Study of Various Properties of Soil under Influence of Pharmaceutical Waste

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Abstract— While the industrial growth in the last 30 years has grown, hence consequent Toxic Releases have grown. The central Ministry of Environment and Forests (MOEF) has estimated a conservative figure of 5 million tons of hazardous waste generation every year in India. Million liters of organic/inorganic waste generated by no of pharmaceutical companies. They disposed their hazardous waste into the environment directly or indirectly which causes serious environment problems thus it is required to establish a hazardous waste landfill to dispose waste on land. The main aim of this study is to compare a physico-chemical behavior and geotechnical characteristics of soil (SM) influenced by pharmaceutical waste with and without landfill. the soil to waste ratio is 5:1 another pan of soil is taken with the same soil waste ratio then compare properties such as specific gravity, permeability ,atterberg's limit ,OMC ,MDD ,shear strength and also chemical testing such as PH has been conducted on 30,60 days period of virgin soil, soil in contaminated pan and soil in contaminated landfill.

Key words: Hazardous landfill, MSW landfill

I. INTRODUCTION

While the industrial growth in the last 30 years has grown, hence consequent Toxic Releases have grown. The central Ministry of Environment and Forests (MOEF) has estimated a conservative figure of 5 million tons of hazardous waste generation every year in India. Major waste generators in India are petrochemical, pharmaceutical, pesticide, paint and dye, petroleum, fertilizer, asbestos, caustic soda, inorganic chemicals and general engineering industries the pharmaceutical drugs manufacturing industries generating different waste product, which are unfavorable to environment. The use of pharmaceutical drugs for various therapeutic needs resulted in detection of pharmaceutical chemicals in the environment. The emitting product from pharmaceutical industries is toxic, such as cyanide, flammable. To keep the Environment ecology unaffected the generated waste should be treated before disposal to the environment and the rate of generation of waste should be minimized. This waste has to be disposed of by suitable disposal methods such as incineration, deep well injection, landfill, surface impoundments, composting, and shallow/deep burial in soil and rock. Engineering landfill has carefully designed and constructed envelope that encapsulates waste and that prevents escape of leachate into environment(NPTEL).

Basically two types of landfill

- MSW landfill
- Hazardous landfill

II. OBJECTIVE OF STUDY

The main objective is to study the effect of the chosen pharmaceutical waste on the index properties and geotechnical characteristic and chemical test (PH). To compare physical properties and geotechnical characteristics of virgin soil, contaminated soil in landfill liners and soil in contaminated pan exposed to weather (ETW).

III. METHODOLOGY

To attain the study objectives, the following steps were Followed:

- Characterizing pharmaceutical waste.
- Assessing various properties of contaminated soils.

Landfill model of 30cm×30cm×30cm has been fabricated with 10mm thick acrylic sheet. The well-graded Silty sand collected from campus of L.D.COLLEGE OF ENGINEERING is filled into model. Initially soil is poured in the model upto 23 cm depth then 1.7mm thick GCL (geosynthetic clay liner) liner placed on soil then above this (GCL) place 7 cm thick layer of gravel and on the top (above gravel layer) geotextile material of 1.4mm thick is placed. The pharmaceutical waste collected from common effluent treatment plant (CETP) located at Ankleshwar Dist: Surat. It should dump from the top (double liner system). For this soil to waste ratio is kept as 5:1. Another pan of virgin soil mixed with pharmaceutical waste with the same soil to waste ratio has prepared without landfill liners. Various tests are conducted on soil to measure different properties as per IS 2720:1991 such as specific gravity, permeability , atterberg's limit ,OMC & MDD , shear strength and also chemical testing such as PH. Comparison of these properties were done after 30,60 days of contamination period with virgin soil.

