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Variability In Some Geotechnical Properties of Two Residual Lateritic Soils from Southwestern Nigeria

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Abstract-* *Lateritic soils derived from granite and banded gneiss along Ondo Ore road in South Western Nigeria were assessed for their suitability or otherwise as landfill liners and highway sub-base/subgrade soils. The investigation was also meant for the determination of variability in the values of some geotechnical parameters. Representative rock samples were collected. Twelve disturbed and undisturbed soil samples were won from an area of 150m2 in each of the study area. Texture and mineralogy of the rocks were determined. Geotechnical tests were carried out on the soil samples by following standard procedures with some modifications to take care of peculiar characteristics of lateritic soils. Coefficient of variation was determined for each of the geotechnical parameters. Permeability coefficient was found to exhibit highest variability (91.25% in granite derived soil and 70.52% in the migmatite – gneiss derived soil). Parameters such as plasticity index, amounts of fine fraction and natural moisture content showed moderate variability, while maximum Dry Density, optimum moisture content and specific gravity of grains showed low variability. The soil were found suitable as landfill liners but unsuitable for sub-base and subgrade soils on the basis of permeability coefficient. The high degree of variability in the values of permeability coefficient calls for detailed sampling of lateritic soils either as foundation or construction materials.

I. INTRODUCTION

Lateritic soils are the most common reddish weathered surface deposits occurring in the tropical and subtropical regions of the world. They occur mostly as the capping of hills and therefore provide excellent borrow areas for extensive use in various construction activities (Goswami and Mahanta, 2007). Nigeria falls within the latitudes 23.5°N and 23.5°S on the earth. The prevailing climatic condition (i.e. tropical climate) aids the formation of lateritic soils. Due to their abundance and importance in engineering and construction works, lateritic soils have gained so much attention from various researchers (Agada and Anthony, 1980; Mesida, 1985; Ajayi, 1987; Ogunsanwo, 1989; Adeyemi et al., 1999; Adeyemi and Wahab, 2008; Amadi, 2010; Adebisi and Adeyemi, 2012; Adeyemi, 2024).

Lateritic soils are mostly utilized for construction works and they are generally regarded as good foundation materials because they are generally non-swelling. However, the use of materials is dependent on their geotechnical properties which determine their suitability either for road construction or waste disposal site (Osinubi, 1998).

To an ordinary man, all lateritic soils are good for all kinds of construction and so they are won without proper laboratory tests, evidence of which is seen in failure of structures (roads, dams, groundwater contamination etc). Despite the widespread usage of lateritic soils in Nigeria, there are well known documented problems associated with the soils. This may be attributed to insufficient geotechnical and geological information on one hand and meagre knowledge of what they could be used for on the other hand.

This study evaluated and compared the variability in geotechnical characteristics such as Atterberg limits, compaction parameters, and permeability of two residual lateritic soils that developed over different parent rocks in southwestern Nigeria. The aim was to assess how some geotechnical properties would vary within the restricted areas.

II. LOCATION OF THE STUDY AREAS

A study location with granite-derived soil is in Ondo town on longitude 004050’22.4” E and latitude 07002’58” N, while the second location with migmatite-gneiss derived soil is located near Ore and it lies on longitude 004051’41.7” E and latitude

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06049'12.7" N (figure 1.1). They are both along Ondo-Ore highway in Southwestern Nigeria.

