

LAND SUITABILITY EVALUATION FOR ARABLE CROP PRODUCTION ON SOILS OF VARYING LITHOLOGICAL MATERIALS IN SOUTHEASTERN NIGERIA

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Abstract

The study investigated suitability of soils of Asu River Group and Imo Clay Shale for groundnut, rice and cassava cultivation in Southeastern Nigeria. Guided by geology, soils developed over varying parent materials viz: Asu River Group and Imo Clay Shale were studied. Soil profiles were dug, described and sampled based on FAO guidelines. Soil samples were taken to the laboratory for various analyses. Data collected were subjected to statistical analysis and compared with known standards. Results indicate varying suitabilities for evaluated crops. Results show that overall suitability for the Asu river group are not currently suitable for groundnut cultivation due to limitation of fertility. Soils of Imo clay shale were all marginally suitable (S_3) for groundnut cultivation due to fertility and drainage. Both soil groups were moderately suitability S_2 (f,s) for rice production with constraints on fertility and some soil physical characteristics. Soils of the Asu river group were currently not suitable N_1 (f) for cassava due to fertility while the soils of Imo clay shale were all marginal suitable for S_3 (f,3) due to fertility and drainage.

Keywords: Arables, evaluation, land quality, soil characteristics.

Introduction

Soil is a basic natural resource with numerous uses. The usage depends on some characteristics and qualities aimed at enhanced productivity. However, these properties are related to the type of parent material of its origin. Their productivity largely influenced by the status of these soil properties and they include but limited soil texture, bulk density, water holding capacity, soil reaction, organic matter content, total nitrogen, base saturation and cation exchange capacity. Soil physical properties is the inherent physical characteristics of soil that influence its behavior and functionality. These include texture, structure, bulk density, porosity, moisture content, permeability, and water retention capacity. These properties significantly affect root development, water and air movement, nutrient availability, and the overall productivity of the soil (Brady and Weil, 2016). Soil physical properties are largely influenced by parent material, climate, topography, and biological activity (Buol *et al.*, 2011). Soil chemical

properties such as pH, organic carbon, total nitrogen, available phosphorus, exchangeable bases (Ca^{2+} , Mg^{2+} , K^+ , Na^+), cation exchange capacity (CEC), and base saturation directly affect plant growth, microbial activity, and chemical reactions within the soil profile (Brady and Weil, 2016). In Southeastern Nigeria, where diverse geological formations such as the Asu River Group and Imo Clay Shale exist, parent material plays a major role in shaping the physical characteristics of soils (Akamigbo, 1984; Obi and Asadu, 2009).

In southeastern Nigeria, soils vary due to lithology and this influences their suitabilities for agricultural and non-agricultural uses. This calls for assessment to unveil their potentials.

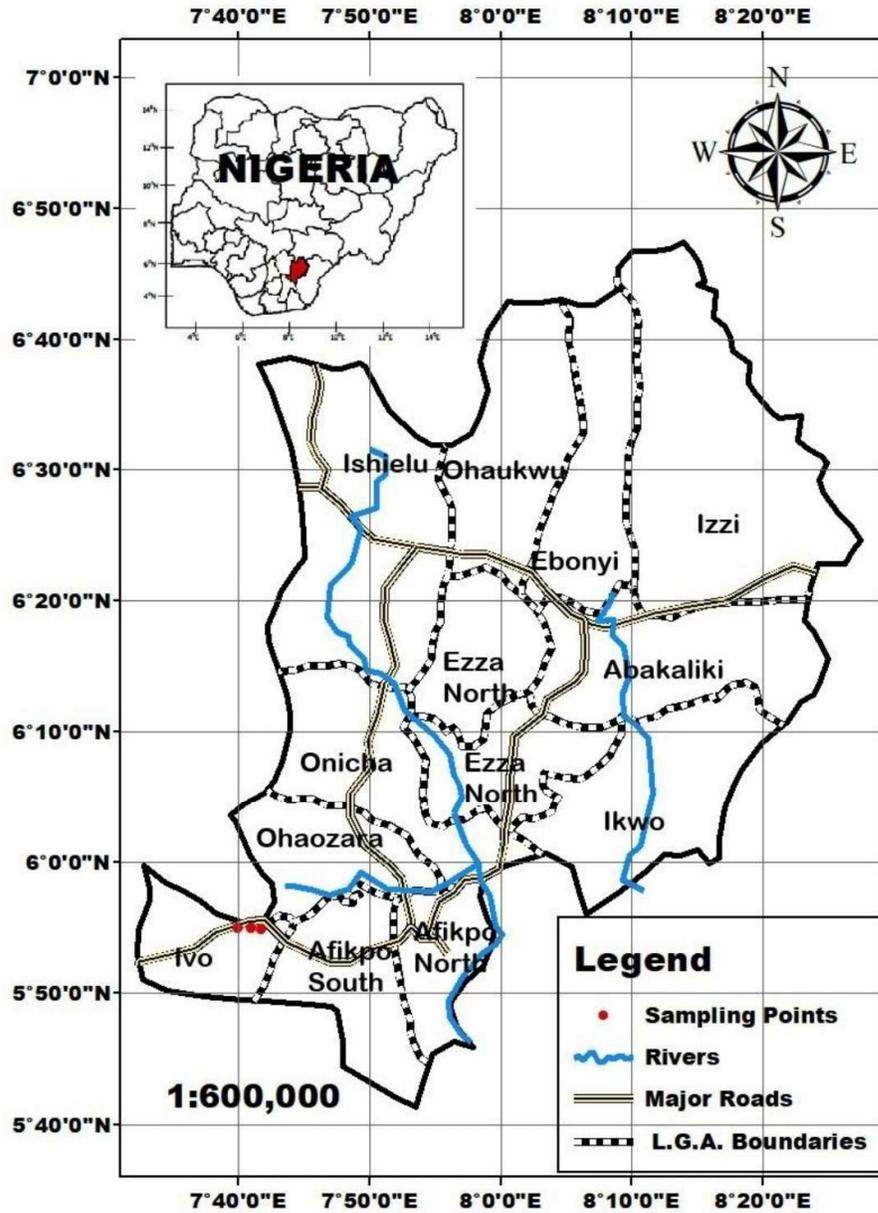
Most soils and soil-related characteristics are not investigated before use leading to land degradation. Given this scenario, the major objective of this study was to evaluate the soils of varying lithological materials in southeastern Nigeria Specific objectives were to;

- i. evaluate the morphological properties of soils derived from different parent materials.
- ii. determine the physical and chemical properties of soils derived from different parent materials.
- iii. evaluate the Land Suitability of soils derived from the Asu river group and Imo clay shale parent materials for groundnut, cassava and rice cultivation.
- iv. estimate the variability among the soil properties of the study area.

