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A Feasibility Study on Siting Municipal Landfill in Ado-Ekiti, Nigeria

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ABSTRACT: The influence of landfill-emplaced soil operated by the Ekiti State Government (Ilokun and Erinfun Dumpsite) as a natural attenuation of contaminants from landfill leachate was investigated, and soil samples were collected from each of the dumpsites and also from a proposed site. Geotechnical and hydraulic conductivity tests were conducted. The results show that, the soil used at the operating dumpsite is classified as sandy soil with a high permeability rate. This will enable large percolation and egress of the waste leachate into the immediate environment while the result from the proposed site is an improvement over the others by reducing the rate of permeability of leachate to Ilokun and Erinfun dumpsite by 16-fold and 9-fold respectively.

KEYWORDS: Dumpsite, Hydraulic Conductivity, Landfill, Leachate, Solid Waste.

I. INTRODUCTION

Despite any government efforts to decrease the amount of waste produced by people, the general human drive to buy new goods and discard old ones means that the dumping of solid waste in landfills or dumpsites will probably always remain. Leachate is generally produced when water percolates through partially saturated waste and removes contaminating solutes into the liquid phase through physical, chemical, and microbiological processes [1]. When not properly contained, leachate could migrate to the immediate soil subsurface including the aquifer [2-4]. Controlling the leachate produced within the refuse fills is the fundamental issue when disposing of waste in landfills or "refuse dumping." According to investigation reports, waste that is disposed of on the ground should be properly confined in a landfill to protect the earth's natural water resources from the pollution that the waste leachate might bring about. The general belief that any soil will provide natural attenuation for any contaminant produced by waste dumping had been disproved by several cases of groundwater pollution [5]. Indiscriminate disposal had been resolved by the creation of regulated landfill sites in advanced countries of the world. But, indiscriminate siting of dumpsites in Nigeria is still prevalent as the cost of constructing an engineered landfill is very high and not affordable by the government of the day. Thus, a sustainable way of containing the danger posed by open dumpsites to groundwater contamination is the use of natural soil liners with low permeability.

II. MATERIALS AND METHODS

A. Study site

The study was conducted in Ado-Ekiti Local Government Area of Ekiti State Nigeria. A site investigation was conducted on the soils used for the two operated dumpsites in Ado-Ekiti (Ilokun Dumpsite and Erinfun Dumpsite) and a proposed clay site also at Ilokun Ado-Ekiti. Erinfun is located along the Polytechnic Road, Ado-Ekiti with a geographical coordinate of 7036’34’’ North, 5016’34’’ West while Ilokun is located along the Ekiti State University Road, with a geographical coordinate of 7o41’18’’ North, 5o15’21’’ East, about (9.11Km) from Ado-Ekiti Metropolis.

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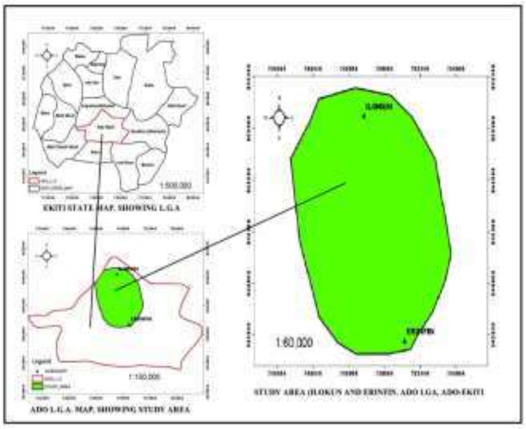

Figure 1: Map showing the study area

B. Sampling procedure

Two soil samples were taken randomly from each of the study sites to enable experimental testing of the characteristics of the soils in the laboratory. The samples were hand-dug and put in protective containers to prevent evaporation and disturbance. The samples were carefully transported to the laboratory immediately; for experimental tests to be conducted on them. Grain size analysis, Atterberg limits analysis, and hydraulic conductivity analysis were conducted.