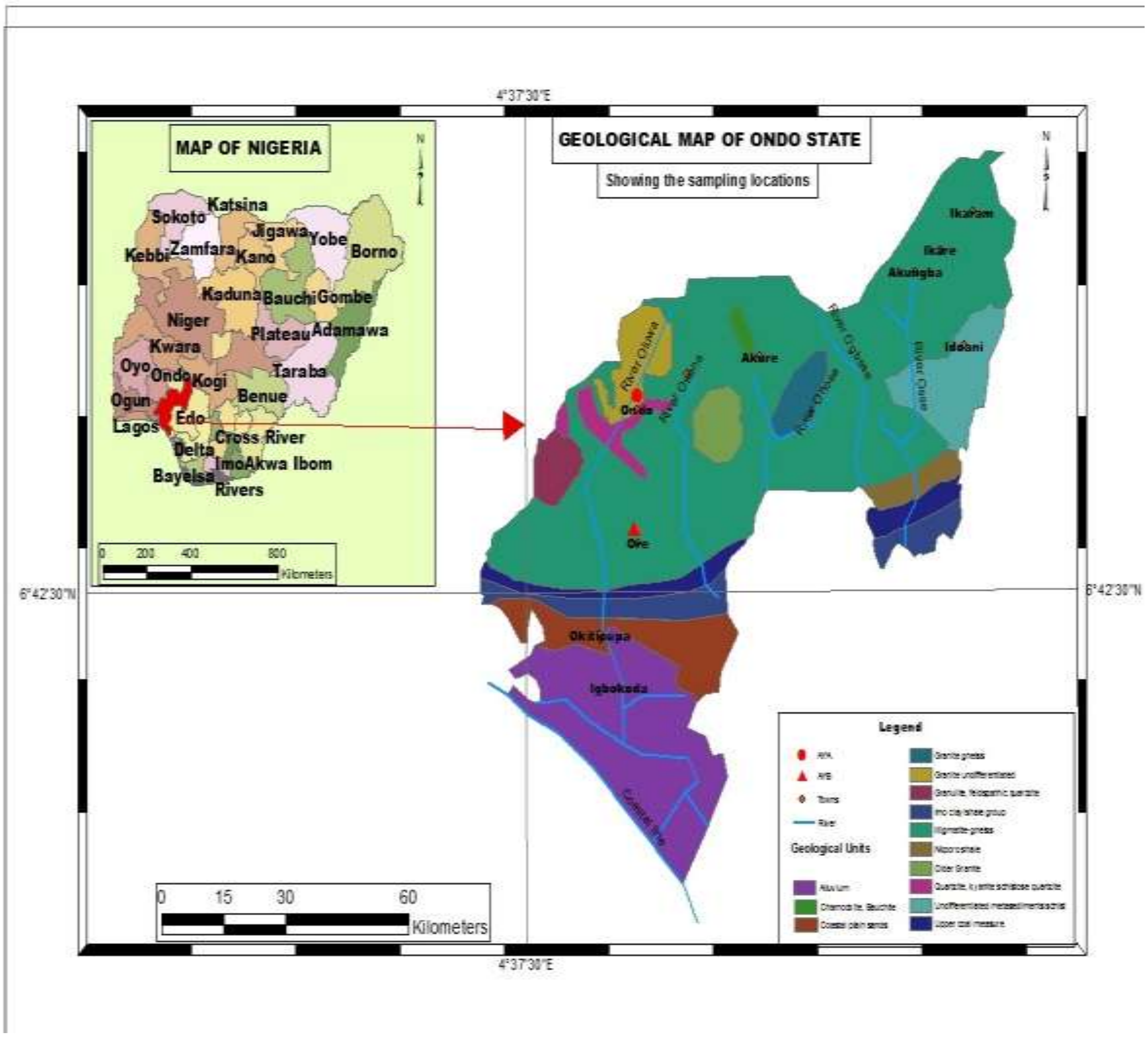

Figure 1: Location and geological map of the study area (NGSA, 2006)

III. METHODS

Twenty-four soil samples (comprising twelve disturbed and twelve undisturbed sample) were collected from each location. Figure 2 shows that twelve (12) soil samples were taken at lateral interval of 5m within an area of 150m2. In addition, rock samples were obtained to correlate their textural characteristics with the geotechnical properties of the soil. All samples were subsequently sent to the laboratory for the underlisted tests.

1. Petrographic studies of rock samples.
2. Index/Classification tests: grain size distribution analysis (sieve analysis and hydrometer), Atterberg limits
3. Specific gravity of grains.
4. Compaction at West African level to determine the soil's Optimum Moisture Content (OMC) and Maximum Dry Density (MDD).
5. Permeability

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The procedures are those specified in the British standards (1a…..) with necessary modifications (such as soaking of air dry derived soil samples in weak calgon (hexametaphosphals) solution to enhance removal of iron oxide coating.

