PROPERTIES OF SOILS OF DISSIMILAR LITHOLOGY SUPPORTING YAM-BASED CROPPING SYSTEM IN SOUTHEASTERN NIGERIA.

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Abstract

This study investigated some physical and chemical characteristics of soils formed from coastal plain sands and shale in selected areas in southeastern Nigeria. A free survey technique using geology map of the area guided field sampling. Soils derived from these parent materials were randomly collected, air-dried, sieved and analyzed in the laboratory. The mean and coefficient of variation were computed on the results of soil analysis in the laboratory. Results of analysis showed that shale geological materials had higher clay and silt content (238.0 and 179.5 g kg^{-1}) than those formed on coastal plain sands (39.0 and 49.0 g kg^{-1}) while coastal plain sands had higher sand content. Base saturation was higher in the soil formed on coastal plain sands (644.5 g kg^{-1}) while organic carbon and effective cation exchange capacity were higher in the soils formed on shale (9.5 g/kg and 48.1cmol/kg). High variation of clay were recorded in shale- derived soils(Abakaliki) (CV= 50.12- 87.06 %) while coastal plain sands- derived soils (Emeabiam) had low to moderate variation (CV= 18.00 – 48.29 %)The amount of K, Ca, and Mg were low. It ranged from 0.01 – 1.75 cmol/kg, 0.04 -0.88 cmol/kg and 0.01-0.72 cmol/kg, respectively. While the highest amount of K occurred in Shale- derived soils of Abakaliki, the highest amount of Ca and Mg occurred in coastal plain sands- derived soils of Emeabiam

Keywords: Characterization, Lithology, Soil properties, Tropical soils.

Introduction

Parent material appears to exert the most dominating influence on soil properties when compared to other pedological factors (Ibanga 2006; Asadu et al., 1990; Allen 2001, 2002).Under natural conditions, the proportion of specific cations present in the soil are largely influenced by the soil parent material and the degree to which climate has promoted the loss of cations by leaching (Brady and Weil, 2002). The variations in clay mineralogy of soils appear to depend mainly on the parent materials from which the soils are derived (Radoslovich, 2006). The knowledge of the relationship between clay mineralogy and geological and weathering conditions is important in order to assess the inherent soil fertility for appropriate large scale land management (Tetsuhiro et al., 2006). The knowledge of the parent material of soil is essential for an understanding of many important characteristics related to the soil nutrient status (Uehera and Gillman, 1981).Knowledge of parent materials, their source of origin, mechanisms for their weathering, and means of transport and deposition are essential to understanding soil genesis (Brady and Weil, 2002). The eastern parts of Nigeria are underlain by crystalline rocks mainly granites (metamorphic rocks) and gneiss of the Precambrian basement complex and some outcrusts of basalt/igneous rock (Orajaka, 1975). The Precambrian basement complex composed of both metamorphic and igneous rocks. In Nigeria in particular and Africa in general, the nature of soils depends largely on the interaction between geological parent material and weathering history with the influence of parent material being strong (Bamjoko et al., 1983; Atkinson and Waugh, 2007).

Southeastern Nigeria is within the area known as " Yam Zone" in West Africa (Ene and Okoli 1985). These two soils overlying different parent materials are used for the cultivation of yam. Yams according to Obigbesan and Agboola 1978 are generally very demanding, and constitute a heavy drain on the nutrient reserves of the land. Nwinyi (1981) observed that the difference between soils of major and non-growing areas appeared to be in their nutritional status, most especially the quantity and proportions of Ca, Mg, K in the soils. Similarly, Ohiri (1982) opined that the variability in yam yield due to chemical factors might have a bearing on the effective cation exchange capacity (ECEC), Mg and K content of soils. He further reported that for yam production, the ECEC of soil typical of southeastern Nigeria should not be below 18.75 cmol/kg soil and base saturation about 27 % while exchangeable Mg and K should be close to 2.3 and 0.31 cmol/kg soil, respectively.

The knowledge of the horizon properties of these soils is important in order to know how best they can be managed for best agricultural management and fertilization for optimum crop production especially yam production and also suitability of the soils for agricultural use.

The goal of the study was to investigate some physical and chemical characteristics of soils formed from two types of parent materials namely; coastal plain sands and shale in southeastern Nigeria. Specific objective of the study was to compare the results of soil analysis under these parent materials with the aim of relating it to crop production.