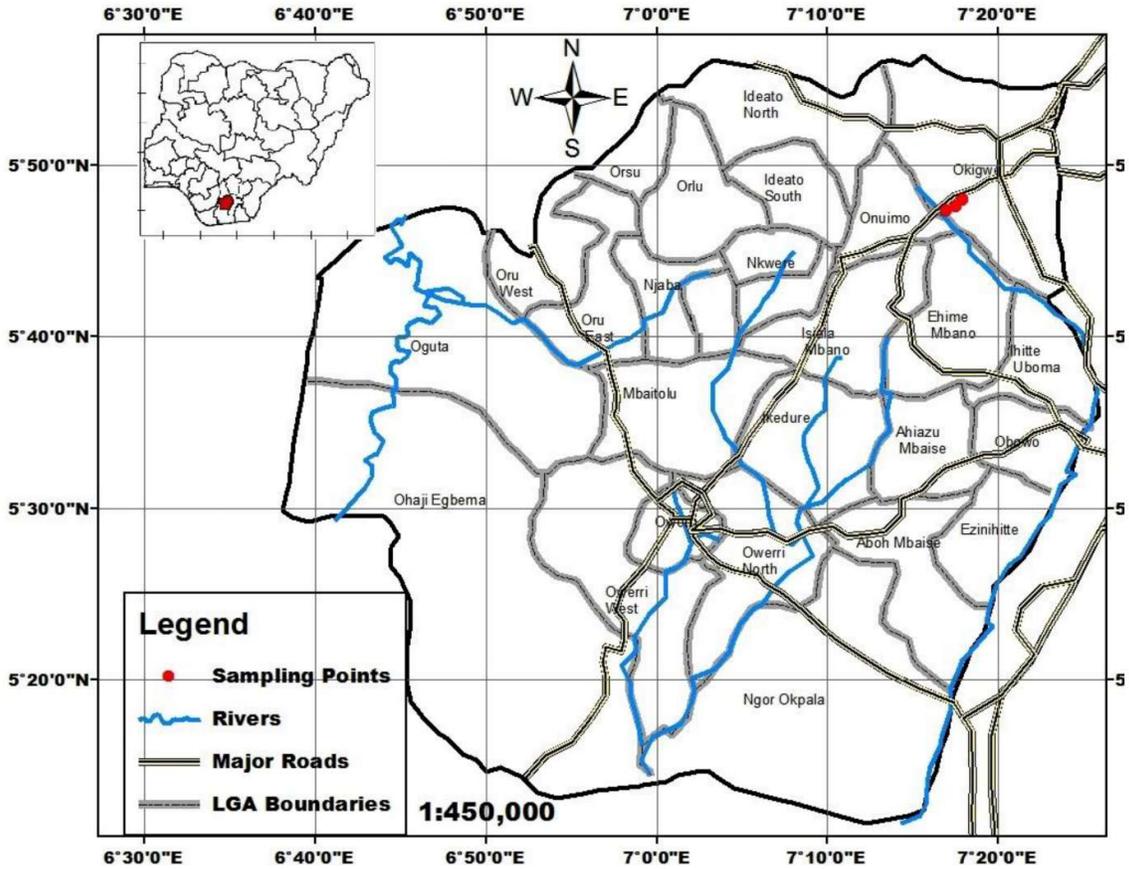
Materials and Method

Study area

This study was carried out in two locations within Southeastern Nigeria: Amuro in Okigwe Local Government Area of Imo State, representing Imo clay shale and Akaeze in Ivo Local Government Area of Ebonyi State, representing Asu river group. Amuro, Okigwe, Imo State is located within latitude $5^{\circ}45'N$ to $5^{\circ}55'N$ and longitude $7^{\circ}15'E$ to $7^{\circ}25'E$ while Akaeze, Ebonyi State lies between latitude $5^{\circ}55'N$ to $6^{\circ}05'N$ and longitude $7^{\circ}40'E$ to $7^{\circ}50'E$. Both areas fall within rioothe humid tropical rainforest zone of Southeastern Nigeria.

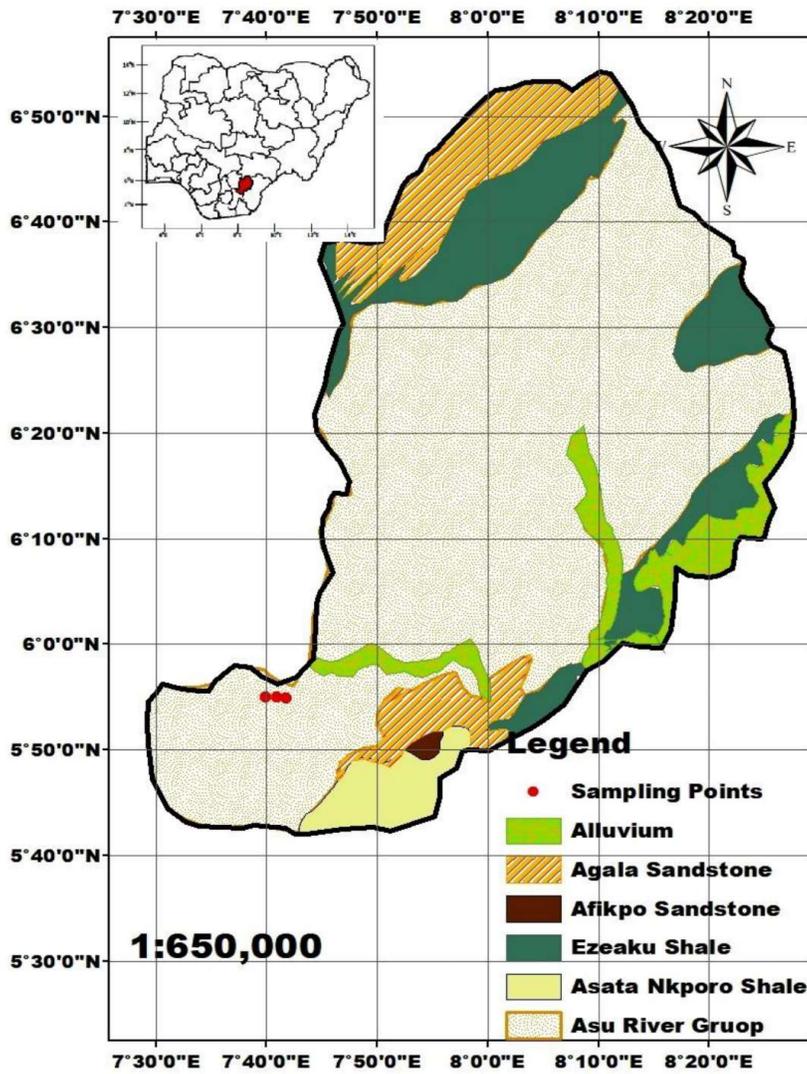


Developed from Open Street Map in ArcMap 10.7, 2025
Fig 3.1: Location Map of the Study Area for Ebonyi State

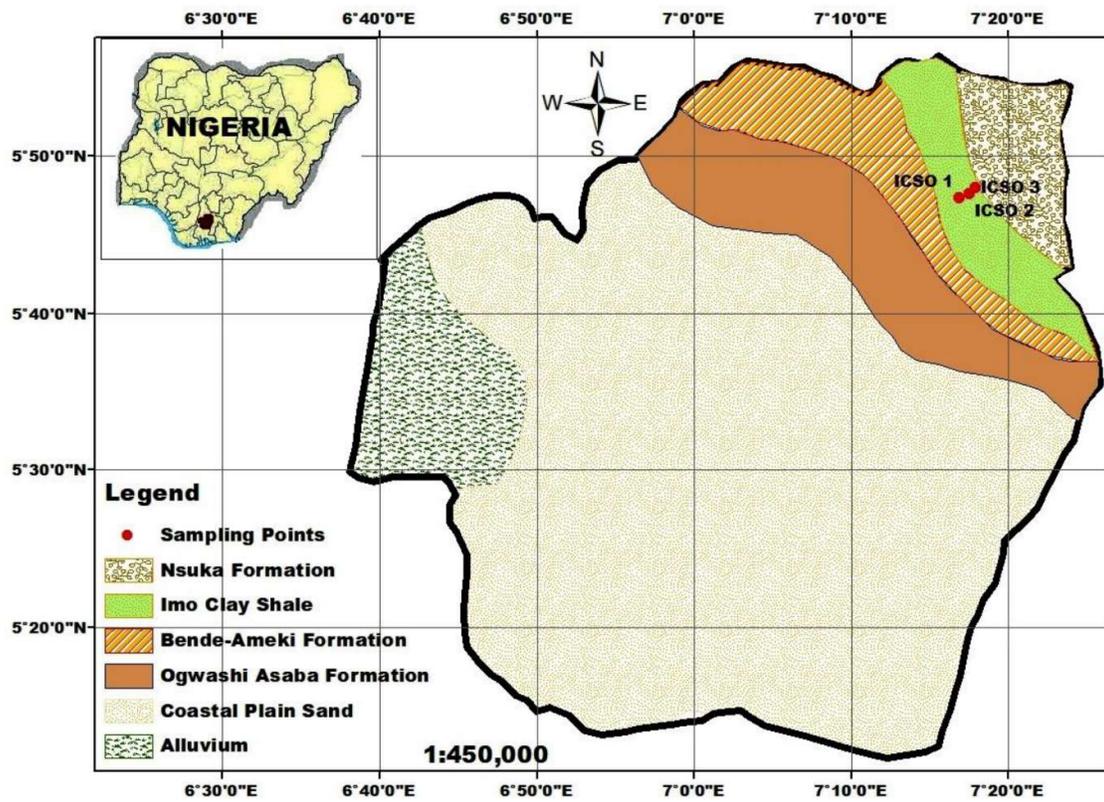


Geology of the areas

Akaeze soils are developed over the Asu River Group, composed of shale, sandstone, and siltstone, noted for moderate permeability and susceptibility to erosion (Akamigbo, 1984). Amuro soils are derived from Imo Clay Shale Formation, which is rich in clayey materials, has poor drainage, and displays shrink-swell behavior under changing moisture conditions (Obi and Asadu, 2009).



