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Full Length Research Paper

Characterization and Classification of Soils Developed from Coastal Plain Sands and Alluvium in Khana Local Government Area of Rivers State, Southern Nigeria

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ABSTRACT: This study was carried out to characterized and classified soils developed from coastal plain sands and alluvium in Khana Local Government Area of Rivers State, Southern Nigeria. It covers 49,631.54 hectares. The main objectives of this study were to delineates, identify and classify the different types of soils in the study area and expressed in a soil map. The methodology used involved soil survey rigid grid method at semi-detailed level (1000 x 500)m (50 ha) which produced eight mapping units and each mapping units were represented by a pedon that was described horizon by horizon from bottom to the top of the profiles and soil samples were collected for laboratory analysis. The results showed that the soils were largely Inceptisols/Cambisol covering 31,832 hectares (64.13%), Entisol/Arenosol (9,100 hectares), Ultisols/Acrisol (5,350 hectares) and Alfisol/Lixisol (3,350 hectares) of total land area. Therefore, the soils of Khana Local Government Area which are largely Inceptisols/Cambisols, Entisols/Arenosols, Ultisols/Acrisols and Alfisol/Lixisol were greatly influenced by the parent materials, climate (rainfall) and to some extent vegetation of the area and the underlying geologic material, the sedimentary rocks weathered into coastal plain sands buried under alluvium at varying degrees at different places in the study area. Thus, these various soil types favoured the cultivation of oil palm, yam, cassava, citrus and to some extent plantain in the study area.

Keywords: Characterization, classification, soils of Khana, Rivers State, Southern Nigeria

INTRODUCTION

Soil classification involves a systemic arrangement of soils into groups or categories on the bases of their characteristics (Esu, 2010). Soils are characterized and classified based on their unique inherent properties in the natural setting (Obi *et al.,* 2014).This is done in order to provide the best management requirements for effective agricultural production (Udoh *et al.,* 2013). Characterization and classification is helpful in the appraisal of soil productivity. This also enhanced sustainable agricultural production in an area. Information on soil characteristics and classification is aimed at equipping land users with more knowledge on land resources (Nwaloka et al., 2019). Thus, to maintain sustainable agriculture, land use planning should be undertaken by investigating the soil through characterization and classification at both local and regional level (Sereke, 2002; Essoka and Essoka, 2014). This provides land users with information about the soil by simply giving name (classification) to different soils found in an area (Akamigbo and Asadu, 1983). According to Olaniyan (2013) in a situation where a reasonable percentage of the total population are crop farmers and shifting cultivation is becoming a thing of the past as it is in Khana Local Government Area, soil information is relevant to crop growth and development; and this could only be obtained from purposeful soil survey which is an essential ingredient toward sustainable crop production There is scanty information on soils of Khana Local Government Area, the few literatures available cover very small area (Peter and Anthony, 2017). Khana soils are derived from coastal plain sands and alluvium which could also be referred to as Ogoni sands (Esu, 2010) and Peter and Ayolagha (2012).

In the most recent UNEP (2010) assessment of Ogoniland, which Khana LGA is an integral part as the largest LGA, details soil characterization, classification and agricultural potentials of Khana soils were not ascertained, rather concentrations were on the hydrocarbon pollution levels of the soils and water of Khana and Ogoniland at large. Therefore, data on the detailed characterization, classification and agricultural potentials of soils of Khana in Ogoniland remain skeletal as this area were not covered by the above research works and as such agricultural transformation in this area might be difficult. As such, the main or major objective of this research therefore, was to characterize, classify and assess the soils developed from coastal plain sands and alluvium and its agricultural potentials in Khana Local Government Area of River State, Southern Nigeria.

MATERIALS AND METHODS

Brief description of the study area

This study was carried out in Khana Local Government Area of Rivers State, Southern Nigeria. It occupies 49, 631.54 hectares of land (Figure 1). It lies between latitude 4.67172N and longitude 7.34398E. It is bordered by five local governments namely: Tai, Gokana, Oyigbo, Opobo/Nkoro and Andoni local government and Akwa Ibom state The rainfall distribution of the study area ranged between 2000 – 2500 mm/annum in a bimodal form with a period of low precipitation popularly known as August break (Oyegun and Olosunorisa 2002). The monthly minimum and maximum temperature varies between 25°C and 28°C; while the relative humidity also varies between 81-87% depending on the season of the year (Ayolagha and Peter, 2012). The vegetation of the study area is the tropical rainforest with multiplicity of tree species that has been tremendously altered by the impact of land degradation occasioned by crude oil pollution, uncontrolled deforestation and continuous cropping system. Soils in the study area are well drained soil formed from coastal plain sand and alluvium of marine deltaic deposits.