Materials and Methods

The southeastern Nigeria agroecological zone includes Imo, Anambra, Enugu, Ebonyi, Rivers, Cross River and Akwa Ibom states lying between Latitude 4^o 15' and 7^o 20' North, and longitude 5^o 05' and 9^o 30' East. It has an area of about 75,488 sq km and lies within the rainforest belt of Nigeria although northern part of the zone is of rainforest savanna ecotone.

Abakaliki (Ebonyi state) is one of the study sites located on latitude 6^o 24' N, and longitude 8^o 30' E. Soils are underlain by Asu River Group (Albian) of Lower Cretaceous age. Abakaliki has an altitude of 50 -100 metres (Ofomata, 1975). It has 4 dry months with the driest month having less than 20 -90 mm rainfall a month. Mean annual temperature ranges from 27 – 28 ^{o}C. Abakaliki lies within the rainforest-savanna ecotone (Igbozurike,1975). The major socioeconomic activities include yam- and rice-based farming.

Emeabiam is in Owerri West of Imo state, lying on latitude 5^o 43' N and longitude 7^o 37' E (Onweremadu, 2006). Soils are derived from coastal plain sands (Benin formation) of Miocene-Pleistocene geologic era. The area has about 2500 mm mean annual rainfall while the mean annual temperature ranges from 26 – 27 ^{o}C. Emeabiam Owerri has a typical rainforest vegetation whose density is declining as a result of demographic pressure. Cassava- and yam-based cropping systems predominate with oil palm forming major plantation crop. Soils were on a flat topography (0 – 1 %).Three profile pits were sunk in each location. These profile pits were described and sampled according to FAO (1990) soil description guideline. Collected soil samples were air- dried and sieved using a 2 mm sieve in readiness for laboratory analysis. In addition 3 core samples per horizon were collected for bulk density determination. Particle size distribution of soils was determined by the hydrometer method as described by Gee and Bauder (1986). Bulk density was determined by the core method as described by Blake and Hartge (1986). The soil moisture content was described gravimetrically. Total porosity was calculated from the results of the bulk density (Vomocil, 1965) :

$TP = 1 – (BD/PD)100$ where

TP = total porosity, BD = bulk density, PD = particle density (2.65 g/cm^3).

Soil pH was determined in 0.1mol/L KCl suspension using a soil: liquid ratio of 1: 2.5 (that is 20 g of dried soil to 50 ml of 0.1mol/L KCl) and values were read off electrometrically using the pH meter. Exchangeable acidity was evaluated titrimetrically (Mclean, 1965) while cation exchange capacity was determined by the method described by Rhoades (1982). Exchangeable cation were extracted with ammonium acetate (NH_4OAC). While Calcium

(Ca), Magnesium (Mg) were evaluated by ethylene diamine tetra acetic acid (EDTA) titration method. Potasium (K) and Sodium (Na) were determined by flame photometry (Jackson, 1962). Total exchangeable base were obtained by summation and percentage base saturation BSAT or V- value was calculated thus :

BSAT = (TEB/ECEC) 100 Where TEB = Total exchangeable bases, ECEC = Effective cation exchanange capacity.

The percentage contribution of each exchangeable basic cation was calculated as its value in cmol/kg and then multiplied by 100.

Soil organic carbon (SOC) was analysed by Walkey and Black method as described by Nelson and Sommers (1982). Soil organic matter was derived by multiplying the value of soil organic carbon by a Bemmelen's factor of 1.724.Percent total nitrogen was measured by micro-kjeldahl digestion method (Bremner and Mulvaney, 1982). Carbon- nitrogen ratio was computed by dividing the value of soil organic carbon by the total nitrogen. Available phosphorus was determined colorimetrically using Bray (11) method (Olsen and Sommers, 1982).

Data analysis : Soil data were subjected to mean and coefficient of variation.

Results and Discussion

Morphological and physical properties of coastal plain sands and shale-derived soils.

Morphologically, soils developed from shale ranged from dark brown to light olive orange in colour, while soils developed from coastal plain sands were dark grayish brown or pale brown to red in colour (Table 1). These variations in soil colour could be attributed to differences in parent materials and drainage conditions. Shale-derived soils were imperfectly to well drained while coastal plain sands-derived soils were well drained (Table 1).Coastal plain sands-derived soils were well drained which could be explained by the sandiness of the soils and the associated macro porosity. Shale-derived soils were imperfectly drained which could be explained by the clayey nature of the soil and the associated small micro pore sizes.

