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Soil Characterization and Classification on Varying Lithology in Imo State South Eastern, Nigeria

Christopher Ikechi OBINECHE[1*], Patricia Akunna ORIAKU[2], Nkechi Udochukwu EZECHIKE[3], Chinwendu Augustina OJIAKU[4], Pamela Ndidi EZEIGWE[5]

[1, 5]Department of Agricultural Engineering Technology, Federal College of Land Resources Technology, P.M.B. 1518 Owerri, Nigeria.

[2,3,4]Department of Soil Science Technology, Federal College of Land Resources Technology, P.M.B.1518 Owerri, Nigeria

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Abstract:
The field study was carried out in Okigwe South-eastern Nigeria. Three profiles were sunk in soils of each of each parent material. Soil samples were subjected to routine and standard laboratory analysis for selected physic-chemical properties. The morphological and physic-chemical properties of the soils varied widely, sand-size particles dominated other particle sizes with the mean values of 448g/kg, 538g/kg, 648g/kg on sandstone, while soils derived from Imo clay shale were 738g/kg and 578g/kg Amuro, 1 and 2, respectively. Clay in Imo shale was highest at Amuro pit 2, 312g/kg and 416g/kg Nihort 1 of false-bedded sandstone. The highest value of bulk density was recorded in Nihort 1, 15g/kg, and 16g/kg Amuro 1, respectively. All the pedons exhibited sandy clay loam on topsoil and relatively more clayey subsoil. The pH of the soil varied from very strong acidic (pH 4.5) to slightly acidic (pH 6.2) in all the soils, except for Amuro pit 2 which had moderately alkaline to strongly alkaline pH 7.9 – 9.05. The pH of the soil varied from very strong acidic to slightly acidic in all the soils, except from Amuro pit 2 which had moderately alkaline to strongly alkaline. Amuro pit 2 had high base saturation 98.0% with no exchangeable aluminum. Others had low to moderate base saturation. Cation exchange capacity was highest at Amuro 1. Moderate to low organic matter and variation was recorded in Amuro 2 except for clay, organic matter, and Ca: Mg ratio. Soils from Nihort 1,2 and 3 and Amuro were classified as class II of the USDA capability classification system. It is observed that the soils of the two parent materials sustains agricultural yield if proper land use practice is adopted.

Keywords: *Classification, Soil, Physiochemical properties, Imo clay shale, false bedded sandstone*

1. INTRODUCTION

Soil is a vital resource for producing the food and fibre needed to support an increasing world population (Pappendick and Parr,1992). Soil is a dynamic resource that supports plant life. It is made of different-sized mineral particles, organic matter, and numerous species of living organisms. Thus, the soil has biological, chemical, and physical properties, some of which are dynamic and can change in response to how the soil is managed. Soils are classified as natural bodies on the basis of their profile characteristics (Brady and Weil,1999). Soil quality is the capacity of a specific kind of soil to function, within natural or managed ecosystem boundaries, to sustain plant and animal productivity, maintain or enhance water and air quality, and support human health and habitation. Changes in the capacity of the soil to function are reflected in soil properties that change in response to management or climate. Its production can be limited by the factors such as soil characteristics, agro-ecological factors, topography, parent material, land use, and management among others. To avert this limitation, the need for a systematic appraisal of the soil resource with respect to their extent, distribution characteristics, behavior, and nutrient status is crucial for developing a productive and sustainable agricultural system

Most farmers in south-eastern Nigeria regard the soil to be the same in every aspect because they are all the same based on geographical location. Igwe (2003) posit that most soils in southeastern Nigeria are not classified but are utilized in land use activities leading to water erosion. Onweremadu (2007) stated that characterization and classification of soil of any given location help in generating soil-related data which are useful in proper and sustained use of soil resource. There is an increasing demand for information on soils as a means to produce food. Agriculture is the predominant economic activity in Nigeria and because of agricultural development and increasing demand for experimental data in Nigeria, much work is carried out on soil characterization. This provides the basic information necessary to create functional soil classification schemes and assess soil fertility in order to unravel some unique soil problems in an ecosystem (Lekwa,1998). The coupling of soil characterization, soil classification, and soil mapping provides a powerful resource for the benefit of mankind, especially in the area of food security and environmental sustainability. This is only possible if there is adequate information on the physicochemical properties of the soil type in question. Too frequently, farmers and other land uses in southeastern Nigeria have treated or handled the soils of this sub-region in a similar manner, wrongly believing that all the soils are the same. This wrong notion and approach has often led to seriously low return on investment, both for agricultural production and other land use types. Based on the notion, the study, therefore, focused on the characterization and classification of soil on varying lithology in Southeastern Nigeria for sustainable agriculture for food security. The major objective of this research is to characterize and classify soils derived from two different parent materials using the USDA Soil Taxonomy and World Reference Base (WRB) and the specific objectives includes to estimate the degree of variability of soil properties among the different soil groups and to establish the degree of relationship among soil properties in the various soils in the study area.