Field studies

A pre-field survey was conducted on 49,631.54 hectares of land in Khana LGA using Semi detailed soil survey. The Administrative Map of Khana Local Government Area showing boundaries, roads and settlements was used as based map for the study. The map was geo-referenced and digitized in an Arch map environment forming the Shape file of the study area. The digitized map of the study area was gridded using (1000 x 500) m ($50ha^{-1}$) measurement at semi detailed soil survey. A total of nine hundred and nine three (993) auger sampling points were identified. The coordinate of each auger boring points were loaded into a handheld Geographical Positioning System (GPS) for easy auger boring point' identification. At each identified point, auger boring was done at depth intervals of 0 -30 cm, 30 – 60cm, 60 – 90cm and 90 – 120 cm except where there were obstructions. After auger boring, areas with identical soil properties based topography, vegetation, drainage and soil textures were grouped to form a mapping unit. From the groupings, Eight (8) mapping units were identified and delineated and one modal profile pit of 2m x 2m x 2m was dug at each representative point identified as a mapping unit (Figure 2). Each pedon was described using FAO guidelines (1990) and soil samples were also collected for laboratory analysis.

Laboratory analysis

Laboratory analysis of soil samples was carried out using standard laboratory procedures most appropriate for the various parameters to be examined. The soil samples collected were air-dried, ground and sieved using 2 mm mesh sieve and were subjected to routine soil analysis most appropriate at the Soil Science Laboratory, Federal University Technology, Owerri, Imo State. Particle size analysis was determined by the hydrometer method (Juo 979). Soil textural classes were determined using textural triangle (Soil Survey Staff, 2003). Bulk density was determined by core method as described by Blake 1965. Soil Reaction (pH) was determined in H_2O and I N KCl solution respectively. Organic carbon was determined by dichromate wet oxidation method of Walkey and Black, (1934) as described in methods of soil analysis (Juo, 1979). Available Phosphorus (P) was determined by Bray and Kurtz No 2 (1945) method as described by Jou (1979) and Loganathan et al. (1984). Total nitrogen was determined by the Macro Kjedahl digestion method as described by Juo (1979) and Loganathan et al. (1984). Basic cations (Ca, Mg, K and Na) were determined by

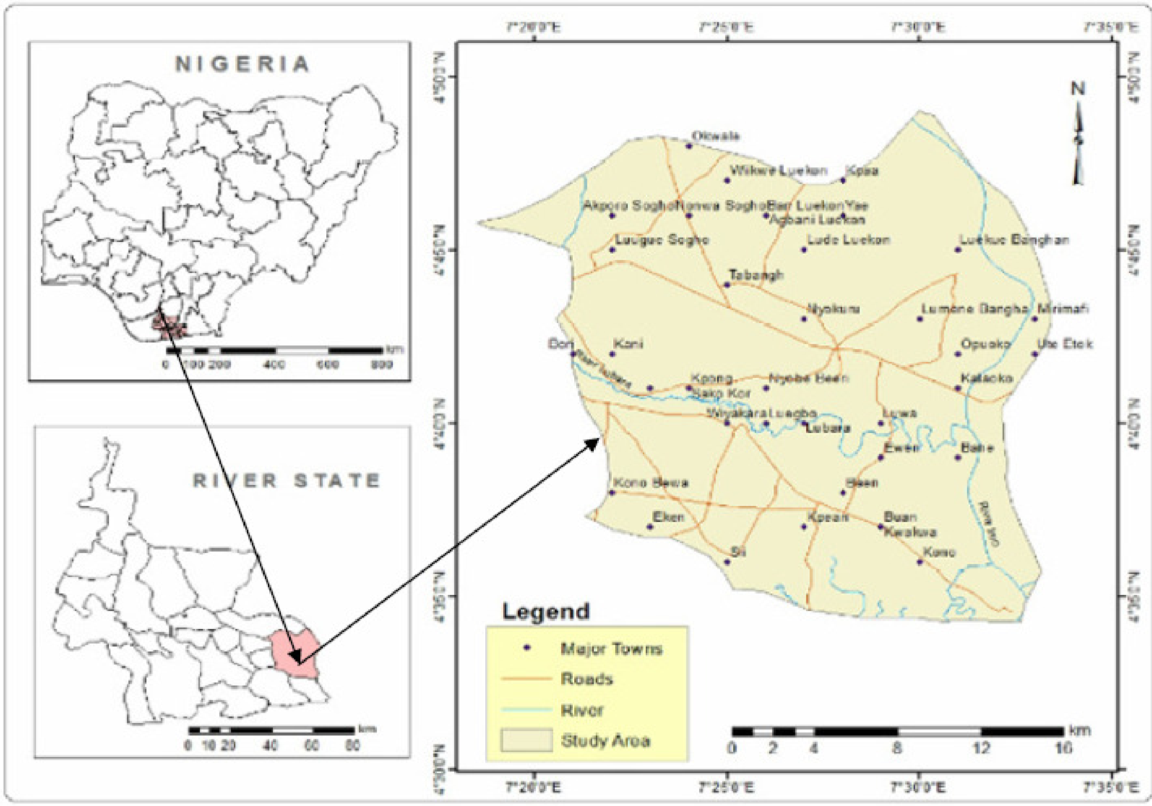

Figure 1. Map of Khana Local Government Area (Project Site).