Results of some soil physico-chemical properties showed that soils formed on shale had higher clay and silt content than the soils from coastal plain sands while soils formed on coastal plain sands had higher sand than soils from shale (Table 2). Soils derived from coastal plain sands contain 954 g kg^{-1} and 92 g kg^{-1} sand in A and B horizons, respectively when compared with 55.7 g kg^{-1} and 45.7 g kg^{-1} in those of soils formed on shale (Table 2). Shale-derived soils (Abakaliki) had more clay (6.32 – 46.32 g kg^{-1}) when compared with coastal plain sands-derived soils (Emeabiam) with 1.2 – 3.3 g kg^{-1} clay (Table 2).High variation of clay were recorded in shale- derived soils(Abakaliki) (CV= 50.12- 87.06 %) while coastal plain sands- derived soils (Emeabiam) had low to moderate variation (CV= 18.00 – 48.29 %) (Table 5). Clayey soils are naturally of low temperature which reduces decomposition rate. In addition to this, clayey soils have micropores which may be limiting to heterotrophic microscopic decomposers, majority of which are aerobes (Tate,1980).

The particle size distributions of soils of the two parent materials are directly related to their grain sizes. This is in line with observation by Ezenwa (1987) that grain size of a parent material was the determinant of soil texture. It will be noted that soils formed on coastal plain sands are coarser-grained than shale, consequently giving rise to more sands and less silt and clay (Table 2 and 4). Changes in soil texture among the two soil group might be due to influence of parent material, land use and climate in the study site. Similar findings were reported by Nnaji et al., (2002).Texture has a profound influence on many soil properties and it affects the suitability of a soil for most uses (Brady and Weil, 2002). Soil texture influences soil shrinkage properties (Boivin et al., 2004), porosity of soils (Chertkov, 2000), cation exchange capacity (Akamigbo and Asadu, 1983), moisture retentivity (Bruand andTessier, 2000) and these properties are of agricultural and engineering importance.

Moisture content ranged from 18.90 – 49.80%.

Generally moisture content was higher in shale-derived soils than coastal plain sands-derived soils. This could be as a result of the sandy texture of the coastal plain sands-derived soils and the tendency of the soils to dry up when they are exposed to intense insolation (Obihara, 1961). Higher moisture content of the shale-derived could be as a result of the texture of the soils. In term of moisture content shale-derived soils was more favourable for yam production and other crops than coastal plain sands-derived soils.

The bulk density values of the pedons were moderate (1.01 – 1.69 mg m^{-3}) and favourable for the production of yam and other crops (Duruigbo, 2004). This result agrees with earlier observations by Wesch (1999), and West et al., (2004) that soils of many strongly weathered soils from the tropical region have low to moderate densities. This is as a result of the presence of iron oxide and halloysite in the soils. Bulk density increased with depth in the two major soil groups although higher values were recorded in Abakaliki soils. Values of bulk density were lower than values reported by Oti (2002). However, Oti (2002) studied eroded soils which are associated with increased bulk density resulting from direct compacting effect of heavy raindrops on unprotected soils with diminished organic matter. Results of bulk density influenced moisture content and total porosity (Table 2).

Chemical properties of coastal plain sands and shale-derived soils

The amount of K, Ca, and Mg were low. It ranged from 0.01 – 1.75 cmol/kg, 0.04 -0.88 cmol/kg and 0.01-0.72 cmol/kg, respectively (Table 3). While the highest amount of K occurred in Shale- derived soils of Abakaliki, the highest amount of Ca and Mg occurred in coastal plain sands- derived soils of Emeabiam

There was low to high base content generally above the established critical levels or ranges in Nigeria soils with the exception of Ca. Low content of Ca could be attributed to soil acidification which leads to leaching of Ca^{2+} ions in the presences of strong acid anions (SO_4^{2-} and NO_3^-) and dominant of H^+ and Al^{3+} ions on the exchange complex as well as in soil solution and drainage water rather than Ca^{2+}. This is unfavourable for the production of yam and other crops.

The ECEC was low. It ranged from 2.16 – 5.49 cmol/kg. The highest occurred in shale-derived soils of Abakaliki while the lowest occurred in coastal plain sands-derived soils of Emeabiam (Table 3). The low ECEC is probably as a result of leaching. The ECEC values were generally higher in the top soil or upper horizon than the subsoil or lower horizon apparently because of the influence of higher level of organic matter in the former. Shale-derived soils had higher effective cation exchange capacity and organic matter while coastal plain sands had higher base saturation (Table 3 and 4). The higher effective cation exchange capacity and organic matter in the shale agrees with Allen (2001) that parent material greatly influences nutrient content and mineralogy of the weathering product in soils. Lack of statistical significance in their differences might be attributable to the fact that the soils are highly weathered. Buol et al., indicated that the younger the soil the more influence and relationship there is of the soil parent material but as the weathering and pedogenic processes proceed, the imprint of the initial material is less and less.