Fig. 1: Model of landfill

IV. RESULTS AND ANALYSIS

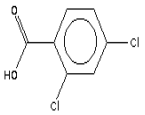
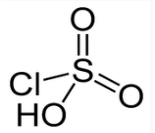
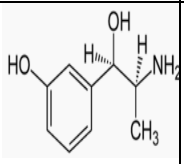
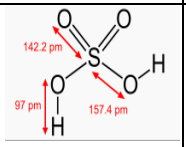
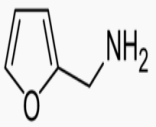
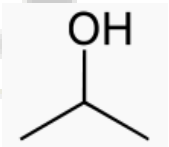
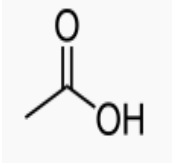
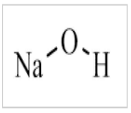
Name of compound	Chemical structure	Chemical formula	solubility
2,4 dicholorobenzoic acid		$C_7H_4Cl_2O_2$	In soluble in water
Cholorosulphonic acid		HSO_3Cl	Soluble in water,cholorabons
Metaramine		$C_9H_{13}NO_2$	Insoluble in water
Sulphuric acid		H_2SO_4	Soluble in water
Asfurfurylamine		C_5H_7NO	Soluble in water
Isopropyl achocal		C_3H_8O	Soluble in benzene, choloroform, ethanol,ether, glycrine Insoluble in salt
Acetic acid		$C_2H_4O_2$	In soluable in water
Sodium hydroxide		NaOH	Soluable in glycirel,water Insoluable in ether

Table 1: Waste characterization

A. *Properties of Geosynthetic Clay Liner:*

Properties of geosynthetic clay liner was found by CETCO, MUMBAI and supplied with product.

GCL	Property Test Method	Test Frequency	Required Values
Bentonite Mass/Area^2	ASTM D 5993	6,000 m^2	4.8 kg/m^2 min. @ 12% 4.29 kg/m^2 min. @ 0%
GCL Tensile strength	ASTM D 6768	6,000 m^2	10 KN/m MARV
GCL Peel Strength	ASTM D 6496	6,000 m^2	6.5 N/cm min
CBR Puncture strength	EN ISO 12236	25,000 m^2	1.6 KN min.
GCL Index Flux	ASTM D 5887	Weekly	1x10-8 m^3/m^2/sec max
GCL Hydraulic Conductivity	ASTM D 5887	Weekly	5x10-9 cm/sec max.

Table 2: Properties of geosynthetic clay liner

B. *Properties of Geotextile:*

A property of geotextile is given RETECH Geosynthetics Ahmadabad.

Property	Test method	unit	values
Mass/Area^2	ASTM D-5261	g/m^2	150
Thickness	ASTM D-5199	mm	1.3
Grab tensile strength	ASTM D-4632	N	540
Elongation @ break	ASTM D-4632	%	60
Trapezoid tear strength	ASTM D-4632	N	230
Puncture strength	ASTM D-4833	N	315
Permittivity	ASTM D-4491	Sec^{-1}	2.4
Apparent opening size	ASTM D-4751	µm	180
Ultraviolet resistance	ASTM D-4355	%@500hrs	70%
Roll length		m	100
Roll width		m	5
Roll weight		kg	75

Table 3: Properties of Geotextile

C. *Properties of Virgin Soil:*

Properties	Values
Grain size distribution	Gravel-0% Sand-77% Silt+clay-23%
Specific gravity	2.611
Liquid limit (%)	18
Plastic limit	Non plastic soil
OMC (%)	12
MDD (kN/m^3)	18.81
Permeability (cm/sec)	1.16×10^{-4}
Field density (kg/m^3)	1595
Field unit weight (kN/m^3)	1.595
Cohesion(kN/m^2)	0.57

Angle of internal friction	35.9º
PH	7.24

Table 4: properties of virgin soil

D. Properties of Contaminated Soil:

1) Grain Size Distribution:

Grain size distribution performed by sieve analysis method as per IS 2720:1991_4. The result of test conducted on virgin soil, soil in contaminated landfill and soil in contaminated pan exposed to weather (ETW) shown in table. After 30 and 60 days of contamination. Results shows that there is no change in grain size of contaminated soil after 30 and 60 days of contamination.

