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GEOTECHNICAL ASSESSMENT OF LATERITIC SOILS FROM A DUMPSITE IN ILORIN (SOUTHWESTERN NIGERIA) AS LINERS IN SANITARY LANDFILLS

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ABSTRACT

This study was carried out to evaluate the impact of leachate from open landfill in the Ita-Amo area of Ilorin, southwestern Nigeria, on the immediate soil. It is also aimed at assessing the suitability of the soil as liners/barrier to prevent pollution of undergroundwater. Specific parameters, such as grain size distribution, Atterberg consistency limit, density and coefficient of permeability, to assess soil as liner in landfill were tested using the BSI 1377 (1990) standard. The results show that the soils have average acceptable values of 0.75% gravel, 32% sand, 48% clay and 19% silt in a compactable sandyclay soil. The result of the Atterberg limits tests showed that the soils are absolutely inorganic clay of low plasticity with average clay activity value of 0.39 which is suggesting non-reactive kaolinitic clay. The dry density of the soils are 1.80Mg/m^3 and 2.1Mg/m^3 when compacted at standard and modified Proctor energies respectively while the coefficient of permeability of the soils are in the order of 1x10^{-9}m/s and 1x10^{-11}m/s respectively. These results compared reasonably with recommendations of several researchers. Thus, the soils satisfied the requirements for use as mineral seals in sanitary landfills. The higher energy of compaction (Modified Proctor) offered lower values of coefficient of permeability and thus recommended.

KEYWORDS: Sanitary, Geotechnical, Dumpsite, Compaction, Atterberg Limit

INTRODUCTION

Human population is increasing on daily basis, so is the corresponding quantity of waste contending for space with man and its impairing effects on the quality of the environment. It is therefore very common to find waste dumps within built-up areas and cities in bags along roads and streets. Attempts by Nigeria government, groups and individual to check these problems include composting, open burning and river dump of refuse. These attempts had severally failed because of their inadequacies (Ige, 2003 and Asiwaju-Bello, 2004).

The city of Ilorin which falls into southwestern and Northcentral, on geological and political classifications respectively is the capital town of Kwara State, Nigeria. It has a total land coverage of over 400km^2 (Africa Atlases, 2007) and a population estimate of 756,400 people (NPC, 2007) which are responsible for the generation of waste often deposited in open spaces, river banks, road side etc. In attempt to alleviate environmental pollution within the city; three (3) final waste disposal sites (unengineered) were located strategically at the outskirt of the city (Figure 1). However, the selection, construction and operational activities of these sites did not consider the geology and impacts on the neighboring environment. One of the disposal sites, along Ilorin – Peke village has been investigated and presented in this study. This study is aimed at assessing the effects of leachate that is generated from the dumpsite on the qualities of soil underlying the waste. The geotechnical properties of the soils and possible upgrading of the site to a modern solid waste containment facility such as sanitary landfill were also evaluated.

Study area description

The study area (Ita-Amo waste disposal site, Ilorin) is located within latitude 8^0 25^0 N and 8^0 30^0 N and longitude 4^0 20^0 E and 4^0 30^{0}E. The approximate area extent of the dumpsite is 3.63x10^{6}m^2 with average dump thickness of about 7.7m(Fig. 1). The site inhabits and still occupying several farmlands. Geologically, the area lies in the Precambrian Basement Complex area of southwestern Nigeria and is underlain by rock of metamorphic and igneous types (Oluyide *et al.,* 1998). However, migmatite predominantly underlies the waste dumpsite; it is characterized by weathered regolith which vary in thickness from place to place. The hydrologic setting of the area is typical of what is obtained in other Basement complex area; where the availability of water is a function of the presence of thick-little clay overburden material and presence of water filled joints, fracture or faults within the fresh Basement rocks. The humid tropical climate of Ilorin has particularly encourage relatively deep weathering of near surface rocks to produce porous and permeable material that allows groundwater accumulation as shallow aquifer which is recharged principally through infiltration of rainwater. At the investigated dumpsite, waste's leachate may also infiltrate to pollute the shallow groundwater.

MATERIAL AND METHOD

A total of four soils samples were collected from shallow wells at different depth within the lateritic zone. The variation in depth of soil sample was necessary to know the geotechnical properties of the whole laterite zone which may be useful as mineral seal in the construction of modern waste containment facility (sanitary landfill). All the soil samples were analyzed with respect to their grain size distribution, Atterberg consistency limits, moisture content- density relationship and the coefficient of permeability (***K***) characteristics at the soil laboratory of the Yaba College of technology,

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Lagos, Nigeria. This was done according to the British Standard (BS) 1377: 1990. The results obtained were later compared with the recommendation of several previous researchers and waste regulatory agencies.

