Legacy Waste Management and Dumpsite Remediation Through Municipal Sanitary Landfills (SLF)

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***Abstract*—Rapid urbanization in India has resulted in a substantial increase in municipal solid waste (MSW), with a large proportion being disposed of in unscientific open dumpsites. These legacy waste sites generate leachate and landfill gases, including methane and carbon dioxide, posing serious risks to groundwater, air quality, and public health. This study addresses the remediation of legacy waste through biomining and the development of Municipal Sanitary Landfills (SLFs) for the safe disposal of residual waste. The work emphasizes scientific landfill planning through systematic site selection based on environmental impact, social acceptance, land availability, transportation distance, and cost considerations. Detailed site investigation and characterization—covering subsoil conditions, hydrogeology, surface water, topography, environmental parameters, and traffic assessment—are incorporated to support effective landfill design. The biomining process enables segregation of legacy waste into useful by-products such as refuse-derived fuel (RDF), recyclable materials, compost, and construction and demolition waste, while minimizing the volume of inert rejects requiring disposal. The study highlights the role of engineered SLFs in mitigating environmental impacts through controlled waste placement, liner systems, leachate collection, and gas management. Post-closure practices, including capping and long-term monitoring, along with the potential for future re-mining, are also considered to enhance landfill sustainability and lifecycle management..**

***Index Terms*—Municipal Solid Waste (MSW), Legacy Waste, Dumpsite Remediation, Biomining, Sanitary Landfill (SLF)**

I. INTRODUCTION

Rapid urbanization and population growth have significantly increased the generation of municipal solid waste (MSW) in India. A large portion of this waste is disposed of in open dumpsites without scientific treatment or containment systems. These legacy waste dumps pose severe environmental and health hazards due to uncontrolled emissions of leachate and landfill gases.

Leachate generated from decomposing waste infiltrates soil and contaminates groundwater, while landfill gases—primarily methane (CH_4) and carbon dioxide (CO_2)—contribute to air pollution and climate change. Methane, being a potent greenhouse gas, significantly increases the global warming potential of dumpsites. Additionally, unregulated dumping leads to issues such as foul odor, vector breeding, fire hazards, and land degradation.

To address these challenges, scientific waste management practices such as biomining and Municipal Sanitary Landfills (SLFs) are being adopted. Biomining involves excavation, segregation, and processing of legacy waste into reusable fractions, reducing the volume of waste requiring final disposal. The residual inert material is then safely disposed of in engineered SLFs, which are designed with proper liners, leachate collection systems, and gas control mechanisms.

This study focuses on the remediation of legacy dumpsites through biomining and the design and operation of SLFs for sustainable waste management.

A. Environmental Impacts and Its Minimisation

In line with the Solid Waste Management (SWM) Rules, 2016 as documented in Section 4.1, sanitary landfills minimise the harmful impact of solid waste on the environment through the use of the following mechanisms:

- a) reduction of groundwater contamination through leachate collection and treatment;
- b) control of surface water contamination through runoff;
- c) reduction of air contamination due to gases, litter, dust, or bad odour;
- d) Control of other problems due to rodents, pests, fire, bird menace, slope failure, erosion, etc.

B. Essential Components Of Municipal Sanitary Landfills

The term sanitary landfill is used herein to describe a unit operation for final disposal of „Municipal Solid Waste" on land, designed and constructed with the objective of minimising impact to the environment and according to the SWM Rules.

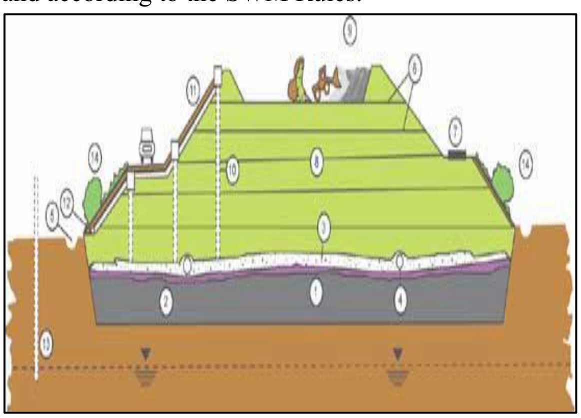

Fig 1: Section of Typical Sanitary Landfill

1. Geological Barrier
2. Impermeable base liner
3. Drainage layer
4. Leachate collection system
5. Storm - water drain ditch
6. Bordering Dam
7. Circulation Road

II. METHODOLOGY

A. Site Selection Criteria

Selection of landfill site is based on:

- Environmental impact
- Social acceptance
- Land availability
- Transportation cost (haul distance)
- Economic feasibility

B. Site Investigation and Characterization

- Detailed investigations carried out include:
- Subsoil investigation (bearing capacity, permeability)
- Hydrogeological study (groundwater level and flow)
- Surface water analysis
- Topographical survey
- Environmental impact assessment
- Traffic and accessibility study

C. Biomining Process

- Biomining of legacy waste involves:
- Excavation of old waste
- Mechanical segregation using trommel screens
- Separation into fractions:
- Fine soil-like material
- Combustible waste (RDF)
- Recyclables (plastic, metal, glass)
- Inert material