Higher values of organic carbon were obtained in soils of Abakaliki (3.0 -24.7 g kg^{-1}) than in soils of Emeabiam (1.0 -15.4 g kg^{-1}) despite the fact that the latter is located in a denser forest. The results varied highly, having a coefficient of variation of greater than 50 % in all the pedons (Table 5).

The available phosphorus content in the pedons varied from 5.93 – 116 mg/kg. The lowest and highest amount occurred in Emeabiam on coastal plain sands. The high phosphorus value may be attributed to certain factors such as phosphorus added as fertilizer or manure, inorganic and mineralized organic phosphorus compounds from plant residues (Nkwopara, 2006).

The relationship between organic matter and effective cation capacity was positive. This agrees with Kadeba and Benjaminsen (1976) who stated that cation exchange capacities of top soils of some forest reserves in Nigerian savannas were strongly dependent on organic matter. Onweremadu et al. (2006) has observed value of organic matter and base saturation percentage 1.14 % and 59 %, respectively on coastal plain sands in lowland states of southeastern Nigeria in contrasts with the values of 0.76 % and 64.45 %, respectively obtained on coastal plain sands.

Conclusion

The study revealed that the soils in southeastern Nigeria overlying different parent materials, that support yam- based cropping system varied in their physical and chemical properties. It was observed that soils varied from coarse to medium texture (sand to clay loam), well drained to imperfectly drained, have low ECEC, slightly to strongly acidic, low to moderate bulk density, unsaturated exchange complex, low to high organic matter, low total nitrogen and low to high phosphorus content.

Based on the soil characteristics and for optimum yam production it is recommended that these soils should be improved through liming with basic slag, use of factory wastes as amendments and utilization of rock phosphate to supply the needed phosphorus. Regular use of organic manure (grass or legume spp., cassava peels, poultry manure) to improve the level of soil organic matter which will in turn improve the effective cation exchange capacity and other properties of the soils such as aeration and porosity is necessary. Finally, use of organic fertilizer to improve the nutrient status of these soils is very important.

It is suggested that increased sampling of soils coupled with application of pedometric techniques in the analysis of collected soil data will go a long way in enhancing reliability and predictiveness of these soil attributes for sustainable soil use in the southeastern agroecology.

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Table 1 : Some morphological properties of soils overlying two parent materials in southeastern Nigeria.

Location	Depth (cm)	Colour	Structure	Drainage	slope (%)
Abakaliki	0 -20	2.5YR5/2	Medium subangular blocky	Well drained	1.5 – 2
	20 – 32	2.5YR3/4	Strong subangular blocky		
	32 – 54	10YR4/4	Strong subangular blocky		
	54 – 80	10YR4/4	Strong subangular blocky		
Abakaliki	0 – 18	2.5YR6/6	Weak granular	Imperfectly drained	0 – 1
	18 – 35	2.5YR5/6	Crumb		
	35 – 70	10YR5/8	Moderately subangular blocky		
	70 –150	2.5YR6/6	Moderately subangular blocky		
Abakaliki	0 – 15	2.5YR4/8	Weak granular	Imperfectly drained	0 – 1
	15 – 75	2.5YR5/6	Moderately subangular blocky		
	75 – 110	2.5YR6.6	Moderately subangular blocky		
Emeabiam	0 – 24	2.5YR3/4	Fine crumb	Well drained	0 – 1
	24 – 48	2.5YR4/4	Medium granular		
	48 – 86	2.5 Y4/8	Medium granular		
	86 – 150	2.5 Y5/6	Medium granular		
Emeabiam	0 – 25	2.5Y3/2	Fine crumb	Well drained	0 – 1
	25 – 60	2.5YR4/4	Fine medium granular		
	60 – 100	2.5Y4/6	Fine medium granular		
	100 – 150	2.5Y5/8	Fine medium granular		
Emeabiam	0 – 30	7.5YR4/4	Fine crumb	Well drained	0 – 1
	30 – 65	2.5YR4/6	Medium granular		
	65 – 100	2.5YR5/6	Fine medium granular		
	100 – 200	10Y4/6	Fine subangular blocky		

Table 2: Selected physical properties of soils overlying two parent materials in southeastern Nigeria.