2. MATERIAL and METHODS

The study area is Okigwe Imo Southeastern Nigeria state. It is located on latitudes (50 45'N – 60 00'N), longitudes (70 15'E – 70 30'E), and with an altitude of about 300m and above. Soils of the area are derived from false bedded sandstones (Ajali Formation) of the Maastrichtian geologic era and proximal to the upper coal measures (Nsukka Formation) of the Danvan geologic era and Imo Clay shale

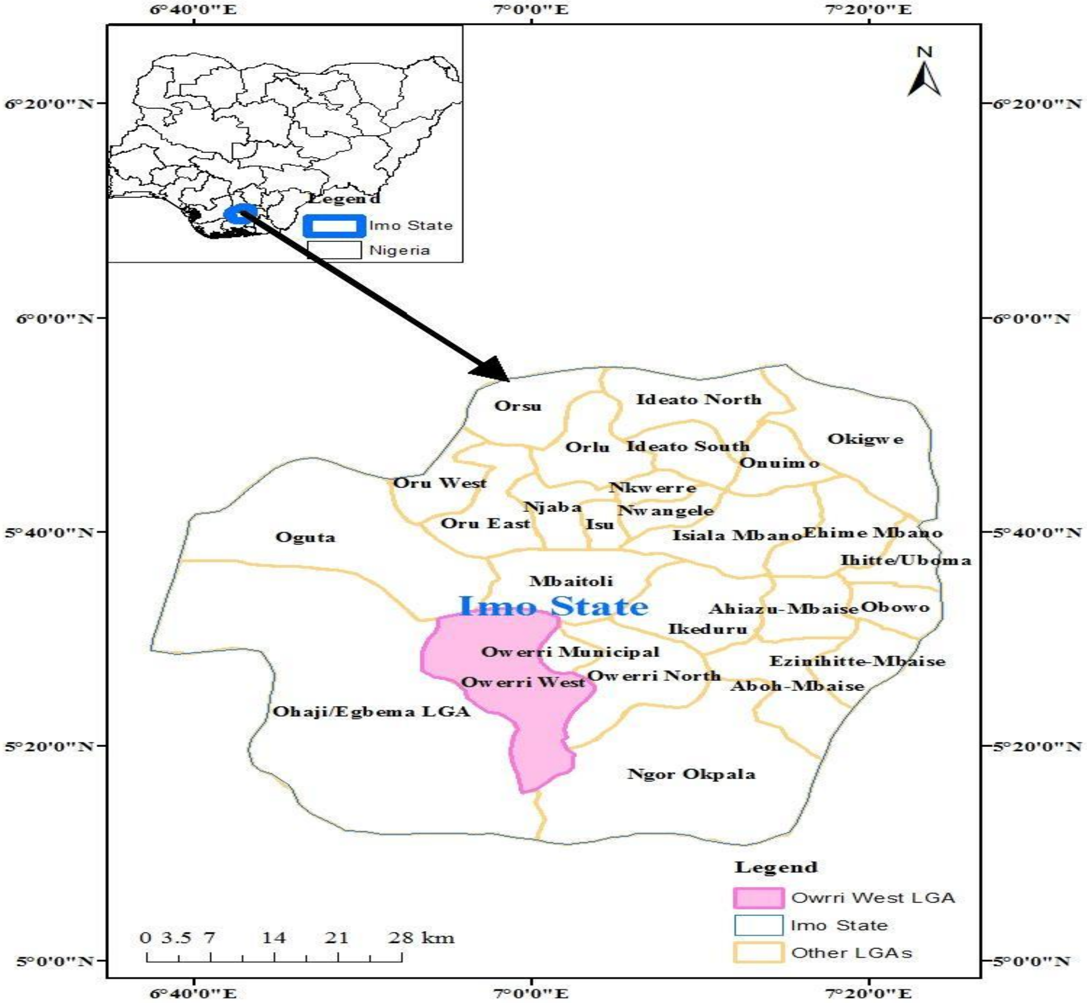

Figure 1: location map of the study area

2.1. Geology of the Area

The study area is a complex geological environment in imo state. The following stratigraphic units underlie the area: the Benin Formation, the Ogwashi – Asaba Formation, the Bende – Ameki Formation, Imo Shale Formation, Nsukka Formation, and Ajali Formation (Nwosu et al., 2010). The Benin Formation is overlain by lateritic overburden and underlain by the Ogwashi _ Asaba Formation which is in turn underlain by the Ameki Formation of Eocene to Oligocene age. The Benib Foramtion consists of coarse-grained gravelly sandstones with minor intercalations of shales and clay. The sand units which are mostly coarse-grained; pebbly and poorly sorted contain lenses of fine-grained sands (Onyeaguocha, 1980). The rainy season starts in April and ends in October with a peak in June and July while the dry season last from November to March.

2.2. Fieldwork

A reconnaissance visit was made to the study area, and materials such as location map, topographic map, geology maps, and Munsell colour chart were used hand-held global positioning system (GPS) receiver (Gamin Ltd Kansas) was used to georeference sampling site. A free soil survey technique was used to locate the sampling point from the two geological formation of the study area. The following were the study site located, False bedded sandstone (NIHORT 1, NIHORT 2, NIHORT 3) and Imo Clay shale (Amruo 1 and 2).

Table 1. Geo-location of sampled sites

Position	Latitude(N)	Longitude (E)	Elevation (m)
NIHORT 1	5^0 52. 67'N	7^0 18.47'	156
NIHORT 2	5^0 52. 68'N	7^0 18.54'	153
NIHORT 3	5^0 52. 87'N	7^0 18.54'	153
AMURO 1	5^0 47. 09'N	7^0 16.29'	129
AMURO2	5^0 48. 25'N	7^0 18.44'	101

2.3. Sample Collection and preparation

Soil profiles were described according to FAO (1989) procedure. A total of five profiles were sunk, three on each parent material. Delineation of horizon boundary was accomplished before actual sample collection. Soil samples collection was based on horizon differentiation. The samples collected were stored in polythene bags and labeled. Samples were air-dry and sieved using a 2 mm sieve preparatory to various laboratory analyses.