	Virgin soil	**Landfill**	**Pan(ETW)**
Gravel(%)	0	0	0
Sand(%)	77	77	77
Silt+clay(%)	23	23	23

Table 5: Grain size distribution test after 30 days

	Virgin soil	**Landfill**	**Pan(ETW)**
Gravel(%)	0	0	0
Sand(%)	77	77	77
Silt+clay(%)	23	23	23

Table 6: Grain size distribution test after 60 days

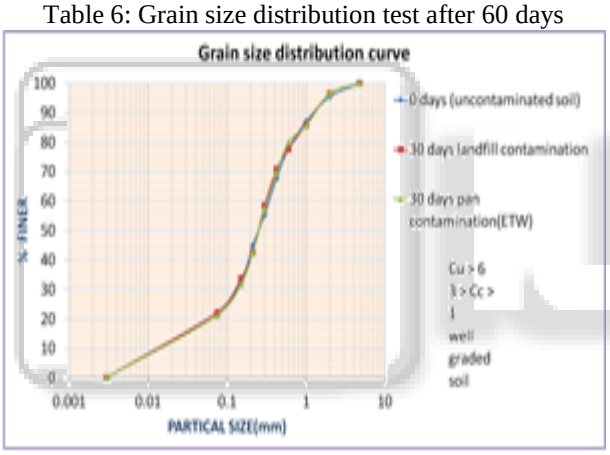


Fig. 2: Grain size distribution test after 30 days

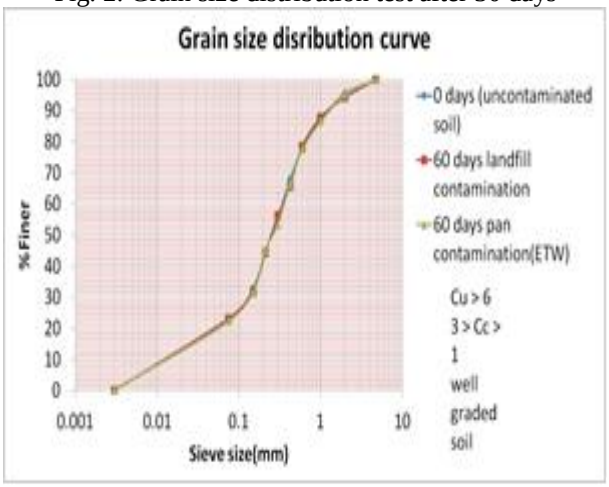


Fig. 3: Grain size distribution test after 60 days

2) Specific Gravity (Is 2720_ 3):

Specific gravity of soil can determine by density bottle fitted with stopper having hole. The bottle is of 50 ml is taken and conduct test as per IS 2720_3. The results of specific gravity are presented in table below.

Specific gravity	0 days	30 days	60 days
Landfill contamination	2.611	2.41	2.383
Pan contamination	2.611	2.54	2.421

Table 7: specific gravity

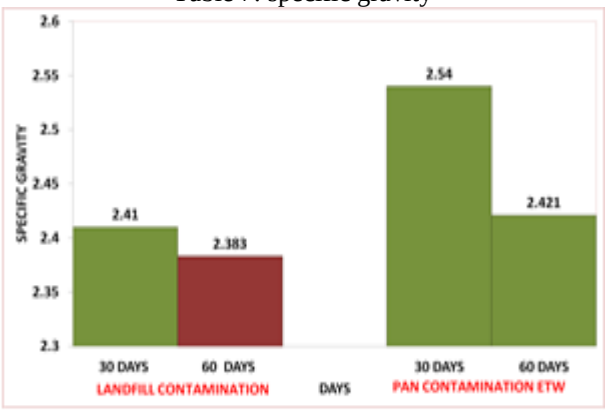


Fig. 4: specific gravity

3) Atterberg's Limits:

a) Liquid Limit By Conepenetrometer (IS 2720_5):

