

# “Development of Economical and Environment Friendly Landfill Liners for Tier II Cities”

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**Abstract-** Rapid industrialization and population explosion in India has led to the migration of people from villages to cities, which generate thousands of tonnes of Municipal Solid Waste (MSW) daily. Municipal solid waste management has become a serious problem because of rapid urbanization and improved economic activities. The insufficient collection and inappropriate disposal of solid wastes represent a source of water, land and air pollution and pose risks to human health and environment. Municipal Solid Waste (MSW) is a complex refuse consisting of various materials with different properties. Leachate resulting from this is a hazardous pollutant to the soil and groundwater underlying. Entering of leachate and heavy metals into the soil leads to the contamination of both soil and groundwater. The fill material, decayed organic soils and soils having continuous contact with sanitary fill environment alter the desired geotechnical properties as well as chemical properties. In an engineered landfill, bottom liner and top cover play an important role in controlling the pollution of groundwater, air and soil. Hence utmost care is required in designing and constructing the liner and cover. But cost of the liner/cover material used for the construction of the liner and covers govern the design philosophy of the liner and cover for waste impoundments, as material required is of very huge quantity. In order to better utilize the locally available materials as landfill liners and covers in countries like India, to make the landfill construction cheaper, a systematic study was needed in the form of geotechnical and geoenvironmental characterization of these locally available soils and other materials. Therefore, the present study is aimed to design eco-friendly and economical single-liner system by replacing some percentages of bentonite clay with with baggase ash or straw fibers to avoid entering of harmful liquids into groundwater. As a part of the present investigation, Karnataka state, in India was chosen and tier II cities are identified across the Karnataka state. In all tier II cities, huballi city is selected for our study. The locally available Halumannu is collected from Unakal village, Hubballi. Specific gravity, Natural moisture content, Consistency limits, Sieve analysis, Hydrometer, Compaction, Consolidation and Unconfined compressive strength tests are conducted on collected soil sample. From the results of the extensive experimental investigations Halumannu is silty soil with low degree of expansion. And the strength of soil is less and it can be increased by adding suitable soil stabilizers like cement, lime.

**Keywords-** Landfill, Liner, Leachate, Anaerobic.

## I. INTRODUCTION

Man is generating and disposing waste materials since the beginning of time. Until recently, disposal of the waste was carried out with little regard for the environment. Due to modern lifestyle the characteristic of the waste becomes less environmentally tolerable. This practice has led to many instances of significant environmental deterioration and health hazards. In this context, in the present study, more emphasis is given to solid waste among the wastes present on the Earth.

Solid waste is all inclusive and it encompasses all types of wastes which are in solid or semi-solid state and are

organic and inorganic in nature. These wastes are generated from human and animal activities and are normally discarded as useless or unwanted material. Hence, solid waste may be defined as waste materials which are in solid or semi-solid state produced by various activities of the society and which have lost.

Solid waste can be broadly classified into Municipal solid waste (MSW). Hazardous or Industrial solid waste and Bio-medical waste. The major portion of solid waste generated in the society is MSW. Municipal solid waste is composed of solid or semi-solid wastes generated by households and wastes of similar nature from shops, markets, offices.

Open areas, industries, hospitals and treatment plant sites, which have no sufficient value to retain. Hazardous or Industrial waste consists of solid wastes which are toxic, ignitable, reactive and/or corrosive in nature.

These wastes are generated in the industrial processes and research centers, whereas bio-medical waste consists of solid wastes generated during the diagnosis, treatment, or immunization of people or animals in healthcare services of the above-mentioned solid wastes, municipal solid waste contributes to about 75% of the total solid waste generated.

Municipal solid waste generation issue is of worldwide concern due to the rapid increase in its quantity and changing characteristics. In the urban context the term municipal solid waste is of special importance due to its impact on the urban environment. Hence the present study emphasises on the management of municipal solid waste.

## II. IMPACT OF MUNICIPAL SOLID WASTE ON THE ENVIRONMENT

Leachate is a liquid waste which is produced from the degradation of the organic portion of the solid waste in combination with percolating rainwater and moisture present within the landfill. During degradation process, 1.0 ton of land filled solid waste produces about 0.2 m of leachate, depending on the type and age of the waste, moisture content in the landfill and seasonal climate. This leachate consists of organic and inorganic constituents, which were absorbed by the water while seeping through the waste layer in the landfill.

If the hydraulic barrier layer of the liner fails to control the seepage of leachate through it, then leachate enters into the underlying groundwater. Posing potentially serious hazards to the public health and environment. For this reason, pollution due to leachate has become a worldwide environmental concern in the recent years. Landfill gas is a mixture of several different gases. Typically it contains 45 to 60% methane and 40 to 60% carbon dioxide by volume.

Landfill gas also contains small amounts of nitrogen, oxygen, ammonia, hydrogen sulphide, carbon monoxide, and no methane organic compounds such as trichloroethylene, benzene and vinyl chloride. Also, methane and carbon dioxide can collect in nearby buildings and displace oxygen in the air and retard purification process of blood in human beings. In addition to this, methane gas has a 21-fold global warming potential as compared to carbon dioxide.

