Journal of Agriculture, Environmental Resources and Management
ISSN2245-1800(paper) ISSN 2245-2943(online)
5(5)650-1220; Jan.2023; pp792-801

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Characterization and Classification of Soils Of Kolokuma/Opokuma Local Government Area of Bayelsa State Southern Nigeria.

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ABSTRACT

The characterization and classification of soils derived from flood plain soils in the humid tropics of the Niger delta of South South Nigeria was studied. Soil morphology, physical and chemical characteristics such as texture, drainage, effective soil depth, nutrients status and were employed and evaluated. The pedons were designated as KO 1-12. Soils are deep and massive in structure and moderately drained to seasonally poor. Textural class of the soils are sandy clay loam, clay loam, loamy sand to sand clay with dominate textural class of sandy clay loam. The overall pH results show that the soils are moderately acidic 4.5—6.0, Organic Carbon varies from 0.009 to 17.87 g/kg, irregularly decreasing down the profiles. Effective cation exchange capacity (ECEC) ranged from 1.85 to 31cmol/kg. The soils are classified according to USDA Soil Taxonomy and correlated with FAO/UNESCO soil map of the world reference base (WRB)Soil Legend. Three soil Orders were present, Alfisols/Lxisols (KO 4 and 12), Inceptisols/Cambisols (KO 2, 3, 5, 6, 7, 8, 9, 10 and 11) and Ultisols/Acrisols (KO 1).

Keywords: characterization, classification, Bayelsa State

INTRODUCTION

The soils of Kolokuma/Opokuma Local Government Area in Bayelsa State in the south south of the Niger delta region of Nigeria occurs in the low lying to gentle sloping land and are developed from deep unconsolidated marine sediments from Pleistocene age known as alluvium deposits underlain by sedimentary rock (Anderson, 1967). These soils are distributed on the physiographic surfaces ranging from 0-36 m above mean sea level. The slope is gradients is about 0-2%. (Ayolagha, *et al*, 2006). Land utilization and management of these soils requires detailed information on the characteristics, extent of distribution, inherent problems and their potentials for various uses. Information on the soil resources of any region contributes to the problem of soil degradation, environment and that of world food crises among others, due to wrong uses and poor management of land resources.

kolokuma/Opokuma Local government is an agrarian community depending majorly on arable crops and fishing as the economic sustenance. Variations existing in the properties of soils formed from diverse alluvium deposits as parent material have not been extensively studied. Hence there is insufficient information to characterize and classify them especially for arable cropping. This study essentially sought to characterize and classify of these soils for rain-fed agriculture.

Materials and Method

Study Area

The research was carried out in Kolokuma/Opokuma local government area in Bayelsa State in the Niger Delta Region south-south Nigeria. The Local Government Area lies between latitude 4° 30′ to 5° 00′ North and longitude 6° 00′ to 6° 30′ East. The area has a humid tropical climate and covers a land mass of about 44.283 km^2 (44,283 hectares). The area lies within the low-lying, broad and gently sloping upper deltaic plain of 0-2% gradient (Anderson 1967) of the Niger Delta. The Niger River divided into distributaries which meander strongly in this plain. It has a udic soil moisture regime with annual rainfall of about 2500 to 3000mm and Isohyperthermic soil temperature regime with mean annual temperature of 27^{oc} and the highest 34^{oc}, during dry season of the year. The lies within the humid tropical rainforest zone of Nigeria.

Field Study

12 areas were selected after reconnaissance survey base on topography and existing mapping units. In each of the mapping unit a profile was sunk and morphological characteristics were performed and described according to the guidelines of soil survey staff (2006) and soil samples collected from identified horizons for laboratory analysis. Observations were also taken as to the current land uses in the area

Laboratory studies

Soils samples collected from the field were air-dried, ground and sieved with 2mm mesh. The soil samples were analyzed for their physical and chemical properties using standard laboratory procedures. Soil particle size distribution was determine by the hydrometer method using sodium hexametaphosphate (Calgon) as the dispersing agent. (Gee and Bauder 1986), textural triangle was used to determine the textural class of the soils. Bulk density was determine by the undisturbed core method by Blake and Hartge (1986) soil reaction (pH)was determine 1:2.5 soil/water using glass electrode pH metre . exchangeable bases (Ca, Mg, Na and K) were determine by using MH_4 OAc method saturation method and Ca and Mg in solution were determine using AAS, while K and Na were determine n flame photometre (IITA,1979). While Exchangeable acidity was determine by the 1NKCl method. Organic carbon was determined by Walkley and Black dichromate wet oxidation method (Nelson and Sommers, 1982). Total nitrogen was determined by the micro-Kjeldahl technique (Bremner and Mulvaney, 1982). Cation exchange capacity (CEC) was determined by the 1N NH_4OA_c Ph 7.0 saturation method and the effective CEC by summation of exchangeable bases and exchangeable Al^{3+} (Soil Survey Laboratory Staff, 2004). Percentage base saturation was calculated as the sum of all base forming cations divided by CEC and multiplied by 100.

