Geo-Chemical Characterization of Ekiti State Soils: Implication for Road Works

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Abstract

This research seeks to evaluate the geo chemical classification of Ekiti State Soils and examine its suitability for road works the study area was divided into three districts thus: Ekiti Central Senatorial Districts (Ekiti Southern Senatorial Districts (ESSD) and Ekiti Northern Senatorial Districts (ENSD). A total of 480 samples were obtained with 160 samples from per districts. Laboratory tests such as Chemical and Geotechnical test were analyzed. The results showed that soil index properties classified the soils of the ECSD into four classes as A-2-4, A-2-6, A-2-7 and A-7-5, the ESSD into Eight as A-2-4, A-2-5, A-2-6, A-2-7, A-4, A-5, A-6 and A-7-5 while ENSD were classified into Six classes as A-2-4, A-2-5, A-2-6,A-2-7, A-6 and A-7-6 respectively. The chemical test showed ECSD has the purest, finest and most economically valuable clay mineral among others and also grouped the districts soils into three classes as: Laterite soil, Lateritic soil and non-Lateritic soil. It is concluded that the soils found in the study area are adequate for Civil engineering works particularly samples from ECSD while other districts will also be adequate if treated with additives to improve their geotechnical properties.

Keywords:
Geo-technical Properties, Geo-chemical properties, Index properties, Laterite classification, Soil classification.

1. Introduction

The Physico-chemical properties of earth materials arise from their fabric (texture and structure) and mineralogical composition. Fabric and mineralogical compositions usually determine the response of these earth materials to events occurring during construction and operation of engineering works. The parameter, nature and efficiency of soils are addressed by engineering mechanics. Subsequently, the obtained data are analyzed and interpreted (Budhu 2007). Research on soil nature that do not consider the physico-chemical and microstructural properties of clay soilsmay be losing an essential update regarding the soil's physical and mechanical properties. This is because most physical and mechanical soil nature can be explained by the soil's physico-chemical and microstructural parameters (Bazile 2018). The chemical composition and mineralogy of lateritic soils is obtained from the composition of the host rocks through the geological process. The constituent clay minerals are bound together by the oxides and hydroxides of iron and aluminum. The cementation forms a coating for the clayey constituents of the soil and further bound them into coarser aggregations which suppress the normal behavior of clay and determines the resistance to degradation of the soil grains (Malomo 1989). Laterite soil chemistry and mineralogy is shown by studies to greatly influence the geotechnical properties, and in certain circumstances, significantly affects the economic potential in the construction industry (Ogunsanwo 1995). This is confirmed by the crystallization of accumulated sesquioxides in the pore spaces which leads to bonding of soil elements and the formation of concretionary structure (Malomo 1989). Studies reveal that mineralogy has very good correlation with the degree of weathering, as kaolinite content is high in early stages of weathering and decreases with increasing weathering, whereas the amount of sesquioxides increases. Furthermore, the silica/sesquioxide (SiO_2/R_2O_3) ratio provides a possible means of predicting the engineering characteristics of lateritic soils (Townsend et al., 1973), and the presence of iron gives it the reddish color. Generally, residual soils are composed of silica (SiO_2), aluminum oxide (Al_2O_3), iron-III-oxide (Fe_2O_3), tin oxide (TiO_2), Magnesium oxide (MgO), calcium oxide (CaO), sodium oxide (Na_2O), potassium oxide (K_2O), and copper (Cu). Others are feldspar, quartz, kaolinite, muscovite, goethite, montmorillonite and traces of other clay minerals as may be found in the parent rock underlining the laterite soil formation. However, the amount of these elements varies vertically and horizontally in any given geological formation, as while as, from region to region. An example of the influence of weathering on the chemical constituent is the iron-oxide content, which is low in the lateritic shale (skeletal arrangement) but comparatively high in the sandstone (matrix arrangement) laterites (Malomo, 1989). The aim of this study is to evaluate the geo-chemical properties of soils in these districts so as to confirm their suitability for Civil engineering works in the study area. However, few attempt has been made by previous researcher (Osuji and Akinwamide 2018), (Bayowa et al. 2014), (Okunade 2007), (Oladapo and Ayeni, 2013), (Owolabi and Aderinola 2014), (Talabi et.al. 2013 etc) to evaluate the index properties of lateritics soil found within the three senatorial districts of Ekiti state, Nigeria. This research will consequently consolidate the data requirement for a web -based geotechnical database management system for Nigerian soils as proposed by (Okunade 2010).