Liquid limit of soil performed by cone penetration test as per IS 2720_5.liquid limit test was conducted on virgin soil, soil contaminated in landfill and soil contaminated in pan exposed to weather (ETW) at the interval of 30 and 60 days of contamination. The result of test conducted on soil after 30 and 60 days shown in table

Liquid Limit(%)	0 days	30 days	60 days
Landfill contamination (%)	18%	16.4%	14.7%
Pan contamination (ETW) (%)	18%	15.7%	15.2%

Table 8: Liquid limit

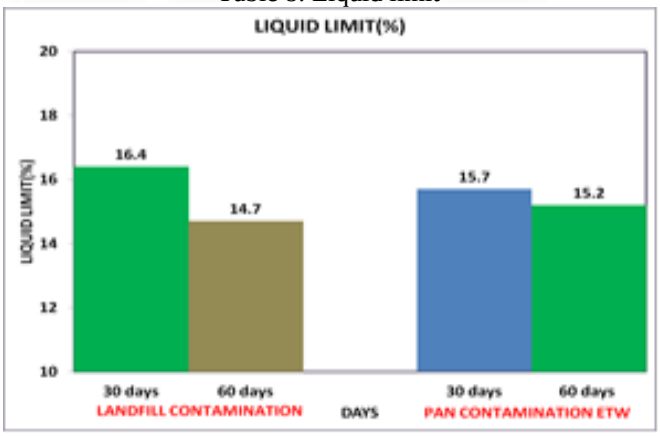


Fig. 5: Liquid limit

b) Plastic Limit (Is 2720_5):

The soil used for landfill contamination, contamination of pan exposed to weather and virgin soil is non-plastic soil. The soil remains non-plastic after 30, 60 and 90 days of contamination.

4) Compaction Test (Is 2720_7):

Standard proctor test was carried out as per IS 2720_7 on soil sample collected from contaminated landfill, contaminated pan exposed to weather and virgin soil at the interval of 30,60 and 90 days of contamination. The plot of

optimum moisture content vs. maximum dry density has drawn for time interval of 30 and 60 days. The result carried out optimum moisture content and maximum dry density shown in table at the interval of 30 days and 60 days of time.

	0 days		**30 days**		**60 days**	
Compaction characteristics	OMC (%)	MDD (kN/m^3)	OMC (%)	MDD (kN/m^3)	OMC (%)	MDD (kN/m^3)
Landfill contamination	12	1.92	13.2	1.71	18	1.66
Pan contamination exposed to weather(ETW)	12	1.92	18	1.8	17.6	1.71