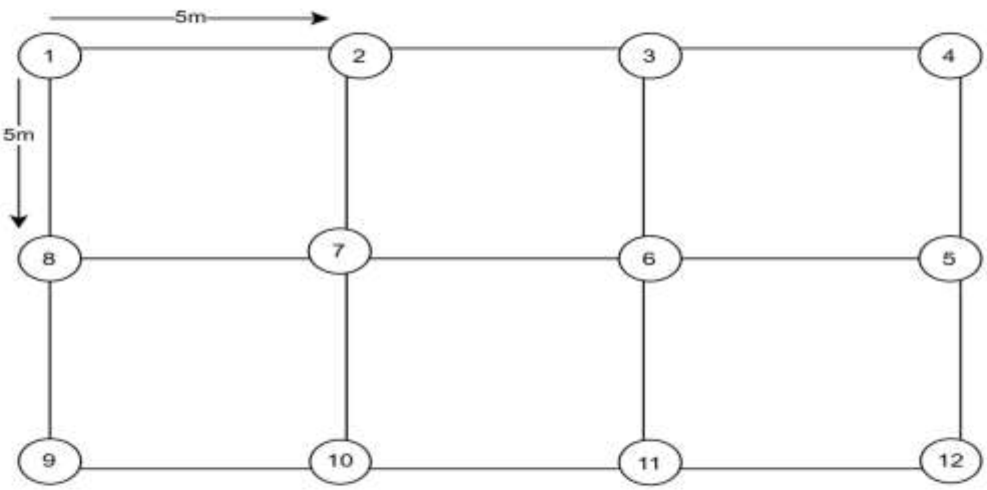

Figure 2: A sketch of each of the sampling locations showing the sample points

IV. RESULTS AND DISCUSSIONS

Petrography of rock samples

Ondo samples of granite are richer in quartz and feldspars, with moderate amounts of mica and little to no hornblende. Their medium texture suggests they might weathered into moderately coarse, well-graded soils while those Ore migmatite-gneiss rock contain more biotite and hornblende, minerals that weather more easily and contribute to finer soil textures.

Table 1: Average modal composition of parent rocks

Minerals / %	Location 1 (GRANITE)	Location 2 (MIGMATITE-GNEISS)
Quartz	37	30
Plagioclase feldspar	19	15
Biotite	10	20
Microcline	24	22
Muscovite	8	-
Hornblende	-	12
Opaque	2	1
Texture	Medium	Fine to medium

Grain size distribution

Table 2 shows the coefficient of variation (CV) of the grain size distribution of the lateritic soils derived from granite and migmatite-gneiss. These values provide insight into the degree of heterogeneity in the particle size distribution of each soil type.

The grain size distribution parameters of the granite-derived and migmatite-derived soils show significant differences in their variability. The coefficient of variation for gravel content is extremely high in granite-derived soil (99.13%) compared to migmatite-gneiss soil (22.11%), indicating a much wider spread in gravel content among granite-derived samples. Conversely, the sand fraction shows relatively similar variation in both soils, with migmatite-gneiss soil exhibiting slightly higher variability (38.62%) than granite-derived soil (33.43%). Silt content displays moderate variation in both soil types, with granite-derived soil having a slightly higher coefficient of variation (15.86%) than migmatite-derived soil (13.66%). However, clay sized content is notably more variable in migmatite-derived soil (22.63%) compared to granite-derived

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soil (14.32%). Lastly, the overall fine fraction (silt + clay) shows lower variability in migmatite-derived soil (9.49%) than in granite-derived soil (13.00%). These differences in the coefficient of variation can be attributed to the differences in the mineralogy of the parent rocks of the soils.

Table 2: Statistical Parameters of grain size distribution of the studied soils.

Grain Size Distribution Parameter	Statistical Parameter	Granite-derived soil	Migmatite-gneiss Soil
% Gravel	Mean	5.75	11.17
	Standard Deviation	5.70	2.47
	Coefficient of Variation (%)	99.13	22.11
% Sand	Mean	28.99	19.08
	Standard Deviation	9.69	7.37
	Coefficient of Variation (%)	33.43	38.62
% Silt	Mean	50.44	54.69
	Standard Deviation	8.00	7.47
	Coefficient of Variation (%)	15.86	13.66
% Clay-sized fraction	Mean	14.87	14.23
	Standard Deviation	2.13	3.22
	Coefficient of Variation (%)	14.32	22.63
Amounts of fine fraction	Mean	65.26	69.75
	Standard Deviation	8.49	6.62
	Coefficient of Variation (%)	13.00	9.49

Specific Gravity of Grains

Table 3 presents a summary of the statistical evaluation of the spatial variability in specific gravity of grains and moisture content of both granite-derived and migmatite-gneiss soils. The coefficient of variation in specific gravity values of the migmatite-derived soils is similar to that of the granite-derived soils. Since specific gravity reflects the degree of laterization of the soils, the similarity in values suggests that both soil types have undergone similar degrees of laterization (Tuncer and Lohnes, 1977).

The spatial variation in moisture content is also relatively low for both soils. However, the degree of variation observed in the granite-derived soils is higher than that in the migmatite-derived soils. This trend can be probably attributed to the observed degree of variation in the clay-sized fraction.

