Municipal Solid Waste Landfills In Cities

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What is a Landfill?

- A sanitary landfill refers to an engineered facility for the disposal of MSW designed and operated to minimize public health and environmental impacts.
- Landfilling is the process by which residual solid waste is placed in a landfill.
Case in Supreme Court

- Pathetic condition of Solid waste practices in India
- No solution in sight
- Mrs Almitra Patel & others – Writ Petition No.888 of 1996
- Committee in 1998
- MSW (M & H) Rules 2000
Environmental Laws in India

- Water Act – 1976
- Air Act – 1981
- Environmental Protection Act – 1986
- Municipal Solid Waste (Management & Handling) Rules - 2000
Important Features of MSW Rules

- Source segregation
- House to house collection
- Reduction of paper and plastic – household level
- Involvement of Rag pickers (recyclable)
- Transportation
- Processing
- Final Disposal
### Schedule II - Gazette - 25<sup>th</sup> Sept 2000

<table>
<thead>
<tr>
<th>Processing of MSW</th>
<th>Biodegradable waste by windrow composting, in-vessel composting, vermi-composting, anaerobic digestion, pelletisation etc.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disposal of MSW</td>
<td>Landfilling to be restricted to non-biodegradable inert waste and any other waste not suitable for other purposes</td>
</tr>
</tbody>
</table>
Processing of MSW

- Windrow composting
- In-vessel composting
- Vermi-composting
- Bio-methanation
- Pelletisation

Landfilling - non-biodegradable inert waste
Site Clearance Committee

- SPCB
- Town & Country Planning Dept
- Forest Dept
- Archeological Dept
- Airport Authority
- Police
- Ground water Board
- Technical Institute – IIT etc
Process of Site Selection

- Potential Site selection
- Selection of Best 2 sites
- EIA of both sites
- Public Participation
- Public Hearing
- Final Selection of site
Site Selection Criteria

- Lake or Pond - > 500 M
- River - > 1000 M
- Flood Plain – No (100 yrs flood plain)
- Highway - > 500 M
- Habitation - > 500 M
- Critical Habitat – Not Allowed
- Wet Lands – Not allowed
Ground Water Level - > 2 M Below landfill base level

Airport - 10 Km from airbase

Water Supply Well - > 500 M

Coastal Regulation Zone – Not allowed

Unstable Zone (seismic) – Not allowed
Cross-Section of Bottom System

- **Leachate collection zone**
- **Leachate collection pipe**
- **Waste**
- **Leachate**
- **Protective layer**
- **Geotextile**
- **Sand**
- **HDPE liner**
- **Compacted clay liner (CCL)**
- **Perforated drainage pipe encased in geotextile**
- **Natural Soil**
Schedule III - Gazette 22(b) Specifications for Landfill Base

- 90 cm clay/amended soil layer having permeability coefficient not greater than $1 \times 10^{-7}$ cm/s
- 1.5mm thk HDPE liner over the above layer.
- Leachate collection & treatment system
- Storm water run-off gutters
Cross-Section of Closure

- Grass vegetative cover
- Vegetative support layer
- Lateral drainage layer
- Flexible membrane barrier layer
- Compacted clay barrier layer
- Waste
Schedule III - Gazette 19 & 21
Specifications for Landfill Cover

- Daily cover of 10cm of soil
- 60 cm clay/amended soil layer having permeability coefficient not greater than $1 \times 10^{-7}$ cm/s or equivalent
- 15cm thk drainage layer on top of soil
- 45cm thk vegetative layer on top of drainage layer.
Post Closure Care-Requirements

The Post-closure care of landfill site shall be conducted for at least 15 years and long term monitoring /care plan shall consist of:

a) Maintaining the integrity & effectiveness of the final cover, making repairs and preventing run-on and run-off from eroding or otherwise damaging the final cover.

b) Monitoring leachate collection system.
Contd ....

c) Monitoring of Ground water and maintaining ground water quality

d) Maintaining and operating the landfill gas collection system to meet the standards.
Monitoring

State Pollution Control Boards to monitor:

a) Collection of samples (water, air, leachate, compost) and their analysis.

b) Inform the District Magistrate or Dy. Commissioner of Municipal Authorities to take steps to implement the rules.

Annual Reports in Form – II
To District Magistrate or Dy. Commissioner.
Who must do what?