C. Grain size analysis

Analysis of soil particles or grains distribution, soil particles grouping into sizes, and relative proportion by mass were carried out using this test. The result is grouped following the America Association of State Highway and Transportation Officials [6].

D. Atterberg limit tests

These tests were carried out following the American Society of the International Association for Testing and Materials method [7]. This set of tests includes; Liquid Limit (LL), Plastic Limit (PL), and Shrinkage Limit tests. Plasticity Index is derived from the limits by subtracting Plastic Limit from Liquid Limit (i.e. PI – LL-PL). The tests are always conducted on the soil samples for analysis of the sample's natural reactions with water. They are also used for the classification of soils.

E. Hydraulic Conductivity Analysis (Falling Head Method)

To determine the permeability (K value) of fine-grained soil, the falling head test with a permeameter is mainly used in the laboratory. The method operates on a saturated column of soil with a uniform cross-sectional area obeying Darcy's law. The liquid that percolates through the saturated column is kept at an unsteady state flow regimen, thereby varying the head and the discharge throughout the test, unlike the constant head method.

To conduct a falling head test, the soil sample is placed in a cylindrical compartment of cross-sectional A and length L placed between conductive plates. Connecting the soil sample column to a standpipe with the cross-sectional area, a, through which the percolating fluid enters the system. The first step of the testing procedure is to saturate the soil sample and fill the standpipes with water to a given level. Next, water is allowed to flow through the sample till the standpipe water hits a given lower limit. The time taken for the water in the upper level to reach the lower level is noted. The standpipe is refilled with water and the test procedures are repeated for a couple of times (3 times). The permeability of the sample can be calculated as:

$$k = \frac{aL}{A.\Delta t}.\log\frac{h_u}{h_l}$$

Where;
L= sample column length
A= cross-sectional area of sample
a= cross-sectional of the standpipe
Δt= time taken for the water column to flow through the sample
hu and hl = upper and lower water levels in the standpipe

III. RESULTS AND DISCUSSION

Particles retained between the sieve size range of 0.075mm and above are classified as coarse material while particles that pass through 0.075mm sieve size are classified are fine materials.

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Table 1: Result of the grain size analysis of soil samples

Sample A (Proposed Site)						
	Test 1			**Test 2**		
SIEVE SIZE (mm)	**MASS RE-TAINED**	**% RE-TAINED**	**% PASSING**	**MASS RE-TAINED**	**% RE-TAINED**	**% PASSING**
9.5	0	0	100	0	0	100
4.75	9	1.8	98.2	14.7	2.94	97.06
2.36	29	5.8	92.4	19.7	3.94	93.12
1.18	39.5	7.9	84.5	50.8	10.16	82.96
0.6	72.5	14.5	70	79.8	15.96	67
0.3	38.5	7.7	62.3	77.7	15.54	51.46
0.15	111	22.2	40.1	80.6	16.12	35.34
0.075	52.5	10.5	29.6	60.9	12.18	23.16
Sample B (Ilokun Dumpsite)						
	Test 1			**Test 2**		
SIEVE SIZE (mm)	**MASS RE-TAINED**	**% RE-TAINED**	**% PASSING**	**MASS RE-TAINED**	**% RE-TAINED**	**% PASSING**
9.5	15	3	97	5.5	1.1	98.9
4.75	39.9	7.98	89.02	36.6	7.32	91.58
2.36	86	17.2	71.82	66.2	13.24	78.34
1.18	60.3	12.06	59.76	86.9	17.38	60.96
0.6	101.6	20.32	39.44	114	22.8	38.16
0.3	135.4	27.08	12.36	142.7	28.54	9.62
0.15	47.8	9.56	2.8	34.7	6.94	2.68
0.075	13.1	2.62	0.18	9.7	1.94	0.74
Sample C (Erifun Dumpsite)						
	Test 1			**Test 2**		
SIEVE SIZE (mm)	**MASS RE-TAINED**	**% RE-TAINED**	**% PASSING**	**MASS RE-TAINED**	**% RE-TAINED**	**% PASSING**
9.5	8.5	1.7	98.3	2.9	0.58	99.42
4.75	9.2	1.84	96.46	18	3.6	95.82
2.36	70	14	82.46	30	6	89.82
1.18	61.8	12.36	70.1	61.6	12.32	77.5
0.6	52	10.4	59.7	77	15.4	62.1
0.3	72.5	14.5	45.2	62	12.4	49.7
0.15	110.5	22.1	23.1	118	23.6	26.1
0.075	95	19	4.1	95	19	7.1