RESULTS AND DISCUSSION

Several criteria have been proposed by various researchers with respect to geotechnical properties of soils to be useful as barriers in landfills (see compilation in Ige *et al.,* 2011). Such criteria have been compared with the results of the investigated parameters and presented in Table 1.

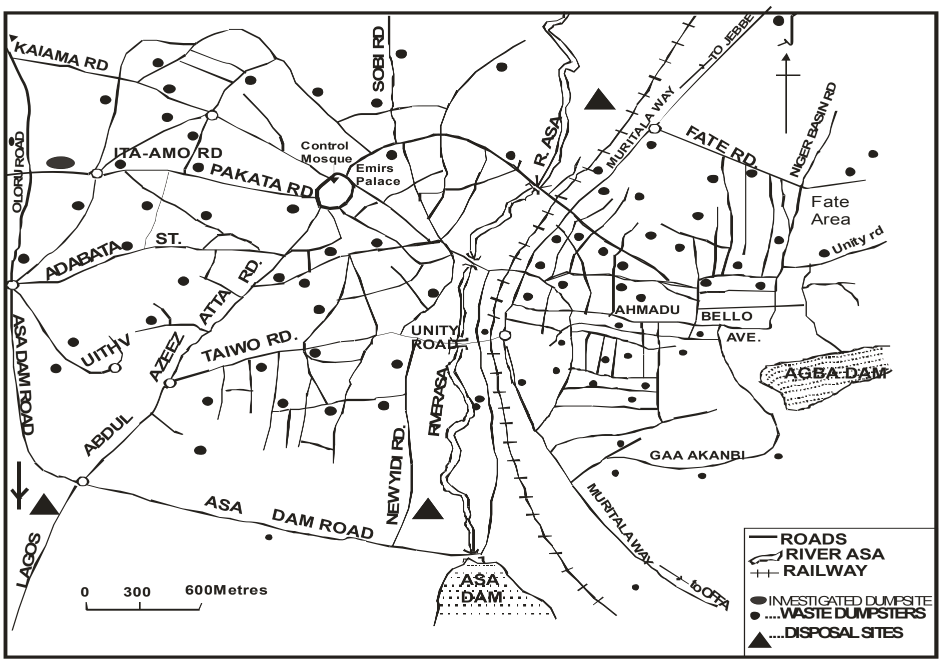

Figure 1 : The Locations of waste dumpsters and final disposal site in Ilorin, Nigeria.

Table 1: Required geotechnical criteria, recommendations and the findings of this study

PARAMETERS	AUTHOR(S)	RECOMMENDATIONS	RESULTS
GRAIN SIZE ANALYSES	Oeltzschner (1992) Bagchi (1994) ONORMS 2074 (1990) ONORMS 2074 (1990) Daniel (1993b), Rowe et al., 1995	Clay fraction ≥20% Largest Grain Size ≤63mm Silt/clay fraction ≥15% Largest grain size <25mm, %Gravel <30, % fine ≥30	%Clay: 41%-51% %Gravel: 0%-2%
ATTERBERG CONSISTENCY LIMITS	Daniel (1993b); Rowe et al(1995) Seymour & Peacock (1994) Oeltzschner (1992)	LL ≥30%, PI≥15% LL ≥30%, PI≥10% LL ≥30%, PI≥15% LL ≥25%, PI≥15% LL ≥30%, PI≥15% Inorganic Clay of low – medium plasticity(CL-CI) and Ac of <1.25	Liquid Limit: 35.34% - 40.56% Plasticity index: 17.15-20.55% Ac: 0.35 - 0.42
MOISTURE CONTENT-DENSITY RELATIONSHPIS	ÖNORMS 2074 (1990) Taha and Kabir (2003)	MDD ≥ 1.71Mg/m^3 MDD ≥ 1.74Mg/m^3	SP: 1.77Mg/m^3- 1.84Mg/m^3 MP: 2.00Mg/m^3- 2.20Mg/m^3
COEFFICIENT OF PERMEABILITY (*k*)	Murphy and Garwell (1998) Mark (2002) Joyce (2003) Fred and Anne (2005)	≤1x10^{-9}m/s ≤1x10^{-9}m/s ≤1x10^{-9}m/s ≤1x10^{-8}m/s ≤1x10^{-9}m/s	SP: 5.3x10^{-8}m/s to 4.0x 10^{-9}m/s MP: 2.3x10^{-11}m/s to 5.1x 10^{-11}m/s

KEY: SP= Standard Proctor LL= Liquid Limit
MP= Modified Proctor PI= Index of Plasticity Ac= Activity of clay

CONCLUSION

The following conclusions were made on the geotechnical evaluation of the Ita-amo waste dumpsite in Ilorin, Nigeria.