Table 9: Compaction characteristics

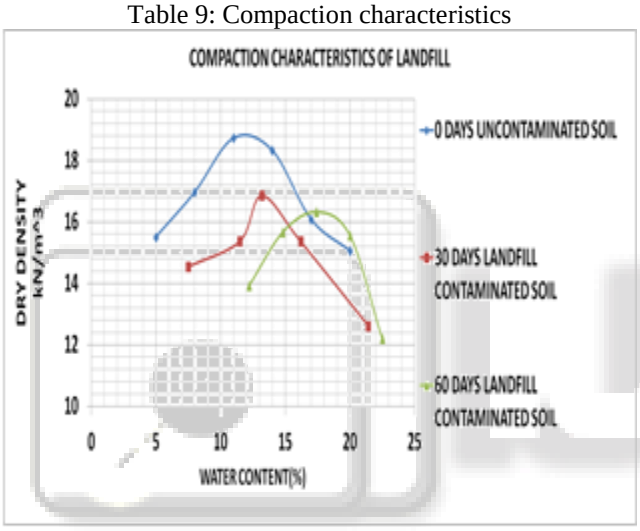


Fig. 6: compaction characteristics of landfill

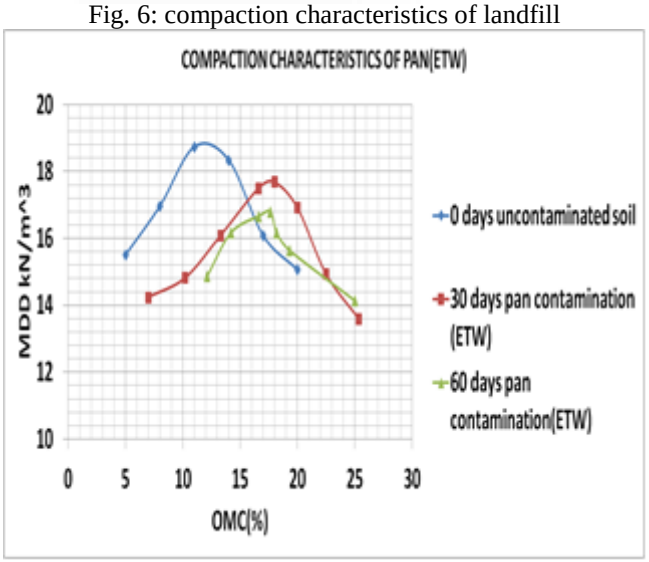


Fig. 7: compaction characteristics of pan contamination (ETW)

5) PERMEABILITY (IS 2720_17):

Permeability test was conduct on soil as per IS 2720_17.Constant head permeability test was carried out on soil samples at the interval of 30 and 60 days. The test results gives co-efficient of permeability for virgin soil, soil in contaminated landfill and soil in pan contamination exposed to weather at the time interval of 30days and 60 days shown in table.

Co-efficient of Permeability	0 days(cm/sec)	30 days(cm/sec)	60 days(cm/sec)
Landfill contamination	1.16×10^{-4}	0.86×10^{-4}	0.71×10^{-4}
Pan contamination exposed to weather(ETW)	1.16×10^{-4}	0.51×10^{-4}	0.60×10^{-4}

Table 10: Co-efficient of permeability

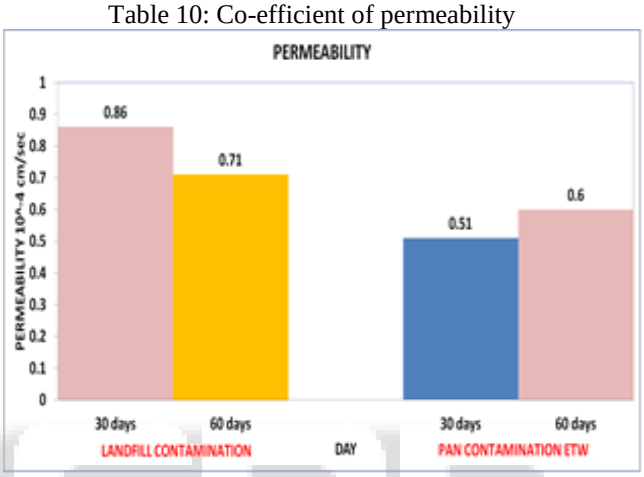


Fig. 8: Permeability

6) Geotechnical Characteristics of Soil:

a) Box Shear Test:

Box shear test was carried out on virgin soil, soil in contaminated landfill and soil in contaminated pan exposed to weather at the interval of 30 and 60 days of time interval as per IS 2720 box shear test was carried out on oven dried sample at the OMC and MDD of 30 and 60 days .the results of box shear test (cohesion and angle of internal friction after 30 days, 60 days and 90 days given in table.

	30 days		60 days	
	COHESION (kN/m^2)	ANGLE OF INTERNAL FRICTION	COHESION (kN/m^2)	ANGLE OF INTERNAL FRICTION
Uncontaminated soil (0 days)	0.57	35.91º	0.57	35.91º
Landfill contamination	0.874	33.19º	0.908	26.84º
Pan contamination exposed to weather(ETW)	0.934	32.24º	1.125	25º