Results and Discussion

Soil characterization and classification

Morphological characteristics

The soils of Kolokuma/Opokuma local government Area are relatively high in sand context and the texture ranged from loam to sandy clay loam. The soils are stratified but their degree of stratification is less pronounced in older landscape where soil pedogenic processes are active. No stones or rocks are found and little or no erosion are seen in the Area. The soils are generally deep, they are beyond 100cm in all the profiles. They are well drained to seasonally poor, as mottles dominated the surface to subsurface of the Profiles. The dominate hue is 10YR on all the soils exception of Pedon 10 which has hue 7.5YR in all the horizons. Pedons 4 ,6, 8 and 10 are well drained soils, the surface soils texture were loam while subsurface soils are loamy sand to sandy clay loam. Profiles 1, 2, 3, 5, 11 and 12 have standing water between 108 and 165cm. Pedon 7 there is a change in structure due to deposition of parent materials of different texture and origin during development of the soils, from 0-79cm depth the soil sandy loam soil which seems to be of different parent material from the coarse pure sand layer at the depth of 80-124cm underlaying coastal plain sand soft fine grain 124-160cm, as a result of coarse texture, less water and nutrient is retained and pedogenesis at that the soils forming processes are less active. (kosuowei, et al, 2021) In pedon 10 the soils are well stratified with sandy loam from 0-67cm, overlaying a sandy horizon with light colour underlaying coarse texture parent material horizon at 165-195cm. In pedon 4 the surface soil texture is clay loam changing to clay in the subsoil with slight patchy cutans. The surface colours of the soils are Dark Brown to Yellowish Brown and Pale Brown to very Pale Brown in subsurface sols; Cambic horizon were therefore found in the pedons. Another feature found in these soils are the presence of abundant mica flakes (muscovite and biotite) in the sand silt fraction which favour the availability of Potassium (Dickson et al, 2020). This indicate that the soils are young and fertile. The soil structures are weak, massive to medium to thin sub angular blocky reflecting the drainage condition of the soils. Ferrous-Manganese concretions are also observed indicating that these soils undergo alternate dry and wet cycles annually due to flooding. These agree with the others findings of (Anderson 1967, Ayolagha et al 2006, Dickson et al, 2021) in this region. The distinctness and the outline of horizons within the profile are from clear smooth to wavy diffused boundaries.

Physical and Chemical Characteristics

The physical and chemical characteristics of the soils are shown in table 2 indicate the Particle size distribution of the soils, it shows that the soils of the profiles contain high values of sand and silt throughout the pedons. Even at the surface soils sand and silt dominated over clay. The sand values in surface soil texture top 50cm predominately loam in pedon 1 and pedon 6; silty loam in pedon 5, 2, 10 and 9. While Pedons 3, 7, 8, 11 and 12 are sandy loam; Pedon 4 has clay loam. The subsurface soils are predominately sand to sandy clay loam. The general increase in silt and sand content in the soils is as a result of annual deposition of materials by flood which makes the initial soil forming processes less active (Anderson, 1967). There are no indications of Argilic properties in these soils which corroborating the facts that the soils are recent (Ayolgha et al 1997). Bulk density and % Porosity values ranged from 0. 97 to $1.68mg/m^2$ in all pedons the results of the bulk density increases and % porosity decreases down all the profilse of the study area. In all physiographic positions of the study area, the values of bulk density are the same except in the last horizon of Pedon 7 which is $2.245mg/m^2$ due to accumulation of coarse sand fractions at lower horizons. And the % porosity is 15. The increase in bulk density in lower horizons may be attributed to the infilling of the pore spaces by alluvial materials from the overlaying horizon leading to compaction (Agbai, et al, 2022) The surface horizon shows lower bulk density values than subsurface horizons, this could be attributed to high organic matter which is distributed on the surface horizon by leaf foliage as reported by (Charles et al 2016).