1.1 Location of the Study area

The location where sample materials for this study was obtained is as shown in fig3.1below

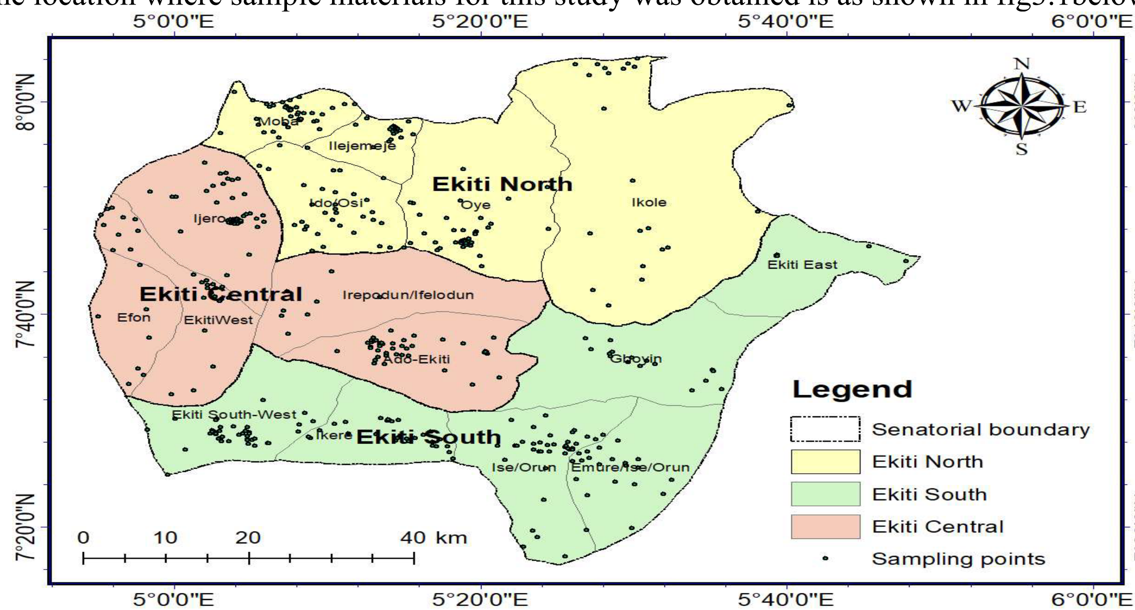

Figure1: Location of the study area– the sixteen local government area of, Ekiti State southwestern Nigeria.

1.2 Geology of the Study Area

Ekiti State is situated entirely within the tropics. It is located between longitudes 40°51′ and50°451′ East of the Greenwich meridian and latitudes 70°151′ and 80°51′ north of the Equator. It lies south of Kwara and Kogi State, East of Osun State and bounded by Ondo State in the East and in the south, with a total land Area of 5887.890sq km. Ekiti State has 16 Local Government Councils. By 1991 Census, the population of Ekiti State was 1,647,822 while the estimated population up on its creation on October 1st, 1996, was put at 1,750,000 with the capital located at Ado-Ekiti. The 2006 population census by the National Population Commission put the population of Ekiti State at 2,384, 212 people. This is under lain by crystal line rocks of Precambrian Basement Complex of southwestern Nigeria, which is also part of the Basement Complex rocks of Nigeria. They are underlain by gneisses, migmatites and meta sediments ranging from Precambrian to Paleozoicage. The lithologies vary considerably, with the following rock units such as banded gneiss, Quartzite, biotitegneiss, biotiteschist, quartz-biotite-schistand pegmatite. Banded Gneiss: This unit covers the southeastern part of the of the state. Texturally, they are medium to coarse grained with alternating bands of light and dark-coloured portions with complete gradation between them. They occur as low-lying outcrops which have been intruded by pegmatite in the southeastern corner of the area

Quartzite: These tend to form good topographic features within the state. Their elevation varies from 20 meters to about 400 metres above the sea level and formed ridges all over the state mostly around the northwestern part of the state The environment displays a hummocky nature with an average elevation of 250m above sea level. It is drained by many rivers/streams flowing dendritically towards the major rivers among them are river Elemi, Ose and Ogbese respectively. The area has tropical climate characterized by high humidity [60–80%] and mean annual rainfall (1500mm) two prominent seasons occurring the area with along rainy season of March to November and short dry season commencing towards ending of November and terminating in early March. The effects of climate change are becoming apparent with exact periods of rainfall activities becoming unpredictable.

