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Impact of Leachate on Permeability Characteristic of Soil around Lapite Dumpsite in Ibadan, Southwestern Nigeria

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Abstract

This study examined the impact of leachate from Lapite dumpsite in Ibadan, Oyo State, Southwestern Nigeria on the permeability coefficient of the soil around the site. Soil samples were taken from upslope and downslope sections of the dumpsite and the geotechnical properties of the samples collected (disturbed and undisturbed) were analyzed at the University of Ibadan, Ibadan and Obafemi Awolowo University soil laboratories. Geotechnical tests conducted include particle size distribution, Atterberg limits, specific gravity and permeability coefficient. The coefficient obtained has higher values which may be as a result of effect of leachate or soil formation of the region. The permeability coefficients of the soil at the downslope section of the dumpsite were found to be higher than those at the upslope section. This shows that leachate has more effect or has travelled faster to downslope section than to the upslope section. Topography might have contributed to this. It is recommended that donor agencies/government should endeavour to convert the dumpsite to a landfill because permeability coefficient of the area is the type that encourages fast flow of leachate out of the dumpsite. This will save the natural resources (soil/groundwater) around the site from contamination.

Keywords: Leachate, Dumpsite, Permeability coefficient, Lapite, Geotechnical properties.

INTRODUCTION

Geotechnical engineering properties of soil play a major role in the selection of soil for engineering construction. Among important parameters obtained from geotechnical test is permeability coefficient (Benson *et al.,* 1984, Ige and Ogunsanwo, 2009). This coefficient is important because it helps to ascertain the ability of soil to allow liquid to flow through it. According to (Adeyemi and Oyediran, 2011, Musa, 2012), this property can be influenced by leachate from dumpsite. Considering these facts, it is necessary to establish the coefficient of permeability of soil around dumpsite because nearly all engineering structures such as buildings, roads, bridges, monuments etc. have to be rested on and founded on this soil (Ayininuola, 2014).

Leachate is produced when the refuse materials dumped into a dumpsite got decayed and dissolved into rain water. After some years the product formed flow laterally and vertically from the centre of the dumpsite to the surrounding soils. As it flows it relates with soil minerals it comes in contact with and chemical reactions occur. This changes the properties of the soil which include physical (colour) and geotechnical properties. According to Evangelin and Ramprasad (2013), it was reported that leachate from municipal solid waste alters geotechnical properties of the soil in a dumpsite.

A study of these properties is vital for the management of the dump yard and also during the reclamation of the site. Lavanda and Clark (1990) measured the hydraulic conductivity of waste as a function of unit weight and discovered that the value has been greatly influenced as a result of leachate generated by the waste. Musa (2012) studied the effects of municipal solid waste on the geotechnical properties of soils. Soil samples taken from three trial pits at depths of 0.5, 1.0 and 1.5 m, were used for the investigation. Two of the trial pits were located around the dumpsite to serve as control points or uncontaminated soil, while the third trial pit was located within the dumpsite to serve as contaminated soil. Soil samples collected were subjected geotechnical test. The results of the investigation show that Municipal Solid Waste (MSW) lowers the specific gravity, maximum dry density, cohesion and the angle of internal friction and increases natural moisture content, fine particle content, optimum moisture content, coefficient of permeability, coefficient of consolidation and coefficient of volume compressibility of the soil. These effects reduced with depth.

Since leachate could influence geotechnical properties (coefficient of permeability), therefore it is important to check the effect of the leachate produced by Lapite dumpsite on the geotechnical properties of the soil around it. The study hence evaluates the impact of leachate on the permeability coefficient of soil around Lapite dumpsite.

Study Area

Lapite dumpsite is located in Lapite village, Akinyele Local Government Area of Ibadan, Oyo State. The site falls within southwestern part of Nigeria. Its geographical locations are latitude 70 33^{I} N and 70 35^{I} N and longitude 30 54^{I} E and 30 56^{I}E. Two principal climatic seasons can be easily distinguishable in this area which is influenced by two major air masses controlling the seasons; the dry season which falls within November and March and the wet season which starts from April and ends in October, with a short dry spell in August. Average annual precipitation is put at about 1,316mm and serves as a major source of groundwater recharge (Jeje, 1983). The water table could fluctuate in response to the seasonality of the rainfall. Ibadan is basically a basement complex area located within the southwestern Nigeria and it is associated with sand deposition (Adeyemi and Oyediran, 2011, Ayolabi and Peters, 2005). Therefore, the site could be described characterized by basement complex rocks material of southwestern Nigeria which comprises igneous and metamorphic rock units (fig. 1).