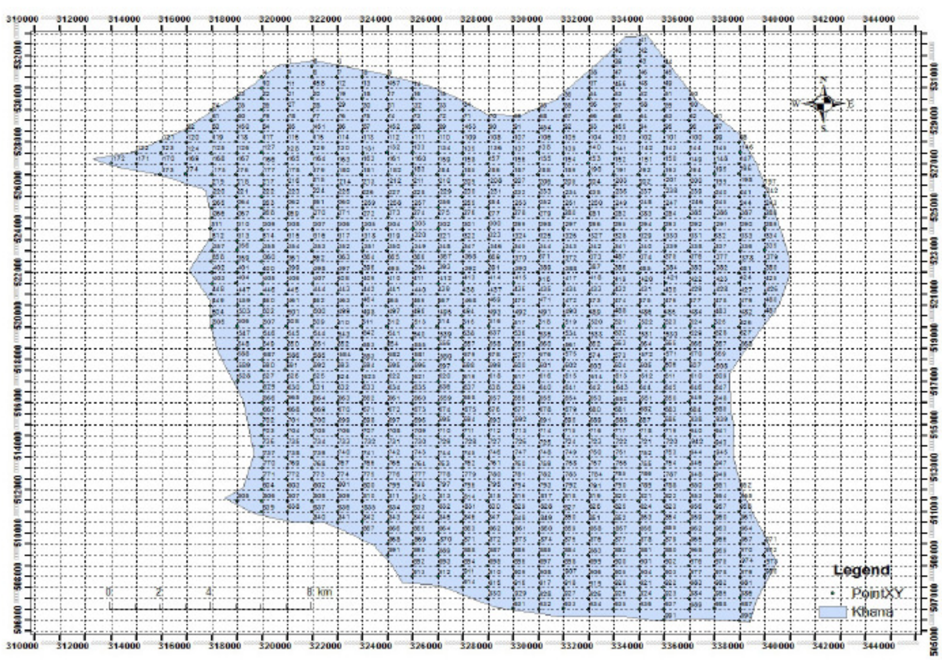

Figure 2. Map of Khana LGA Showing 993 Auger Boring Points

extracting with neutral ammonium acetate (I M NH_4OAc) buffered at pH 7.0. Exchangeable cations: Ca, Mg, K and Na were leached from the soil with NH_40Ac solution. Na and K were determined with a flame photometry. ECEC was determined as the sum of total exchangeable bases plus exchangeable acidity. Base Saturation was calculated using total exchangeable bases divided by CEC and multiplies by 100.

Soil map and soil classification

Soil map of the study area was produced using relevant soil morphological properties and data from laboratory analysis to produce a digitalized soil map of the study area. Soil classification was done using the data obtained from morphological descriptions of the pedons in the field and data obtained from laboratory analysis. Based on the results obtained from the laboratory analysis and field morphological properties, the pedons were classified according to Soil Taxonomy (Soil Survey Staff, 2014) and correlated with FAO/ISIC/IUSS/World Reference Base for Soil Resources (2014) methods of soil classification at Order, Suborder, Great group and Subgroup level for USDA and Reference Soil Groups (RSG) with the necessary prefixes and suffixes using WRB.