Table 11: Box shear test

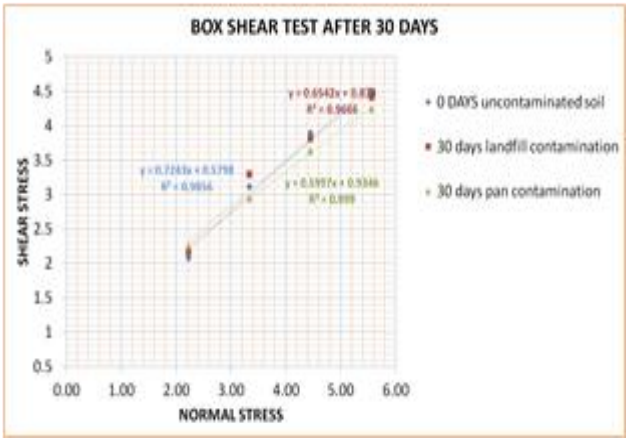


Fig. 9: Box shear test after 30 days

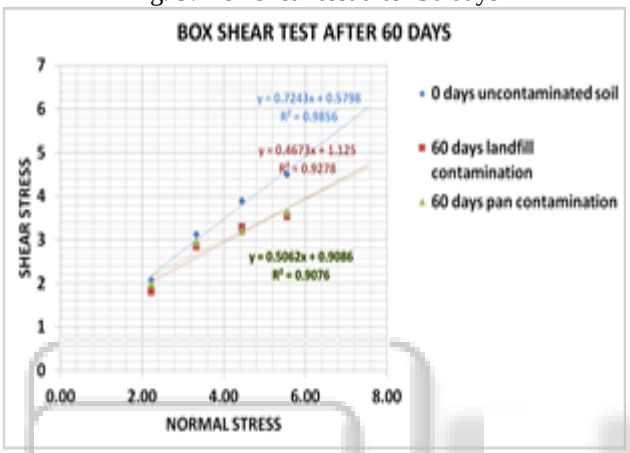


Fig. 10: Box shear test after 60 days

7) Chemical Test:

a) PH Test:

PH is defined as the negative logarithm (base 10) of the activity of hydronium ions in a solution. PH below 7 is acidic and PH of above 7 is alkaline and 7 PH is natural. Soil does not show better behavior within a pH range that is strongly acid to mildly alkaline. Acidic soil and basic soil consists of soluble salts and other materials removed by effluent on the geotechnical properties of soil(TRIPATHI). It is also found that soil parameters are tremendously changes and the output of Specific Gravity, Liquid Limit ,Content of soil sample badly affected.