The subsurface geology reveals two basic lithology; clay and sand deposits. These deposits may be interbedded in places with sandy clay or clayey sand and occasionally with vegetable remains. The rock materials in this area include; the banded Gneiss Complex, pegmatites, migmatites and the Older Granites (Adeyemi and Oyediran, 2011, Ayolabi and Peters, 2005). These consist of loose and light grey sand mixed variously with varying proportion of vegetation matter on the lowland; while the reddish and brown loamy soil exists in the upland. The geology of the area is underlain by inter-bedded sands, gravelly sands, silts, and clays. The sub-surface is made up of semi-permeable to impermeable material.

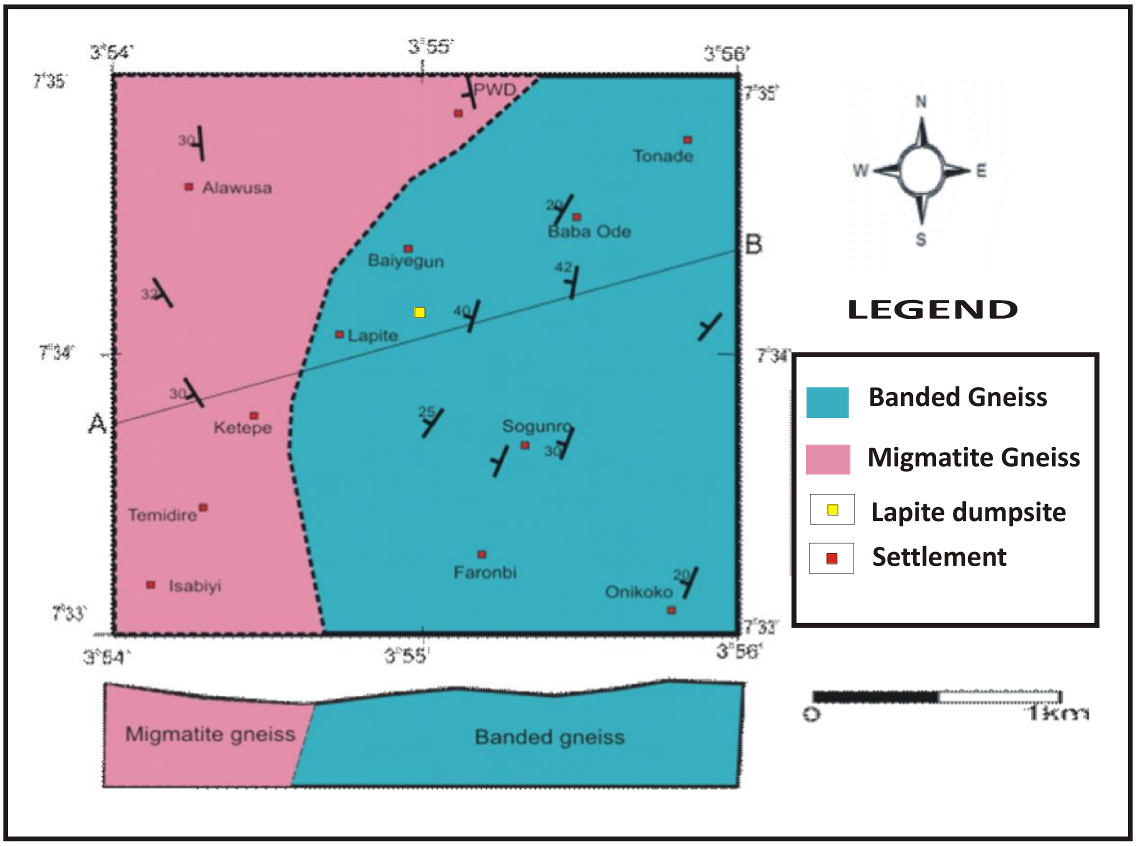

Figure 1: Geographical and geological map of the study area
Source: Oguntayo (2013)

MATERIAL AND METHODS

The open dumpsite selected for the study is owned by Oyo State government and it is located between Oyo-Ibadan old and the newly constructed expressway. The site has been in existence for the past 18 years (Plate 1.0). Two sampling points were located at 120m and 160m from the dumpsite's fence at the upslope and downslope sections. Soil samples were collected at 1m, 2m, 3m and 4m depth respectively. These samples were labelled accordingly (Fig. 2.0). Both disturbed and undisturbed samples were collected. The specimens were subjected to following tests which include natural moisture content, particle size distribution, specific gravity and permeability. The tests were carried out in accordance with standard (BS 1377, 1998).