RESULTS AND DISCUSSION

Morphological characteristics of soils of the study area

Table 1 shows the results of morphological characteristics of soils in the study area. It reveals that soil colour (hue, chroma and value (moist) using Munsell colour chart) varied from dark brown (0-18cm) to yellow brown (103-131cm) depth in Pedon 1. In Pedon 2, the colour varied from Dark gray (0-12cm) to Yellowish brown (YB 10YR5/1) at 99-200cm depth. Pedon 3 soil colour varied from Dark gray (DG 10YR $4/3$) to Dark yellowish brown (DYB 10 YR $4/4$) at 133-200cm depth. The soils colour also varied from dark brown (7.5YR $5/3$) to Brown 7.5YR $4/3$ in Pedon 4, brown 7.5YR $3/2$ to light brown 7.5YR. The dark brown coloration of the top soils depict the presence of organic matter in the top soils, which confirmed the findings and reports of Plaster, (1992) and Brady and Weil, (2002). In Pedon 2, it was loamy sand at both the surface and sub-surface horizon; Soil texture in Pedon 3 ranged loamy sand to sandy clay loam; It was all loamy sand in Pedon 4, but in Pedon 5, soil texture ranges from sandy loam to loamy sand, while soil colour in Pedon 6 ranged from loamy sand to sandy clay loam and sandy loam to sandy clay loam (78-200) depth in Pedon 7 and textural class also ranged from loamy sand and sandy loamy in Pedon 8 respectively. Results of soil structure in the study area revealed that soil structure in Pedon 1 ranged from granular and sub-angular blocky at surface and sub-surface horizon (0 -73 and 103 - 131cm; Fine grained to sub-angular blocky in Pedon 2, but it was all sub angular blocky in Pedon 3. In Pedon 4, crumby to sub angular blocky in Pedon 5, sub-angular blocky in pedon 6, crumby to sub angular blocky in Pedon 7 and granular in Pedon 8 respectively. Soil consistence ranged from friable to firm (moist) in Pedon 1. All firms (moist) in Pedon 3, all loose in Pedon 4, all firm in Pedon 5, friable to firm in 6 loose to firm in Pedon 7 and friable to firm in Pedons 8. Consistence was non sticky, slightly sticky, sticky and slightly plastic and plastic. Soils of the study area in all the Pedons were all well drained soils except that of Pedon 4 that was poorly drained. All the horizons were well drained except Pedon 5 that had a very high water table. The near absent of mottle in the soils also confirmed the well drain condition of the soils under study that is also in line with the observation and report of Sen et al. (1997). Soil boundaries in the study area ranged from clear smooth to diffused in Pedon 1, abruptly wavy to clear smooth in Pedon 2 and clear smooth in the horizons in Pedon 3, 4, 5, 6, 7, and 8.

Physical properties of soil of the study area

The physical properties of the soils of the study Area are presented in (Table 1). The physical properties as revealed in Table 1 showed that sand size particle dominated other soil separates across the 8 Pedons in the Study Area. Sand fraction ranged from 705.5 to 792.4g/kg in Pedon 1, 833.6 to 863.6g/kg in Pedon 2, 712.6 to 802.4 g/kg in Pedon 3, 792.4 to 802.4 g/kg in Pedon 4,702.2 to 802 g/kg^{-1} in pedon 5, 760 to 781.6 g/kg in Pedon 6, 691.2 to 812.4 g/kg in Pedon 7 and 813.6 to 853.6 g/kg in Pedon 8 respectively. High sand particles at surface soils confirmed the report of Akamigbo and Asadu (1983), who stated that sand particles are predominant at surface horizon due the process of eluviation in soils. The dominant of sand fraction is also influenced by the parent material from which the soils are formed as reported by Akpan-Idiok, (2012). The silt content of soils in the Study Area also showed some degree of variability in all the Pedons in the Study Area. Silt content also ranged from 40 to 120 g/kg in Pedon 1, 23.6 to 103.6 g/kg in Pedon 2, 50 to 70 g/kg in Pedon 3, 60.2 g/kg in Pedon 4, 100.2 to 140.1 g/kg, in Pedon 5, 702.4 to 781.6 g/kg in Pedon 6, 60.2 to 110 g/kg in Pedon 7 and 53.6 to 63.6 g/kg in Pedon 8 respectively. The gram per kilogram of clay content of Soils in the Study Area also varied. Clay fraction ranged from 137.4 to 177.6 g/kg^{-1} in Pedon 1, 62.8 to 132.8 g/kg in Pedon 2,147.6 to 227.4 g/kg in Pedon 3, 137.4 to 147.4 g/kg in Pedon 4, 57.9 to 197.6 g/kg in Pedon 5, 64.4 to

Table 1: Morphological and physical characteristics of soils of the study area.