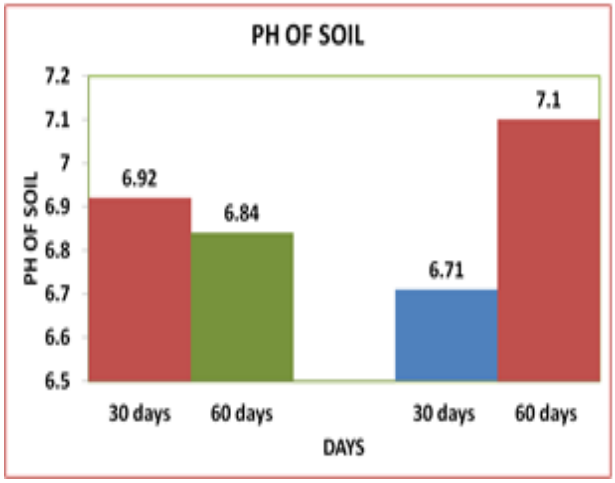


Fig. 11: PH of soil

V. CONCLUSIONS

- In case of particle size there is no change in particle size after contamination (landfill, pan) of 30 and 60 days.
- Liquid limit of contaminated soil is lower than the virgin soil after 30 and 60 days.
- Liquid limit of soil contaminated in landfill is higher than soil contaminated in pan after 30 days but liquid limit of soil contaminated in landfill is lower than soil contaminated in pan after 60 days.
- Soil remains non plastic after 30 and 60 days of contamination.
- OMC increases and MDD decrease after 30 and 60 days of contamination as compare to virgin soil.
- OMC increases and MDD decreases in case of soil in contaminated landfill and OMC decreases and MDD increases of soil in contaminated pan (ETW) after 60 days as compared to 30 days of contamination.
- Specific gravity of contaminated soil decreases with time with compare to virgin soil.
- Specific gravity of soil in landfill is less than the soil in pan after 30 and 60 days of contamination.
- Co-efficient of permeability reduced after 30 days and 60 days of contamination is noted.
- The contaminated soil in pan has less co-efficient of permeability than contaminated soil in landfill after 30 and 60 days.
- As the OMC increases and MDD decreases angle of internal friction decreases and cohesion increases with time.
- After 30 and 60 days, Soil in contaminated landfill has less angle of internal friction and more cohesion as compared to soil in contaminated pan.
- PH of soil reduces and it changes from alkaline to acidic by the period of 30 days.
- However, after 60 days of contamination PH of soil increases in case of soil in contaminated pan as compared to soil in contaminated landfill.

REFERENCES

[1] Bagchi, A. "Design of Landfills and Integrated Solid waste management." (2004) John Wiley and Sons Incorporation, USA.
[2] H.S.Nandan, Shiveraju R, C. Ramakrishnegowda "Impact Of Municipal Solid Waste Disposal On Geotechnical Properties Of Soil" Proceedings of Indian Geotechnical Conference December 15-17,2011, Kochi (Paper NoL-183).
[3] IS 2720(Part 4)-1985 "Grain size Analysis".
[4] IS 2720(Part 5)-1985 "Determination of liquid and plastic Limit.
[5] IS 2720(Part 7)-1980 "Determination Of Water Content-Dry Density Relation Using Light Compaction"
[6] IS 2720(Part 13)-1986 "Direct Shear Test".
[7] IS 2720(Part17)-1986 "Laboratotary Determination Of Permeability".
[8] IS 2720(Part 29)-1975 "Determination Of Dry Density Of
[9] Soils In-Place By The Core-Cutter Method".

[10] Janice L. Rubll and David E. Daniet "Geosynthetic Clay Liners Permeated With Chemical Solutions And Leachates" Journal of Geotechnical and Geoenvironmental Engineering, Vol. 123, No. 4, April, 1997. ©ASCE, ISSN 1090-0241/97/0004-0369-0381 Paper No. 12599.
[11] Musa Alhassan "Effect Of Municipal Solid Waste On Geotechnical Properties Of Soils" International Journal of Environmental Science, Management and Engineering Research Vol. 1 (5), pp. 204 - 210, Sept. - Oct., 2012.
[12] National Guidelines for Hazardous Waste Management.
[13] "NPTEL Lecture On Geoenvironmental".
[14] Snjaykumar shukla. "Fundamental of geosynthetics".
[15] Sruti Pillai, Anju Eizbath Peter, Sunil B.M., and Shrihari S. "Soil Pollution near a Municipal Solid Waste Disposal Site in India" International Conference on Biological, Civil and Environmental Engineering (BCEE-2014) March 17-18, 2014 Dubai (UAE).
[16] Thesis on "Aerobic Biological Treatment Potential Of Effluents From Two Kolkata-Based Bulk Drug Industries".
[17] Tripathi A, Misra D. R "A Study Of Physico-Chemical Properties And Heavy Metals In Contaminated Soils Of Municipal Waste Dumpsites At Allahabad, India" International Journal Of Environmental Sciences Volume 2, No 4, 2012 ISSN 0976 – 4402.
[18] "USEPA. (1988). Final Cover on Hazardous Waste Landfills and Surface Impoundments." US EPA Guide to Technical Resources for the Design of Land Disposal Facilities" EPA/530-SW 88-047.
[19] Vijayarangam Murugaiyan, Raman Saravanane "Influence of Pharmaceutical Effluent on the Physico – Chemical Behavior and Geotechnical Characteristics of Clayey and Silty Soils" International Journal of Soil, Sediment and Water: Vol. 2: Iss. 3, Article 4.