The results of Chemical properties of the study area: The pH values of the study area varied from 4.3 to 6.3. There are generally slightly acidic in reaction, the pH values are irregular from surface to subsurface soils, with careful observation the pH values are low in the surface and higher in down the profile depth, the increase in soil pH is irregular and not consistent pattern is expected of the tropical climate condition where the soils are formed, exchangeable bases are usually leached down the soil solum by high rainfall there by increasing the pH values down the profile (Nsirimah et al, 1997). Total exchangeable acidity, the total exchangeable H^{+} and Al^{++} ranged from 0.327 to 10.58 cmol/kg is high in surface horizons in all the soils. It has an irregular distribution pattern similar to that of sand and silt in the particle size distribution decreases in values down the soil solum depth, this might be attributed to organic matter at the surface soils with careful observation as organic matter increases in surface horizons level and decreases in subsurface horizons so is the total exchangeable acidity. The phenomenal is in agreement with (Ayolagha *et al* 1996) with similar study in this region. Organic carbon of these soils ranged from 0.60-17.7 mg/kg , it varied from very low to medium with surface horizons having higher values than lower horizons in all the profiles. The distribution pattern is relatively regular, increases at the surface horizons and decreases down the profile. This trend has nothing to do with physiographic position of the soils. However, land use activities maybe the main responsibilities for such differences in organic carbon values.

The farming practices of slash and burn during intensive cultivation might have cause the distinction surface organic matter which is derived from organic carbon which have important role in soil fertility. Total Nitrogen of the soil in the study area, varies from 0.09-0.16 mg/k. It also have irregular distribution pattern. The total nitrogen in the soils is similar to that of soil Organic Carbon throughout the profiles in the study area, from surface horizons to the subsurface horizons. Available Phosphorous values are very high in all profiles of the study area. They ranged from 8.15 - 59.4 mg/kg . this high values may be attributed to the fishing activities and fish ponds in the area. These activities attract sea birds and egrets which is one of the source of (guano) phosphorous. Available P decreases from the surface horizons to the subsurface horizons down the soil solum depth. The distribution pattern is irregular similar to that of Organic carbon in the soils. The high values of available P is in agreement with other report findings in the Niger Delta by (Dickson et al, 1997, Ayolagha et al, 2006, Kosuowei, et al, 2021). Cation Exchange capacity or sum of bases (Ca, Mg, Na, K) values ranged from 1.34 to 20.82 cmol/kg, they are also irregularly distributed down the profiles, with similar tread as that of Organic Carbon in the area.

RESULTS AND DISCUSSON

Table 1: Morphological Characteristics

Pedon	Horizon	Depth cm	Munsell colour	Textural class (field)	Structure	Consistence (moist)	Roots	Boundary
KO 1	A	0-15	10YR 6/3	SCL	Crumbs	Friable	common	Smooth clear w.
	B	15-68	7.5YR 6/6	Clay Loam	Medium Sub Angular Blocky	Firm	Few	smooth diffused
	Bwg	68-110	7.5YR 6/1	Clay loam	Thin sub Angular blocky	Firm	Very few	
KO 2	Ap	0-14	10YR 5/4	Silty Clay	Crumbs	Friable	Many	Clear wavy
	B	14-57	10YR 5/4	Silty clay	Med. sub angular blocky	Firm	Few	Wavy diffused
	Btw	57-97	10YR 4/4	Loam	Med. sub angular blocky	Firm	Very few	Wavy diffused
	Bwg	97--137	10YR 5/5	Loam	Thin sub angular blocky	Firm	None	Wavy diffused
	Bcg	137-180	10YR 5/1	Sandy clay	Thin sub angular blocky	Firm	None	
KO 3	Ap	0-10	10YRS 3/2	silty Loam	Crumbs	Friable	Many Fine	Clear Smooth
	B	10-24	10YRS 4/3	Sandy loam	Med. sub angular blocky	Friable	Few Med.	Wavy diffused
	Bw	24 - 43	10YRS 4/2	Sandy loam	Thin sub angular blocky	Friable	Few	Smooth diffused
	Bwg	43-96	7.5YR 3/4	Sandy loam	Thin sub angular blocky	Friable	Very Few	Smooth diffused
	2Bwg	96-180	10YR6/6	Sandy loam	Thin Sub angular blocky	Firm	None	
KO 4	A	0-18	7.5YR 4/2	Silty clay	Crumbs	Friable	Medium common	Smooth Wavy
	AB	18-28	7.5YR 5/3	Clay loam	Med. Sub Angular Blocky	Firm	Few medium	Wavy diffused
	Bt	28-76	7.5YR 5/6	Clay	Med. Sub Angular Blocky	Very firm	None	Gradual diffused
	Bcg	76-180	7.5YR 6/3	Sandy clay loam	Sub Angular Blocky	Very Firm	None	
KO 5	Ap	0-12	10YR 4/1	Silty Loam	Crumbs	Friable	abundant	Smooth diffused
	B	12-32	10YR 5/4	Loam	Thin sub angular blocky	Soft	Common	Smooth diffused
	Bw	32-49	10YR 6/3	Clay loam	Thin sub angular blocky	Firm	Few	Smooth diffused
	2Bw	49-110	10YR 6/1	Sand Clay loam	Thin sub angular blocky	Firm	Very few	
KO 6	Ap	0-10	10YR 4/3	Silty loam	Crumbs	Friable	abundant	Wavy clear
	AB	10-33	10YR 5/4	Silty loam	Thin sub angular blocky.	Firm	common	Smooth diffused
	B	33-75	10YR 6/4	Sandy Clay	Med. sub angular blocky.	Firm	Few	Smooth diffused
	Bcg	75-180	10YR 7/3	Sandy clay loam	Med. sub angular blocky	Firm	None	
KO 7	Ap	0-16	10YR 4/6	Loam	Crumbs	friable	Common Medium	Wavy Clear
	B	16-37	10YR 5/4	Sandy loam	Thin sub angular blocky.	Firm	Few	Wavy clear
	Bt	37-63	10YR 6/3	Sandy loam	Thin sub angular blocky	Firm	Very .few	Smooth clear
	Bc	63-79	10YR 6/4	Sandy loam	Thin sub angular blocky	Firm	Very few	Smooth clear
	Bcg	79-124	10YR 7/6	Sand	Single grains	Loose	None	Smooth clear