Developed from Open Street Map in ArcMap 10.7, 2025
Fig. 3.3 Geological Map of the Study Area for Ebonyi State



Developed from Open Street Map in ArcMap 10.7, 2025
Fig 3.4. Geological Map of the Study Area for Imo State

3.3 Climate

The climate of the region is tropical with distinct wet and dry seasons. Rainfall is bimodal, ranging from 1,800 mm to 2,200 mm annually, and the mean annual temperature is between 26°C and 28°C. Relative humidity is typically high, ranging from 70% to 90% throughout the year (NIMET, 2020).

Vegetation

Amuro, located in Okigwe Local Government Area of Imo State, falls within the humid tropical rainforest zone, though much of the natural vegetation has been modified due to human activities. It consists of shrubs, scattered trees (such as oil palm, iroko, and mahogany), herbaceous plants and grasses. Common vegetation includes *Eleusine indica*, *Chromolaena odorata*, and *Pennisetum purpureum* (elephant grass). Farm fallows and bush regrowth dominate uncultivated areas, and agroforestry species such as oil palm, plantain, and banana are frequently seen.

Akaeze, situated in Ivo Local Government Area of Ebonyi State, share is found lying within the derived savanna transitional zone between rainforest and grassland. The vegetation is composed of grasses such as *Andropogon spp.* and *Imperata cylindrica*. Prominent economic trees include oil palm (*Elaeis guineensis*), breadfruit, mango, and bush mango (*Irvingia gabonensis*). Seasonal bush burning is common and further affects vegetation composition.

Socio-economy

Both communities use farming as source of satisfying household needs. They engage in processing agricultural products. Some get their financial needs from their involvement in cottage industries while a good number are government workers. Smallholder agriculture is common where a variety of crops are cultivated. Land clearing is by slash and burn.

Field studies

Guided by geology of the area, three (3) profile pits were dug in each on soils of each parent material: Asu River Group and Imo Clay Shale Soil profiles were described in the field using standard procedures outlined by the FAO (2006) and Soil Survey (2014). Observations included horizon boundaries, colour (Munsell chart), texture (by feel method) structure, consistence, root distribution, faunal activities and presence of concretions or mottles. Core sampler was used in the field for the collection of soil sample for soil bulk density determination. Soil samples were collected horizon by horizon, which gave a total of twenty three (23) samples, bagged and taken to the laboratory.

Laboratory Analysis

The samples were air-dried, crushed and sieved using 2mm sized sieve before used for analysis. Selected physical and chemical properties of the sampled soils for by evaluation of soils underlain by shale were determined. These properties were determined as follows:

Bulk density: It was determined by the core sampler method according to the procedure of Grossman and Reinsch (2002). **Particle size distribution:** It was determined by using Bouyoucos Hydrometer method according to the procedure of Gee and Or (2002).

Total porosity: It was calculated from the result of bulk densities and particle density.

Moisture content: it was determined by gravimetric method as described by Tara (2005).

Soil pH: It was measured in a suspension as soil/water ratio 1:2.5 and determined using glass electrode pH meter as described by Hendershot *et al.*, (1993).

Organic carbon: It was determined by the wet oxidation procedure according to Walkley and Black method (Nelson and Sommers, 1982).

Total nitrogen: It was determined using the modified micro Kjeldhal method according to the procedure of Bremner and Mulvaney (1982).

Available phosphorus: It was done using the Molybdenum blue colour Bray Alpha method (Olsen and Sommers, 1982).

Exchangeable bases: It was determined from Ammonium Acetate (NH₄OAc) leachate of the soil (Thomas, 1982). Exchangeable Calcium and Magnesium were determined by the EDTA (Ethylene Diamine Tetra-acetic Acid) versanate titration method while exchangeable sodium and potassium were determined by flame photometer method (Jackson, 1962).

Exchangeable acidity: It was determined by leaching the soil with INKCL and titrating 0.05N NaOH (McLean, 1965).

Effective cation exchange capacity: It was derived by the summation of the total exchangeable bases and total exchangeable acidity (Brady & Weil, 2010).

Base saturation (BS): it was determined using the following relationship between exchangeable bases and effective cation exchange capacity.

$$\% BS = \frac{\text{Total exchangeable basic cations}}{\text{ECEC}}$$

Total exchangeable bases (TEB): total exchangeable bases were determined by summing up the exchangeable basic cations. (Brady and Weil, 2002).

Exchangeable Acidity (AL+H): it was determined by titration as described by (Juo, 1979).

Exchangeable sodium percentage (ESP): it was determined using the following relationship. between sodium and effective cation exchange capacity.

Aluminium saturation: this was determined by using the following relationship between aluminium and effective cation exchange capacity.

Land suitability classification

Land Suitability Evaluation was done using FAO guidelines where the data obtained from the work were cross- matched with land requirements of

selected crops. The selected crops were; groundnut, rice and cassava. Land requirement tables are presented in Tables; 3.1, 3.2 and 3.3.

Table .1: Land Requirement for Groundnut

Land Qualities/characteristics	Factor Suitability Rating			
	Highly suitable (S ₁)	Moderately suitable (S ₂)	Marginally suitable (S ₃)	Not suitable (N)
Climate (C)				
Rainfall (mm)	>700	600-700	500-600	<500
Temperature (°C)	22-28	18-22	15-18	<15
Soilphysical characteristics (S)				
Soil depth (cm)	>120	75-120	30-75	<30
Soil texture	SCL, SL, SiL, LS	CL, Si, CL	S, SC, SiC	C
Topography(t) Slope (%)	0-2	2-5	5-8	>8
Drainage	Well drained	Moderately drained	well Imperfectly drained	Poorly drained
Soil fertility status (f)				
pH	5.8-6.2	5.5-5.7, 6.3-6.5	5.0-5.4, 6.6-7.0	<5,>7
Total N (g kg ⁻¹)	>0.5	0.2-0.5	0.2	<0.2
Available P (mg kg ⁻¹)	>20	10-20	5-12	<0.5
CEC (cmol(+) kg-1)	>12	6-12	4-6	<64
Base saturation (%)	>80	50-80	40-50	<40
Organic C (g kg ⁻¹)	>12	8-12	5-8	<5

Source: FAO (1983).

LS =Loamy Sand, SL = Sandy Loam, CL = Clay Loam, SiL = Silt Loam, SiCL = Silt Clay Loam C = Clay, S = Sand, SC = Sandy Clay.

Table .2 Land Requirements for Rice

Land Qualities/characteristics	Factor Suitability Rating			
	Highly suitable (S ₁)	Moderately suitable (S ₂)	Marginally suitable (S ₃)	Not suitable (N)
Climate (C)				
Rainfall (mm)	≥ 1500	1200-1500	1200-1500	<1000
Temperature (°C)	20-27	18-20	16-18	< 16
Soil physical characteristics (S)				
Soil depth (cm)	>50	20 - 50	10 - 20	< 10
Soil texture	Clayloam, loam, sandyclay loam, silt	Sandy/clay/loam	Loam	Loamy sandy
Topography(t)Slope (%)	2 - 3	1 - 2	0 - 1	Any
Drainage	Poor	Imperfect	Moderate	Well drain
Soil fertility status (f)				

pH	5.8-5.9	5.3-5.8	<5.0	
Total N (g kg ⁻¹)	>0.2	0.1-0.2	0.05-0.1	<0.05
Phosphorus (g kg ⁻¹)	394-538	321-393	263-320	84-262
Potassium (g kg ⁻¹)	141-213	120-140	102-119	45-101
Base saturation	>80	50 – 80	40 - 50	<40
Carbon (%)	102-248	54-101	26-53	3-25

Source: FAO (1983).