- Different levels
- Central Level – CPCB
- State Level – SPCB
- State Govt.
- District Level
- Municipal Level - Corporation. Palika, Nigam, Council or any Local body.
Responsibility of Municipal level

- Infrastructure development – Segregation, storage, Collection, Transportation, Processing & Disposal
- Apply for Authorisation for setting up – processing and disposal facility
- Notify waste collection and segregation schedule to generators - to comply
- Organise awareness programmes – segregate, reuse and recycle
- Submit annual reports.
- Concerned persons could be fined.
- Generate funds for future landfills
Data for Landfill & Closure design

- Subsoil investigation
- Hydro-geological investigation
- Topography
- Climatic conditions
- Geological & Seismic
Design Issues for Landfill

- Liner system at Base and sides
- Leachate collection & treatment facility
- Gas collection & treatment facility
- Final Closure system
- Surface water drainage system
- Environmental monitoring system
- Post Closure maintenance & monitoring
Design issues for Closure

- Total impermeability from top
- Gas outlets
- Permanent stability of waste heap
- Large settlement for landfill base
Availability of land types for landfills

- Flat plain land
- Sloping land (Hilly area)
- Abandoned quarry
- Landfill on top of existing waste
Flat plain land

- Most common type
- Economical
- Easy to construct
- Constructed partly above and partly below ground level
  - Ground water table
  - Leachate removal system
  - Soil testing - modification required
Sloping land (Hilly area)

- Contours
- Steep slopes
  - Stability of soil
  - Use of geosynthetic material
  - Stability of geosynthetic layers
- Strom water gutters
- Cut and fill volumes of soil to be optimized
Abandoned quarry

- Easy acquisition
- Blasting - cracks and crevices
- Hydrogeology of the area
- Sealing of cracks & crevices
- Uneven surface - chiseling/control blasting
- Leachate collection system, pumping
- Adaptation of geosynthetic material in the given situation
Landfill on top of existing waste

- Last option
- Closure system may be required
  - Stable waste slopes
  - Leveling of dumped waste
  - Unhygienic working conditions
  - Problems – fire, smoke, odour, litter & leachate
- Costly and time consuming
Landfill on top of existing waste (cont'd)

- Settlement of waste
- Leachate collection system
- Release of gas
Landfill facilities

- Site to last for 20-25 yrs
- Access roads
- Equipment shelters
- Weigh Bridge
- Administrative Office
- Location for waste inspection facility
- Temporary storage sites
Landfill facilities (contd)

- Area for stockpiling cover material
- Surface water drainage system
- Leachate management
- Gas management
- Environmental monitoring facilities
- Fencing and green belt
- Fire Protection
# Liner Materials

## Table: Typical Liner Materials

<table>
<thead>
<tr>
<th>Liner Type</th>
<th>Primary Barrier</th>
<th>Secondary Barrier</th>
<th>Tertiary Barrier</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single Liner System</td>
<td>Clay, BES or Hydraulic Asphalt</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Composite Liner System</td>
<td>FML</td>
<td>Clay, BES, GCL</td>
<td>N/A</td>
</tr>
<tr>
<td>Double Liner System</td>
<td>Clay, BES, GCL or FML</td>
<td>Clay, BES, GCL, FML</td>
<td>N/A</td>
</tr>
<tr>
<td>Multiple Liner System</td>
<td>FML</td>
<td>Clay, BES or GCL or FML</td>
<td>Clay, BES, GCL</td>
</tr>
</tbody>
</table>

*BES – Bentonite Enhanced Soil  GCL – Geosynthetic Clay Liner  FML – Flexible Membrane Liner*
Liner Systems

The selection of a liner is determined on a site specific basis in order to:

a) To control seepage of leachate from landfill into the environment

b) To assist in controlling the migration of landfill gas in the soil.

c) To retain consistent performance in its operating environment through the expected design life.

d) To assist in the control of any groundwater ingress into the landfill
Geomembrane Liners
(Characteristics)

- HDPE/LLDPE
- Smooth/Textured
- Various thickness – 0.5mm to 2.5mm
- Chemically resistant
- High tensile strength
- Low permeability – \((1 \times 10^{-12} \text{ cm/s})\)
- Resistant to stress cracks
- Flexible – elongation (15%)
- U.V. Radiation resistant
- Long Life – 40 – 50 years
  (warranty of 20 years)
# Seepage Rates