Pedon Design	Horizon depth	Colour (moist)	TC	Structure	Consistence	Drainage	Boundary	Roots	Sand	Silt	Clay	BD	TP
									←	g/kg	→	g/cm³	%
PEDON 1													
A	0-18	7.5YR 3/3 (DB)	SL	G	Friable	WD	CS	M2 rts	792.4	40	167.4	1.4842	44.2
AB1	18-40	10 Y4/3 (DGB)	SL	G	Friable	WD	Diffused	CI rts	772.4	50	177.6	1.623	38.98
AB2	40-73	10YR 5/2 (GB)	SL	G	Friable	WD	Diffused	FI rts	762.6	70	167.4	1.841	30.79
BW1	73-102	10YR 4/4 (DYB)	SL	Crumb	Loose	WD	Diffused	VFI rts	706.5	120	174.5	1.334	49.84
BW2	102-131	10 YR 5/4 (YB)	LS	SAB	Firm	PD	CS	VF1Yts	772.6	90	137.4	1.7492	32.72
PEDON 2													
A	0-12	10YR 4/1 (DG)	LS	F G	Friable	WD	AW	M2 rts	833.6	103.6	62.8	1.478	44.44
AB1	12-26	7.5YR3/2(VDG)	LS	G	Friable	WD	CS	F2 rts	863.6	53.6	82.8	1.346	49.4
AB2	26-40	2.5YR 5/2 (G)	LS	Crumby	Loose	WD	CS	Vfl rt's	833.6	73.6	92.8	1.566	41.33
BW1	40-99	10 YR ¾ (LB)	LS	SAB	Loose	WD	AW	Vfl rts	833.6	43.6	122.8	1.512	43.16
BW2	99-200	10 YR ¾ (YB)	LS	SAB	Loose	WD	AW	vf2 rts	843.6	23.6	132.8	1.731	34.94
PEDON 3													
A	0-23	7.5YR 4/1 (DB)	LS	SBK	Firm	WD	CS	M2 rts	802.4	50	147.6	1.5080	42.8
AB	23-60	7.5YR 4/4 (B)	SL	SBK	Firm	WD	CS	f2 rts	782.5	60	157.5	1.7320	36.2
B	60-78	7.5YR5/8 (DYB)	SL	SBK	Firm	WD	CS	f2 rts	762.4	50	187.6	1.8701	34.26
Bt	78-145	10 YR 6/8 (PY)	SCL	SBK	Firm	WD	CS	vf1 rts	722.4	70	207.6	1.7492	37.32
Bt2	145-200	10 YR 7/8 (YB)	SCL	SBK	Firm	WD	CS	vf1 rts	712.6	60	227.4	2.8920	30.20
PEDON 4													
A	0-23	7.5YR5/3(DB)	LS	FG	Loose	PD	CS	M1rtC	802.4	60.2	137.4	1.4892	46.24
Abw	23-50	7.5 YR 4/3 (B)	LS	FG	Loose	PD	CS	M1rts	792.4	60.2	147.4	2.3050	31.80

Table 1: Continues: Morphological and physical characteristics of soils of the study area.

Pedon design	Horizon depth	Colour (moist)	TC	Structure	Consistence	Drainage	Boundary	Roots	Sand	Silt	Clay	BD	TP
									←	g/kg	→	g/cm³	%
PEDON 5													
A	0-13	7.5YR 3/2 (DB)	LS	Crumby	Firm	WD	CS	M2rts	802	140.1	57.9	1.6501	40.32
AB	13-46	7.5YR3/4 (DB)	SL	SBK	Firm	WD	CS	f2 rts	762.2	150	87.8	1.7440	36.30
AW1	46-71	7.5 YR 4/6 (SB)	SL	SBK	Firm	PD	CS	vf1 rts	722.4	120.2	157.4	1.7459	37.24
BW2	71-120	7.5 YR 6/4 (LB)	SL	SBK	Firm	PD	CS	vf1 rts	702.2	100.2	197.6	1.8016	34.62
PEDON 6													
A	0-26	7.5YR 4/1 (DG)	LS	SBK	Friable	WD	CS	M2 rts	781.6	154	64.4	1.4401	50.20
AB	26-52	7.5YR3/1(VDG)	LS	SBK	Friable	WD	CS	C1 2 rts	760	140	100	1.4926	47.28
B	52-114	7.5YR4/4 (DYB)	SCL	SBK	Firm	WD	CS	C2 rts	720.4	140	139.6	1.6012	41.16
Bt	114-200	7.5YR 6/4 (LYB)	SCL	SBK	Firm	WD	CS	vf2 rts	702.4	91.2	206.4	1.7309	36.1
PEDON 7													
A	0-17	10 YR 4/1 (DG)	SL	Crumby	Loose	WD	CS	M2 rts	812.4	110	77.6	1.6081	24.44
AB	17-35	10YR 5/4 (DYB)	SL	SBK	Firm	WD	CS	f2 rts	801.6	101.4	97	1.8624	35.27
B	35-78	10YR 4/6 (PYB)	SL	SBK	Firm	WD	CS	vf1 rts	760	140	100	2.3152	30.64
Bt	78-200	10 YR 6/4 (LYB)	SCL	SBK	Firm	WD	CS	vf1 rts	691.2	60.2	248.6	1.5022	43.76
PEDON 8													
A	0-22	10YR 2/2 (VDB)	LS	Granular	Friable	WD	CS	M2 rts	853.6	53.6	92.8	1.537	42.22
Ah	22-36	10 YR 4/3 (B)	LS	Granular	Friable	WD	CS	1 rts C	823.6	53.6	112.8	1.568	41.05
AB	36-50	10YR 6/3 (LYB)	SL	Crumby	Loose	WD	CS	vf2 rts	823.6	43.6	132.8	1.581	40.56
B	50-109	10 YR 5/3 (LB)	SL	SBK	Firm	WD	CS	vf1 rts	813.6	63.6	122.8	1.663	37.48
BW	109-200	10YR5/6 (PYB)	SL	SBK	Firm	WD	CS	vf1 rts	813.6	63.6	122.8	1.683	36.71

Key: DB = Dark brown, DGB = Dark gray brown, GB = Gray brown, DYB = Dark yellowish brown, YB = Yellowish brown, SL = Sandy loam, LS = Loamy sand, G = Granular, SAB Sub-angular Blocky, WD = Well drained, PD = poorly drained, CS = Clear Smooth, M = Many, I = Fine, 2 = Medium, F = Few, C = Common, VF = Very Few, rts = roots. TC = Textural class, BD = Bulk density.