2.4. Laboratory Analyses

The soil samples were analysed for certain selected properties that are necessary for proper scientific classification of the soils. These include physical properties such as particle size distribution, bulk density, and hydraulic conductivity. Chemical properties such as soil pH, exchangeable bases (Ca^{2+} Mg^{2+} K^+ Na^+) exchangeable acidity (Al^{3+} and H^+), total nitrogen, available phosphorus, and organic carbon. The particle size distribution was determined by the hydrometer method according to the procedure of (Gee and Or, 2002), silt clay ratio was obtained by calculation, and soil moisture content was determined gravimetrically by weighing an oven drying soil sample collected from the field at 105^0c until a constant weight was attained (Obi,1990), Bulk density was determined using the core samplers according to the procedure of (Grossman and Reinsch, 2002), soil pH was determined using distilled water on Beckman Zeromtic pH meter using a glass electrode at a 1:2:5 soil water ratio (Thomas, 1996), exchangeable acidity and organic carbon(OC) was determined by an unbuffered saturated solution such as in KCL at the pH of the soil (Mclean,1982) and Walkey and Black wet oxidation method (Nelson and Sommer,1982) respectively. Exchangeable bases (Ca, Mg, K, Na) was determined from the soil in 1 m ammonium acetate solution (Thomas, 1996), and soil organic matter was determined by calculating % organic matter = % organic carbon x 1.724, where 1.724 = correlation factor (Van Bemelies constant factor), exchangeable potassium and sodium in the extract was determined by the use of flame photometric method while calcium and magnesium was determined using ethylene diamine tetra acetic acid titration method (EDTA). Total nitrogen and available phosphorus was determined using Micro-Kjedahl digestion method and Bray 11 method (Olsen and Sommers, 1982) respectively, effective cation exchange capacity (ECEC) was determined using summation of all exchangeable bases and acidity (Carter, 1993), total exchangeable base (TEB) was determined by summation of all the exchangeable bases, percentage base saturation was determined using the formula: percentage base saturation $=\frac{TEB}{CEC} X\ 100$.

Aluminum saturation was calculated using the formula$\frac{AL}{CEC} x\ 100$. Soil classification and properties of soils was classified according to USDA soil Taxonomy and World Reference Base for soil Resources.

2.5 Data and Statistical Analyses

Data collected were subjected to simple descriptive statistics, means, standard deviation, and coefficient of variation (CV). Variability of soil properties on the two parent materials was estimated using the coefficient of variation. Ranking of variability and sample regressions was performed using (Wilding, 1985). Correlation analyses of the model $Y=a + b_1 X_1 + b_2 X_2 + b_3 X_3 + \ldots\ldots\ldots + b_n X_n + U$ was used.
Where Y = dependent variable, a = intercept (constant), b = slope, X = independent variable, U = stochastic factor.

Coefficient of variation as ranking according to Wilding (1985)

Level %	Ranking
CV < 15	Low Variation
CV 15 – 35	Moderate Variation
CV < 35	High Variation

2.6 RESULTS and DISCUSSION

The result of soil texture is shown in table 4.0. This indicates that the soil texture ranges from sandy loam to sandy clay loam in Amuro 1 and Amuro 2. This is in line with the work of Eshett (1985), who observed that the texture of surface horizons of soils in humid tropics is dominantly loamy sand to sandy loam. Sharato et al, (2002) posit sandy clay loam on shale parent materials in the lower Benue valley of Makurdi which is in accordance with the sandy clay loam reported for Amuro 2 of the Imo Clay shale while Amuro 1 had a uniform sandy clay loam texture throughout the profile. The matrix colors at the topsoil (A horizon) were darker than the subsoil. This may be attributed to the low organic matter content which decreases down the profile. The soil moisture content mean values for Amuro 1 and 2 were 65 g/kg and 99 g/kg, there an increase in moisture content in Amuro 2, hence Oikeh et al (1998) reported the same trend of increment due to high water and clay content down the profile in Guinea savanna zone of Nigeria. While NIHORT 1, 2, and 3 has no definite distribution pattern of moisture content as clay content increased at the subsoil of the profile but low at the top, increasing down the profile before decreasing in the last horizon. Ohiri et al (1985) and Sharato et al (2002) posit similar conclusions in their various studies. Highest mean value of bulk density was recorded in Amuro 1 (16.0 g/kg) when compared with the soils of Imo clay shale and false bedded sandstone.