	2Bcg	124-160	10YR 7/3	Sand	Fine Sand	Loose	None	
KO 8	A	0-26	10YR 5/3	Loam	Thin Granular	crumbs	Medium Common	Wavy Clear
	AB	26-48	10YR 7/6	Loam Sand	Medium sub angular blocky	Hard	Few. Medium	Smooth diffused
	B	48-67	10YR 6/6	Sandy Loam	Medium sub angular blocky	Hard	Few. Medium	Smooth diffused
	Bw	67-102	7.5YR 6/6	Sandy Loam	Medium sub angular blocky	Hard	Very Few	Smooth diffused
	Bwg	102-128	10YR 7/3	Loamy Sand	Thin sub angular blocky	Hard	None	Smooth diffused
	2Bwg	128-180	10YR 7/2	Sand	Thin sub angular blocky	Very firm	None	
KO 9	Ap	0-39	10YR 5/4	Loam	Crumbs	Friable	Abundant	Wavy clear
	B	39-66	10YR 4/4	Silty loam	Thin sub angular blocky	Firm	Common	Wavy Clear
	Bw	66-100	10YR 4/3	Silty Loam	Thin sub angular blocky	Firm	Few	Smooth Diffused
	Bwg	100-180	10YR 6/4	Silty loam	Medium sub angular blocky	Firm	Very Few	
KO 10	Ap	0-29	7.5YR 3/4	Sandy loam	Massive medium granular	Friable	Abundance fine	Wavy clear
	B	29-67	7.5YR 4/3	Sandy loam	Massive medium granular	Friable	Common	Smooth clear
	Bw	67 -123	7.5YR	Sandy Loam	Massive medium granular	Friable	Few	Smooth clear
	Bw_2	123-162	7.5YR 5/4	Loamy Sand	Thin Sub Angular Blocky	Friable	Few	Smooth clear
	Bwg	162-180	7.5YR 5/3	Sand	Coarse single grain	Friable	Very few	
KO 11	Ap	0-33	10YR 5/4	Sandy loam	Crumbs	Friable	Common	Wavy diffused
	B	33-67	10YR 5/3	Sandy Loam	Thin SAB	Friable	Few	Wavy diffused
	Bw	67-96	10YR 6/3	Sandy clay loam	SAB	Firm	Few	Wavy diffused
	Bwg	96-163	10YR 6/2	Sandy clay loam	SAB	Firm	none	
KO 12	Ap	0-30	10YR 4/3	Sandy loam	Medium granular	Friable	Common	Smooth Clear diffused
	Bw	30-75	7.5YR 4/3	Loam	Thin sub angular blocky	Friable	Few Fine	Smooth Clear gradual
	Bwg	73-143	7.5YR 4/3	Loam	Thin sub angular blocky	Friable	Very Few	

Soil Classification

The soils are classified based on USDA Soil Taxonomy, Twelfth Edition (Soil Survey Staff, 2014) and correlated with FAO/UNESCO Soil Legend, World Reference Base of Soil Resources (WRB, 2014). The soils of the study area, have three major soil types (Orders) Inceptisols/Cambisols, Alfisols/Lixisols and Ultisols/Acrisols. It consists of 12 mapping units, with each mapping unit represented by a pedon.