2.0 Materials and Methods

2.1 Materials

The materials used in this study include the global positioning system device (GPS), other materials include, field notebook and data sheets, sample bags, sample labels, trowel, spade and scoop. During these fieldworks four hundred and eighty (480) disturbed soil samples were collected from borrowed pits found within the three Senatorial Districts of Ekiti State Southwestern Nigeria at the average horizon/depthof2m from the ground surface and analyzed for various index and geo chemicals properties. Index properties test were analyzed in The Federal Polytechnic Ado-Ekiti (FPA) geotechnical laboratory according to procedures and methods proposed by British Standard BS1377 (1990), the XRF analysis was carried out at Engineering Material and Development Institute Akure (EMDI). The soils were classified on the basis of their engineering behavior according to Unified Soil Classification Systems (USCS) and the America Association of State Highway and Transportation Officials (AASHO) system classification.

2.2. Methods

2.2.1 Soil Index Properties Tests

The soil index tests such as Gs, grain size analysis, Natural moisture content, and consistency limit test were all carried out in compliance with standard specified in BS 1377 (1990).

2.2.2 X-ray Fluorescence (XRF) Analysis

The bulk chemical compositions of the thirty soil samples were determined by X-Ray Fluorescence (XRF) analysis. Samples were oven-dried at 100°C for 12 hours for adsorbed water measurements. The powdered samples were then mixed with a binder (ratio of 1: 9 in grams of C-wax and EMU powder) at a ratio of 2: 9 (2-gram binder and 9 gram sample). The powder mixture was then pelletized at a pressure of 15 K bars for 1 minute. A Phillips Analytical PW1480 X-Ray Fluorescence spectrometer using a Rhodium Tube as the X-ray source was used. The technique reports concentration as % oxides for major elements.

2.2.3 Geochemical Classification of Ekiti Senatorial Districts (ESD)

Silica – Sesquioxide of Iron and Aluminum Molar Ratios (SSMR) silica/sesquioxide of iron and aluminum molar ratio for the classification of soils (Winterkorn et al. 1947) as cited in (Adeyemi 2004) and Osuji and Akinwamide (2018) have suggested the use of the silica/sesquioxide of iron and aluminum molar ratio for the classification of soils. While soils with ratio less than 1.33 were classified as true laterites, those with ratio between 1.33 and 2.00 were classified as lateritic soils and soils whose ratio is in excess of 2.00 were decided to be non-lateritic tropical soils. The Four hundred and eighty soil samples (480) were obtained from the three senatorial districts of Ekiti State, Eight (8) town were chosen from each senatorial districts twenty (20) samples was obtained per town which were later regrouped (reduced) based on their degree of laterization into Eighteen soil samples (18) as described below according to (De Graff Johnson,1972).

The first 160 soils samples were obtained from Ekiti Central Senatorial District (ECSD) were regroup (reduced) to four locations by soils classification with Silica – Sesquioxide of Iron and Aluminum Molar Ratios (SSMR) as:

a) [IY 1-20 & IFLD 1-20] as ADO-EKITI
b) [EF 1-20] as EFON-EKITI
c) [IG 1-20] as IGEDE-EKITI
d) [IPT 1-20 & ARMK 1-20] as IJERO-EKITI

The second 160 soils samples obtained from Ekiti Southern Senatorial Districts (SSD) were regroup (reduced) to eight locations by soils classification with Silica – Sesquioxide of Iron and Aluminum Molar Ratios (SSMR) as:

a) [ISE 1-20] as ISE-EKITI
b) [IKR 1-20] aa IKERE-EKITI
c) [EMR 1-20] as EMURE -EKITI
d) [ILW 1-20] as ILAWE -EKITI
e) [OD 1-20] as ODE-EKITI
f) [AIS 1-20] as AISEGBA -EKITI
g) [IMS 1-20] as IMESI-EKITI
h) [OM 1-20] as OMUO -EKITI

