Municipal solid waste handing in India: special reference to Pune City

A. Purandare¹ & J. Purandare²
¹Eco Designs India Private Limited, India
²England Geosystem, U.S.A.

Abstract

After the historic directive of the Supreme Court of India, the Ministry of Environment formed legislation in year 2000 regarding the handling and disposal of municipal solid waste (MSW) to be followed by all the Municipal Corporations in India. In 2002, citizens lodged a complaint in the Bombay High Court against the Pune Municipal Corporation for non compliance of the law. This Corporation, which handles 1000 tons of MSW daily, appointed our firm to design and supervise the closure of the existing waste dump and to carry out a short-term and long-term landfill site development. This was the first scientifically designed and executed landfill and closure work in India. Apart from landfill development, a system was also designed for the segregation and recycling of waste in a manner that is unique to the Indian setting. The treatment of biodegradable organic waste by vermi-composting and composting has also been carried out by individuals and at the landfill site respectively.

This model of waste management will be replicated at numerous places in India. A detailed cost analysis has been worked out for each section of the waste handling process to give guidance to more than 400 cities which have to incorporate the modern system of handling their MSW. Details of each of the stages provided could be beneficial in the development of MSW systems in developing countries.

Keywords: landfill, solid waste, MSW, disposal, handling, cost, India.

1 Introduction

Urbanisation is taking place at a very fast pace in India. The migration of people from villages to cities is putting a tremendous pressure on the infrastructure in all
the major cities. One of the most visible effects of this is the inadequate cleaning and disposal of solid waste that is generated. Due to the lack of expertise, the Municipal Authorities continued to dispose the MSW by dumping it in open areas. The fires and other constant problems at dumping ground along with ground water contamination due to leachate caused a lot of opposition from Non-Government Organizations (NGOs). In response to litigation, the Supreme Court of India directed the Government to form legislation and rules for all Municipalities to follow. The MSW 2000 handling and disposal rules now govern the design of all facilities with respect to municipal solid waste [1].

2 Conditions at all cities in India

In order to recommend the right method of waste disposal, it was necessary to first classify the waste stream. The National Environmental Engineering Research Institute (NEERI) took the initiative to characterize the MSW that is typically generated in a large number of Indian cities. The study showed that about 45% to 55% waste is biodegradable food waste, 15% is recyclable material, and the remaining is of non-organic nature. It is the high biodegradable food content which causes conditions of extreme health hazard at the dumping ground. It also creates leachate of high BOD and high microbial contamination. These wastes also attract other vectors which cause highly objectionable conditions in the surrounding area. As there were no criteria for the selection of dumping grounds, many of them now lie in the midst of commercial and residential areas causing a lot of health concerns.

In light of these conditions, the new MSW 2000 Rules have laid down norms for site selection, waste handling and disposal, and methods of construction of landfills. The guidelines recommend segregating the waste at the time of collection, recycling the appropriate fraction, treating the organic part of the waste, and disposing the remaining waste in an appropriate manner. Although several options exist in converting the organic waste into renewable energy, the rules recommend composting the biodegradable fraction, since this is a low cost option and is an excellent resource for agriculture. These rules also empower citizens to take legal action by approaching the high courts if the local body fails to perform its duty.

3 Conditions at Pune landfill

Until the year 2000, the manner in which the MSW was handled and disposed was no different than the rest of the country. Pune, being a city with a population of about 3 million generates about 1000 tons of waste daily. A large part of this waste was being dumped by the municipal authorities in the midst of the village of Uruli Dewachi, which is in the outskirts of Pune. In the presence of favorable legal framework, the affected persons started taking legal redress for their grievance about improper handling of waste at the dumping ground. The villagers of Uruli Dewachi who were affected by the dumping ground of Pune Municipal Corporation in their midst approached the Bombay High Court with a
public interest litigation. The court ordered Pune Corporation to immediately improve their waste disposal practices as stipulated in MSW 2000 rules. The design and supervision of this work of closure and landfill design was awarded to our firm.

The conditions at the Uruli Dewachi dumping site were appalling. The entire area was swarming with flies and the odor was unbearable. The dump was on fire daily and these had to be brought under control with huge quantities of water. The ground water was heavily contaminated by leachate and the open wells, which were a source of water for drinking as well as irrigation for the villages, had become unfit for use even for agriculture. It was difficult to eat food in the village with swarms of files and thick smoke from burning garbage. Dissatisfied with the lack of initiative from the authorities the villagers had begun protesting on the streets by obstructing trucks bringing in the waste. Our firm was brought in to quickly remedy the situation.