Soils classification using USDA key to Soil Taxonomy. Pedon 1 qualified for Ultisols soil Order, as it has "by sum cations" of less than 35% at a specify depth and an argillic or kandic horizon. It also fell into udic on the basis of its soil moisture regime, it is placed in the great group *udult* and *kandiudult* because with increase in depth it does not have clay decreases up to 20% or more "relatively" from the maximum clay content. So pedon 1 further qualifies for *Oxyaquic Kandiudult* subgroup because it is saturated with water in normal years in one of more layers within the mineral soil surface for 30 or more cumulative days. In terms of WRB classification, the Pedons in the study all have mottlings, which is stagnic properties, Pedon 1 correspond to *Stagnic Nitic Acrisol (Clayic, Oxyaquic)*.

Pedons 2,3,5,6,7,8,9,10 and 11 fell under the soil Order Inceptisols, as they did not possess any of the other diagnostic horizons except Cambisols subsurface horizons on the basis of udic soil moisture regime with the resultant effect on colour, organic carbon content and base saturation, they are placed in suborder udepts. Pedons 2,3,5,6 and 10 qualifies for Eutrudepts great group because of the base saturation values that are greater than 50% in all the profiles and between the depth of 25cm and 100cm from mineral surface. Pedons 7, 8, 9 and 11 qualities for dystrudepts great group because they characteristically have low ECEC values, they are lower than 24cmol/kg in all pedons. Furthermore, pedons 2, 7, 8, 10 and 11 qualifies for *fluvaquentic* subgroup because they all have fluvic properties with irregular decrease in Organic Carbon values. Pedon 3 qualifies for *Oxyaquic Eutrudepts* because the pedon is saturated with water in normal years in one or two layers within 150cm in mineral soil surface for 30 or more accumulative days. Pedon 5 qualifies for *Fluventic Eutrudepts* subgroup because it also has fluvic properties at a depth of 125cm below the mineral soil surface, an organic carbon content of 0.2% or more in the pedon. Pedon 9 qualifies for *Ruptic Alfic dystrudepts* because each has 10 to 50:% (by volume) illuvial parts that otherwise meet the requirement for argillic horizon. Pedon 6 qualifes for *Typic Eutrudept* because the base saturation values are high between the depth of 25cm to 100cm from the surface horizon.

Pedons 4 and 12 qualified for Alfisols because it has layer that has 20% low clay content and below that layer it increases in 3% or more in fine earth fraction. They also possess plinthic properties in one or more horizons within the 150cm of the mineral horizons. Pedon 4 qualifies for *Plinthaquic Kandiudalf* because it has saturated water condition, while Pedon 12 fell into subgroup *Plinthic kandiudalf*. In WRB classification, Pedon 4 correspond to Stagnic Plinthic Lixisol (Clayic, Oxyaquic) it has plinthic properties and Pedon 12 correspond to Stagnic Plinthic Lixisol (siltic,eutric).

In WRB classification, the Pedons all have mottlings that is they have Stagnic properties. Pedon 2 correspond to Epistagnic fluvic Cambisols (epiclayic, eutric) because of the stagnic properties in surface horizon. Pedon 3 correspond to Stagnic endogleyic cambisols (Oxyaquic, eutric) because the pedon has hydromorphic properties within subsurface soil. Pedon 5 correspond to Stagnic Endo-plinthic cambisol (Siltic, Eutric), it has plinthic properties in the subsoil, Pedon 6 correspond to Stagnic fluvic cambisol (siltic, Eutric), Pedon 7 correspond to Stagnic Fluvic cambisols (skeletic,dystric), Pedon 8 correspond to Stagnic fluvic cambisol (dystric, manganiferric), Pedon 9 correspond to Stagnic Endogleyic Fluvic Cambisol(Siltic, Dystric), Pedon 10 correspond to Plinthic Fluvic Cambisol (endo-skeletic, Eutric), Pedon 11 correspond to Stagnic endoplinthic Fluvic cambisol (siltic,dysric, manganiferric) because this pedon plinthic properties.