1. The overall engineering characteristics of the soil samples collected from test pits, irrespective of the depth of recovery, show that the soils are inorganic clay with low to medium plasticity (Fig.2).
2. Generally, these types of soils possess desirable characteristics to minimize hydraulic conductivity of compacted soils.
3. The indices properties (liquid limit, plastic limit, percentage fine, percentage gravel (Fig.3) and clay activity) of the soil samples satisfy the basic requirements as barrier materials in landfills.
4. The clay portion is inactive, thus the soils will be less likely to be attacked by waste chemical.
5. The soils have hydraulic conductivity of less than 1×10^{-9} m/s when compacted with both modified and standard Proctor compaction efforts.

This result compared favorably with the recommendations of several researchers (Table 1). Also higher energy of compaction is recommended because it gives lower and better values of coefficient of permeability for the compacted soils.

Table 2: Grain size analysis, Atterberg Consistency limits and the Coefficient of Permeability of soil samples

S/N	Well No	Depth(m)	γ (Mg/m^3)	Gs	Gravel (%)	Sand (%)	Clay (%)	Silt (%)	Fine (%)	WL (%)	WP (%)	PI(%)	PPC	Ac	STANDARD PROCTOR	MODIFIED PROCTOR
1	W1	1.15	2.04	2.69	2	28	48	22	70	35.34	18.19	17.15	CL	0.35	1.1×10^{-9} m/s	**3.4×10^{-11}m/s**
2	W2	2.70	1.67	2.64	1	34	45	20	65	39.14	20.80	18.34	CI	0.41	4.0×10^{-9} m/s	**5.1×10^{-11}m/s**
3	W3	4.50	1.60	2.63	0	28	51	2`	72	39.80	21.31	18.49	CI	0.39	5.3×10^{-8} m/s	**3.6×10^{-11}m/s**
4	W4	3.10	1.91	6.61	0	36	49	15	64	40.56	20.01	20.55	CI	0.42	3.7×10^{-9} m/s	**2.3×10^{-11}m/s**
		Av	**1.81**	**2.64**	**0.75**	**32**	**48.3**	**19**	**68**	**38.71**	**20.00**	**18.63**	**CI**	**0.39**	**3.53×10^{-8} m/s**	**1.6×10^{-11}m/s**

KEY: WL = Liquid Limit; PI = Index of Plasticity; γ = Natural Density; WP = Plastic Limit; Ac = Activity of Clay; Gs = Specific Gravity; Av = Average; PPC= Plots on Plasticity Chart

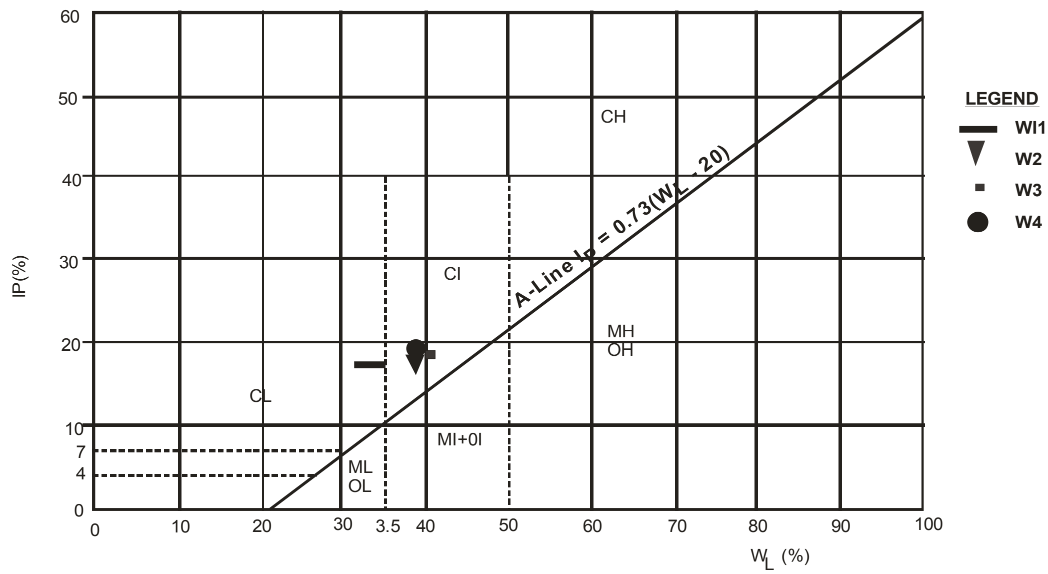

Fig.2 : Position of soil samples on the Casagrande's Plasticity chart.