Table .3 Land Requirements for Cassava

Land Qualities/characteristics	Highly suitable (SI)	Moderately suitable (S2)	Marginally suitable (S3)	Not suitable (N)
Factor Suitability Rating				
Climate (C)				
Rainfall (mm)	1100-1500	900-1100	500-900	<500
Temperature (°C)	18-30	12-18	<12	Any
Soil physical characteristics (S)				
Soil depth (cm)	>100	100-75	50-75	<50
Soil texture	L, SC, CL, SCL	L, SiCL, SL	S, SiC	C
Topography (t) Slope (%)				
	0-5	5-12	12-20	>20
Drainage				
	Well drained 1	Moderately- well drained 2-3	Imperfectly drained 4	Poorly drained 5
Soil fertility status (f)				
pH	6.1-7-3	5.1-6.0, 7.4-7.8	<4.0, >8	Any
Total N (g kg ⁻¹)	>2.0	1.0-2.0	<1.0	Any
Available P (mg kg ⁻¹)	>25	6.25	<6	Any
CEC (cmol(+) kg ⁻¹)	>16	3-16	<3	Any
Base saturation (%)	>35	20-35	<20	Any
Organic C (g kg ⁻¹)	>20	15-20	8-15	<8

Source: FAO (1983). LS =Loamy Sand, SL = Sandy Loam, CL = Clay Loam, SiL = Silt Loam, SiCL = Silt Clay Loam, C = Clay, S = Sand, SC = Sandy Clay.

Statistical Analysis

The data collected from the field experiments and various laboratory analysis were presented in tables. Data were also subjected to coefficient of variation. Correlation was used to estimate degree of relationship among soil properties of the two locations, while CV was used to determine vertical distribution of soil properties. Result of the CV was ranked using the method of Wilding et al., (1994)

Results and Discussion

Morphological properties of soils

Morphology of soils are shown on Tables 4 and 5. Both soils were deep, well to imperfectly drained, dominated by sub-angular to columnar structures and friable to firm soil consistence. Soil colour was darker in all epipedons as compared to grayish colouration in endopedons.

Table 4.: Morphological Properties of soils of Asu River Group

	Profile number	pit	Horizon	Depth (cm)	Colour (moist)	Consistence	Structure	Texture	Root development	Faunal activity	Boundary
Colours;	PIT 1		A	0-6	7.5YR3/2	Mfr	1fsbk	SCL	abt	abt	Cs
			AB	6-19	7.5YR4/3	Mfi	1fsbk	SCL	m	m	Dw
			Bg ₁	19-37	5YR4/2	Mvfi	1fcol	SCL	vf	ab	Cw
			Bg ₂	37 - 120	10YR3/2	Mvfr	2mcol	SCL	ab	ab	–
	PIT 2		A	0-9	7.5YR4/2	Mfr	1vfsbk	SCL	abt	abt	Cs
			AB	9-21	7.5YR3/2	Mfi	1fsbk	SCL	f	f	Ds
			Bg ₁	21-48	5YR4/4	Mfi	1vfcoll	SCL	f	vf	Dw
			Bg ₂	48-120	5YR3/2	Mvfi	2mcol	SCL	vf	ab	–
	PIT 3		A	07	7.5YR4/3	Mfr	1fsbk	SCL	abt	abt	Cs
			AB	7-24	7.5YR3/2	Mfi	1fabk	SCL	m	m	Ds
			Bg ₁	24-41	5YR4/6	Mfi	1fabk	SCL	f	vf	Ws
			Bg ₂	41-100	5YR4/3	Mvfi	2fabk	SCL	vf	ab	–

YR=Yellow-Red, 7.5= Hue, 7.5YR^{3/2}=dark brown, dull, 5YR^{4/2}= Reddish brown, 10YR^{3/2}=Dark yellowish brown, Consistence; m=moist, v = very, fr = friable, fi = firm, Structure; 1,2,3,= weak, moderate, and strong. F,m,c= fine, medium, and coarse. Sbk = Sub-angular block structure. Abk = Angular block structure, Texture; S= sand, C= clay, L= loam, SCL = Sandy clay loam, Root development; abt=absent (no visible root in the observed soil layer), vf=very fine, f=fine, m=medium, Boundary; cs = clear smooth, ds = diffuse smooth, dw = diffuse wavy, ws = wavy smooth, abt=abundant

Table 5. Morphological Properties of soils of Imo Clay Shale

Profile pit number	Horizon	Depth (cm)	Colour (moist)	Consistence	Structure	Texture	Root development	Faunal activity	Boundary
PIT 1	A	0-8	10YR2/2	Mfr	1vfsbk	SCL	abt	abt	Cs
	AB	8-21	10YR2/2	Mfr	1fsbk	SCL	m	m	Ds
	Bg ₁	21-52	5YR4/6	Mvfi	1fcol	SCL	vf	vf	Ds
	Bg ₂	52-109	10YR3/6	Mvfr	2mcol	SCL	abt	abt	–
PIT 2	A	0-7	7.5YR3/2	Mfr	1vfsbk	SCL	abt	abt	Cs
	AB	7-23	5YR4/3	Mfi	1vfcoll	SCL	m	m	Ds
	Bg ₁	23-59	5YR4/4	Mfi	1fcol	SCL	f	f	Ws
	Bg ₂	59-112	2.5YR4/6	Mvfi	2mcol	SCL	vf	vf	–
PIT 3	A	0-9	7.5YR3/2	Mfr	1vfsbk	SCL	abt	abt	Cs
	AB	9-23	7.5YR4/2	Mfi	1fsbk	SCL	abt	abt	Ws
	Bg ₁	23-100	5YR3/4	Mfi	2fsbk	SCL	m	m	–

Colours; YR=Yellow-Red, 7.5= Hue, 7.5YR^{3/2}=dark brown, dull, 5YR^{4/2}= Reddish brown, 10YR^{3/2}=Dark yellowish brown, Consistence; m=moist, v = very, fr = friable, fi = firm, Structure; 1,2,3,= weak, moderate, and strong. F,m,c= fine, medium, and coarse. Sbk = Sub-angular block structure. Abk = Angular block structure, Texture; S= sand, C= clay, L= loam, SCL = Sandy clay loam, Root development; abt=absent (no visible root in the observed soil layer), vf=very fine, f=fine, m=medium, Boundary; cs = clear smooth, ds = diffuse smooth, dw = diffuse wavy, ws = wavy smooth, abt=abundant

PHYSICAL PROPERTIES

The physical properties of the soils of the study area; Asu river group and Imo clay shale are presented in Tables 6 and 7.

4.2.1 Particle Size Distribution

In the soils of Asu river group, the sand content ranged from 678.4 g/kg to 818.4 g/kg with mean value of 740.9 g/kg in profile pit 1. In soil profile pit 2, the sand content ranged from 658.4 g/kg to 818.4g/kg with a mean value 748.4 g/kg, while in soil profile pit 3, it ranged from 658.4 g/kg to 828.4 g/kg with mean value of 745.9 g/kg. However, the epipedons (surface horizons) had the highest sand content in all the soil profile pits underlain by the Asu river group. The sand content ranged from 570.7 g/kg to 601.7 g/kg with mean value of 591.0 g/kg in profile pit 1. In soil profile pit 2, the sand content ranged from 550.7g/kg to 630.7 g/kg with a mean value 593.2 g/kg, while in soil profile pit 3, it ranged from 590.7 g/kg to 650.7 g/kg with mean value of 624.0 g/kg. The result of the

coefficient of variation (CV) showed low variation (CV<15%) in the three profile pits of the Imo clay shale. The silt fraction ranged from 121.1 g/kg to 132.1 g/kg in soil profile pits 1 and in profile pit 2, it ranged from 102.1 g/kg to 132.1g/kg with mean value of 114.6 g/kg. Also, in profile pit 3, it ranged from 72.1 g/kg to 112.1g/kg with mean value of 85.4 g/kg. The result of the coefficient of variation (CV) showed low variation in profile pits 1 and 2 (CV<35%) and moderate variation (CV>15≤35) in profile 3. The clay content ranged from 269.2 g/kg to 297.2 g/kg with mean value of 281.5 g/kg in soil profile pit 1, it ranged from 267.2 g/kg to 317.2 g/kg with mean value of 292.2 g/kg in profile pit 2, while in soil profile pit 3 clay content ranged from 277.2 g/kg to 297.2 g/kg with a mean value of 290.5 g/kg. The clay content of the soils satisfies optimum requirement for production of arable crops such as rice (Sys *et al.*, 1991 in Mohammed *et al.*, 2020).