Conclusion And Recommendations

Characterization and classification of kolokuma/opokuma soils qualify them for agricultural land use which will benefit farmers and the state at large. As farming is one of the major occupations of the rural dwellers. The starting point of management of these soils are:

1. **The area is annually flooded and with other environmental problems. Flooding cycles should be carefully observed for arable cropping and other agricultural activities.**
2. **Adequate drainage system should be employed for all- year- round farming.**
3. **The soils of the study area will require balance fertilizer and organic manure application for large scale farming**

Table 4:3:2 Physical and Chemical Characteristics

Horizon		g/kg	g/kg	mg/kg	←		cmol/kg				→	%	g/kg			
Depth cm	**pHw**	**Org. C**	**T N**	**Avl.P**	**Ca**	**Mg**	**Na**	**K**	**CEC**	**TEA**	**ECEC**	**B S**	**Sand**	**Silt**	**Clay**	**Textural Class**
KO 1																
0—15	4.3	7.58	0.66	30.0	5.15	2.25	1.86	1.567	10.82	10.58	21.40	50	484	280	236	Sandy Clay Loam
15--68	5.0	2.39	0.23	37.6	1.8	2.10	2.10	1.720	7.62	9.20	16.82	33	384	410	306	Clay Lpam
68--110	5.4	4.59	0.41	49.0	2.0	1.78	1.74	1.334	6.90	8.60	15.50	44	364	370	276	Clay Loam
KO 2																
0—14	5..0	17.77	1.14	37.8	3.7	1.836	1.83	1.377	8.74	9.10	19.84	43	404	160	436	C lay
14--57	5.2	3.79	0.39	11.1	4.0	2.600	2.60	1.760	10.96	2.40	13.36	83	404	160	436	C lay
57--97	5.3	2.00	0.15	10.0	4.5	2.654	2.65	2.535	12.34	3.0	15.34	76	484	320	196	Loam
97--137	5.3	7.98	0.63	42.7	7.6	2.230	2.23	1.201	13.26	4..84	18.00	73	424	240	236	Sandy Clay Loam
137--180	5.1	2.79	0.19	44.8	5.3	2.002	2.00	1.651	10.95	3.08	14.03	72	624	80	296	Sandy Clay Loam
KO 3																
0—10	6.5	15.0	1.4	18.0	8.4	2.4	1.90	1.30	14.00	11.60	25.60	88	656	240	114	Sandy Loam
10--24	6.7	14.4	1.0	20.0	6.8	2.0	1.50	2.40	12.7	5..03	17.72	81	678	120	202	Sandy Clay Loam
24--43	6.8	3.4	0.2	10.0	6.0	2.8	1.10	1.80	11.7	5.30	17.00	88	606	140	244	Sandy Clay Loam
43--96	6.9	1.2	0.1	10.0	4.8	1.6	2.10	1.20	9.70	5.40	15.10	81	602	140	348	Sandy Clay Loam
96--180	5.8	1.0	0.2	11.5	4.0	0.8	2.42	2.10	9.32	4.00	13.32	80	572	140	288	Sandy Clay Loam
KO 4																
0—18	4.7	7.18	0.60	28.60	9.1	3.10	1.133	1.154	14.39	6.94	21.33	67	556.8	80	363.2	Sandy Clay
18—28	4.8	2.19	0.22	30.1	5.9	1.17	1.219	1.307	9.59	7.20	16.79	50	526.8	120	353.2	Sandy Clay
28—70	5.5	5.59	0.46	39.2	2.8	2.31	2.315	1.931	9.35	1.24	10.59	72	364.0	60	576,0	Clay
70—180	5.0	4.59	0.46	11.9	1.40	1.25	1.230	0.854	4.74	6.08	11.42	62	544.0	60	396.0	Sandy Clay
KO 5																
0—12	5.0	17.56	1.60	28.0	7.0	0.88	1.306	1.359	10.55	5.30	15.85	66	456.8	320	193.2	Loam
12--32	5.1	7.18	0.56	53.2	4.2	1.50	1.437	0.975	8.07	2.84	10.96	81	404.0	400	196.0	Loam
32--49	4.9	4.39	0.34	43.4	7.4	0.84	1.218	1.111	10.57	4.04	14.97	70	476.8	320	203.2	Loam
49--110	5.3	6.98	0.49	51.1	9.0	3.51	1.652	1.051	15.21	1.12	16.33	93	476.8	310	213.2	Loam
KO 6																
0—10	5.1	1.400	0.133	11.55	2.5	0.90	1.788	1.334	3.40	0.88	10.80	60	57.68	13.00	29.32	Sandy Clay Loam
10--33	4.9	0.519	0.050	26.0	1.0	0.67	1.055	1.054	4.11	2.60	10.48	36	45.68	26.00	28.32	Sandy Clay Loam
33--75	5.2	0.512	0.057	16.4	2.3	0.68	1.291	1.208	4.08	1.64	11.19	49	45.68	28.00	22.32	Sandy Clay Loam
75--200	5.2	0.500	0.025	18.0	3.0	0.78	1.552	1.080	1.08	1.80	10.01	64	59.60	8.00	32.40	Sandy Clay Loam
0—10	5.1	1.400	0.133	11.55	2.5	0.90	1.788	1.334	3.40	0.88	10.80	60	57.68	13.00	29.32	S C L
KO 7																
0—16	4.7	3.49	0.66	82	3 36	1.33	0.583	0.779	0.304	0.194	6.56	92	522.7	340	137.3	Sandy Loam