According to the Intergovernmental Panel on Climate Change, methane emissions from the landfills contribute to 18% of the total methane emission into the atmosphere, ranging from 9 to 70 megaton's annually [3: 4]. Short-

term studies carried out on full-size landfills, using the data from landfill, the gas extraction tests indicate a range of landfill gas generation between 0.05 and 0.40 m of landfill gas per kg of waste placed into a landfill. Hence strong liner and cover systems are required to contain the leachate and gas within the landfill, till these are collected for further process.

## III. PROBLEMS ASSOCIATED WITH IMPROPER MANAGEMENT OF MSW

Improper management of municipal solid waste in the open pits without any containment facility (i.e., landfill) leads to groundwater and soil contamination by leachate, surface water contamination through runoff, pollution of air due to landfill gases. It also leads to other problems such as litter, dust, bad odor, rodents, pests, fire hazard and bird menace in the surrounding area. As mentioned earlier the major components produced during the solid waste degradation process.

But it is difficult to understand the production rate, composition and properties of leachate and gases, to design a system to reduce the effects of these on the environment. Leachate is produced when water percolates through the layers of waste material, absorbs water and water-soluble compounds present in the refuse that accumulate as it moves through the landfill.

Thus, leachate may be composed of liquids that originate from a number of sources, including precipitation, groundwater, consolidation, initial moisture storage and reactions associated with decomposition of waste materials. The chemical characteristics of leachate vary as a function of various factors, including the quantity produced, the original nature of the buried waste materials and the various chemical and biochemical reactions that may occur as the waste materials decompose. Due to variety and complexity of wastes that may be land filled, it is difficult to predict all of the chemical reactions and products that may be produced in these reactions.

## IV. METHODOLOGY

- Literature study on various research papers related to landfills, landfill-liner systems and design of landfill liners.
- Marking the grey areas/dots from various research papers.
- Defining problem definition.
- Defining the objectives.
- Case Study.
- Listing tier II cities of Karnataka.
- Collecting population and waste generation rate per day of tier II cities of Karnataka.
- Collecting soil samples used for this study in tier II cities.

- Conducting the experiments on collected soil sample to assess the properties of the soil.
- Analysis of obtained experimental results and classification of soil sample collected based on results.
- Checking suitability of soil for landfill liner design.
- Collection of data required for design of landfill liner system.
- Design of suitable landfill liner system.

## V. CASE STUDIES

Case has been conducted in 3 cities namely Dumping site Ranebennur, Landfill Site CMC koppal, Dumping Site TMC koppal, and its been observed that there is overflow of landfill, Maintenance and operation of vermi compost requires more labors and There is lot of odor due to low maintenance.

Following Merits and Demerits have been found out from the Case studies:

### 1. Merits:

- Keeps city clean.
- Production of vermi compost benefits community economically.
- Vermi compost can be used as manure in agriculture. Proper segregation of solid wastes is done.
- Bailed solid waste is sent to cement factories.
- Manure produced is used for agricultural processes.
- Recyclable materials are separated and recycled.
- The ash obtained after burning of non degradable waste is sent to brick factory.
- Weighbridge is maintained so well that it will help in knowing the weight of waste generated easily.

### 2. Demerits:

- There is lot of odor due to low maintenance.
- Burning may lead to air pollution.
- There are no separators in this site. Manual separation by labors may take more time.
- There are no machines for incineration process.
- Currently no production of manure by composting even though there are composting units.
- Labour availability is low for manure production.
- Open incineration which causes air pollution.

### 3. Experiments to be conducted:

Tests conducted	Test Method
Moisture Content	IS 2720 Part 2 – 1993
Sieve Analysis	IS 2720 Part 4 – 1985
Specific Gravity	IS 2720 Part 3 – 1963
Consistency Limits	IS 2720 Part 6 – 1972
Compaction Test	IS 2720 Part 7 – 1980
Permeability Test	IS 2720 Part 17 -1986
Unconfined Compressive Strength	IS 2720 Part 11–1993

## VI. EXPERIMENTAL RESULTS

Sl.No.	Description	Site
1	Specific Gravity	2.26
2	Moisture Content , %	3.98
3	Grain size distribution	
i	% of gravel , %	16
ii	% of coarse sand , %	2.8
iii	% of medium sand , %	10.4
iv	% of fine sand , %	12
v	% of fines , %	58.8
4	Standard Proctor Test	
i	MDD, (g/cc)	1.5
ii	OMC, %	26
5	Consistency Limits	
i	Liquid Limit , %	50
ii	Plastic Limit , %	38.35
iii	Plasticity Index , %	12.15
iv	Shrinkage Limit , %	17.29
6	Unconfined Compressive Strength, (kPa)	40
7	Hydrometer test	
i	% of clay , %	5.83
ii	% of silt , %	94.07
8	Consolidation Test	
i	Permeability of soil, (cm / sec)	$3.45 \times 10^{-7}$
ii	Permeability of soil with bentonite clay,(cm/sec)	$1.7 \times 10^{-7}$