Location	Horizon	Depth (cm)	Sand (g/kg)	Silt (g/kg)	Clay (g/kg)	Textural class	TP (g\kg)	BD (mg/m^{-3})	MC (g/kg)
Abakaliki	Ap	0 – 20	736.8	120	143.2	Sandy loam	410	1.45	228
	B1	20 – 32	856.8	80	63.2	Loamy sand	450	1.45	214
	Bt1	32 – 54	656.8	100	243.2	Sandy clay loam	390	1.62	205
	Bt2	54 – 80	576.8	180	243.2	Sandy clay loam	360	1.69	214
Pedon 2 : Abakaliki on shale									
Abakaliki	Ap	0 – 18	816.8	80	103.2	Loamy sand	550	1.19	189
	A2	18 – 3	556.8	100	343.2	Sandy clay loam	520	1.19	381
	Bt1	35 – 7	476.8	100	403.2	Sandy clay	460	1.60	275
	Bt2	70 – 150	456.8	180	463.2	Sandy clay	400	1.60	230
Pedon 3 : Abakaliki on shale									
Abakaliki	A	0 – 15	696.8	100	203.2	Sandy clay loam	610	1.04	348
	Bt1	15 – 75	456.8	140	403.2	Sandy clay	530	1.24	456
	Bt2	75 – 11	476.8	100	423.2	Sandy clay	450	1.40	498
Pedon 4 : Emeabiam on Coastal plain sands									
Emeabiam	Ap	0 – 24	966.0	22	12	Sand	610	1.04	204
	A2	24 – 42	954.0	23	24	Sand	420	1.24	216
	Bt1	48 – 86	940.0	37	23	Sand	520	1.28	231
	Bt2	86 – 150	920.0	47	23	Sand	460	1.44	224
Pedon 5 : Emeabiam on Coastal plain sands									
Emeabiam	Ap	0 – 25	954.0	22	24	Sand	400	1.26	189
	A2	25 – 6	930.0	42	28	Sand	400	1.42	351
	B1	60 – 100	954.0	22	24	Sand	460	1.59	275
	B2	100 – 150	920.0	47	23	Sand	520	1.60	231
Pedon 6 : Emeabiam on Coastal plain sands									
Emeabiam	Ap	0 – 30	945.0	32	23	Sand	520	1.01	189
	A2	30 – 65	930.0	42	28	Sand	620	1.15	341
	B	65 – 100	920.0	42	28	Sand	510	1.26	265
	C	100 – 200	920.0	47	33	Sand	570	1.29	228

TP = Total porosity, BD = Bulk density, MC = Moisture content

Table 3 : Selected chemical properties of soils overlying two parent materials in southeastern Nigeria.