16--37	5.1	0.740	0.18	10.6	2.72	1.08	0.528	0.283	0.672	0.227	5.51	84	650	222.8	127.2	Sandy Loam
37--63	5.6	6.09	1.07	11.6	3.64	1.16	0.492	0.295	1.440	0.891	7.91	70	662.0	262.	75.2	Sandy Loam
63--79	5.2	3.25	0.36	176	4.08	1.00	0.437	0.296	0.528	0.334	6.67	87	542.8	312	145.2	Sandy Loam
79--124	6.3	0.68	0.12	28.5	1.20	0.94	0.437	0.259	0.768	0.305	4.23	71	928	5.2	2.0	Sandy
124--160	6.1	2.19	0.28	36.4	2.68	1.25	0.257	0.293	0.411	0.480	5.37	87	862.8	62	75.2	Loamy sand
KO 8																
0—39	6.4	7.58	0.40	370.5	10.4	3.20	0.273	0.124	0.480	0.400	14.87	80	513.6	350	136.4	Loam
39—66	6.0	3.79	0.61	225.4	7.6	2.25	0.211	0.098	0.360	0.080	10.60	85	473.6	432	96.4	**Loam**
66—100	5.1	2.50	0.36	370.3	3.20	0.94	0.084	0.064	1.200	1.020	6.51	65	483.6	370	146.4	**Loam**
100-180	5.5	0.60	0.16	225.4	5.04	1.25	0.170	0.083	0.896	0.240	7.53	86	593.8	330	176.4	**Loam**
KO 9																
0—26	5.1	0.409	0.118	28.9	2.24	2.35	0.282	3.301	0.256	0.203	8.63	94	49.00	30.28	20.72	Loam
26—48	5.0	0.150	0.030	33.7	2.28	1.24	0.574	0.263	0.800	0.322	5.47	79	74.60	20.68	4.72	Loamy Sand
48—67	5.2	1.666	0.054	34.8	1.96	0.45	0.463	0.290	0.880	0.140	4.19	75	74.60	20.68	4.72	Loamy Sand
67--102	5.7	0.130	0.154	35.5	0.96	0.81	0.459	0.320	1.379	0.725	4.55	54	72.80	13.48	11.72	Sandy Loam
102--128	4.5	0.499	0.040	35.7	0.64	0.50	0.385	0.296	0.385	0.341	2.55	64	83.00	10.28	6.72	Loamy Sand
128--180	5.8	0.349	0.009	36.4	0.64	0.13	0.265	0.265	0.248	0.298	1.85	59	88.00	8.28	3.72	Sand
KO 10																
0—29	5.3	1.60	0.370	14.7	7.13	2.96	0.387	0.291	10.76	0.327	11.09	98	522.8	332.	145.2	Sandy Loam
29--67	5.0	.0.59	0.020	59.4	3.32	1.50	0.281	0.281	5.38	1.029	6.41	81	542.8	342.	115.2	Sandy Loam
67--123	6.0	0.90	0.029	21.9	2.20	1.08	0.274	0.277	3.83	0.600	4.43	86	720.8	204.	35.2	Loamy Sand
123--162	5.5	1.80	0.040	23.0	5.84	2.29	0.269	0.296	8.67	2.022	10.69	79	842.8	92.	65.2	Loamy Sand
162--195	5.4	2.10	0.038	59.33	5.16	2.04	0.574	0.285	8.23	2.473	10.70	53	922.8	62.	115.2	Loamy Sand
KO 11																
0—33	6.0	4.19	0.52	21.14	5.12	1.88	0.244	0.267	0.352	0.156	8.02	93	657.8	297	45.2	Sandy Loam
33--67	5.0	1.30	0.33	17.64	3.80	0.36	0.388	0.278	0.848	0.538	3.21	64	680.8	300	39.2	Sandy Loam
67--96	5.7	3.69	0.36	18.51	4.76	1.39	0.207	0.276	1.180	0.664	9.47	78	660.8	294	45.2	Sandy Loam
96--163	5.1	7.58	1.20	22.54	2.72	1.08	0.216	0.245	0.880	0.265	7.43	78	655.8	320	19.2	Sandy Loam
KO 12																
0—30	5.4	.6.18	0.130	11.34	3.36	1.01	0.118	0.103	0.496	0.180	5.326	93	60.36	20.00	19.64	Sandy Loam
30—73	5.6	.2.18	0.130	14.00	10.28	4.02	0.086	0.057	0.860	0.160	15.460	94	45.36	33.00	17.64	Loam
73—143	4.7	12.97	1.145	25.46	9.23	3.24	0.156	0.081	0.864	0.641	14.345	89	42.36	31.00	26.64	Loam