The area used for waste dumping was an abandoned rock quarry. As it was Government-owned and of very little economic use, it was given to the Pune Municipal Corporation (PMC) for dumping waste. Till we reached the site, an adjoining piece of land was being mined as rock quarry with daily blasting. Years of blasting had caused deep fissures and complete shattering of rock to a considerable depth. The site geology has 20m of basalt with 7m of weathered rock followed by basalt. The weathered layer carries a ground aquifer and is the primary source of water feeding the open wells in the area. It is seen at about 8m to 10m depth in the open wells in the village. A major quantity of leachate is formed during the monsoon season which lasts for about 3 to 4 months. However the large quantities of water used for putting out daily fires formed leachate and the ground water contamination throughout the year. The contamination was seen up to a distance of 2 km from the dump site.

4 Design objectives

In order to address the immediate concerns at the site and to address future issues, the objectives for the design were two fold; a short term objective and a long term objective. The short term objective essentially aimed at stopping the foul odour and fly nuisance arresting the occurrence of fires, and reducing the formation of leachate. This could be done by completing closure of the waste heap. The site plan is presented in Figure 1. The PMC did not have sufficient land for a large sized landfill and was still in the process of acquiring the adjacent land. However this acquisition was not expected to be completed within a year, and therefore it was necessary to construct a smaller landfill that would have a one-year capacity. This constituted Phase 1 of the project. The long-term objective (Phase 2) would include the design and construction of a larger landfill capable of handling all the waste generated over a 20 year period. Due to the lack of space, it was decided to construct the small first phase landfill on top of the closed pre-existing waste dump. As part of the requirements stipulated in the MSW 2000 rules, a composting platform was also designed in the available area. This is shown in the site plan.
The sequence of handling waste would be as follows.

i. The total waste would be taken on to the composting platform;

ii. There would be aerobic composting by weekly turning the heaps;

iii. After turning for 4 weeks, partially composted waste would be passed through screens, separating the non–biodegradable and large size waste;

iv. Partially composted material would be stacked for further composting and maturing;

v. Recyclables would be removed from non–biodegradable fraction of the waste and the inert waste would be disposed in the landfill.

![Site plan](image)

**Figure 1:** Site plan.

The total waste collected by PMC was 1000 tons/day. Based on the waste characteristics and the handling method summarized above, it was expected that about 35% by weight of the incoming waste would need to be disposed off into the landfill.

In order to fulfill the short term and long term goals to meet MSW 2000 norms and the court directives, the following sequence was followed:

i. Closure of the waste;

ii. Construct a landfill with a 1-year capacity over the closed area;

iii. Construct a composting platform;

iv. Construct landfill with a 20-year capacity along with a composting facility.

### 5 The main design issues

Several issues needed consideration while designing the closure system and landfill over the pre-existing waste heap. Some of the important issues included:

i. Permanent stability of waste heap;

ii. Total impermeability from the top;

iii. Passive venting of gas;

iv. Possible large settlement of waste.
5.1 Closure details

The existing waste heap was about 15m to 17m in height with a slope at the face of about 70°. Large parts of this unstable slope were falling down. The first task was to alter the waste slope to a slope which was stable and had the required factor of safety. The slope was changed to 1:3 (about 18°) by using dozers. Consolidation was achieved by using 10 ton capacity rollers. The area under the slopes was built up in stages so that rollers could be used properly. The waste was covered with layers of soil, LLDPE liner of 0.75mm thickness, non-woven geotextile of 5mm thick (270gm) followed by a 300mm soil layer. A 50mm thick layer of good earth was placed on top to facilitate the planting of a grass cover. Vertical and horizontal drains were provided on the slope to catch rain water and divert it to the main drain at the bottom of the slope.

A section of closure detail is shown in Figure 2.

![Section of closure](image)

Figure 2: Section of closure.

![Section of landfill](image)

Figure 3: Section of landfill.
As the smaller landfill was to be constructed on top of the closure, the top was leveled to slopes which would facilitate the drainage of leachate collected by the pipe system constructed at the bottom of the landfill section. The liner section for the landfill is shown in Figure 3.

### 5.2 Landfill details

The LLDPE liner used for landfill was of 1.5mm thickness. The main reason for using LLDPE liner on the slopes as well as the landfill bottom was to provide flexibility for the likely settlement of the landfill bottom to ensure that the liner would sustain the strains and elongation coming with such a settlement.

Since the original waste had been in place at the site for more than 8 years, with about 50% organic content, it would start releasing methane after closure. As there was no system available in India for creating wells and extracting gas, a simple system of gas collection at the top layer of waste was constructed with a 200mm thick sand layer. This layer was provided to draw the gas to the outer periphery of the landfill and release it to atmosphere. Collecting and using this gas is under consideration now.