Plate 1: Pictorial representation of Lapite dump site section

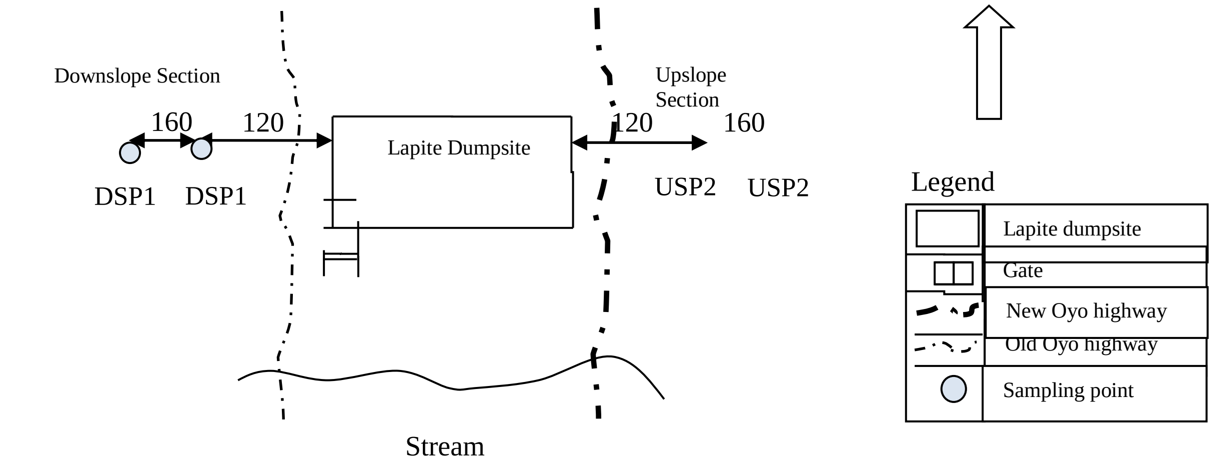

Figure 2: Cross section of the sampling points location around the dumpsite

RESULTS AND DISCUSSION

The results of the geotechnical tests carried out on the soil samples collected were presented in the Table 1 and 2. According to Table 1 the natural moisture content (NMC) at the upslope ranges from 8.25%-13.49% while at the downslope, the value ranges from 9.56%-21.52%. The trend shows that at each sampling points, NMC value at the upslope is less than downslope's value (fig. 2.0). This could be as a result of effect of topography; water flows from the upslope to the downslope. This suggests that the effect of leachate would easily be felt at the downslope than upslope section of the site because topography contributes to a fast flow of liquid towards downslope than upslope. The specific gravity of the soil samples collected at the upslope ranges from 2.46-2.67 while at the downslope it ranges from 2.43-2.67. This specific gravity range of value suggests that the soil at the upslope and downslope contains similar soil materials or minerals. The value further suggested a sandy soil with silty or organic substance (Musa, 2012, Adunoye and Agbede, 2013). The table further showed that soil samples obtained at both the upslope and downslope portion of the dumpsite are coarse grained soil (%passing 75μm<50%) and they are dominated with sand followed by silt material (Ayininuola, 2014). The liquid limits ranged from 34% to 50% at the upslope and 22% to 51% at downslope section. This suggests a soil with high permeability coefficient (Bagchi, 1994). The plasticity index for upslope and downslope ranges from 8.4%-23.4% and 11.8%-27.2% respectively. This suggests a soil with low-medium plasticity (Gidigasu, 1972). The values of permeability coefficients presented in Table 2 at the downslope were higher than those at the upslope. This suggests that the soil at the downslope is more permeable than those at the upslope. According to (Evangelin and Ramprasad, 2013), leachate increases coefficient of permeability. Considering the fact that topography could contribute to flow of leachate as raised earlier, it could be suggested that leachate has percolated through the soil and the effect is more felt at the downslope than at the upslope region. This is evidence in the variation of coefficient of permeability presented in Figure 3. Leachate contains a lot of anions and cations. The cations are exchangeable types leading to replacement of mono cations in soil with dia and tri cations that will produce strong bond among soil particles (Ayininuola, 2014). All these would account for the higher values of permeability coefficient obtained.