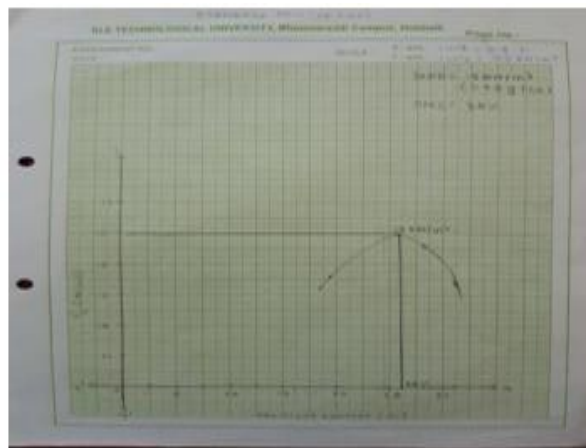


Fig 1. Compaction Test Graph

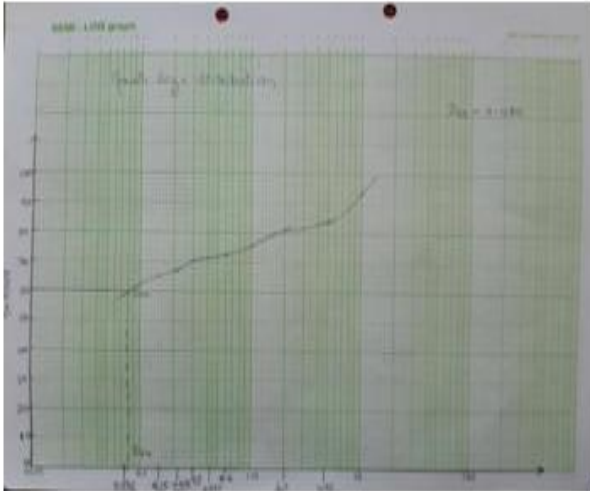


Fig 2. Grain Size Distribution Graph.

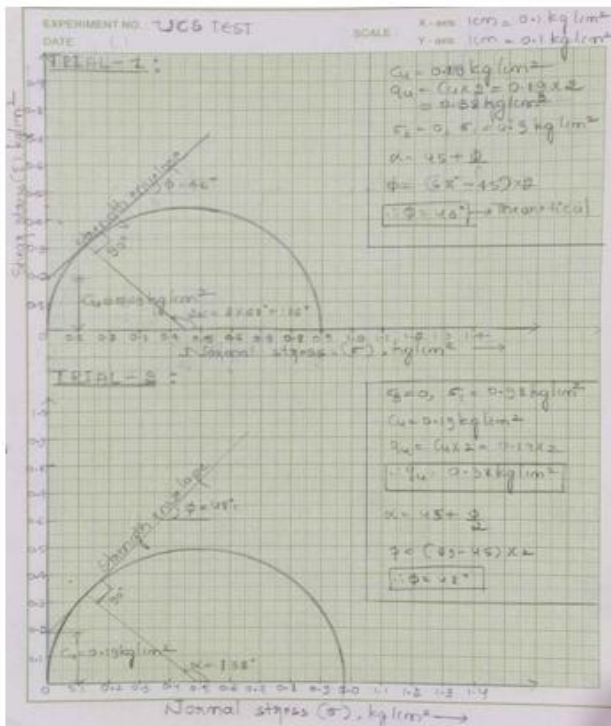


Fig 3. UCS Test Graph.

## VII. CONCLUSION

The case study has been carried out in landfill site of Koppal, dumping sites of Ranebennur and Talikoti. We observed that there is a need of proper cover material. The collected soil sample (Halumannu) from Unkal village, Hubballi is fine grained silty soil. The soil is highly compressible and the degree of expansion is low.

The soil is impermeable. The strength of soil is less and it can be increased by adding suitable soil stabilizers. The soil with 6% of bentonite clay, and straw fibers it becomes impermeable to highly impermeable.

## VIII. ACKNOWLEDGMENT

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## REFERENCES

- [1] "Integrated Solid Waste Management: a Life Cycle Inventory second edition" by Forbes R McDougall, Peter R White, Marina Franke and Peter Hindle. Second edition published by Blackwell Science, 2001
- [2] "Landfill Manuals, Landfill site design" published by Environmental protection agency (EPA), Ireland.
- [3] Annexure 17: Estimation of landfill capacity, landfill height, landfill area. <http://cpheeo.gov.in/upload/uploadfiles/files/annex17.pdf>
- [4] Site selection process for landfills by Prof. Manoj Datta: <https://youtu.be/tRKWIV4iVzI>
- [5] Site selection using Google Earth tool: <https://youtu.be/XUPNY58UL50>
- [6] Contour map using Google Earth tool and QGIS: <https://youtu.be/aJm9lewzooU>