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Short Communication

Cost effective natural liner system for solid waste landfill

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Abstract

Municipal solid waste is rapidly increasing problem right from human civilization. Increasing amount of solid waste is severely affecting human health and surrounding environment. One of the preferred methods to deal with solid waste disposal is sanitary landfill, which is designed to minimize the impact on environment. Major problem is caused to ground water by generation of leachate. Hence, Synthetic liners are used with layers of soil having permeability less than 1 x10^{-7} to prevent the flow of leachate out of landfill. Synthetic liners are costly and cannot be used in rural areas, where financial feasibility can be achieved by locally available clay liner. This study makes an attempt to produce liners with locally available soil samples and using admixture to make low permeable barrier. This study aims on checking geotechnical properties of various locally available soils and use them in layers as liner system in prototype models.

Keywords: Landfill, leachate, liner, permeability, soil.

Introduction

In developed and developing countries like India, the disposal of waste has become one of the serious problems. The proper management is essential to treat and dispose off the waste. Sanitary landfills are effective method designed to treat, dispose off the solid waste. Landfills are consisting of bottom liner system to create barrier between solid waste and environment[6,1]. The most important in designing and maintaining a landfill is leachate management. The leachate contains water and water-soluble compounds in refuse, which accumulates in the landfill[4]. To protect the landfill, low permeable liners are provided to prevent migration of leachate to the surrounding[6].

In rural areas now, the problem of solid waste is increased day by day. The generation of solid waste is disposed off on unscientific landfill site. The greatest threat to ground water is leachate, caused by solid waste.

The leachate management can be done by geo-synthetic liner, which are costlier and leading towards maximum investment. Local authorities cannot afford such option like geo-synthetic protection for landfill liner. Hence it is necessary to provide cost effective alternative to geosynthetic liner system. This can be achieved by using locally available natural material. The main focus is on geotechnical properties of various soil samples which can be used as natural liner with low permeability. This is done to prevent uncontrolled release of leachate into environment.

Literature review: The liners are designed to prevent leakage of leachate from the landfill. This is done using local soils mixes with bentonite to form amended soil liners. Bentonite is mostly used as it is low permeable clay[6-8]. Cost effectiveness can be achieved by locally available soil such as laterite soil and kuttanad clay, in order to reduce hydraulic conductivity[1]. Liners can be prepared by using fly ash and bentonite mixture. If the bentonite mixed 16-20% with fly ash, showed hydraulic conductivity less than 1x10^{-7} [9], which fulfil the criteria for liner. Whereas, clay, 10% bentonite, and 15% tile chips give better result and also reduction in amount of chemicals after passing through liner[4]. Using fly ash 2.5% and lime with varying percentage up to 6% can be used in clay as a liner gives lowest permeability[5]. Waste material such as coal ash (fly ash and pond ash) can be used as liner with bentonite 2% to 20%. After adding 20% of bentonite in fly ash and 12% in pond ash mixture shows permeability less than 1x10^{-7}cm/sec[2]. combination of zeolite and sepiolite can be used as a liner, with 30% sepiolite by weight of zeolite. It can be effectively used in bottom lining system for hazardous, industrial, municipal waste[3]. In turkey, zeolite, perlite, bentonite mixture can be used as a liner for sanitary landfills. Where, natural zeolite showed effective removal for NO_3, NH_4, PO_4, COD and organic matter[10].

Materials and methods

The soil samples used for study are locally available black cotton soil, laterite soil, white soil. The black cotton soil is collected from Kolhapur city and white soil is collected from demolished debris of old house where good quality and adequate quantity of white soil is available. The laterite soil is collected from Kankavali, District Sindhudurg, Maharashtra. The admixtures used for the study are fly ash and lime.

Material properties: Physical properties of clay are determined, such as liquid limit, plastic limit, OMC, permeability.

Table-1: Physical properties of soils.

Property	Black cotton soil	Laterite soil	White soil
Liquid limit (%)	71.62	52.28	48.44
Plastic limit (%)	25	27	33
Optimum moisture content (%)	26	18	24
Maximum dry density (g/cc)	1.4	1.54	1.56
Permeability (cm/sec)	2.07×10^{-6}	3.27×10^{-4}	1.20×10^{-5}

Permeability test on different combination: The permeability test is carried out for multiple soil layer according to IS:2720 (part-17) 1986 using permeability experiment by falling head method.

Table-2: Permeability of soil.

Combination of material	Permeability (cm/sec)
Black cotton soil+ white soil + laterite soil	1×10^{-5}
Fly ash 6% +white soil Laterite soil +black cotton soil	5.05×10^{-6}
(black cotton + fly ash 6%) + (white soil +fly ash 6%) + (laterite soil + fly ash 6%)	1.87×10^{-6}
Black cotton + lime 6%+fly ash 6% Laterite + lime6%+ fly ash 6% White + lime 6% +fly ash 6 %	2.05×10^{-7}

Liner design: In this study, three different prototype models are designed. The liner is placed according to their permeability, from lowest, moderate to highest (LHM)permeability i.e. laterite soil, white soil, black cotton soil, highest, moderate to lowest (HML) permeability, and moderate highest to lowest (MHL) permeability with 6% weight of lime, fly ash added respectively. Soil is collected which passes from 4.75mm sieve. The model is prepared in 1000 litter syntax tank. The leachate collection pipe is provided at the top of liner with maintaining slope as leachate collection pipe and to check the generation of leachate. At the bottom of the liner, another PVC pipeis provided to check seepage of leachate from the liner. Solid waste collected from Zoom dumping site, a garbage dumping area in Kolhapur, which is filled in prototype model above the liner. Each prototype consisting of approx. 500kg solid waste and thickness of the liner consisting of 3cm each.

Results and discussion

To create a practical situation water is sprinkled over the waste every day and seepage is checked, following results were obtained from the same. First 10 lit of water are sprinkled every day for 10 days no seepage was observed in all three models. For 20 lit of water seepage is observed after 5 days in HML & MLH were as in LMH seepage is observed after 7 day. For 30 lit of water in HML and MLH seepage is observed after 3 days were as in LMH it is observed after 4 days. For saturation condition after 3 hours seepage is seen in all 3 models. The seepage test is carried out after closing leachate collection pipe placed above liner system.

Figure-1: Prototypemodels for the liners.

Table-3: Comparison of three models.

	Seepage observed		
capacity of water /day	Lowest to highest permeability	Highest to lowest permeability	Moderate lowest to highest
10 litres	--	--	--
20 litres	Very low	Moderate	Moderate
	7^{th}day	5^{th}day	5^{th} day
30 litres	Very low	Moderate	Moderate
	4^{th}day	3^{rd}day	3^{rd} day
Saturation stage	After 3 hours	After 3 hours	After 3 hours

Table-4: Analysis of pre-post leachate.

Tests	Pre analysis	Post analysis
pH	5.49	6.63
TS (mg/l)	13480	7560
TDS (mg/l)	11600	7440
TSS (mg/l)	1880	120
COD (mg/l)	10400	8400
BOD (mg/l)	700	180

Conclusion

In this study cost effective liners are designed to protect surrounding environment from leachate pollution from landfill site. Landfill site consists of leachate collection pipe to collect the leachate from the waste. If leachate collection system malfunctions the leachate may seep through the soil. These cost-effective liners can be used for rural areas where construction of landfill site is not possible, in that case these liners can sustain the leachate up to desired level as well as if leachate seep from the liner then parameters of leachate decreases at some extent minimizing the impact of ground water pollution.

Figure-2: Sealing material above the waste.

Figure-3: Pre post analysis of leachate.

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