The coefficient of permeability is one of the key parameter affecting most soils behaviour and this must be considered before soil could be selected for civil engineering design and construction (Bension, 1984). Several investigators and waste management agencies recommended different range of permeability coefficients in the selection of soil for civil engineering construction (Ige nd Ogunsanwo, 2009, Ayininuola, 2014, Rahman *et al.,* 2013). Musa (2012) recommended 1x10-9m/s as the minimum allowable value for soil to be useful for landfill liner. Considering the result of permeability of this study most of the soils have their coefficients within the range of 10-5-10-6m/s which indicates a higher value than recommendation of several authors (Rahman *et al.,* 2013, Mark, 2002).This means the soil could support faster rate of flow of liquid through it because the higher the coefficient the more permeable a soil will be.

The result of this study therefore suggests that the rate of flow of leachate through the soil at the downslope will be faster than those at the upslope section.

CONCLUSION AND RECOMMENDATIONS

Geotechnical tests were conducted to study the impact of leachate on the coefficient of permeability of soil around Lapite dumpsite. The following conclusions are drawn from the experimental work:

- Topography could contribute to variance in natural moisture content value obtained for downslope and upslope region of the site.
- Lower values of the specific gravity obtained also suggest the presence of organic content in the soil.
- Atterberg limits result also establishes that action of leachate on the soil might have contributed to the higher value of plasticity of the soil.
- The soil around the site is dominated by sand-silt soil supporting the effect of leachate in the formation of silt materials in the soil.
- The coefficient of permeability assumed higher value. Therefore, it can be established that leachate from the dumpsite has started affecting the geotechnical index of the soil around the dumpsite.

Recommendations

The findings of this study is an eye opener and it is recommended for Lapite Dumpsite Management Authority, planners, member of public and engineers as they approach this part of the city (Ibadan, Oyo State) for construction or any other technical use. This will also be very useful towards land development activities of the area in order to meet the land requirement in urban areas as people migrate to the vicinity.

This study also recommends that donor agencies, government and other stakeholders concern should intensify effort to convert the dumpsite to a landfill site. This will be very helpful in the biodiversity conservation of natural resources (soil/groundwater) around the site.

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Table 1: Geotechnical Index of the soil at the upslope and downslope section Lapite dumpsite

Variable	Upslope section								Downslope section							
	USP1A1	USP1A2	USP1A3	USP1A4	USP1B1	USP1B2	USP1B3	USP1B4	DSP2A1	DSP2A2	DPS2A3	DSP2A4	DS P2B1	DS P2B2	DS P2B3	DS P2B4
NMC	8.66	8.25	10.19	13.36	12.31	13.49	10.06	9.24	9.56	12.91	14.93	9.82	13.14	21.52	12.59	13.19
Specific Gravity	2.6	2.67	2.66	2.46	2.54	2.53	2.65	2.67	2.69	2.48	2.43	2.67	2.54	2.56	2.48	2.55
%passing 75Um	28.4	31.1	34.83	40.8	36.03	38.75	38.75	37.675	28.4	31.1	34.83	40.8	36.03	38.75	38.75	37.675
Gravel	5.48	20	6.85	3.5	6.8	22.5	4.8	2.3	8.7	4.03	-	13.9	9.125	15.4	10.8	17.75
Sand	56.1	51.1	50.5	60.5	64.8	52.4	45.6	54.9	36.6	57.12	68.9	59.5	60.63	47.8	42.03	50.57
Silt	32.7	23.9	36.3	30.8	24.2	21.1	41.5	36.6	46.88	32.95	26.3	22.71	26.25	31.1	40.58	27.38
Clay	5.2	4.2	6.4	5.4	4.16	4	8.07	6.2	7.8	5.9	4.8	3.89	4	5.7	6.6	4.3
Liquid limit	35	45	50	35	34	50	40	36	31	33	35	51	32	30	24	22
Plastic Limit	16.7	27.5	31.4	19.5	10.6	32.4	31.6	27	15.7	5.8	15.4	29	16.2	15.6	11.3	10.2
Plasticity Index	18.3	17.5	18.6	15.5	23.4	17.6	8.4	9	15.3	27.2	19.6	22	15.8	14.4	12.7	11.8