## TYPICAL COMPARATIVE SEEPA GE RATES

<table>
<thead>
<tr>
<th>Material</th>
<th>Thickness (m)</th>
<th>Conductivity (m/s)</th>
<th>Defects</th>
<th>Seepage (L/ha/d)</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clay</td>
<td>1</td>
<td>$1 \times 10^{-9}$</td>
<td>None</td>
<td>1720</td>
<td>Darcy</td>
</tr>
<tr>
<td>Clay</td>
<td>1</td>
<td>$1 \times 10^{-8}$</td>
<td>None</td>
<td>17200</td>
<td>Darcy</td>
</tr>
<tr>
<td>Clay</td>
<td>1</td>
<td>$1 \times 10^{-9}$</td>
<td>1% area at $1 \times 10^{-6}$</td>
<td>17200</td>
<td>Darcy</td>
</tr>
<tr>
<td>HDPE</td>
<td>0.001</td>
<td></td>
<td>None</td>
<td>3</td>
<td>Gross et al 1990</td>
</tr>
<tr>
<td>HDPE</td>
<td>0.001</td>
<td></td>
<td>5x3 mm holes/ha</td>
<td>3000</td>
<td>Gross et al 1990</td>
</tr>
<tr>
<td>HDPE over Mineral</td>
<td>0.001</td>
<td>$1 \times 10^{-10}$</td>
<td>5x3 mm holes/ha</td>
<td>1</td>
<td>Gross et al 1990</td>
</tr>
<tr>
<td>HDPE over Mineral</td>
<td>0.001</td>
<td>$1 \times 10^{-8}$</td>
<td>5x3 mm holes/ha</td>
<td>30</td>
<td>Gross et al 1990</td>
</tr>
</tbody>
</table>

**Rates obtained by measurement**

<table>
<thead>
<tr>
<th>Material</th>
<th>Rate</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>HDPE/Mineral</td>
<td>CQA, 50% probability level</td>
<td>Aiken &amp; Roberts, 1994</td>
</tr>
<tr>
<td>HDPE/Mineral</td>
<td>No. CQA 50% probability level</td>
<td>Aiken &amp; Roberts, 1994</td>
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Geomembrane Installation

a) Inspection of subgrade surfaces
b) Anchor trench
c) Liner Deployment
d) Seaming
- Double Hot wedge
- Fillet Extrusion
- Seam properties – ASTM D6392
e) Pipe Penetration and Attachments
Field Quality Assurance Program (through CQA personnel)

- Trial Seam – Twice Daily
- Destructive Seam Test – per 150 M – GRI GM14
- Non-Destructive Seam Test – All seams
  - Vacuum Box – ASTM D 5641
  - Air Pressure Test – ASTM D 5820
Operating a Landfill
Phase-wise construction of landfill

Figure 6.2 Phasing

A: Phasing plan

Most sensitive visual & noise receptors

Direction of working - ideally, away from sensitive receptors and towards site entrance

Site entrance

Haul road

B: Phase 2 in operation

In preparation

Under restoration

Possible location of borrow pit/stockpile area

C: Phase 4 in operation

Under restoration

In preparation

Restored

D: Phase 6 in operation

Under restoration

Restored

In preparation

In operation
Daily cell, cover, lift & phase of a landfill
Operational Points

- Provisions of required liner systems, leachate collection system, gas vents and capping system
- Identification, record-keeping and reporting of quantities and types of wastes received.
- Waste compaction & Daily cover
Operational Points (contd)

- Check for compatibilities of different wastes.
- Divide landfill into cells. Non-compatible wastes placed in different cells.
- Closure of landfill on individual cell completion.
Closure of Landfill

- Maintain Stable slopes
- Prevent infiltration of rain water
- Enhance surface drainage
- Avoid fire, odour, litter, bird and rodent menace
- Proper Gas venting or collection
- Maintain vegetation on top of soil
Post-Closure Care

- Short & Long term Vegetative Growth
- Leachate management
- Surface water management
- Environmental monitoring
  (Landfill gas, Ambient Air, surface water, ground water, leachate)
- Cover rehabilitation and repair work
The Owner/Operator shall prepare detailed financial estimates for Funding Agency:
- Operating annual cost
- Cost of Closure – Self/Third party
- Cost of post closure care for 15 years.
- Trust Fund – for above work whenever required.
- Fixed Initial cost
- Insurance Cover – Human & Environment.
Thanks for being with us

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