206.4 g/kg in Pedon 6, 77.6 to 248.6 g/kg in Pedon 7 and 92.8 to 132.8 g/kg^{-1} in Pedon 8 respectively. The results of the textural class showed that it ranges from sand to Sandy clay loam, with loamy sand and sandy loam dominating some of the horizons in most of the Pedons across the study area. But density also ranged from 1.334 to 1.4843g/cm^2 in Pedon 1, 1.346 to 1.731 g/cm^2 in Pedon 2, 1.5080 to 2.8920g/cm^2 in Pedon 3, 1.4892 to 2.3050 in Pedon 4, 1.6501 to 1.8016 g/cm^2 in Pedon 5, 1.4461 to 1.7309 g/cm^2 in Pedon 6, 1.5022 to 1.8624 g/cm^3 in Pedon 7 and 1.537 to 1.683 g/cm^2 in Pedon 11 respectively. Total Porosity followed the same trend as was observed in soil bulk density of Soils in the Study Area.

Chemical Characteristics of soils of the study area

Table 2 shows the results of the chemical properties of the soils in the study area across the eight pedons. From the results, it is revealed that soil reactions (pH) in water ranged from acidic (4.31) in Bt-horizon of pedon 6 to slightly acidic (6.16) in horizon-A of pedon 2. Soil pH decreased from 6.13 in BW horizon to 5.43 in AB horizon of pedon 1. In pedon 2, soil pH varied from5.6 to 6.16. It also decreased from 5.4 to 6.11 in pedon 3. From the results, it is also observed that soil pH increased from 5.43 to 6.08in pedon 4. Soil pH level also increased from 4.50 to 5.71 in pedon 5; while in pedon 6, its ranged from 4.31 to 4.81 (very acidic) at surface horizon, pedon 7 results shows that soil reaction (pH), decreased from 5.9 to 4.7 and increased from5.59 to 5.83 in pedon 8. Generally soil pH decreased down the depth of the profile across the eight (8) pedons. Organic carbon content of soils in the study area decreased in relationship to profile depths from 14.15 g/kg to 1.40 g/kg in A-horizon in pedon 1 and BW- horizon in pedon 8 respectively. The results revealed that soil organic carbon across the eight pedons was generally. It was also observed that generally, organic carbon were higher at surface horizon than subsurface level of the soils in the study area. Decrease in soils organic carbon content with depth also collaborated with the report of Thurow and Smith, (1998) and Essoko and Essoka, (2014). Total nitrogen contents of the soils in the study area ranged from very low (0.24 g/kg) in BW2-horizon of pedon 5 to low (1.39 g/kg) in A-horizon of pedon 1. The results also revealed that total N decreased down the profile depth in all the pedons. Total N of soils under study was very due to excessive leaching experienced in the study area as a result of intensive rainfall experienced in the area confirming the findings of Udo and Ogunwale, (1986). Available phosphorus in soils of the study area ranged from1.82 m/kg^{-1} (very low) to 57.47 m/kg. The results also shows that, there was no decreased in available P content down the profile depths as observed in pH, organic carbon and total nitrogen, rather there were differences in the level of available P nonlinear to soil depths across pedons in the study area. Exchangeable calcium (Ca^{2+}) in soil of the study area ranged 0.10 cmol/kg^{-1} to 1.61cmol/kg^{-1} in Bw1-horizon pedon 5, while exchangeable magnesium varied from 0.02 cmol/kg^{-1}in pedon 2 to 0.95cmol/kg^{-1}in pedon 3. Soil magnesium content was very low compared to that of calcium as seen from the results in (Table 2). Exchanged potassium (K) and sodium (Na) also ranged from 0.116cmol/kg^{-1} to 0.301 cmol/kg^{-1} and 0.128 cmol/kg^{-1} and 0.607cmol/kg^{-1} respectively. The value of Ca:Mg ratio ranged from1:1 to 5:1, Extractable exchangeable acidity values varied from 0.448 cmol/kg^{-1} to 2.16 cmol/kg^{-1}. Level of extractable hydrogen (EH^+) ranged from 0.176 cmol/kg^{-1} to 2.12 cmol/kg^{-1}. Exchangeable Aluminum (Al^+) and Hydrogen (H^+) in soils of the study area are very low. However, soluble aluminum in the soils with pH greater than 5.0 is an acidification threat to soils in the study area. TEA ranged from 0.62 cmol/kg^{-1} to 4.28 cmol/kg^{-1}. Results effective cation exchange capacity (ECEC) of the soils in the study area also shows that, it was very low (1.758 cmol/kg^{-1}) to moderate (6.265 cmol/kg^{-1}) in Bt_2- horizon of pedon 3. C: N ratio shows some degree of variation and ranged from 4.2:1 to 32.4:1 in pedon 5.Base saturation varied from 21.22% in Bt_3 horizon of pedon 3 to 61.621% in pedon 7.