Table 6: Physical Properties of soils of Asu River Group

Profile number	pit	Horizon	Depth (cm)	Sand (g/kg)	Silt (g/kg)	Clay (g/kg)	Bulk Density (g/cm ³)	Total Porosity%	Moisture Content (g/kg)
PIT 1	A		0 - 6	818.4	16.0	165.6	1.08	59.28	23.99
	AB		6 - 19	758.4	16.0	225.6	1.27	52.15	22.34
	Bg ₁		19 - 37	708.4	96.0	195.6	1.22	53.96	21.94
	Bg ₂		37- 120	678.4	76.0	245.6	1.21	54.33	22.61
	Mean			740.9	51.00	208.10	1.20	54.93	22.72
	CV			8.30	80.80	16.50	6.80	5.60	3.90
PIT 2	A		0 - 9	818.4	16.0	165.6	1.23	53.58	27.86
	AB		9-21	798.4	96.0	105.6	1.26	52.45	21.22
	Bg ₁		21- 48	718.4	96.0	185.6	1.25	52.83	23.27
	Bg ₂		48 -120	658.4	76.0	265.6	1.07	59.62	20.68
	Mean			748.4	71.0	180.6	1.20	54.62	23.26
CV			9.90	53.30	36.60	7.40	6.20	14.00	
PIT 3	A		0 - 7	828.4	46.0	125.6	1.27	52.15	24.37
	AB		7 - 24	778.4	13.6	208.0	1.31	50.56	21.87
	Bg ₁		24 - 41	658.4	96.0	245.6	1.29	51.56	28.34
	Bg ₂		41-100	718.4	96.0	185.6	1.14	56.98	23.05
	Mean			745.9	62.9	191.2	1.25	52.81	24.41
	CV			9.90	64.30	26.30	6.10	21.20	11.50

*CV< 15% -low variability, CV > 15 ≤ 35% - moderate variability, CV > 35% - High variability

Table 7: Physical Properties of soils of Imo Clay Shale

Profile pit number	Horizon	Depth (cm)	Sand (g/kg)	Silt (g/kg)	Clay (g/kg)	Bulk Density (g/cm³)	Total Porosity %	Moisture Content (g/kg)
PIT 1	A	0 - 8	601.7	121.1	277.2	1.36	48.68	16.98
	AB	8 - 21	600.7	130.1	269.2	1.37	48.30	13.65
	Bg ₁	21 - 52	590.7	127.1	282.2	1.44	45.66	13.25
	Bg ₂	52 -109	570.7	132.1	297.2	1.65	37.74	12.90
	Mean		591.0	127.6	281.5	1.46	45.10	14.20
	CV		2.4	3.8	16.5	9.3	11/3	13.3
PIT 2	A	0-7	630.7	102.1	267.2	1.31	50.57	19.25
	AB	7-23	610.7	102.1	287.2	1.44	45.66	17.09
	Bg ₁	23-59	580.7	122.1	297.2	1.50	43.40	16.30
	Bg ₂	59-112	550.7	132.1	317.2	1.57	40.75	16.07
	Mean		593.2	114.6	292.2	1.46	45.10	17.18
	CV		5.9	13.1	7.1	7.6	9.2	8.4
PIT 3	A	0-9	650.7	72.1	277.2	1.27	52.08	20.14
	AB	9-23	630.7	72.1	297.2	1.56	41.13	17.79
	Bg ₁	23-100	590.7	112.1	297.2	1.57	40.75	14.91
	Mean		624.0	85.4	290.5	1.47	44.65	17.61
	CV		4.9	27.0	4.0	11.6	14.4	14.9

*CV < 15% -low variability, CV > 15 ≤ 35% - moderate variability, CV > 35% - High variability

Bulk Density

The values of bulk density in all the horizons of the three profile pits of Asu river group (Table 6) varied from 1.07 g/cm³ to 1.31g/cm³ (pit 1&2) and 1.25 g/cm³(pit 3) and standard deviation of 0.08 (1&3) and 0.09 (pit 2). The values of bulk density in all the horizons of the Imo clay shale (Table 7) varied from 1.27 g/cm³ to 1.65 g/cm³ with mean values of 1.46g/cm³ (pits 1 & 2), 1.47 g/cm³ (pit 3). The bulk density of the soils were irregular down the pits for Asu river group while it increases down the profile pits in Imo clay shale. The increase in bulk density in the soils of the Imo clay shale might be attributed to compaction and less organic matter content down the soils. The increase in bulk density down the profile pits in Imo clay shale is in consonant with earlier works of Onweremadu and Duruigbo (2007). The irregular bulk density in Asu river group might be due to the depositional pattern of the particle sizes, while its low mean values might be attributed to cultivation or lower organic matter content. This agrees with earlier findings of Onweremadu (2009)

Moisture Content

The values of moisture content of all the horizons of the three profile pits of Asu river group (Table 6) ranged from 20.68 g/kg to 28.34 g/kg with mean

values 22.72 g/kg (pit 1), 23.26 g/kg (pit 2), 24.41 g/kg (pit 3). The values of moisture content of all the horizons of the three profile pits of Imo clay shale (Table 7) ranged from 12.90 g/kg to 20.14 g/kg with mean values of 14.20 g/kg (pit 1), 17.18 g/kg (pit 2) and 17.6 g/kg (pit 3). The moisture content of the soils were irregular in distribution down the pits for Asu river group might as well be attributed to the irregular bulk density distribution down the profile pits. The downward decrease in moisture content of the soils of the Imo clay shale might also be attributed to the downward decrease of the total porosity.

Chemical Properties

Tables 8 and 9 represent the chemical properties of soils of the Asu river group and Imo clay shale respectively.

Soil Reaction (pH)

The values of soil pH in (H₂O) in all the various horizons of the three profile pits of Asu river group (Table 8) varied from 4.89 to 5.65 (very strongly acidic to moderately acidic, Esu, 1991) with mean values of 5.43 (pit 1), 5.32 (pit 2) and 5.33 (pit 3). The values of soil pH in (H₂O) in all the various horizons of the three profile pits of Imo Clay shale (Table 9) varied from 5.31 to 5.52 (strongly acidic,

