope direction in Figure 2-1. The bottom of the SWD site needs to be gently sloped to promote leachate drainage to the cleanout lines (see Figure 2-2).

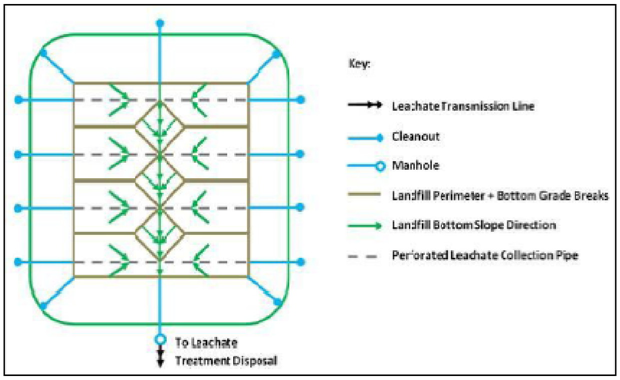

Figure 2-1. Typical Layout of Leachate Collection System (top view)

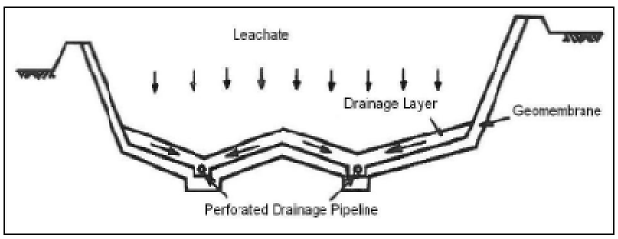

Figure 2-2. Side View of Leachate Drainage Slopes

The leachate extraction system at many of these sites drains the leachate using gravity; however, low permeability of organic material makes gravity less effective for moving leachate. Leachate pumps are helpful in improving circulation at certain sites. In the gravity systems, if the LFG vent wells are not emanating LFG because of positive pressure within the waste mass, then possible air intrusion into the waste mass can occur and result in semi-aerobic conditions. A semi-aerobic waste mass generates less LFG because activity of methanogenic bacteria is suppressed. If an active LFG extraction system is attached to vent wells that are also used for leachate management, then care should be taken to avoid air intrusion into the waste mass [6].

Once the leachate has been collected from the SWD site, there are several options to properly manage disposal. These options include on-site treatment (for example, aeration or reverse osmosis) and disposal to a wastewater treatment plant or discharge to surface water, transport to a wastewater treatment plant, evaporation and recirculation.

Grading and Re-grading SWD Site Slopes

SWD site slopes should be maintained to be no steeper than a 3:1 (3 horizontal to 1 vertical) grade. Steep side slopes can cause instability leading to side slope failure, erosion and loss of the soil cover. Loss of the soil cover and the eventual side erosion can lead to breakouts of leachate and LFG, as well as air infiltration into the waste mass. The intrusion of air into the waste mass can lead to underground fires. If the SWD site has an LFG collection system, side slope air infiltration can reach the system and cause dilution and lowering of the quality of the LFG. Figure 2-3 provides an example of slope recommendations for SWD sites. Side slopes should be designed to be considerably less steep, such as slopes with a grade of 5:1, in seismically active areas or in areas with poor soils [6].

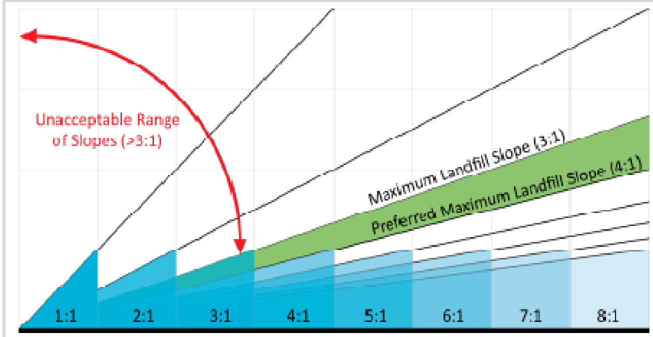

Figure 2-3. SWD Site Slope Recommendations

Final Capping Systems [6]

The objectives of the final capping system are to: (1) minimise infiltration of precipitation into the waste mass, thus reducing leachate generation, (2) minimise air intrusion into the waste mass, (3) promote good surface water drainage, and (4) control LFG emissions.

For efficient LFG collection, final covers minimise the creation of leachate and minimise fugitive emissions of LFG, allowing for improvement of LFG collection.

Final capping systems can include different components such as a buffer layer at the waste interface, gas channels, infiltration prevention (composite liners), cover soils, erosion layer (topsoil) and vegetative cover. For LFG collection, the most important factor of the final capping system is its permeability. Permeability affects LFG management and system performance.