Classification of soils of the study area

Soils of the study area (Khana Local Government Area) were classified based on morphological and physicochemical characteristics of the soil using key to Soil Taxonomy (USDA) Soil Taxonomy/Soil Survey Staff (2010) and FAO/ISIC/IUSS World Reference Base for Soil Resources (2014) system of soil classification. The soils were classified at Order, Suborder, Great group and Subgroup level using semi detailed type of soil survey system. Soil map showing the different types of soils identified in the study area are shown in (Table 3 and Figure 3). Pedon 1, 3, 5 and 8 fell under the inceptisols order as they do not have a distinct pedogenic diagnostic horizon, rather they possessed a cambic subsurface horizon with base saturation < 50% (by NH_4OAc)in soil horizon. Due to their hyperthermic soil temperature and udic and per udic moisture regime as a result of seasonal dryness for at least 90 days or more water cumulative days per year, they were placed under the Udepts suborder. Pedon 1, 3, 5 and 8 were further placed into the Dystrudepts great group due to their low base saturation < 50 % from surface horizon to the subsurface horizon within 50cm of mineral soil surface and absent of fragipan and duripan and sulfudic horizon. Pedon 1 and 3 were further placed into the subgroup Oxyaquic Dystrudepts, because they were saturated with water in one or more layers within 100cm of the mineral soil surface for either 20 or more consecutive days or 30 or more cumulative days depending on the season of the year.

Table 2. Chemical properties of soils of the study area.

Horizon		pH	OC	OM	TN	Alv. P	Ca^{2+}	Mg^{2+}	K^+	Na^+	Ca:Mg	$EA1^{3+}$	EH^+	TEA	ECEC	C:N	BS
	Depth (cm)	(H_2O)	← g/kg^{-1}			mg/Kg^{-1} →	← cmol/kg^{-1}				→	←	cmol/kg^{-1}		→		%
PEDON 1 Oxyaquic Dystrudept/ Stagnic Endogleyic Cambisol (Oxyaquic, Hyperdystric)																	
A	0-18	5.66	14.15	24.59	1.39	10.88	0.78	0.40	0.200	0.183	2:1	1.76	1.04	2.80	4.483	10:01	34.865
AB_1	18-40	5.43	11.11	19.15	1.08	15.63	1.0	0.81	0.189	0.162	1:1	1.84	1.65	3.49	5.651	10:01	38.039
AB_2	40-73	6.08	12.08	20.83	1.04	9.27	1.0	0.82	0.177	0.135	1:1	1.15	1.03	2.18	4.312	12:01	49.44
BW_1	73-102	6.13	5.13	9.75	0.54	12.43	0.60	0.41	0.170	0.140	2:1	0.84	0.52	1.36	2.68	10.43:1	49.254
BW_2	102-131	5.55	4.16	7.17	0.40	18.23	0.80	0.46	0.164	0.150	2:1	0.75	0.75	1.55	3.124	10.4:1	56.335
PEDON 2 Typic Udipsamment/Haplic, Hypoferralic Arenosol (Hyperdystric																	
A	0-12	6.16	10.57	18.23	1.09	6.23	0.63	0.23	0.301	0.607	2:1	1.14	0.496	1.64	3.408	9.70:1	51.86
AB	12-26	5.94	8.28	14.27	0.89	4.76	0.37	0.12	0.254	0.47	3:1	0.624	0.432	1.056	2.280	9.30:1	54.1
B	26-40	5.96	4.39	7.57	0.39	2.94	0.19	0.05	0.277	0.411	4:1	0.720	0.432	1.152	2.06	19.4:1	46.65
BW_1	40-99	6.05	3.09	5.33	0.36	9.17	0.10	0.02	0.276	0.366	5:1	0.768	0.480	1.248	2.01	8.58:1	37.91
BW_2	99-200	5.6	1.40	2.41	0.23	5.94	0.25	0.07	0.276	0.494	4:1	0.800	0.440	1.24	2.33	6.09:1	47.03
PEDON 3 Oxyaquic Dystrudept/Plinthic Endogleyic Cambisol (Oxyaquic, dystric																	
A	0-23	6.08	10.06	17.34	0.90	39.08	1.50	0.95	0.198	0.220	1.58:1	1.76	1.48	3.24	6.108	10.59:1	46.955
AB	23-60	5.14	8.15	14.05	0.63	26.19	0.10	0.40	0.180	0.202	2.25:1	1.44	1.40	2.84	4.522	12.93:1	34.104
B	60-78	6.11	6.26	10.79	0.59	14.23	1.00	0.36	0.161	0.190	2.78:1	1.32	1.05	2.37	4.081	10.61:1	41.926
Bt_2	78-145	5.28	4.18	7.21	0.42	12.64	1.10	0.56	0.142	0.183	1.96:1	2.16	2.12	4.28	6.265	9.95:1	47.647
Bt_3	145-200	5.97	2.13	3.67	0.30	13.22	0.50	0.31	0.135	0.170	1.61:1	2.11	2.03	4.14	5.255	7.1:1	21.218
PEDON 4 Aquic Udipsamment/Haplic Endostagnic Arenosol (Greyic, Hyperdystric)																	
A	0-23	5.43	10.83	18.67	1.07	20.11	1.1	0.17	0.21	0.238	1.13:1	1.01	0.95	1.96	3.678	10.12:1	34.059
Abw	23-50	6.08	10.17	17.53	0.98	6.44	0.80	0.72	0.116	0.128	1.11:1	1.12	1.04	2.16	3.924	10.38.1	44.954
PEDON 5 Typic Dystrudept/Haplic Ferralic Cambisol (Chromic, Hyperdystric)																	
A	0-13	5.71	11.1	19.14	0.41	24.19	0.10	0.38	0.181	0.186	1.58:1	1.30	0.90	2.20	3.047	27.1	24.839
AB	13-46	5.12	12.0	20.69	0.37	22.80	0.50	0.24	0.169	0.174	2.08:1	1.41	2.12	3.53	4.613	327.4:1	28.750
BW1	46-71	4.92	8.0	13.79	0.30	21.69	1.61	0.44	0.160	0.186	3.41:1	1.31	2.06	3.57	5.766	27:1	53.228
BW2	71-120	4.50	6.21	10.70	0.24	9.33	1.40	0.40	0.149	0.174	3.51:1	1.9	2.12	4.02	6.484	26.1	55.228