Table 4.0 Morphological Characteristics of soils of the research site

Horizon	Depth (cm)	Matrix colour	Texture	Structure	consistency	Drainage
Amuro 1						
A	0 - 17	Dull Reddish Brown (5 YR 5/4)	SCL	Sbk	Firm	Wd
AB	17 -79	Dull Orange (7.5 YR 6/4)	SL	Sbk	Firm	Wd
Bt1	79 - 98	Dull Orange (7.5 YR 6/4)	SL	Sbk	Firm	Wd
Bt2	58 - 125	Light Brown Grey (5 YR 7/2)	SL	Sbk	Firm	Wd
Bt3	125 - 160	Dull Yellow Orange (10 YR 7/3)	SL	Sbk	Firm	Wd
Amuro 2						
A	0 -26	Dull Orange (7.5 YR 6/4)	SCL	Sbk	Firm	Pd
AB	26 - 60	Dull Orange (7.5 YR 6/4)	SCL	Sbk	Firm	Pd
Bt1	60 - 100	Dull Orange (7.5 YR 6/4)	SCL	Sbk	Loose	Pd
Bt2	100 - 140	Dull Orange (7.5 YR 6/4)	SCL	Sbk	Firm	Pd
Bt3	140 - 160	Dull Orange (7.5 YR 6/4)	SCL	Sbk	Loose	Pd
NIHORT1						
A	0 - 15	Reddish Brown (5 YR 4/3)	SCL	Sbk	Loose	wd
AB	15 - 45	Yellowish Red (5 YR 4/6)	SCL	Sbk	firm	wd
Bt1	45 - 80	Red (2.5 YR 4/8)	C	Sbk	firm	wd
Bt2	80 - 120	Red (2.5 YR 5/8)	SL	Granular	firm	wd
Bt3	120 - 180	Red (10 YR 4/8)	SL	Sbl	firm	wd
NIHORT2						
A	1-18	Very Dark Brown (7.5 YR 2.5/3)	SCL	Sbk	loose	wd
AB	18 - 50	Dark Brown (7.4 YR ¾)	SCL	Sbk	firm	wd
Bt1	50 - 75	Red (10 YR 4/6)	SL	Granular	firm	wd
Bt2	75 - 120	Red (2.5 YR 8/8)	SCL	Sbk	firm	wd
NIHORT3						
A	1- 20	Very Dark Brown (2.5 YR 2.5/2)	SCL	Sbk	firm	wd
AB	20 - 60	Very Dark Brown (7.5 YR 4/3)	SCL	Sbk	firm	pd
Bt1	60 - 90	Brown (7.5 YR 4/3)	SCL	Granular	firm	Pd

Table 4.1 Physical properties of some soil derived from false bedded sandstone

	Depth (cm)	soil moisture content(smc)	Sand	silt (g/kg)	Clay	Textural class	silt/clay ratio(g/kg)	Bulk density (mg/m^3)	soil hydraulic (g/kg)
				NIHORT 1 (false bedded sandstone)					
A	0 – 15	62.6	628	120	252	SCL	0.48	14.7	0.3
AB	15 - 45	96.5	508	160	332	SCL	0.48	14.9	0.2
B1	45 - 80	80.9	328	80	592	C	0.13	16.9	0.2
B2	80 - 120	62	388	140	472	SC	0.29	14.2	0.9
B3	120 - 160	64.4	388	180	432	SC	0.41	15.5	1.4
Mean		73.7	448	136	416		0.36	15	0.7
				NIHORT 2 (false bedded sandstone)					
A	1-18	118.1	648	80	272	SCL	0.29	13.4	0.19
AB	18 - 50	95.2	468	100	432	SC	0.23	15.1	0.12
B1	50 - 75	76	368	160	472	SC	0.33	13.9	0.13
B2	75 - 120	113.3	668	20	312	SCL	0.38	15	0.23
Mean		100	538	90	372		0.3	14	0.2
				NIHORT 3 (false bedded sand stone)					
A	1-20	73.7	628	100	270	SCL	0.37	14.3	0.12
AB	20 - 60	92	728	60	210	SCL	0.28	14	0.24
B	60 - 90	112.1	588	140	272	SCL	0.51	13.9	0.13
Mean		93	64.8	100	251		0.44	14	0.2

=sandy loam, C = clay, LS = loamy sand, SCL = sandy clay loam

Table 4.2 Physical properties of soil derived from Imo Clay Shale

Horizon	Depth (cm)	Soil moisture content (smc)	Sand	Silt	Clay	Textural	Silt/clay ratio	Bulk density(mg/m^3)	Soil hydraulic conductivity (g/kg)
AMURO 1									
A	0 – 17	66	750	80	190	SCL	0.42	14.9	15.4
AB	17 – 79	59.8	750	70	180	SL	0.38	16.1	13.1
B1	79 – 98	35.4	750	90	160	SL	0.58	17.0	2.2
B2	98 – 125	112.2	650	50	300	SL	0.16	16.5	64.7
B3	125 - 150	56.1	790	30	160	SL	0.18	16.1	0.6
Mean		65	730	64	198		0.3	16	19
AMURO 2									
A	0 – 26	82.2	580	90	310	SCL	0.29	12.3	0.5
AB	26 – 60	104.2	580	90	310	SCL	0.29	12.4	0.5

B1	60 – 100	111	580	110	330	SCL	0.33	13.2	1.4
B2	100 - 140	100.9	560	100	310	SCL	0.32	13.5	1.4
B3	140- 160	92.7	590	110	300		0.36	13.9	3.8
Mean		99	578	100	312		0.3	13	1.52