The third 160 soils samples were obtained from Ekiti Northern Senatorial Districts (ENSD) were regroup(reduced) to six locations by soils classification with Silica – Sesquioxide of Iron and Aluminum Molar Ratios (SSMR) as :

a) [ID 1-20] as IDO-OSI-EKITI
b) [OUT 1-20] as OTUN-EKITI
c) [ILJ 1-20] as ILEJEMEJE-EKITI
d) [OY 1-20] as OYE-EKITI
e) [IKL 1-20] as IKOLE-EKITI
f) [AYT & AYD] as AYETORO EKITI

3.0 Results and Analysis

3.1 Geo - Chemical Composition of Ekiti Senatorial Districts (ESD)

The Physico-chemical properties of earth materials arise from their fabric (texture and structure) and mineralogical composition. Fabric and mineralogical compositions always determine the response of these earth materials to situation happening during construction and activities of engineering works. Tables 1 – 3 present the results of geochemical analysis of the studied soil samples. The major oxides present in all the studied soils are silicon oxide (SiO_2), aluminum oxide (Al_2O_3), iron oxide (Fe_2O_3), magnesium oxide (MgO), manganese oxide (MnO), potassium oxide (K_2O), Calcium oxide (CaO), titanium oxide (TiO_2), sodium oxide (Na_2O) Copper (Cu), Sulphur (S), Nickel (II) Oxide (NiO), Yttrium oxide(III) (.Y_2O_3) The studied soil samples are characterized by high proportion content of SiO_2, Al_2O_3 and Fe_2O_3 and small amount of the rest oxides which also serves as impurities (associated minerals) These minerals are non-plastic when wet or harden by drying or firing; neither do they impart these properties to the clay (Mukherjee, 2013), they are any other mineral presence in the clay that does impart plasticity. They could be term impurities. The Ekiti Central Senatorial Districts (ECSD) samples show slightest occurrence of associated minerals in contrast to Ekiti Northern Senatorial Districts (ENSD) with most content of the associated minerals. This indicates ECSD as the purest, finest and most economically valuable clay mineral among others. The engineering implication of the above analysis showed that the soils found in the study area are adequate for Civil engineering works particularly samples from ECSD while other districts will also be adequate if treated with additives to improve their geotechnical properties.

Table 1: Summary of Ekiti Central Senatorial Districts Geochemical parameters

DISTRICTS ZONES				OXIDE INVESTIGATED									
EKITI CENTRAL	SiO_2	Al_2O_3	Ti_2O	Fe_2O_3	K_2O	MgO	Na_2O	MnO	CaO	Cu	S	NiO	Y_2O_3
ADO	47.3	23.2	2.6	13	0.11	0.19	0.01	0.01	0.12	ND	0.03	0.03	0.01
EFON	45.1	20.1	2.3	11.6	0.21	0.1	0.01	0.01	0.08	ND	0.01	0.01	ND
IGEDE	40	21.3	2.1	11.4	0.19	0.15	0.01	0.01	0.1	ND	ND	0.03	ND
IJERO	39.1	19.4	1.3	7.95	0.08	0.18	ND	ND	0.03	1.02	ND	0.02	0.01

Table 2: Summary of Ekiti Northern Senatorial Districts Geochemical parameters

DISTRICT ZONES						OXIDE INVESTIGATED							
EKITI NORTH	SiO_2	Al_2O_3	Ti_2O	Fe_2	K_2O	Mg	Na_2	MnO	CaO	Cu	S	NiO	Y_2O_3
IDO-OSI	42.56	29.07	0.66	25.92	0.67	0.12	0.01	0.005	0.18	0.02	067	0.03	0.03

OTUN	47.76	27.66	0.52	18.53	3.53	0.08	0.02	0.52	0.55	0.03	0.64	0.05	0.07
ILEJEMEJE	44.11	28.67	0.73	24.88	0.44	0.11	0.006	0.07	0.22	0.02	0.52	0.06	0.01
OYE	40.9	28.03	0.57	29.23	0.74	0.006	0.03	0.07	0.20	0.03	0.02	0.02	0.006
IKOLE	47.39	27.38	1.72	26.79	0.55	0.07	ND	0.10	0.15	0.02	0.05	0.05	0.03
AYETORO	28.22	27.61	1.33	23.01	0.53	0.12	0.006	0.08	0.19	0.29	0.59	0.59	0.01