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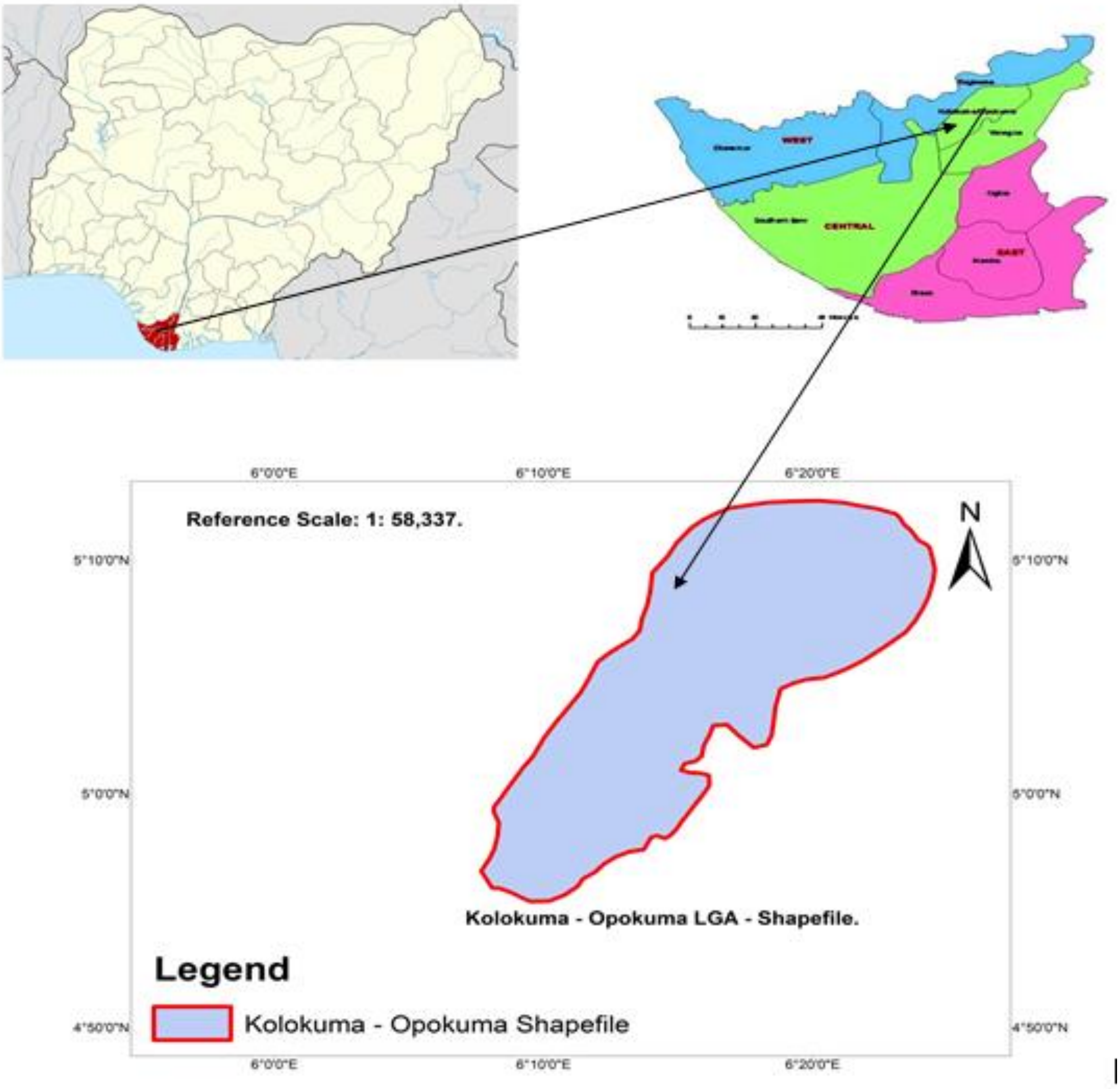
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