SL = sandy loam, C = clay, LS = loamy sand, SCL = sandy clay loam

2.7 Results of Some Chemical properties of the soils

The result of the chemical properties of the soils of clay shale and sandstone are shown in tables 4.3 and 4.4. The soil pH ranged from 5.85 – 9.05 and mean values of 6.2 – 8.5, according to Eshett (1985) a similar observation was achieved (4.1 – 8.5) on soil overlying shale parent materials at ofonatam village in Cross River State Nigeria. Organic carbon content values ranges from 12 – 13 g/kg while having the highest value of 33.4 g/kg in Amuro 1. This is in accordance with Igwe (2003) who posit that when soils erode negative soil properties such as crusting, nutrient depletion, and loss of organic matter occur. In sandstone, the highest value was seen at the surface horizon of NIHORT 1 and 2 except in NIHORT 3. Percentages mean value of total nitrogen in all the pedon in clay shale 0.8 – 1.0 g/kg, Onweremadu et al (2007) reported 12 to 220 g/kg in the selected topsoils in Imo State. The low TN content is due to high nitrogen losses sustained through the leaching of nitrates. Sandstone recorded same low value; this may be because the total nitrogen has a structural relation with organic matter with a large quantity of nitrogen derived from it. The organic matter content of Imo clay shale was high at the topsoil and in sandstone, the mean value were between 13 – 24 g/ kg. The C/N ratio of clay shale has mean values of 11.2 and 14.5 %, C/N ratio value had an irregular distribution pattern at all physiographic position. While the sandstone mean values were between 12.3 – 13.0 %. Onweremadu and Anikwe (2007), reported a range of 9 – 16% of C/N ratio on soils of the shale of Isienyi Ibeku. This is attributed to the influence of plant residues while the low value at the subsoil can be posit to the fact that soil organic matter becomes closely bound to the mineral matter. The Available phosphorus means value of Imo clay shale and false bedded sand stone ranges from 3.2 – 15.7 mg/kg and 2.2 – 3.3 mg/kg. The mean values of total exchangeable bases (TEB) in the clay shale and the sand stone are 2.2 – 18.9 cmol/kg and 3.8 – 5.5 cmol/kg, while the exchangeable calcium and sodium mean values of the clay shale 0.8 – 9.1 cmol/kg and 0.4 – 1.3 cmol/kg and for sand stone mean values are 2.6 – 2.9 cmol/kg and 0.1 – 0.2 cmol/kg, hence there was no definite trend in both soils as recorded by Onweremadu (2007) who observed such for top soils of selected towns in Imo State. The magnesium mean values of the clay shale are 0.09 – 9.2 cmol/kg and 1.2 – 2.0 cmol/kg for sand stone. The mean value of effective cation exchange capacity of clay shale ranged from 4.1 – 19.1 cmol/kg, while sand stone is from 5.8 – 6.9 cmol/kg, respectively. The mean value of Ca/Mg ratio ranges from 0.5 – 10.5 mg/kg for clay shale and 1.3 – 2.0 mg/kg for sand stone. According to Landon (1991) Ca: Mg ratios less than 3.0 negatively influence calcium and phosphorus availability in the soil, Also the base saturation mean value ranges from 54 – 97 % for clay shale and 59.3 – 79.3 % for sand stone respectively

Table 4.3 chemical properties of soils derived from false bedded sandstone of NIHORT

Horizon	Depth (cm)	pH (H2O)	KCL	O.C	O.M	T.N	C:N Ratio	TEA	AL	H	Ca	Mg	K	Na	TEB	ECEC	BS %	Ca:Mg Ratio	K:Mg Ratio	Avl.P (g/kg)
			→	g/kg	←						→		Cmol/kg	←						
A	0 -15	5.08	3.71	30.3	52.2	0.26	11.6	2.4	0.9	1.5	3.5	1.4	0.22	0.11	5.23	7.31	73.3	2.5	0.15	9.37
AB	15 -45	4.96	3.6	10.4	17.8	0.08	13.0	1.4	1.0	0.4	3.2	1.6	0.16	0.09	5.05	6.45	78.2	2.0	0.11	2.82
Bt1	45 -80	5.67	3.47	6.8	11.2	0.05	13.6	2.7	1.4	1.3	1.6	1.0	0.15	0.12	2.87	5.61	51.8	1.6	0.15	1.49
Bt2	80 – 120	4.34	3.72	6.7	11.6	0.05	13.4	1.5	0.9	0.7	2.6	1.2	0.26	0.19	4.25	5.75	73.9	2.1	0.12	2.34
Bt3	120 – 160	5.79	3.59	6.7	11.6	0.05	13.4	0.6	0.4	0.2	2.2	1.2	0.15	0.07	4.25	4.2	85.7	1.8	0.12	0.96

mean		5.1	3.6	12.0	24.0	0.1	13.0	1.6	0.9	0.8	2.6	1.2	0.2	0.1	4.3	5.8	59.7	2.0	0.13	3.3
A	1 – 18	5.11	3.72	14.6	25.1	0.12	12.6	2.2	1.2	1.0	3.0	1.2	0.24	0.1	4.54	6.74	67.3	2.5	0.2	4.68
AB	18 – 50	5.74	4.41	7.4	12.7	0.06	12.33	1.8	1.2	0.6	1.8	1.2	0.25	0.12	3.37	5.17	65.1	1.5	0.2	1.69
Bt1	50 – 75	5.67	3.57	14.9	25.7	0.12	12.41	2.0	1.2	0.8	3.8	2.2	0.24	0.15	6.39	8.39	76.1	1.7	0.1	2.16
Bt2	75 – 120	5.13	3.72	12.4	21.3	0.1	12.41	1.9	0.9	1.0	3.2	1.6	0.26	0.12	5.18	7.17	73.5	2.0	0.16	2.87
mean		5.4	3.8	12.0	21.0	6.1	12.3	1.9	1.1	0.8	2.9	1.5	0.2	0.1	3.8	6.8	70.5	1.9	0.2	2.2
A	1 – 20	4.33	3.27	5.5	9.6	0.04	13.75	0.8	0.3	0.5	1.8	1.4	0.23	0.14	3.57	4.37	81.6	1.2	0.16	1.42
AB	20 – 60	5.21	4.73	14.2	24.4	0.12	11.8	0.9	1.0	0.9	3.5	2.6	0.32	0.21	6.63	8.53	77.7	1.3	0.14	2.66
Bt1	60 – 90	5.28	4.89	12.4	21.3	0.1	12.4	1.7	1.1	0.6	3.66	2.2	0.29	0.22	6.37	8.01	78.7	1.66	0.13	2.54
mean		4.9	4.3	12.0	13.0	0.08	12.6	0.6	0.8	0.5	2.9	2.0	0.2	0.2	5.5	6.9	79.3	1.3	0.14	2.2