Table 3: Summary of Ekiti Southern Senatorial Districts Geochemical parameters

DISTRICTS ZONES				OXIDE INVESTIGATED									
EKITI SOUTH	SiO_2	Al_2O_3	Ti_2O	Fe_2	K_2O	Mg	Na_2	MnO	CaO	Cu	S	NiO	Y_2O_3
ISE-EKITI	50.98	28.96	0.28	12.35	2.29	0.17	0.02	0.09	3.97	0.03	0.97	0.05	0.02
IKERE-EKITI	56.61	26.53	0.22	11.71	3.34	0.09	0.09	0.06	0.11	0.25	0.73	0.47	0.06
EMURE-EKITI	60.28	23.45	0.61	8.74	5.59	0.09	0.04	0.09	0.48	0.03	0.79	0.03	0.03
ILAWE-EKITI	74.05	21.67	0.36	8.74	5.07	0.13	0.04	0.09	0.28	0.03	0.22	0.58	0.01
ODE-EKITI	45.2	25.79	0.79	26.22	0.94	0.08	0.01	0.05	0.25	0.02	0.58	0.03	0.02
AISEGBA-EKITI	50.98	27.99	0.34	15.14	3.74	0.23	0.01	0.07	0.21	0.28	0.81	0.04	0.02
IMESI-EKITI	79.72	13.59	0.10	2.58	0.91	0.01	0.23	0.04	0.19	0.26	0.77	0.04	0.02
OMUO-EKITI	58.41	22.43	0.17	12.78	3.51	0.25	0.30	0.28	0.73	0.28	0.74	0.05	0.10

3.2. Classification of Ekiti Senatorial Districts Soils by Chemical Composition

Table 4 and Figure 2 present the final relative developed geotechnical -based map and their chemical composition of the Ekiti State Senatorial Districts soils which revealed the three classes of soils found in Ekiti State and their Civil engineering application.

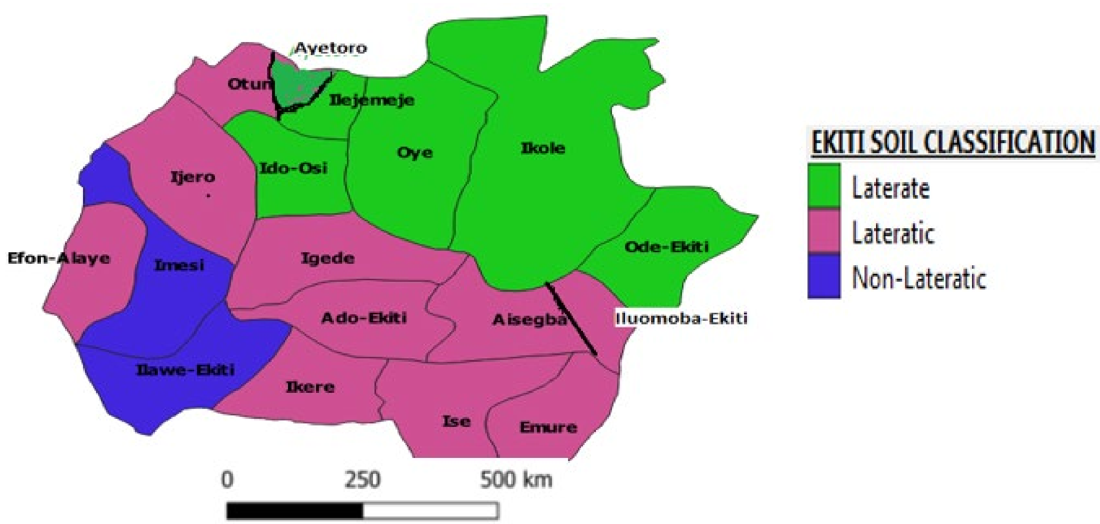

Figure 2: Geotechnical Base Map

Table 4: Summary of Ekiti State Soils classification based on chemical composition.