Table 1 shows the result of the grain size analysis. Soil samples from the proposed site show that above 70% of the soil is coarse while less than 30% is fine which shows that there is a considerable amount of clay in the sample according to AASHTO soil classification. Samples from the Ilokun dumpsites a high percentage of about 99% of the sample are coarse while just less than one percent is of fine material. This indicates that the sample is purely sandy. The samples from the Erifun dumpsite also show similarity to the Ilokun dumpsite with about 95% coarse material and 5% fine material.

As shown in Table 2, samples from the proposed site consist of liquid limit, plastic limit, plasticity index, and shrinkage limit of 48%, 35%, 17.6%, and 3.1 respectively. Using the AASHTO method of classification, the soil can be classified as A-2-7 clayey soil of fair rating in terms of possible use as a landfill liner. Samples from the Ilokun dumpsites consist of a liquid limit of 19.3%. The samples show no sign of plasticity and shrinkage. Using the AASHTO method of classification, the soil can be classified as A-3 sandy soil of very poor rating as landfill liner. Samples from the Erifun dumpsite show a liquid limit of 24.15%. Similar to the samples from Ilokun dumpsites, it shows no sign of plasticity and shrinkage. Using the AASHTO method of classification, the soil can be classified as A-2-4 silty sandy soil of poor rating in terms of possible use as a landfill.

Table 2: Results of the Atterberg limit tests

	Sample A (Proposed Site)		**Sample B (Ilokun Dumpsite)**		**Sample C (Erifun Dumpsite)**	
Atterberg Limit Test	1	2	1	2	1	2
Liquid Limit (LL)	47.8	48.0	18. 6	19.9	24. 5	23. 8
Plastic Limit (PL)	36.1 5	33.3 5	-	-	-	-
Plasticity Index (PI)	11.6 5	14.6 5	18. 6	19.9	24. 5	23. 8
Shrinkage Limit (SL)	3.2	3.0	0.2	0.1	-	-

Table 3 shows the sample average of the hydraulic conductivity results. The hydraulic conductivity of (K) of the samples from the proposed site is 351.73m/yr which shows that the rate of percolation in this soil will be slower when compared with a hydraulic conductivity of 5147.29m/yr and 2679.45m/yr of samples from Ilokun and Erifun of respectively. For municipal solid waste landfill, a composite liner in which the base layer of the liner has a hydraulic conductivity of less or equal to 0.032m/yr is recommended by Environmental Protection Agency [8]. In most cases, this layer is made of an artificial layer of enhanced soil.

Table 3: Results of the hydraulic conductivity of soil samples

	Sample A (Proposed Site)		**Sample B (Ilokun Dumpsite)**		**Sample C (Erifun Dumpsite)**	
Permeability Test	1	2	1	2	1	2
Hydraulic Conductivity (m/yr)	351.6	351. 8	540 0	4893. 7	2457.1 6	3015.8 6

IV. CONCLUSION

The outcome of the analysis of the results shows that the locations of existing dumpsites are not appropriate due to the nature of the soils on which the wastes are emplaced. The soils were classified as sandy soil with a high permeability rate. The high saturated hydraulic conductivity of each soil will enable large percolation and egress of the waste leachate into the immediate environment, therefore polluting both the surface water and the groundwater. The proposed site is an improvement over the sites used as landfill by the State Government. The high clay content of the soil in the site reduces significantly the rate of permeability of the leachate when compared to the existing landfills. The rate of seepage is reduced by about 16-fold at the Ilokun landfill and about 9-fold at the Erifun Landfill

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