O.M organic matter, OC organic carbon, TN total nitrogen, TEA total exchangeable acidity, AL aluminum, H hydrogen, Ca calcium, Mg magnesium, K potassium, Na sodium, TEB total exchangeable base, CEC cation exchange capacity, BS base saturation, Avl. P Available phosphorus

Table 4.4 chemical properties of soil derived from Imo clay shale

Horizon	Depth(cm)	pH (H_2O)	K CL	O.C → g/kg	O.M ←	T.N	C:N Ratio	TEA	AL	H →	Ca	Mg	K Cmol/kg	← Na	TEB	ECEC	BS %	Ca:Mg Ratio	K:Mg Ratio	Avl .P (g/kg)
	AMURO 1																			
A	0 -17	6.50	4.84	33.4	57.6	2.2	15.18	0.84	0.44	0.44	1.20	0.16	1.05	0.55	2.96	3.84	79	7.5	6.5	5.60
AB	17 -79	6.23	4.60	13.3	22.9	1.1	12.09	2.15	1.70	0.45	0.70	0.11	0.94	0.49	2.24	4.43	51	6.3	8.5	1.77
Bt1	79 -98	5.85	4.45	10.8	13.5	1.0	10.8	1.77	1.41	0.36	0.78	0.06	0.96	0.48	2.28	4.07	58	13.0	16.0	1.88
Bt2	98 – 125	6.46	4.49	6.0	10.2	0.6	10.0	2.74	2.24	0.5	0.91	0.07	0.45	0.12	1.55	4.38	38	13.0	6.4	4.65
Bt3	125 – 160	6.01	4.62	3.2	5.5	0.4	8.0	2.43	2.01	0.43	0.65	0.05	0.75	0.35	1.80	4.26	44	13.0	15.0	2.14
mean		6.2	4.6	13.0	22	1.0	11.2	2.9	1.9	0.4	0.8	0.09	0.8	0.4	2.2	4.1	54	10.5	10.4	3.2
	AMURO2																			
A	0 – 26	7.93	6.40	17.5	30.1	1.4	12.50	0.26	0.0	0.26	9.36	9.30	0.47	0.15	19.28	19.51	98	1.00	0.05	18.06
AB	26 – 60	8.52	6.84	12.7	21.4	0.9	14.11	0.22	0.0	0.22	8.90	9.30	0.30	0.15	18.65	18.87	98	0.95	0.03	22.37
Bt1	60 – 100	8.80	7.05	10.7	18.1	0.7	15.28	0.21	0.0	0.21	9.02	9.25	0.37	0.17	18.81	18.95	97	0.92	0.04	15.85

Bt2	100 – 140	9.05	6.95	9.1	15.5	0.6	15.16	0.19	0.0	0.19	8.48	9.12	0.33	0.17	18.10	18.24	98	0.02	0.03	13.07
Bt3	140 – 160	8.35	6.89	7.7	12.9	0.5	15.40	0.19	0.0	0.19	9.80	9.06	0.31	0.66	19.83	19.95	98	0.08	0.03	9.33
mean		8.5	6.8	12.0	19.0	0.8	14.5	0.2	0.0	0.2	9.1	9.2	0.4	1.3	18.9	19.1	97	0.5	0.03	15.70

O.M organic matter, OC organic carbon, TN total nitrogen, TEA total exchangeable acidity, AL aluminum, H hydrogen, Ca calcium, Mg magnesium, K potassium, Na sodium, TEB total exchangeable base, CEC cation exchange capacity, BS base saturation, Avl. P Available phosphorus

2.8 Variability of Some Selected Soil Properties of False Bedded Sand Stone and Imo Clay Shale

The results of the variation of the some selected soil properties are as shown in table 4.5. Amruo 2 recorded low variation in almost all the selected soil properties when compared with Amruo 1 and NIHORT 1, 2, and 3 respectively. Bulk density and pH values across the sand stone and Imo clay shale shows low variation, this could be attributed to the high incidence of leaching of basic cation under high annual rainfall saturation. Sand and clay had a moderate variation in NIHORT 1, 2 and low in NIHORT 3, while sand variation in Amuro 1 and 2 were low. The clay variation in Amuro 1 is moderate while in Amuro 2 has high variation. The low variation in sand recorded in NIHORT 3, Amuro 1 and Amuro 2 may be attributed to the absence of well-developed argillic horizons Onweremadu and Anikwe (2007) reported similar argillation in soils of south eastern Nigeria. Table 4.6 shows result of the variability of the selected physic-chemical properties of soils of the two parent materials, this indicates that the soil have high productive potential

Table 4.5Variability of some selected soil properties of false bedded sand stone and Imo clay