LONGITUDE	LATITUDE	DISTRICTS	SSMR VALUES	SOIL CLASS
	EKITI CENTRAL SENATORIAL DISTRICTS			
7.6201^{0}N	5.2242^{0}E	ADO	1.31	LATERITIC- SOIL
7.6886^{0}N	4.9244^{0}E	EFON	1.42	LATERITIC SOIL
7.6485^{0}N	5.1177^{0}E	IGEDE	1.23	LATERITIC SOIL
7.8118^{0}N	5.6675^{0}E	IJERO	1.43	LATERITIC SOIL
	EKITI SOUTHERN SENATORIAL DISTRICTS			
7.4563^{0}N	5.4332^{0}E	ISE-EKITI	1.23	LATERITE SOIL
7.4991^{0}N	5.2319^{0}E	IKERE-EKITI	1.4	LATERITIC SOIL
7.4317^{0}N	5.4622^{0}E	EMURE-EKITI	1.87	LATERITIC SOIL
7.5924^{0}N	5.1120^{0}E	ILAWE-EKITI	2.44	NON-LATERITIC
7.6500^{0}N	5.5500^{0}E	ODE-EKITI	0.87	LATERITE SOIL
7.6008^{0}N	5.4808^{0}E	AISEGBA-EKITI	1.18	LATERITIC SOIL
7.5542^{0}N	5.5872^{0}E	IMESI-EKITI	4.89	NON-LATERITE
7.6315^{0}N	5.4463^{0}E	ILUOMOBA-EKITI	1.66	LATERITIC SOIL
	EKITI NORTHERN SENATORIAL DISTRICTS			
7.8618^{0}N	5.3058^{0}E	IDO-OSI-EKITI	0.77	LATERITE SOIL
7.9903^{0}N	5.1250^{0}E	OTUN-EKITI	1.03	LATERITIC SOIL
7.9593^{0}N	5.2380^{0}E	ILEJEMEJE-EKITI	0.82	LATERITE SOIL
7.7988^{0}N	5.3286^{0}E	OYE-EKITI	0.71	LATERITE SOIL
7.7983^{0}N	5.5145^{0}E	IKOLE-EKITI	0.87	LATERITE SOIL
7.7617^{0}N	5.7249^{0}E	AYETORO-EKITI	0.56	LATERITE SOIL

Its analysis reveals that Ekiti State Soils is sub divided into three types namely (Laterite soil, Lateritic soil and non-Lateritic soil) as shown in figure 1. From the foregoing, the geochemical classification has showed that, Ekiti Central Senatorial Districts (ECSD) soils are predominantly lateritic soils only and Ekiti South Senatorial Districts (ESSD) soils has shown that the three types of soils discovered in this research work can be found in the Southern Senatorial Districts as Laterite soil, Lateritic soil and Non-Lateritic soil while Ekiti State Northern Senatorial Districts (ESNSD) has also showed that two out of the three soils discovered were found in the Northern Districts as Laterite soil and Lateritic soil. However, it is noteworthy that in terms of volume of material ESCD has the highest follow by ESSD while ESND has the lowest quantity of lateritic soil conversely, this research also established the ESNSD has the highest volume of laterite soil followed by ESSD while ESCSD has none. Also, this research has shown that only ESSSD has the third type of soil, non-Lateritic soil. The geotechnical implication of the above analysis is that Lateritic soils materials constitute the most common materials for the construction of earth dams, highways, embankments, airfields as well as foundation materials to support structures for future Civil engineering sub-structures and super structures in the ESCSD and it will also serve as economy boost for people around these districts. Conversely, Laterite soils are highly weathered soils rich in secondary oxide of iron, alumina or both.it contain large amount of quartz and Kaolinite it’s not uniquely identified with any particular parent rock. They constitute the most common material in ceramics industry, production of compressed earth block in construction industry and low volume road with adequate compaction effort these properties will make suitable for use in the near future particular for investors who might need such raw materials for production of their finished goods.

4. Conclusions

Geo-chemical classification of Ekiti state soils: implication for road works was evaluated**.** A trial pit 1-2 m deep was excavated and 480 samples of undisturbed soils was obtained for laboratory tests. From the results obtained and findings the following conclusions are drawn.

The studied soil samples are characterized by high proportion content of SiO_2, Al_2O_3 and Fe_2O_3 and small amount of the rest oxides which also serves as impurities (associated minerals) for all the three districts' soils. The Ekiti Central Senatorial Districts (ECSD) samples show slightest occurrence of associated minerals in contrast to Ekiti Northern Senatorial Districts (ENSD) with most content of the associated minerals. This indicates ECSD as the purest, finest and most economically valuable clay mineral among others.