Landfill Site Selection

Selection of Landfill site is a complicated process and involves various social, economic and environmental factors. Landfill sites in major cities face the ‘Not in my backyard Syndrome’ (NIMBS). In the past few years Delhi is struggling to get new Landfill sites in addition to the existing sites. All the existing sites have been exhausted and selecting new sites is the need of the hour. Finding suitable Landfill site is one of the most challenging factors in implementing Solid Waste Management for any city (Rushbrook and Pugh, 1999; Tchobanoglous et al., 1993). Landfill Site selection for waste disposal is a complex process as it must incorporate social, environmental and technical factors (Kontos et al., 2005). Geographic Information Systems (GIS) is a very useful tool in managing spatial data for site selection. Some Studies has been done by combining GIS and Analytical Hierarchy Process (AHP) where GIS is useful in handling the data and AHP is used for ranking the various sites (*Alavi et al*., 2015). The main factors and sub-factors used in the studies done for site selection are given below [10]:

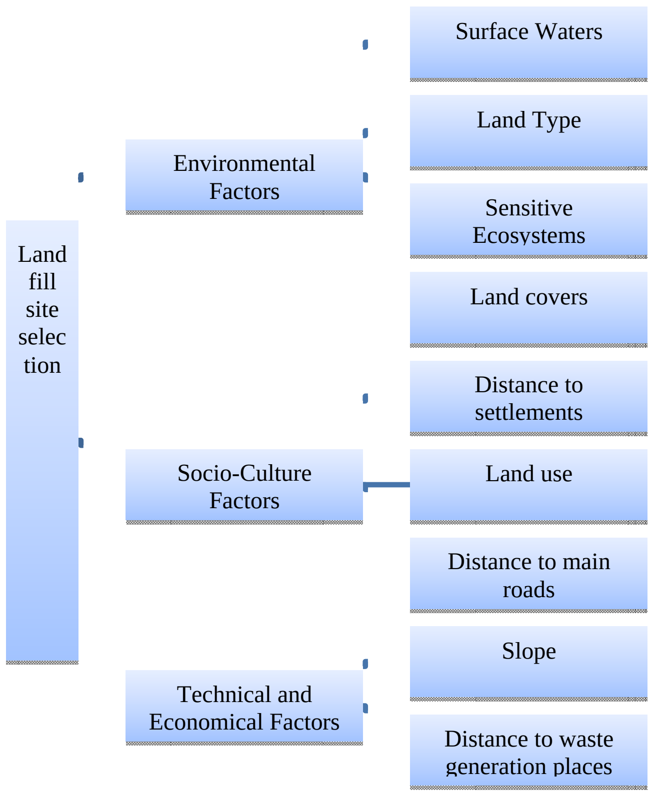

Figure 3: Hierarchy structure for the landfill site selection problem[10]

In the study done by *Alavi et al*., using AHP for The relative importance of each criterion showed that the most important ones were sensitive ecosystems and surface water, while the least important criterion was slope as shown in Table 3 [10].

Table 3: Pairwise comparison matrix and relative importance weights of the evaluation criteria

Criteria	A	B	C	D	E	F	G	H	I	Weights
A	1	1	2	3	4	5	6	7	9	0.259267
B	1	1	2	3	4	5	6	7	9	0.259267
C	0.5	0.5	1	2	3	3	3	4	5	0.147988
D	0.33	0.33	0.5	1	2	2	3	4	5	0.106635
E	0.25	0.25	0.33	0.5	1	2	2	2	4	0.071947
F	0.2	0.2	0.33	0.5	0.5	1	2	2	3	0.056883
G	0.16	0.16	0.33	0.33	0.5	0.5	1	2	2	0.04244
H	0.14	0.14	0.25	0.25	0.5	0.5	0.5	1	2	0.033049
I	0.11	0.11	0.2	0.2	0.25	0.33	0.5	0.5	1	0.022524

A, surface waters; B, sensitive ecosystems; C, distance to settlements; D, soil type; E, land uses; F, land cover; G, distance from waste generation places; H, roads; I, slope

After analysing the above factors, for South MCD wards Bijwasan (48), Chhawala (39) and Najafgarh (138) under Najafgarh Zone area can be considered for new suitable Landfill sites. However, there will be the disadvantage of distance of these sites from the other wards of the South MCD which will increase the cost of disposal. Central and South Zone are disqualified because of their proximity to settlements and many areas in Central Zone are near or fall in the category of Ridge and A sola wildlife sanctuary.

For North MCD, Bakhtawarpur (2), Bankner (5), Bawana (30), Holambi Khurd (4), Kanjhawala (35) wards can be considered for suitable Landfill sites.

None of the areas under East MCD qualify for a suitable Landfill site because of the scarcity of available Land; proximity to settlements and Yamuna Flood-plain. East MCD identified one site near Sonia Vihar on Yamuna Floodplain which was opposed by the locals and environmentalists.

CONCLUSION

In this study we have seen that Sanitary Landfill is the most suitable method for dumping the waste in comparison to open and controlled dumping. Shifting to Sanitary Landfill will help Delhi to use its Solid Waste more efficiently and generate more electricity from the Landfill Waste to energy plants. It will further help in reducing the air pollution and frequent accidents as compared to the existing sites.

It is important that Sanitary landfill sites should be prepared using bottom liner, LFG venting, final cover and leachate management on the lines of international best practices discussed in this paper.

Closure of Landfill sites is of paramount importance for Delhi as all the sites have breached their capacity and are currently overflowing. Inspite of a court ban, illegal dumping continues.

Selection of new sites can be done using the criteria discussed in Landfill site selection. This paper suggests to MCDs to start a new site in Nazafgarh Zone and two sites in North MCD along with immediate closure of the existing sites.

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