The design of the larger landfill has just started with the possession of the land. As it was also part of a rock quarry, the design will have to take into consideration the fractured vertical faces of rock which would have to be sealed. The method proposed is to grout the cracks and then gunite the vertical surface with a weld mesh tied to the rock by anchor bolts.

### 5.3 Costs associated with current project

Costs associated with the two phases of the project are summarized in Table 1.

<table>
<thead>
<tr>
<th>Phase</th>
<th>Area (m²)</th>
<th>Capacity (MT)</th>
<th>Cost (Rs.)</th>
<th>Cost Rs./m²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Closure</td>
<td>34600</td>
<td>840,000</td>
<td>10,008,000</td>
<td>291</td>
</tr>
<tr>
<td>Landfill No.1</td>
<td>12,400</td>
<td>73194</td>
<td>8,757,400</td>
<td>706</td>
</tr>
<tr>
<td>Composting Pad</td>
<td>19,000</td>
<td>---</td>
<td>19,000,000</td>
<td>1000</td>
</tr>
</tbody>
</table>

### 6 Cost studies

Separate studies have been carried out on 80 cities on their present systems of collection and handling waste up to the landfill site and the costs vary from Rs. 650/- (E 11.8) to Rs. 1800/- (E 32.7) per ton, depending on the efficiency of manpower used and the level of mechanization in the handling. This cost compares well with the costs incurred while constructing the landfill in Pune.

Studies have also been conducted on the cost structure of centralised composting plant at the landfill. The cost is worked out on the basis of financial...
cost of the infrastructure and operating cost. This works out to between Rs.750/-
to Rs.900/- (E 13.6 to E 16.4) per ton of compost. It is possible to sell compost
with reasonable profits to farmers producing vegetables, flowers and
horticulture. The total requirement for compost is several times more than what
can be produced. To create awareness, all the Agri research stations, Agriculture
universities and Department of the Government are coming together for this joint
effort. This would also promote Green Farming and substantially reduce the use
of chemical fertilizer.

7 Reduction of waste reaching landfill

In order to reduce total costs of MSW handling and treatment, it would be
necessary to reduce the waste at the point of waste generation. If a reduced
quantity of waste arrives at the first collection point, costs, which depend on the
total tonnage handled, would reduce proportionately. The strategy adopted for
each type of waste is different. The three broad categories are

i. Bio-degradable organics (wet waste)
ii. Recyclables.
iii. Non-organic.

Bio-degradable organics: Daily collection as dry and wet waste is carried out
from all the householders in separate containers. The same system is followed by
bulk generators of waste, such as hotels, restaurant, hostels, and canteens. This
waste is typically taken to the composting yard at the landfill site. Individual
households and small waste generators are encouraged to carry out vermi-
composting. Vermi-composting is normally not recommended beyond 100
kg/day. The area required for vermi-composting is about 1 m² for 1 kg of waste
day. Another system of wet waste reduction is by using anaerobic digestion,
thereby producing usable biogas. This process is typically used to handle waste
between 2 ton/day to 10 ton/day.

All the above options are being explored in the city of Pune, taking in to
account the economic strata of people and their willingness for a particular
system. This is adopted by hotels and factory kitchens where the biogas can be
used for cooking or water heating.

Recyclables: It has been a practice in India to allow rag-pickers to collect
recyclable waste and earn a living by selling it. It was decided not to displace
these people from the present chain. As door-to-door collection of waste has
been started, recyclable are being picked up and taken to a central location in the
Municipal wards where rag-pickers are allowed to take away that which can be
sold.

In the city of Pune, approximately 6,000 rag-pickers have been given identity
cards by one NGO and closely monitored.

The main aim in encouraging vermi-composting and rag-picking is to
substantially reduce the waste quantity from the primary waste collection points
thereby reducing the quantity of waste which needs to be transported from the
city to the landfill site.
8 Scope for work in India

Due to the new rules applicable to all Municipal bodies with a population greater than 50,000, more than 400 towns and cities that come under its preview, would require to perform closures and constructing new landfills. It would also be necessary to incorporate modern methods of handling waste to replace the manual handling of waste that is currently being employed. In the construction of closures and landfills, liners and geotextiles would need to be imported. During landfill closures, expertise in gas collection wells and gas extraction would be required. Equipment and machinery required for storage and handling of waste and possible treatment options for organics are other areas in which technology could be brought into Indian MSW market. Hence a large market concerned with MSW handling and disposal exists and needs to be commercial exploited.

References

[8] Purandare A.N., Tendulkar G.M. Execution Cost of MSW Landfills in India