Table 8: Chemical Properties of soils of Asu River Group

Profile pits	Horizon	Depth	pH(H ₂ O)	pH(KCl)	OC(g/kg)	TN (g/kg)	AVP (mg/kg)	Ca Mg K			Na			TEB	Al	H	TEA	ECEC	BS%	Alsat	C/N	Ca/Mg	ESP	SAR
								→	→	→	←	←	←											
PIT 1	A	0-6	5.51	5.14	1.16	0.24	5.46	4.31	1.22	0.01	0.03	5.57	0.59	1.37	1.96	7.55	73.6	7.81	4.83	3.53	0.54	0.02		
	AB	6-19	5.13	5.03	0.84	0.14	9.38	3.10	1.03	0.05	0.05	4.18	0.87	1.18	2.05	6.28	67.4	13.85	6.00	3.01	1.22	0.03		
	Bg ₁	19-37	5.65	5.17	0.60	0.13	9.03	2.70	0.98	0.02	0.05	3.75	0.92	1.43	2.35	6.26	59.9	14.69	4.62	2.75	1.33	0.04		
	Bg ₂	37-120	5.41	5.10	0.26	0.08	6.57	2.60	0.99	0.04	0.03	3.66	0.98	1.07	2.05	5.71	64.1	17.16	3.25	2.62	0.01	0.02		
	Mean		5.43	5.11	0.72	0.15	7.61	3.18	1.06	0.03	0.04	4.29	0.84	1.26	2.10	6.45	66.25	13.38	4.68	2.98	0.78	0.03		
	CV		4.1	1.2	53.2	45.4	25.0	24.7	10.6	60.9	28.9	20.6	20.6	13.2	8.1	12.1	8.7	29.7	24.1	13.5	79.8	34.8		
PIT 2	A	0-9	5.55	5.15	0.84	0.14	7.28	4.10	1.38	0.03	0.08	5.59	0.61	1.23	1.84	7.43	75.2	8.20	6.00	2.97	1.43	0.05		
	AB	9-21	5.35	5.07	1.84	0.14	6.30	3.90	1.36	0.07	0.12	5.45	0.84	1.37	2.21	7.60	71.7	11.05	5.41	2.86	0.02	0.07		
	Bg ₁	21-48	5.34	5.07	0.86	0.24	7.24	3.70	1.45	0.02	0.04	5.21	0.92	1.38	2.3	7.51	69.4	12.25	1.79	2.55	0.76	0.02		
	Bg ₂	48-120	5.02	4.88	1.04	0.23	6.79	3.41	1.32	0.03	0.03	4.79	1.23	0.99	2.22	7.01	68.3	17.54	4.52	2.58	0.63	0.02		
	Mean		5.32	5.04	1.15	0.19	6.90	3.78	1.38	0.04	0.07	5.26	0.90	1.24	2.14	7.39	71.15	12.26	4.43	2.74	0.71	0.04		
	CV		4.1	2.3	41.2	29.3	6.6	7.8	3.9	59.1	60.9	6.7	28.5	14.6	9.6	3.5	4.3	31.9	42.0	7.6	81.5	61.2		
PIT 3	A	0-7	5.40	5.09	1.10	0.22	9.31	2.82	1.20	0.02	0.04	4.08	0.49	1.02	1.51	5.58	72.9	8.78	5.00	2.35	0.98	0.02		
	AB	7-24	4.89	4.61	0.84	0.14	7.98	2.50	1.02	0.06	0.16	3.74	0.70	1.31	2.01	5.75	65.0	12.17	4.60	2.45	4.27	0.012		
	Bg ₁	24-41	5.49	5.12	0.80	0.17	7.91	3.70	1.45	0.02	0.05	5.22	0.87	1.51	2.41	7.60	68.7	11.44	4.70	2.55	0.95	0.03		
	Bg ₂	41-100	5.54	5.14	1.00	0.22	6.89	3.14	1.03	0.02	0.02	4.21	0.93	1.55	2.48	6.69	62.9	13.90	4.55	3.05	0.47	0.01		
	Mean		5.33	4.99	0.94	0.19	8.02	3.04	1.18	0.03	0.07	4.31	0.75	1.35	2.10	6.41	67.38	11.57	4.71	2.60	1.67	0.02		
	CV		5.6	5.4	15.0	21.1	12.4	16.8	17.1	66.7	93.2	14.8	26.5	18.0	21.2	14.6	6.5	18.4	4.3	12.0	105.0	50.5		

*CV = Coefficient of variation; CV ≤ 15 = low variation, >15 – 35 = medium variation, > 35 = high variation, *CV = Coefficient of variation; CV ≤ 15 = low variation, >15 ≤ 35 = medium variation, > 35 = high variation, OC=Organic carbon AvP = Available P, TEB = Total Exchangeable bases, AlSat= Aluminum Saturation EA= Exchangeable Acidity BS= Base Saturation, ECEC= Effective Cation Exchange Capacity.

Table 9: Chemical Properties of soils of Imo Clay Shale

Profile pits	Horizon	Depth	pH(H ₂ O)		OC pH(KCl) (g/kg)	TN (g/kg)	AVP (mg/kg)	Ca Mg K → (cmol/kg)			Na TEB Al ←			H	TEA	ECEC	BS%	Alsat	C/N	Ca/Mg	ESP	SAR
Pit 1	A	0-8	5.31	5.09	17.3	1.40	4.29	1.72	0.30	0.17	0.03	2.22	0.61	1.09	1.70	3.92	56.60	15.56	12.36	5.73	1.35	0.03
	AB	8-21	5.35	5.11	15.8	1.30	5.91	1.69	0.28	0.17	0.04	2.18	0.65	1.07	1.72	3.90	55.90	16.66	12.15	6.04	2.33	0.05
	Bg ₁	21-52	5.37	5.12	12.00	0.20	2.35	1.32	0.24	0.13	0.04	1.74	0.68	0.89	1.57	3.30	52.50	20.61	6.00	5.50	2.29	0.04
	Bg ₂	52-109	5.45	5.16	9.70	0.70	2.18	1.30	0.24	0.09	0.05	1.68	0.70	0.93	1.63	3.31	50.8	21.15	13.85	5.41	2.97	0.05
	Mean			5.37	5.12	13.70	0.90	3.68	1.51	0.27	0.14	0.04	1.96	0.66	1.00	1.66	3.61	53.93	18.50	24.59	5.67	2.24
CV			1.1	0.6	25.4	62.2	48.0	15.2	11.3	27.3	20.4	14.5	5.4	10.0	4.1	9.7	5.2	15.1	96.1	5.0	29.9	22.5
PIT2	A	0-7	5.41	5.14	15.2	1.20	4.35	1.62	0.32	0.14	0.03	2.11	0.66	1.20	1.86	3.97	53.1	16.62	12.66	5.06	1.42	0.03
	AB	7-23	5.37	5.11	14.3	1.10	4.52	1.57	0.31	0.13	0.05	2.06	0.69	1.14	1.83	3.89	53.0	17.73	13.00	4.91	2.43	0.05
	Bg ₁	23-59	5.50	5.21	11.2	0.90	2.06	1.31	0.25	0.10	0.05	1.71	0.75	0.83	1.58	3.29	52.0	22.79	12.44	5.24	2.92	0.05
	Bg ₂	59-112	5.39	5.12	6.30	0.60	1.82	1.27	0.20	0.08	0.08	1.63	0.78	0.83	1.61	3.24	50.3	24.15	10.50	6.35	4.91	0.10
	Mean			5.42	5.15	11.75	0.95	3.19	1.44	0.27	0.11	0.05	1.88	0.72	1.00	1.72	3.60	52.10	20.32	12.15	5.39	2.92
CV			1.1	0.9	34.2	27.9	45.3	12.3	20.7	24.5	39.3	12.9	7.6	19.8	8.5	10.7	2.5	18.2	9.2	12.1	50.2	51.9
PIT3	A	0-9	5.38	5.10	15.0	1.20	3.71	1.60	0.27	0.12	0.04	2.03	0.67	1.21	1.88	3.91	51.9	17.13	12.5	5.93	1.97	0.04
	AB	9-23	5.52	5.21	9.00	1.18	1.77	1.33	0.21	0.08	0.09	1.71	0.77	0.97	1.74	3.45	49.6	22.32	7.62	6.33	5.26	0.10
	Bg ₁	23-100	5.42	5.18	7.00	0.77	1.23	1.2	0.18	0.09	0.14	1.61	0.94	0.75	1.69	3.32	49.1	28.31	9.09	6.66	8.69	0.16
	Mean			5.44	5.16	10.33	1.05	2.24	1.38	0.22	0.10	0.09	1.78	0.79	0.98	1.77	3.56	50.20	22.59	9.74	6.31	5.31
CV			1.3	1.1	40.3	23.1	58.3	14.8	20.8	21.5	55.6	12.3	17.2	23.6	5.6	8.7	3.0	24.8	25.7	5.8	63.2	60.0

*CV = Coefficient of variation; CV ≤ 15 = low variation, >15 ≤ 35 = medium variation, > 35 = high variation, OC=Organic carbon AvP = Available P, TEB = Total Exchangeable bases, AlSat= Aluminum Saturation EA= Exchangeable Acidity BS= Base Saturation, ECEC= Effective Cation Exchange Capacity.