Table 3: Statistical Parameters of the Specific Gravity of Grains and Moisture content of Soils

Soils	Parameters		
		Specific Gravity of Grains	Moisture Content (%)
Granite-Derived	Range	2.55-2.65	11.21 – 16.21
	Mean	2.59	13.58
	Standard Deviation	0.028	1.65
	Coefficient of Variation (%)	1.16	12.11
Migmatite-Derived	Range	2.55-2.65	12.24 – 16.32
	Mean	2.59	14.54
	Standard Deviation	0.028	1.26
	Coefficient of Variation (%)	1.11	8.69

Atterberg Limits

Table 4 summarizes the statistical parameters of the consistency limits of the studied soils. For the granite-derived soil, the values of the Liquid Limit

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(LL) ranges from 38.00% to 52.02%, the Plastic Limit (PL) from 18.90% to 32.82%, and the Plasticity Index (PI) from 16.66% to 27.12%. The coefficient of variation (CV) indicates that the LL (9.38%) and PI (12.78%) have moderate variation, while the PL shows higher variability (15.33%). These values suggest that granite-derived soil exhibits a fairly plasticity characteristics, contributing to more predictable behaviour in engineering applications such as foundation design and earthworks.

In contrast, migmatite-gneiss derived soil shows a slightly wider range in LL (35.00% to 52.40%) and a narrower range in PI (17.62% to 21.83%). The variability differs notably; the LL (12.39%) and PL (18.20%) have higher coefficients of variation, indicating more variation in the moisture limits, while the PI has a lower variability (6.87%), implying a relatively stable plastic range. However, the greater variability in LL and PL could still affect the soil's volume change behaviour under changing moisture conditions.

The coefficient of variation of the plasticity index (12.78%) of the granite-derived soils is (6.87%) about double that of the migmatite-gneiss derived soil.

Table 4: Statistical Parameters of the Atterberg Limits of the studied soils

Soil Type	Statistical Parameter	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)
Granite-Derived Soil	Range	38.00-52.02	18.90-32.82	16.66-27.12
	Mean	46.36	25.98	20.39
	Standard Deviation	4.34	3.98	2.61
	Coefficient of Variation (%)	9.38	15.33	12.78
Migmatite-Derived Soil	Range	35.00-52.40	17.38-30.78	17.62-21.83
	Mean	44.70	25.27	19.35
	Standard Deviation	5.54	4.60	1.33
	Coefficient of Variation (%)	12.39	18.20	6.87

Maximum Dry Density (MDD) and Optimum Moisture Content (OMC)

Table 5 shows the statistical parameters of the compaction characteristics of Maximum Dry Density (MDD) and Optimum Moisture Content (OMC) of the two residual soils.

For the granite-derived soil, the values of the MDD ranges from 1641 to 1822 kg/m³ with a low coefficient of variation (3.72%), indicating that this soil compacts to a fairly consistent density. Its OMC ranges from 17.2% to 22.6%, with moderate variability (CV of 8.76%), meaning the moisture

needed to achieve optimum compaction is fairly predictable.

In comparison, the migmatite-derived soil shows a slightly wider MDD range (1611 to 1875 kg/m³) and higher variability (CV of 5.14%), suggesting its compacted density varies more between samples. Its

OMC ranges from 16.9% to 23.6% with a moderate coefficient of variation (10.83%). Both soils have low to moderate variations with granite-derived soil being slightly more consistent.

Table 5: Coefficients of Variation of Dry Density (MDD) and Optimum Moisture Content (OMC) of the Studied Soils

Soil	Parameter	MDD (Kg/m^3)	OMC (%)
Granite-Derived soil	Range	1641-1822	17.20-22.6
	Mean	1727.41	20.44
	Standard Deviation	64.72	1.79
	Coefficient of Variation (%)	3.72	8.76
Migmatite-Derived Soil	Range	1611-1875	16.9-23.6
	Mean	1753.66	19.94
	Standard Deviation	90.14	2.16
	Coefficient of Variation (%)	5.14	10.83

Permeability Coefficient of the Studied soils
The values of the permeability coefficient of the soils show significant variability, as presented in Table 11. The granite-derived soil exhibited a higher mean permeability of 1.16 x 10−8m /s, than the 6.84 x 10−9m/s for the migmatite-derived soil.

The coefficient of variation (CV%) further emphasizes the heterogeneity, with granite-derived soils showing a CV of 91.25%, which is significantly higher than the 22.64% observed for migmatite-gneiss soils. This suggests that the granite-derived soils are not only more permeable but also more variable in structure and pore connectivity likely due to differences in mineral composition, weathering extent, or particle packing.

Although the coefficient of variation of permeability coefficient is high in both soils, granite-gneiss derived soil samples have higher variability.