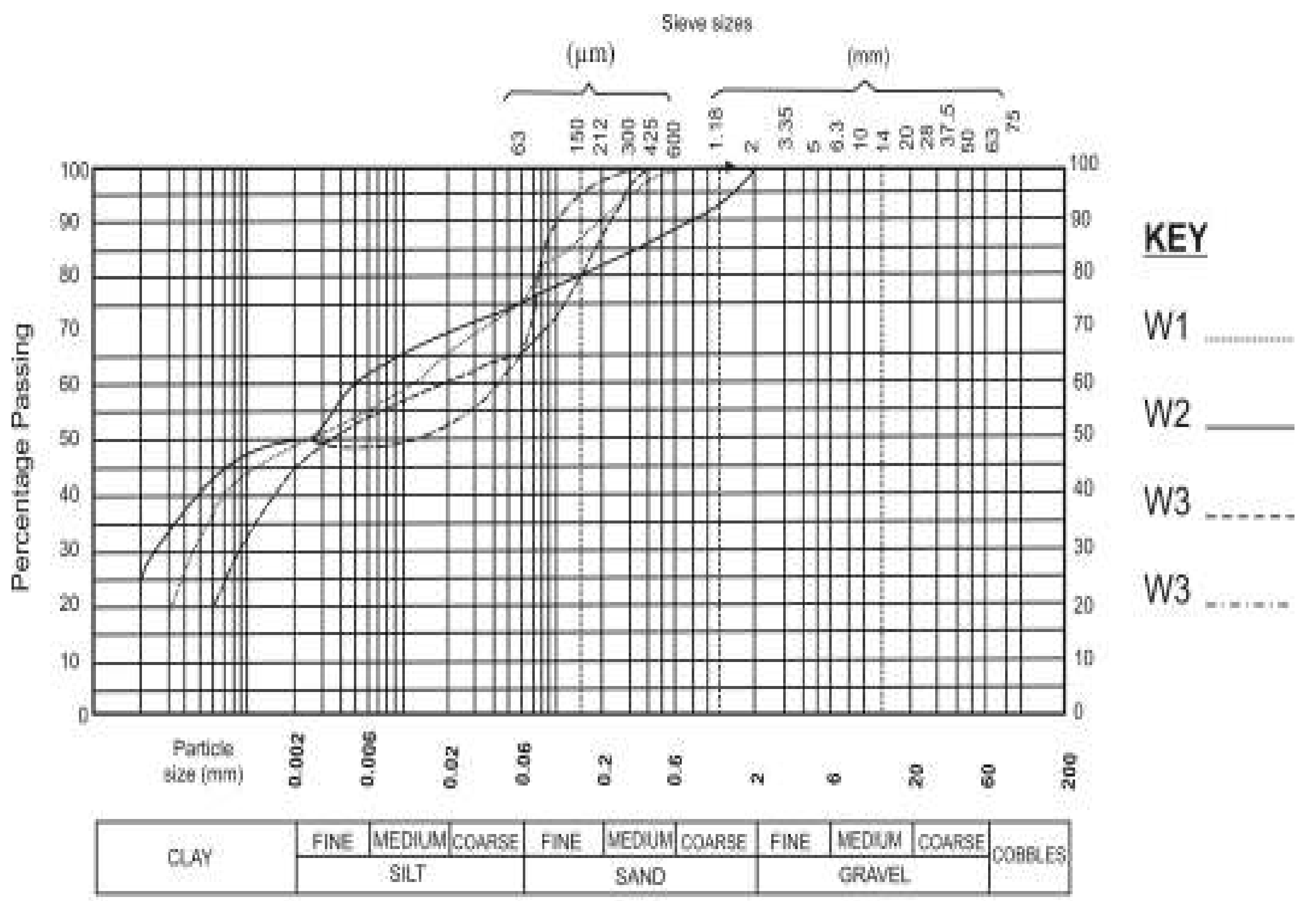

Fig: 3. The Grain size distribution curves for analyzed soil samples

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