The Geo-chemical classification analysis reveals that Ekiti State Soils is sub divided into three types namely (Laterite soil, Lateritic soil and non-Lateritic soil). The classification shown that, Ekiti Central Senatorial Districts (ECSD) soils are predominantly lateritic soils and Ekiti South Senatorial Districts (ESSD) soils showed that the three types of soils discovered in this research work can be found in the Southern Senatorial Districts as Laterite soil, Lateritic soil and Non-Lateritic soil while Ekiti State Northern Senatorial Districts (ESNSD) has also showed that two out of the three soils discovered were found in the Northern Districts as Laterite soil and Lateritic soil. However, it is noteworthy that in terms of volume of material ESCD have the highest follow by ESSD while ESND has the lowest quantity of lateritic soil conversely, this research also established the ESNSD has the highest volume of laterite soil followed by ESSD while ESCSD has none. Also, this research has shown that only ESSSD has the third type of soil, non-Lateritic soil.The research has shown data obtained and applied in this work in the development of Geo-based map for Ekiti State Senatorial districts soils as well as analysis performed through specific tools for information manipulation.It's concluded that the Geo-chemical database developed will allow geographical understanding of geology, lithology, pedology, and declivity, as well as geotechnical mapping, thus in-forming geotechnical engineering properties of subsurface soils for many uses in the planning and execution of engineering services within the study area.

References

AASHTO, Standard Specifications for Transportation Materials and Methods of Sampling and Testing. U.S America, 2004.

Adeyemi, G. O., and Salami, R., Some Geotechnical Properties of Two Termite-reworked Lateritic Soils from Ago-Iwoye, Southwestern Nigeria, Mineral Wealth: The quarterly publication of the Scientific Society of the Mineral Wealth Technologists, Athens. Vol. 133, 35 – 41, 2004.

Bayowa, O.G. Olorunfemi, O.M. Akinluyi, O.F., andAdemilua, O.L.,A Preliminary Approach to Groundwater Potential Appraisal of Ekiti State, Southwestern Nigeria. International. *Journal of Science. and Technology.* Vol. 4, No. 3, pp. 48-58, 2014.

Budhu M., Soil Mechanics and Foundations. 2nd Ed. Hoboken, NJ: Wiley; P 656

De Graft-Johnson, J. W. S., Lateritic Gravel Evaluation of Road Construction. *Journal of soil Mech Div Amst Soc Civil Eng,* 98, 1245–1265, 1972.

Malomo, S.,Microstructural Investigation on Laterite Soils.Int. Asst. of Eng. Gel. Bull. Vol. 39, pp. 105 – 109, 1989.

Mukherjee S.,The Science of Clays: Applications in Industry, Engineering and Environment, ISBN DOI 10.1007/978-94 -007- 6683 9¬ (e – book), 2013.

Nazile., The Importance of Clay in Geotechnical Engineering. Current Topics in the Utilization of Clay in Industrial and Medical Applications, 2018.

Ogunsanwo, O. L., Influence of Geochemistry and Mineralogy on the optimum geotech. Utilization of some laterite Soils from SW Nigeria. *Journal. Ming and Geol*, Volume31, 2: pp. 183 – 188, . 1995.

Okunade, E.A.,Eng. Properties of Lateritic Adobe Bricks for Local Bldg. Construction and Recommendations for Practice. *J. of Eng. and Applied* Sci. Vol. 2 No 9. pp.1455-1459, 2007.

Okunade, E.A., Design and Implementation of a Web-Based Geotech. Database Mgmt. System for Nigerian Soils. Modern Applied Sci. Vol. 4. No. 11. pp. 36-42, 2010.

Oladapo, M. I., and Ayeni, O. G., Hydro Geophysical Investigation in Selected Parts ofIrepodun LG. Area of Ekiti State, South West Nigeria. *J. of Geol. and Ming Research*. Vol. 5, No 7, pp. 200-2007, 2010.

Osuji O.S., and Akinwamide J.T., Physico-Chemical Properties of Lateritic Soils in Ado-Ekiti, South Western Nigeria. *Universal Journal of Environmental Research and Technology,* Volume 7, Issue 1: 10-18, 2018.

Owolabi, T.A., and Aderinola, O. S., Geotech.Evaluation of Some Lateritic Soils in Akure South, Southwestern Nigeria. *Electronic Journal .of Geotech. Eng.*Vol. 19, pp. 6675-6687, 2014.