Organic Carbon

The values of organic carbon in all the various horizons of the three profile pits of Asu River Group (Table 8) varied from 0.26 g/kg to 1.84 g/kg (very low to moderate, Esu, (1991) with mean values of 0.72 g/kg (pit 1), 1.15 g/kg (pit 2) and 0.94 g/kg (pit 3). The values of organic carbon in all the various horizons of the three profile pits of Imo clay shale (Table 9) ranged from 6.30 g/kg to 17.3 g/kg (low to high, Esu, 1991) with mean values of 13.70 g/kg (pit 1), 11.75 g/kg (pit 2) and 10.33 g/kg (pit 3).

Total Nitrogen

The values of the total nitrogen in all horizons of the Asu River Group (Table 8) varied from 0.08 g/kg to 0.24 g/kg (low to medium, Esu, 1991) with mean values of 0.15 g/kg (pit 1), 0.19 g/kg for profile pits (2 and 3). The values of total nitrogen in all the horizons of the Imo clay shale ranged from 0.20 g/kg to 1.40 g/kg (medium to high, Esu, 1991) with mean values 0.90 g/kg (pit 1), 0.95 g/kg (pit 2) and 1.05 g/kg (pit 3). The total nitrogen had similar trend with organic carbon in all the profile pits in both Asu River Group and Imo clay shale. Higher total nitrogen content was also recorded in Imo clay shale than the Asu River Group. The higher total nitrogen content of the epipedons is also in agreement with the earlier findings of Mohammed *et al.*, (2015) and Alem (2014) which stated that higher content of total nitrogen in epipedons indicates higher organic matter in the surface horizons.

Available Phosphorus

The values of available phosphorus in all the horizons of the various profile pits in Asu River Group (Table 8) ranged from 5.46 mg/kg to 9.38 mg/kg (low, Esu, 1991) with mean values of 7.61 mg/kg (pit 1), 6.90 mg/kg (pit 2) and 8.02 mg/kg (pit 3) and standard deviation of 1.90, 0.46 and 1.00 for profile pits 1, 2 and 3 respectively while the values of Available phosphorus in all the horizons of the three profile pits in Imo clay shale (table 4.6) ranged from 1.23 mg/kg to 5.91 mg/kg, (Esu, 1991) with mean values of 3.68 mg/kg (pit 1), 3.19 mg/kg (pit 2) and 2.24 mg/kg (pit 3). The values of available phosphorus were low at the both study areas. It was however lower in the soils of Imo clay shale.

Exchangeable Basic Cation

The values of exchangeable calcium in all the various horizons of the three profile pits of Asu River Group (Table 8) varied from 2.50 cmol/kg to 4.31 cmol/kg (low, FAO, 2006) with mean values of 3.18 cmol/kg (pit 1), 3.78 cmol/kg (pit 2) and 3.04 cmol/kg (pit 3). The values of exchangeable magnesium in all the various horizons of the three profile pits of Asu River Group (Table 8) varied from 0.98 cmol/kg to 1.45 cmol/kg (low to medium, FAO, 2006) with mean values of 1.06 cmol/kg, (pit 1), 1.38 cmol/kg (pit 2), 1.18 cmol/kg (pit 3). The values of Exchangeable sodium in all the horizons of the three profile pits of Asu River Group (Table 8) varied from 0.02 cmol/kg

to 0.16 cmol/kg (very low to low, FAO, 2006) with mean values of 0.04 cmol/kg (pit 1), 0.07 cmol/kg (pits 2 and 3).

The values of exchangeable calcium in all the various horizons of the three profile pits of Imo clay shale (Table 9) ranged from 1.20 cmol/kg to 1.72 cmol/kg (low, Esu, 1991, very low FAO 2006) mean values of 1.511 cmol/kg (pit 1), 1.44 cmol/kg (pits 1 and 2), 1.38 cmol/kg (pit 3). The values of exchangeable magnesium in all the various horizons of the three profile pits of Imo clay shale (Table 9), ranged from 0.18 cmol/kg to 0.32 cmol/kg (very low to low, FAO, 2006) with mean values of 0.27 cmol/kg each for pits 1 and 2, 0.22 cmol/kg (pit 3). The values of exchangeable potassium in all the horizons of the various profile pits of Imo clay shale (table 4.6) varied from 0.08 cmol/kg to 0.17 cmol/kg (low to medium, Enwezor *et al.*, 1981) with mean values of 0.14 cmol/kg (pit 1), 0.11 cmol/kg (pit 2) and 0.10 cmol/kg (pit 3). The values of exchangeable sodium in all the horizons of the three profile pits of Imo clay shale (Table 9) ranged from 0.03 cmol/kg to 0.14 cmol/kg (very low to low, FAO, 2006) with mean values of 0.04 cmol/kg (pit 1), 0.05 cmol/kg each for pit 2 and 3.

Generally, values of exchangeable cations were low in the both study sites.

Total Exchangeable Acidity (Exchangeable Al and H)

The values of total exchangeable acidity in all the various horizons of the three profile pits of Asu River Group (Table 8) ranged from 1.51 cmol/kg to 2.48 cmol/kg (low to medium, Enwezor *et al.*, (1981) with mean values of 2.10 cmol/kg (pit 1), 2.14 cmol/kg (pit 2), 2.10 cmol/kg (pit 3) and standard deviation of 0.17, 0.21, 0.43 for profile pits 1, 2 and 3 respectively. While the values of total exchangeable acidity in all the horizons of the three profile pits of the Imo clay shale (Table 9) varied from 1.57 cmol/kg to 1.88 cmol/kg (low, Enwezor *et al.*, 1981) with mean values of 1.66 cmol/kg (pit 1), 1.72 cmol/kg (pit 2), 1.77 cmol/kg (pit 3) and standard deviation of 0.07, 0.14 and 0.09 for profile pits 1, 2 and 3 respectively.

Effective Cation Exchangeable Capacity (ECEC)

The values of effective cation exchange capacity (ECEC) in all the horizons of the three profile pits of Asu River Group (Table 8) varied from 5.71 cmol/kg to 7.60 cmol/kg (low), (Esu, 1991, medium, Enwezor *et al.*, 1981) with mean values of 6.45 cmol/kg (pit 1), 7.39 cmol/kg (pit 2), 6.41 cmol/kg (pit 3) and standard deviation of 0.78, 0.26 and 0.91 for pits 1, 2 and 3 respectively. While the values of ECEC in the horizons of the three profile pits of Imo clay shale (Table 9) ranged from 3.24 cmol/kg to 3.97 cmol/kg (low), (Esu, 1991) with mean values of 3.16 cmol/kg (pit 1), 3.60 cmol/kg (pit 2), 3.56 cmol/kg (pit 3) and standard deviation of 0.35, 0.38 and 0.31 for pits 1, 2 and 3 respectively.

The values of ECEC recorded in the soils were less than the critical values of 10cmol/kg as reported by Ibia (1995).

Base Saturation (BS)

The values of base saturation in all the various horizons of the three profile pits of Asu River Group (Table 8) varied from 59.9 % to 75.2 % (moderate to high, Esu, 1991) with mean values of 66.25 % (pit 1), 71.15 % (pit 2), 61.38 % (pit 3) and standard deviation of 5.78, 3.05 and 4.39 for profile 1, 2 and 3 respectively. While the values of base saturation in all the horizons of the three profile pits of Imo clay shale (table 4.6) varied from 49.1 % to 56.6 % (moderate, Esu, 1991) with mean values of 53.93 % (pit 1), 52.10 % (pit 2), 50.20 % (pit 3) and standard deviation of 2.78, 1.29 and 1.49 for profile pits 1, 2 and 3, respectively.

The mean values of all the three profile pits of the Asu River Group were above critical values of 60cmol/kg as reported by Landon, (1991). While those of the Imo clay shale fell below the critical value of 60cmol/kg established by Landon (1991).