Soil properties	NIHORT1	Ranking CV %	NIHORT 2	Ranking CV %	NIHORT 3	Ranking CV %	AMURO 1	Ranking CV %	AMURO 2	Ranking CV%
Sand	27	MV	27	MV	11	LV	7.5	LV	2.5	LV
Silt	28	MV	64	HV	40	HV	38	HV	10	LV
Clay	31	MV	26	MV	14	LV	30	MV	44	HV
S/clay ratio	42	HV	21	MV	30	MV	51	HV	9.3	LV
SHC	21	MV	20	MV	21	MV	43	HV	9.3	LV
BD	7.5	LV	6.5	LV	1.4	LV	5.5	LV	5.4	LV
pH (H_2O)	11	LV	6.5	LV	11.2	LV	5.5	LV	5.4	LV
TEB	22	MV	26	MV	31.2	HV	2.5	LV	3.3	LV
ECEC	20	MV	19	MV	33	MV	37	HV	13	LV
BS	53	HV	7.5	LV	3.2	LV	29	MV	10	LV
OM	85	HV	28	MV	42	HV	95	HV	34	MV
Ca : Mg ratio	17	MV	23	MV	17	MV	32	MV	84	HV

MV= Moderate variation, HV= High variation, LV= Low variation, SHC= Soil moisture content, BD=Bulk density, TEB= Total exchangeable base, TEA= Total exchangeable acidity, ECEC= Exchangeable cation exchange capacity, BS= Base saturation, OM= Organic matter

Table 4.6Variability of some selected physic-chemical properties of soil of the two parent materials

Soil properties	**Clay shale**	Ranking CV %	**Sand stone**	Ranking CV %
Sand	16.5	MV	22.0	MV
Silt	28.0	MV	44.0	HV
Clay	48.0	HV	24.0	MV
S/clay ratio	62.0	HV	52.0	HV
SHC	6.4	LV	9.6	LV

BD	15.7	MV	21.2	MV
pH (H_2O)	23.7	MV	21.0	MV
TEB	6.3	LV	5.1	LV
ECEC	16.1	MV	26.3	MV
BS	35.0	HV	34.3	MV
OM	10.6	LV	24.0	MV
Ca : Mg ratio	50.7	HV	57.0	HV

MV= Moderate variation, HV= High variation, LV= Low variation, SHC= Soil moisture content, BD=Bulk density, TEB= Total exchangeable base, TEA= Total exchangeable acidity, ECEC= Exchangeable cation exchange capacity, BS= Base saturation, OM= Organic matter

2.9 Relationship among soil properties

The result of the relationship among the selected physic-chemical properties of the soil indicates that sand correlated negatively with clay and highly significant in the two parent materials. Soil moisture correlates negatively with clay in sand stone and positively within clay shale. The relationship was not significant in both soils, while result shows that clay soil has the capacity to retain water because of its tiny pores. Clay also correlated negatively with ECEC in sand stone and positively in clay shale, but both were not significant. This is in accordance with Verheye (2006) who posit that ECEC increases with an increase in the clay content.

Taxonomy Classification

Taxonomy classification of the selected soils around Okigwe L.G.A. based on the physical, chemical, and morphological characteristics, and it was classified using USDA soil taxonomy system (soil survey staff, 2003) and World reference base system (W.R.B). The soils at Nihort 1, 2 and 3 had argillic (Bt) horizon as determined by the distribution of clay down the profile and low silt/clay ration indicating advanced stage of weathering. In addition, percentage base saturation greater than 35% is recorded in the soil of false bedded sand stone, therefore the soil belong to the soil order Alfisol, suborder Udalf, great group Hapludaf, sub-group Typic Hapludaf, W.R.B soil class Luvisols, W.R.B soil unit Arenic luvisols. Soils of Amuro 1 were classified as Inceptisols because of the poorly developed diagnostic horizons and properties, while soils of Amuro 2 have high clay content of greater than 30% throughout the depth of the profile and it was classified as Vertisols. W.R.B soil class for Amuro 1 and 2 are Cambisols and Vertisols, respectively.

Land capacity classification of soil according to USDA system

The physicochemical properties of the soils, the nature of the landscape, and the soil depth, the soils of NIHORT 1,2 and 3 were grouped as class II of the USDA capability classification system. They are moderately suitable due to uneven plain of the slope which ranges from 2 – 6 % and are derived from sand stone. Amuro 1 with slight predisposition to erosion, slow subsoil permeability, and existence of iron concentrations at a depth of 98 – 152 cm, indicating poor drainage, was placed in class II. Amuro 2 was placed in class III due to its moderate susceptibility to erosion, moderate drainage limitation with a slope of 2 – 4 %.

DECLARATION OF COMPETING INTEREST

We they authors hereby declare that there is no conflicting of interest whatsoever.

3. CONCLUSION

An unrestricted soil survey techniques used was aided with geological map of the area. Three (3) soil profiles were sunk, profile pit was defined based on the FAO procedure and samples were collected according to the horizon differentiation. The samples were exposed to laboratory analysis for the selected physicochemical properties and the results were analyzed using suitable statistical tools. The result from various soils as shown in the tables suggests that soils vary not only in parent materials but then again in many key physicochemical properties. Consequently their capability to support varying categories/kinds of land use is anticipated to vary. The soil properties from the characterization of the selected soil on the study area were utilized in the classification of the soil according to the USDA soil taxonomy and WRB soil classification systems. Hence it is observed that the false bedded sand stone and clay shale were in class II. There was positive correlation between organic matter and ECEC, organic matter and total nitrogen in both soils. The correlation was highly significant (p= 0.1), clay correlates negatively with ECEC in both soil and were not significant. Finally it is found that soils from the selected areas are suitable for agricultural practices, lowland crops like rice can be grown on about 42 % of the soils due to the seasonal fluctuations of water table. This study will go a long way to assist researchers, farmers, and agriculturist who will want to embark on massive agricultural production in different countries of the world that has similar land terrain.