Talabi, A. O., Ademilua, O. L., Ajayi, O. Z. and Oguniyi, S. O..Preliminary Geophysical Evaluation of Orin Bauxite Deposit, SW Nigeria. *J. of Emerging Trends in Eng*. and Applied Sci. Vol. 4, No 3, pp. 432-437, 2013.

USCS, ASTM Standard D2487, "Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)," ASTM International, West Conshohocken, PA, 2000, DOI: 10.1520/D2487-00, 2000. www.astm.org

Winterkorn, H. P., and Tschebotarioff, G. T., Sensitivity of Clay to Remolding and its Possible causes: Highway Res. BoardI'roc. pp. 435-442, 1947.

Biography

Engr. Akinwamide Joshua is a Ph.D. Researcher in the Department of Civil Engineering University of Benin, Edo-State Nigeria, with a broad knowledge in geotechnical engineering/Civil Engineering Materials. He is a lecturer at the Federal Polytechnic, Ado-Ekiti, Ekiti -State Nigeria. He is a Registered Civil Engineer by Council of Regulation of Engineering in Nigeria (COREN). A corporate Member Nigerian Association Technologist in Engineering (NATE). He holds M. ENG in Geotechnical Engineering. He has over 15years working experience as a Geotechnical engineer and Quality Control and Quality Assurance Specialist.as a researcher he has publish over 15 papers in peer-reviewed journals, conferences and workshops at both local and international level

Engr. Prof. Jacob Odeh Ehiorobo is a professor of applied geomatic, Water resources and environmental system engineering. He is a professor in the Department of Civil Engineering, University of Benin, Edo- State Nigeria. He has held several administrative positions in the university such as Dean of Faculty of School of Environmental, Director of External Linkage for the University and Deputy Vice Chancellor Administration. Upon graduating with Bsc, Msc and PhD as a prolific researcher he has publish over 100 papers in peer-reviewed journals, conferences and workshops at both local and international level.Engr. Prof. Jacob Odeh Ehiorobo research interest includes: Deformation Surveys and Analysis, Precise engineering surveys, GNSS Positioning and Geodetic Surveys . Remote sensing and GIS Applications in Disaster Monitoring and Control, Water Resources Modelling and Environmental Hazards Analysis, Highway and Transportation including Automatic Vehicle location.

Engr. Prof. Sylvester Obinna Osuji is a Professor of Structural engineering in the Department of Civil engineering, University of Benin, Edo-State Nigeria and currently a Visiting Professor on Accumulated Leave at the Department of Civil Engineering, College of Technology, Federal University of Petroleum Resources, Effurun, Delta State, Nigeria. Engr. Prof. Sylvester Obinna Osuji hasheld several administrative position in the University of Benin, Edo-State such as : Head of department of Civil Engineering, Sub -Dean School of Engineering and Deputy Director procurement for the University of Benin. Upon graduating with BSC Civil engineering, M.ENG Structural engineering and PhD in structural Engineering. He has published more than 70 papers in peer-reviewed journals,conferences and workshops at both local and international level.Engr. Prof. Sylvester Obinna Osujiis also a practicing lawyer who holds LLB (Law), (University of Benin, Benin City, Nigeria) – 2006, B.L., (Nigerian Law School, Abuja) – 2007and L.L.M (Masters of Law) (University of Benin, Benin City, Nigeria) – 2009.

Engr. Dr. Ebuka Nwankwo is an associate professor in the Department of Civil Engineering, faculty of Engineering University of Benin. Dr Nwankwo graduated with a first-class honour in Civil Engineering in 2005 from the Federal University of Technology Owerri. After spending some time in the industry, Dr Nwankwo proceeded for his MSc and PhD in Structural Engineering from the Imperial College London. In 2014, he was awarded a PhD from Imperial College. Dr. Nwankwo has published over 35 articles in peer review journals. Dr Nwankwo has been a visiting researcher at the University of Liverpool. He is COREN registered and member of the Nigerian Society of Engineers (NSE). He has been involved in the training and mentoring of young engineers for NSE. He has a wide range of experience in civil engineering design and project management. He has been called up to give his expert opinions on my projects within and outside Nigeria. Dr Nwankwo has also worked as professional structural engineer in Paris. He has been involved in the design of high-rise structures and geotechnical investigations for civil infrastructure.