Aluminium Saturation (Al-sat)

The values of aluminium saturation in all the various horizons of the three profile pits of Asu River Group (Table 8) varied from 7.81 % to 17.54 % with mean values of 13.38 % (pit 1), 12.26 % (pit 2), 11.57 % (pit 3) and standard deviation of 3.98, 3.91 and 2.12 for pits 1, 2 and 3 respectively, while the values of aluminium saturation in all the horizons of the three profile pits of Imo clay shale (table 4.6) ranged from 5.556 % to 28.31% with mean values of 18.50 % (pit 1), 20.32 % (pit 2), 22.59 % (pit 3) and standard deviation of 2.79, 3.71 and 3.59 for profile pits 1, 2 and 3, respectively.

Exchangeable Sodium Percentage (ESP)

Values of ESP in all the horizons of the three profile pits of Asu River Group (Table 8) varied from 0.01 % to 4.27 % with mean values of 0.78 % (pit 1), 0.58 % (pit 2), 1.67 (pit 3) and standard deviation of 0.62, 0.58 and 1.77 for profile pits 1, 2 and 3, respectively, while the values of ESP in the various horizons of the three profile pits of Imo clay shale (table 4.6) ranged from 1.35 % to 8.69 with mean values of 2.24 % (pit 1), 2.925 (pit 2), 5.31 % (pit 3).

Ibia, (1995) reported 15 % as critical value of ESP that will limit crop performance. From the study all the mean values of all the profile pits of the both location were not up to this limit.

Land suitability evaluation for groundnut production

The land suitability evaluation for groundnut production is presented in Table 10. The suitability of the soils of Asu river group are N_1 (f) for profile pit 1, N_1 (f) for profile pit 2 and N_1 (f) for profile pit 3. It thus means that the overall suitability for the Asu river group are not currently suitable for groundnut cultivation due to limitation of fertility (in the case of

total nitrogen and organic carbon) which can be corrected to make the soils to become marginally suitable on potential suitability. However, on suitability based on land qualities, the Asu river group soils were highly suitable based on climate, highly, moderately and marginally suitable based on soil physical characteristics. The suitability of the soils of Imo clay shale were all marginally suitable (S_3) for groundnut cultivation. However, profile 1 and 2 was marginally suitable due to fertility S_3 (f) (available phosphorus) while profile pit 3 was marginally suitable S_3 (f) due to fertility (available phosphorus) and soil physical characteristics (drainage).

Table .10: Suitability classification of the soils for groundnut production

Land Qualities/ Characteristics	Asu River Group		Imo clay shale				S ₁
	Profile pits 1		2	3	1	2	
Climate (C)							
Rainfall (mm)	S ₁						
Temperature (°C)	S ₁						
Soil physical characteristics (S)							
Soil depth (cm)	S ₂						
Soil texture	S ₁	S ₁	S ₂	S ₁	S ₁	S ₁	
Topography (t)	S ₁	S ₂	S ₁	S ₂	S ₂	S ₂	
Slope (%)							
Drainage	S ₂	S ₂	S ₃	S ₂	S ₂	S ₃	
Soil fertility status (f)							
Ph	S ₃						
Total N (g kg ⁻¹)	N ₁	N ₁	N ₁	S ₁	S ₁	S ₁	
	S ₃						
Available P (mg kg ⁻¹)							
Base saturation (%)	S ₂						
Organic C (g kg ⁻¹)	N ₁	N ₁	N ₁	S ₁	S ₂	S ₂	
Overall Suitability	N ₁ (f)	N ₁ (f)	N ₁ (f)	S ₃ (f)	S ₃ (f)	S ₃ (f)	

=highly suitable S₂ = moderately suitable S₃ = marginally suitable N₁ = currently not suitable

Land suitability evaluation for rice production

The land suitability evaluation for rice is presented in Table .11. The suitability for the soils of Asu river group for rice production were moderately suitability S₂ (f,s) for profile pit 3, and marginal suitability S₃ (s) for profile pits 1 and 2. The suitability constraint for profile pit 3 was fertility and soil physical characteristics, while for profile pits 1 and 2, was soil physical characteristics. The suitability for the soils of

Imo clay shale for rice production was moderately suitable S₃ (f,s) for profile pit 3 with suitability constraint of fertility and soil physical characteristics, it was marginally suitable S₃ (s) for profile pits 1 and 2 with suitability constraint of soil physical characteristics (drainage).

Table .11: Suitability classification of the soils for rice production

Land Qualities/ Characteristics	Asu River Group		Imo clay shale				S ₁
	Profile pits 1		2	3	1	2	
Climate (C)							
Rainfall (mm)	S ₁						
Temperature (°C)	S ₁						
Soil physical characteristics (S)							
Soil depth (cm)	S ₁						
Soil texture	S ₁	S ₃	S ₁	S ₁	S ₃	S ₁	
Topography (t)	S ₂	S ₁	S ₂	S ₁	S ₁	S ₁	
Slope (%)							
Drainage	S ₃	S ₃	S ₂	S ₃	S ₃	S ₂	
Soil fertility status (f)							
Ph	S ₂	S ₃					
Total N (g kg ⁻¹)	S ₂	S ₂	S ₂	S ₁	S ₁	S ₁	
Available P (mg kg ⁻¹)	S ₂	S ₃					
Base saturation (%)	S ₁	S ₂					
Organic C (g kg ⁻¹)	S ₁	S ₂	S ₂	S ₁	S ₂	S ₂	
Overall Suitability	S ₃ (s)	S ₁ (s)	S ₂ (s)	S ₃ (f)	S ₂ (f)	S ₃ (f)	

=highly suitable S₂ = moderately suitable S₃ = marginally suitable N₁ = currently not suitable

Land suitability evaluation for cassava production

The land suitability evaluation for cassava production is presented in Table 12. The suitability of soils of the Asu river group for the three profile pits for cassava was currently not suitable N₁ (f) due to fertility (organic carbon). While the soils of Imo clay shale were all marginal suitable for S₃ (f,3) for profile pit 3 and marginal suitable S₃ (f,s) for profile pits 1 and 2. The constraint for profile pit 3 was fertility (organic carbon and available phosphorus) and soil physical characteristics (drainage).

Parameter	Units	Asu River Group			Imo clay Shale		
Rainfall	Mm	1700-2250			2000-2500		
Temperature	%	24-30			27-30		
Relative humidity		70-85			75-80		
Profile pit No.		1	2	3	1	2	3
Soil Physical characteristics (S)							
Soil depth	cm	0-120	0-120	0-100	0-109	0-112	0-100
Soil Texture		SCL	SCL	CL	SCL	SCL	SCL
Slope	%	1-2	2-3	1-22	2-3	2-3	2-3
Drainage		Moderately drained	Imperfectly drained	Moderately drained	Moderately drained	Moderately drained	Imperfectly drained
Sand	g/kg	740.9	748.4	745.9	591.0	593.2	624.0
Silt	g/kg	51.0	71.0	62.9	127.6	114.6	85.4
Clay	g/kg	208.1	180.6	191.2	281.6	292.2	290.5
Soil fertility status (f)							
pH(H ₂ O)		5.37	5.42	5.44	5.43	5.32	5.33
Total Nitrogen	g/kg	0.15	0.19	0.19	0.90	0.95	1.05
Available P	Mg/kg	7.61	6.90	8.02	3.68	3.19	2.24
ECEC	Cmol/kg	6.45	7.39	6.41	3.16	3.60	3.56
Exchangeable cations (C)	Cmol/kg		3.78	3.04	1.511	1.44	1.38
Base saturation	%	66.25	71.15	61.38	59.93	52.10	50.20
Organic carbon	g/kg	0.72	1.75	0.94	13.70	11.75	10.33
Al. saturation	%	13.38	12.26	11.57	18.50	20.32	22.59
ESP	%	0.78	0.58	1.67	2.24	2.93	5.31

Table 12: Suitability classification of the soils for cassava production

Conclusion

Soils varied in land characteristics and qualities and these variations influenced their suitabilities for groundnut, rice and cassava production.

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