REFERENCE

1. Brady, N.C., Weil, R.R.(1999). The nature and properties of soil. Abridge (ed) of the nature and properties of soils 13th ed.
2. Bremner, J.M., Mulvaney, C.S., (1982). Total – Nitrogen In: methods of soil analysis part 2. AL page, RH Millar, and DR Keeney editions.

American society of agronomy Madison, W1 Pp 595 - 624
3. Carter, G.F., (1993). The humid soils process and time geography ReV. 46: 488 – 507
4. Eshett, E.T., (1985). Soil characterization and farming of Agronomy, University of Ibadan Nigeria
5. FAO (Food and Agriculture Organization) (1983). Guidelines and evaluation for rain-fed agriculture. Agriculture soils bulletin No.52 Rome.
6. Gee, G.W. Or D. (2002). Particle size analysis. In: JH Dane and GC Topp (eds). Methods of soil analysis, part 4. Physical methods soil science society of America(SSSA). Book series No.5 ASA and SSA Madison, W1, pp 255 – 293
7. Grossman, R.B., Reinch, T.G.,(2002). Bulk density and liner extensibility.In: Methods of soil analysis part 4. Physical methods soil science society of America. Book series No.5 ASA and SSA Madison, W1, pp 201 – 228
8. Igwe, C.A., (2003). Shrink – swell potential of flood plain soils in Nigeria in relation to moisture content and mineralogy. International Agrophysic 17, pp47 – 55
9. Landon, J.R., (1991). Booker tropical soil manual. Longman Scientific and Technical Essex, UK. Pp 474
10. Lekwa, M.U., (1998). Soil survey and land evaluation for irrigated rice paddy at Igwe river flood plain, Abia state. University of Nigeria Research Publications
11. Maclean, E.D., (1982). Methods of soil analysis part 11. Aluminum In: a black (eds). 1st edition American society of Agronomy Monography. Pp 86 – 994
12. Nelson, D.W., Summers, E., (1982). Total C, organic matter.Miller RH and Keeny DR (eds) method of soil analysis. Part 2. Chemical and microbiological properties 3rd edition
13. Nwosu, L.I., Nwankwo, C.N., Emujakpore, G., (2010).Determination of Dar- Zarouk parameters for the assessment of ground water resources potentials. Case study of Imo state, southeastern Nigeria. *Journal of economics and sustainable development*
14. Obi, M.E., (1990). Soil physics: A compendium of lectures.The University of Nigeria Nsukka, southeastern Nigeria publication pp 103
15. Ohiri, A.C., Igbokwe, M.C.,,Lekwa, G. (1985).Physicochemical characteristics, classification, and management of Selected yam soils of northern Nigeria. In: soil fertility soil tilth and post–clearing land degradation In the humid tropics, proceedings of the international society of soil science (commission IV and VI) Pp 68 – 81.
16. Oikeh, S.O., Chuke, V.O., Carsky, R.J., Weber, G.K., Horst,W.J., (1998). Legume rotation in the moist tropical savanna Managing soil nitrogen dynamics and cereal yields in farmers fields experimental agriculture. Pp 34:73:83
17. Olsen, R.S., Sommer, L.E.,(1982). Phosphorus In: methods of soil analysis part 2. (edition page AL, Millar RH and Keeney DR). American society of agronomy Madison, Wisconsin pp 15 - 72
18. Onyeagucha, A.C., (1980). Petrography and depositional environment of the Benin formation. *Journal of mining geology 17(2); 147 – 151*
19. Onweremadu, E.U., (2007). Availability of selected soil nutrients in relation to land use and landscape position *International journal of soil science 2(2); 128 – 134*
20. Onweremadu, E.U., Anikwe, M.A.N., (2007). Soil wettability characteristics of a forested catena in relation to organic matter fractions. *International journals of soil science 2(3); 211 – 207*
21. Papendick, R.I., Parr, J.F., (1992). Soil quality: The key to sustainable agriculture. American journal of alternative agriculture 7: 2 – 3
22. Sharato, R., Ojanuga, A.G., Ajayi, S.O., (2002). Fe and Al oxide dynamism in representative profile in the lower Benue Valley, Nigeria. *Journal of agriculture science technology 12 (1) :21 – 31*
23. Soil survey staff, (2003). Keys to soil taxonomy. 9th edition.USDA natural resources conservation service, Washington DC. Pp 338.
24. Thomas, G.W., (1996). Soil pH and soil acidity. In: methods of soil analysis, part 3, chemical methods. LD Sparks edition. Soil science society America (SSSA) book series. No 5 USDA soil taxonomy, (1979). Agriculture handbook No.
25. 435. Washington DC; USDA soil conservation service.USDA- NCRS, (1996). Soil quality information sheet soil quality indicators: aggregate stability. Prepared by the nation soil survey centre in conjunction with the sloil quality department of the Natural Resources Conservation Centre (NCRS) and national soil tilt laboratory of the United States Department of Agriculture (USDA)
26. Verheye, W., (2006). Soil and soil sciences: land use, land cover, and soil sciences. Vol IV. In: UNESCOEncyclopaedia of life support systems. Paris United Nations Educational, Scientific and Cultural Organization
27. Wilding, L.P., (1985). Spatial variability, its documentation. Accommodation and implication to soil surveys. Pp 166 – 194. In: DR Nelson and J Bouma (editions) soil spatial variability produce Wageningen, Netherland.