Location	Horizon	Depth (cm)	pH(1 :2.5) H20	pH(1 :2.5) KCl	Organic C (g/kg)	Total N (g/kg)	Avail. P (mg/kg)	Exch.acidity H+ (cmol/kg)	Exch.acidity Al3+ (cmol/kg)	ECEC (cmol/kg)	Base sat. (g/kg)	Exch.cations Na (cmol/kg)	Exch.cations K (cmol/kg)	Exch.cations Ca (cmol/kg)	Exch.cations Mg (cmol/kg)
Pedon 1 :Abakaliki on shale															
Abakaliki	Ap	0 – 20	6.1	5.3	24.7	1.3	64.4	0.01	1.44	4.62	687.6	1.12	1.75	0.28	0.02
	B1	20 – 32	5.9	4.9	21.9	1.2	88.2	2.40	0.32	5.49	504.6	1.10	1.25	0.36	0.06
	Bt1	32 – 54	6.6	4.8	13.5	0.9	25.9	1.04	1.04	3.85	459.7	0.95	0.40	0.38	0.04
	Bt2	54 – 80	6.5	5.9	6.0	1.4	27.3	0.98	0.96	5.00	612.0	0.95	0.32	1.27	0.32
Pedon 2 : Abakaliki on shale															
Abakaliki	Ap	0 – 18	6.3	4.9	13.0	1.0	22.4	2.00	0.72	4.60	408.7	0.95	0.75	0.14	0.04
	A2	18 – 35	6.1	4.5	11.0	3.2	35.0	1.36	0.88	4.50	502.2	1.10	1.00	0.13	0.03
	Bt1	35 – 70	6.1	4.6	3.6	2.7	57.4	1.68	0.64	4.14	436.9	1.10	0.52	0.16	0.04
	Bt2	70 – 150	6.6	4.7	3.4	3.0	25.4	2.00	0.64	4.44	405.4	1.10	0.52	0.17	0.01
Pedon 3 : Abakaliki on shale															
Abakaliki	A	0 – 15	5.7	4.9	23.3	1.7	63.0	1.44	0.96	4.53	470.1	1.10	0.85	0.12	0.06
	Bt1	15 – 75	6.0	4.2	21.9	1.1	32.9	1.44	0.88	4.27	456.7	1.10	0.50	0.29	0.06
	Bt2	75 – 110	6.9	5.5	3.0	1.7	21.0	1.76	0.80	5.32	518.8	1.25	0.52	0.69	0.03
Pedon 4 : Emeabiam on Coastal Plain Sands															
Emeabiam	Ap	0 – 24	5.3	4.2	8.6	0.6	49.88	0.30	1.20	3.46	566.5	0.88	0.04	0.88	0.16
	A2	24 – 48	5.8	4.6	6.4	0.3	40.05	0.30	0.65	2.39	602.5	0.84	0.09	0.48	0.08
	B1	48 – 86	4.1	3.3	2.6	0.2	49.05	0.10	0.76	2.16	601.9	0.77	0.03	0.48	0.08
	B2	86 – 150	4.1	3.9	2.6	0.9	95.54	0.10	0.65	3.36	776.8	0.76	0.01	1.60	0.24
Pedon 5 : Emeabiam on Coastal Plain Sands															
Emeabiam	Ap	0 – 25	3.6	2.8	15.4	1.5	45.58	0.80	1.07	3.37	445.0	0.73	0.05	0.56	0.16
	A2	25 – 60	4.2	3.3	4.7	0.7	108.46	0.20	0.97	2.95	603.4	0.87	0.03	0.48	0.40
	B1	60 – 100	4.1	3.2	4.8	0.5	116.61	0.10	0.86	2.82	659.5	0.86	0.04	0.40	0.56
	B2	100 – 150	4.1	3.1	1.0	0.1	48.69	0.20	0.86	2.51	577.7	0.86	0.03	0.04	0.16
Pedon 6 : Emeabiam on Coastal Plain Sands															
Emeabiam	Ap	0 – 30	4.7	3.5	13.8	1.3	10.81	0.30	1.30	5.25	695.2	0.93	0.56	0.88	1.28
	A2	30 – 65	4.7	3.7	3.2	0.3	5.93	0.30	0.83	4.66	542.6	0.87	0.46	0.48	0.72
	B	65 – 100	4.7	3.7	2.6	0.3	7.56	0.10	3.02	5.48	230.6	0.91	0.33	0.40	0.72
	C	100-150	4.9	4.8	1.9	0.2	9.13	0.10	1.51	4.35	629.9	0.89	0.01	0.72	1.12

Table 4: Mean values of some properties of selected soils overlying two parent materials in southeastern Nigeria

Soil properties	Coastal Plain Sands	Shale
Silt（mg/kg）	49.0	179.5
Clay（mg/kg）	39.0	238.0
Organic carbon（mg/kg）	7.6	9.5
ECEC（cmol/kg）	40.9	48.1
Base saturation（mg/kg）	644.5	482.6

Table 5 : Coefficient of variation (CV) of the study area.

Some soil Phycico-chemical properties	Abakaliki on shale pedon 1 %	Abakaliki on shale pedon 2 %	Abakaliki on shale pedon 3 %	Emeabiam on Cps pedon 1 %	Emeabiam on Cps pedon 2 %	Emeabiam on Cps pedon 3 %
silt	62.33	66.78	40.88	64.08	62.59	24.76
clay	87.06	83.27	50.12	48.29	18.00	23.57
BD	2.58	30.00	21.14	17.60	20.41	18.64
OC	89. 09	96.15	100.00	100.00	100.00	100.00
ECEC	25.32	8.14	21.23	4.20	23.71	17.81
BS	31.59	17.73	9.57	25.77	10.06	67.92
Av. P	99.00	78.29	78.52	73.82	82.28	43.66

Cps: Coastal plain sands, BD : Bulk density, OC : Organic carbon, ECEC : Effective cation exchange capacity, BS : Base saturation, Av. P : Available phosphorus.