TABLE 6: Coefficients of Variation

Soil	Parameters	Permeability Coefficient (m/sec)
Granite-Derived Soil	Mean	1.16×10^{-8}
	Standard Deviation	1.05×10^{-8}
	Coefficient of Variation (%)	91.15
Migmatite-Derived Soil	Mean	5.18×10^{-9}
	Standard Deviation	1.17×10^{-9}
	Coefficient of Variation (%)	22.64

V. CONCLUSIONS

This study examined the geotechnical variability of the values of geotechnical properties of two lateritic soils derived from granite and migmatite-gneiss in South Western Nigeria. Based on the laboratory test results and statistical analyses, the following conclusions can be drawn:

(i) Granite was found to be richer in quartz and feldspars with a medium texture, while the migmatite-gneiss contained more biotite and hornblende with a finer texture. These mineralogical differences significantly influence the geotechnical properties of the derived soils.

(ii) Both soils exhibited greater overall heterogeneity, especially in their permeability coefficients, suggesting a more complex particle size distribution. Specific gravity values were consistent across both soil types, indicating similar degrees of weathering.

Moisture content, however, varied more significantly in the granite-derived soils.

(iii) Granite-derived soils exhibited more uniform plasticity characteristics with lower variability in plasticity index, whereas the migmatite-derived soils showed higher plasticity index variability, potentially affecting their behaviour under fluctuating moisture conditions.

(iv) Granite-derived soils had slightly higher maximum dry densities and required lower optimum moisture content, suggesting better compaction potential.

VI. RECOMMENDATIONS

Based on the findings of this study, the following recommendations were made:

i. Despite general trends observed, the variability in geotechnical parameters highlights the importance of site-specific laboratory testing before utilization, especially for critical engineering projects.
ii. Further Research: Additional studies incorporating chemical and mineralogical analyses (e.g., XRD or SEM) may help further clarify the influence of parent rock composition on soil behaviour and inform more accurate classification and usage.
iii. Sampling of residual soils should be done at close intervals in view of fairly high values of coefficient of variation for most of the parameters determined in this study.

REFERENCES

[1] AASHTO 1986. Standard specification for transportation materials and method of sampling and testing. 14th edition. American Association of State Highways and Transportation Officials Washington, DC, USA.

[2] Adebisi, N.O. and Adeyemi, G.O., 2012. Assessment of Compressibility Characteristics of Residual laterised soils in southwestern Nigeria. Science Focus, 17 (2) 2012 pp 198-208. Faculty of Pure and Applied Sciences, LAUTECH, Printed in Nigeria.

[3] Adeyemi, G.O., Adefabi, A.A. and Abimbola, A.A., 1999. The influence of parent rocks on some engineering properties of two Laterite soils in Southwestern Nigeria. Nigerian Journal of Science Vol 33. pp. 93-101.

[4] Adeyemi, G.O., 2003. The influence of topography on some engineering and geological Characteristics of sandstone derived lateritic soil from Ishara, SW, Nigeria", Journal of Applied Science and Tech., Vol.3, pp. 1- 6.

[5] Adeyemi, G.O., and Wahab, K.A. 2008. Variability in the geotechnical properties of a lateritic. Bull Engineering Geology Environment. 67:579-584.

[6] Adyemi, G.O. 2024. Engineering Geology for Students and Professionals. 162 pp. Tallwalls Publishing Company.

[7] Agada, O.A. and Anthony, W.C., 1980. "Geotechnical Characteristics of Some Residual Soils and their Implications on Road Design in Nigeria". Technical Lecture. Lagos, Nigeria. pp. 1-16,

[8] Ajayi, L.A., 1987. Foundation in residual soil deposit of Nigeria. Soil Mechanics and foundation Engineering. 9th conference for Africa Vol 1.

[9] Amadi, A., 2010. Evaluation of Changes in Index Properties of Lateritic Soil Stabilized with Fly Ash. Leonardo Electronic Journal of Practices and Technologies. ISSN 1583-1078 Issue 17, July –Dec 2010. pp. 69-78.

[10] Goswami, R. K. and Mahanta, C., 2007. Leaching characteristics of residual lateritic soils stabilized with fly ash and lime for geotechnical applications. Waste Management, 27(4), pp. 466–481.

[11] Mesida E.A., 1985. The influence of Geological Factors on the Engineering Properties of some Western Nigeria Residual Laterite soils as Highways Construction Material. Unpublished Ph.D Thesis, University of Ife, Nigeria.

[12] Nigeria Geological Survey Agency. 2006. Generalized Geological Map of Nigeria, pp 1.

[13] Ogunsanwo O., 1989. Some geotechnical properties of two laterite soils compacted at two different energies. Technical note. Eng. Geol., Amsterdam 26, pp 261-269.

[14] Osinubi, K.J., 1998. Permeability of lime-treated lateritic soil. Journal of Transport Engineering, 124(5), pp. 465–469.