D. Sanitary Landfill Design (SLF**)**

The SLF is designed with:

- Bottom liner system (HDPE + clay layer)
- Leachate collection system
- Gas venting system
- Daily and final cover system
- Stormwater drainage

E. Disposal and Capping

- Only 2–3% inert reject is disposed in SLF
- After filling, landfill is capped with ~2 m soil layer
- Long-term monitoring is implemented

III. RESULTS AND DISCUSSION

The remediation of the legacy dumpsite through biomining and subsequent disposal of inert material in a Municipal Sanitary Landfill (SLF) demonstrates a significant improvement in waste management efficiency and environmental safety.

A. Biomining Efficiency and Material Recovery

The biomining process enabled effective segregation of legacy waste into reusable and disposable fractions. A major portion of the excavated waste consisted of fine soil-like material, indicating advanced decomposition of organic matter over time. This fraction can be utilized for land reclamation or as daily cover in landfill operations.

Table 1 Output of Biomining Process

Sr. No.	Material Type	Percentage (%)
1	Compost / Fine Soil	40–50%
2	RDF (Combustible Fraction)	20–25%
3	Recyclables (Plastic/Metal)	10–15%
4	C&D Waste	10–15%
5	Inert Reject (SLF Disposal)	2–3%

B. Environmental Impact Reduction

Prior to remediation, the dumpsite exhibited uncontrolled leachate generation and landfill gas emissions, posing risks to groundwater and air quality. Post-remediation, the removal of legacy waste significantly reduced the source of contamination.

Table 2 Environmental Impact Reduction

Parameter	Before Remediation	After Remediation
Leachate Generation	High	Controlled
Methane Emission	Uncontrolled	Reduced
Land Utilization	Poor	Improved
Groundwater Risk	High	Minimized

C. Performance of Sanitary Landfill (SLF)

The SLF designed for disposal of inert rejects incorporates essential components such as impermeable liners, leachate drainage layers, and gas venting mechanisms. These features collectively prevent contamination of surrounding soil and groundwater.

Table 3 SLF Performance Parameters

Component	Function
Liner System	Prevents leachate seepage
Leachate Collection	Controls liquid waste
Gas Venting System	Releases landfill gas safely
Daily Cover	Reduces odor and pests
Final Cover (2 m soil)	Ensures long-term stability

IV. CONCLUSION

- Open dumping remains a common practice due to its low cost, but it leads to serious environmental and health hazards.
- Biomining is an effective technique for reducing legacy waste volume and recovering valuable materials such as RDF, compost, and recyclables.
- Only a small fraction (2–3%) of inert waste requires disposal in sanitary landfills.
- Scientific site selection and detailed investigation are essential for effective landfill design.
- Engineered SLFs significantly reduce risks associated with leachate and gas emissions through proper containment and management systems.
- Operational challenges such as lack of funds, poor infrastructure, and maintenance issues affect landfill performance.
- Post-closure practices such as capping and long-term monitoring are essential for environmental safety.
- Re-mining of SLFs after 25–30 years can further enhance resource recovery and sustainable land use.

REFERENCES

[1] Municipal Solid Waste Management Manual 2016 (Part I - Overview, II - Manual, III – Compendium) published by Central Public Health and Environmental Engineering Organization (CPHEEO) - Government of India

along with German International cooperation. http://cpheeo.gov.in/upload/uploadfiles/files/Part3.pdf

[2] Plastic Waste Management Rules 2016, [Published in the Gazette of India, Part-II, Section-3, Sub-section (i)] Ministry of Environment, Forest and Climate Change, dated 18th March 2016. https://cpcb.nic.in/displaypdf.php?id=cGxhc3RpY3dhc3RlL1BXTV9HYXpldHRlLnBkZg==

[3] Smart City Mission Statement and Guidelines published by Ministry of Urban Development Government of India on June 2015. https://smartnet.niua.org/ content/2dae72ca-e25b-4575-8302-93e8f93b6bf6

[4] Climate Smart Cities Assessment Framework developed by Ministry of Housing and Urban Affairs, Government of India in the year 2020. https://www.niua.org/csc/assets/ pdf/CSCAF_2_Booklet.pdf.

[5] Central Pollution Control Board (CPCB). "Guidelines for Disposal of Legacy Waste (Dumpsites)", 2019.

[6] Central Pollution Control Board (CPCB). "Manual on Municipal Solid Waste Management", 2016.

[7] Ministry of Environment, Forest and Climate Change (MoEFCC). Solid Waste Management Rules, 2016.

[8] Central Public Health and Environmental Engineering Organisation (CPHEEO). Manual on Municipal Solid Waste Management, 2016.

[9] Bureau of Indian Standards (BIS). IS 1893 (Part 1): Criteria for Earthquake Resistant Design of Structures, 2016 (for landfill stability considerations).

[10] Bureau of Indian Standards (BIS). IS 2720 (Various Parts): Methods of Test for Soils