Table 2.0: Coefficient of Permeability of soil at the upslope and downslope sections of Lapite dumpsite

Sampling Point		A1	A2	A3	A4	B1	B2	B3	B4
Permeability coefficient (k) x 10^{-5}m/s	Upslope section	1.66	2.46	0.99	0.56	1.66	2.87	2.27	0.35
	Downslope section	2.98	3	3.17	2.98	2.5	2.7	3.12	1.2

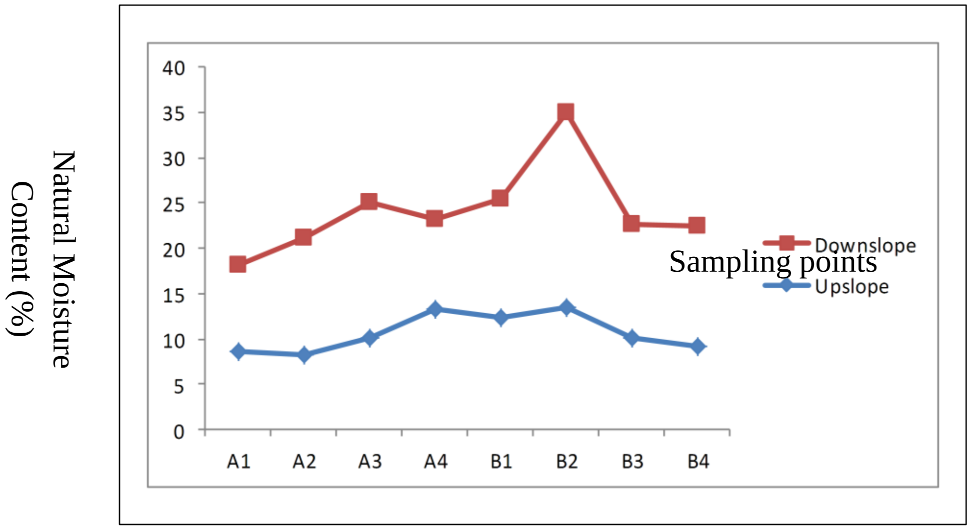

Figure 2: Trend of Natural moisture content (NMC) of soil at upslope and downslope of sites around Lapite dumpsite

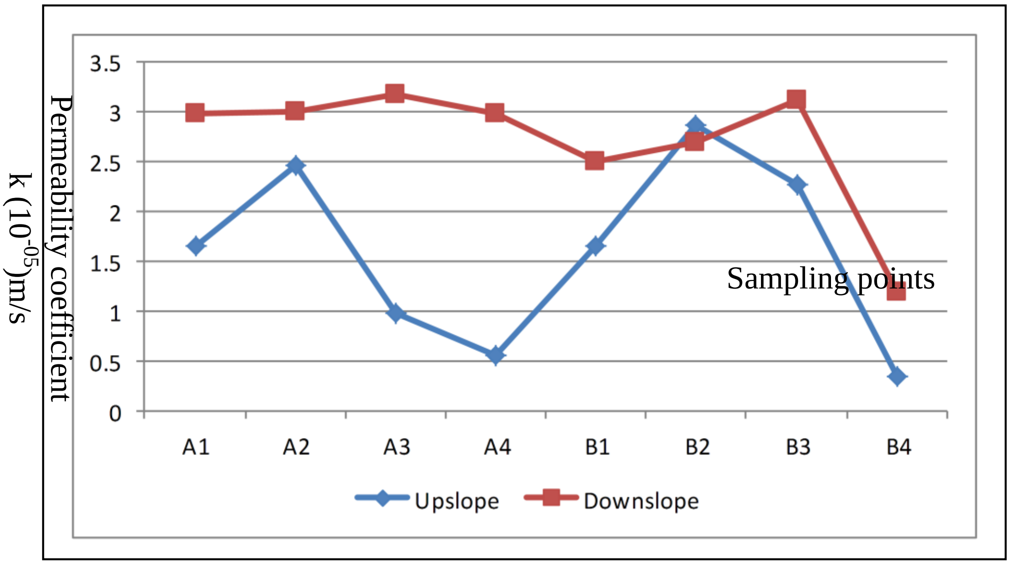

Figure 3: Variation of coefficient of permeability of soil at upslope and downslope of sites around Lapite dumpsite

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