Table 2 Continues: Chemical properties of soils of the study area.

Horizon		pH	OC	OM	TN	Alv. P	Ca^{2+}	Mg^{2+}	K^+	Na^+	Ca:Mg	$EA1^{3+}$	EH^+	TEA	ECEC	C:N	BS
	Depth (cm)	(H_2O)	← g/kg^{-1}			mg/kg^{-1} →	← cmol/kg^{-1}				→	←	cmol/kg^{-1}		→		%
PEDON 6 Typic Kandiudults/Haplic Vetic Acrisol (Hyperdystric)																	
A	0-26	4.81	11.1	19.14	0.45	23.9	0.90	0.66	0.170	0.220	1.36:1	1.60	1.12	2.72	3.86	2.6:1	32.397
AB	26-52	4.62	9.11	15.71	0.31	13.14	0.60	0.48	0.170	0.208	1.25:1	1.09	1.47	2.56	4.018	29.4:1	29.889
B	52-114	4.5	3.0	5.17	0.23	14.00	0.50	0.46	0.167	0.196	1.08:1	1.10	1.08	2.18	3.503	13.4:1	32.490
Bt	114-200	4.31	4.10	7.07	0.26	14.00	0.50	0.67	0.168	0.169	1.1	0.60	0.67	1.27	2.775	16:1	28.809

Table 2 Continues: Chemical properties of soils of the study area.

PEDON 7 Oxyaquic Kandiudalf/Gleyic Vetic Lixisol (Arenic, Oxyaquic)																
A	0-17	5.9	10.01	17.26	1.12	30.88	0.90	0.66	0.196	0.194	1.36:1	1.84	1.12	3.04	4.99	8.93:1	48.653
AB	17-35	5.7	8.06	13.99	0.86	13.09	0.92	0.44	0.161	0.182	2.09:1	1.16	1.00	2.16	3.863	9.4:1	30.367
B	35-78	4.90	6.11	10.88	0.71	10.16	1.10	0.83	0.160	0.180	1.33:1	0.96	1.14	2.1	4.37	8.9:1	54.035
Bt	78-200	4.70	4.18	7.21	0.49	9.59	1.00	0.48	0.145	0.146	2.08:1	0.84	1.03	1.89	3.641	8.53:1	61.621
PEDON 8 Fluventic Dystudept/Haplic Fluvic Cambisol (Chromic dystric)																
A	0-22	5.83	3.49	6.02	0.70	7.78	0.21	0.08	0.258	0.385	2.68:1	0.912	0.496	1.408	2.341	5.06:1	37.85
Ah	22-36	5.69	2.59	4.47	0.33	57.47	0.43	0.18	0.250	0.426	2.39:1	0.592	0.368	0.96	2.246	7.85:1	57.26
AB	36-50	5.59	3.69	6.36	0.47	10.85	0.32	0.09	0.283	0.418	3.56:1	0.592	0.336	0.928	2.039	4.16:1	54.49
B	50-109	5.72	3.19	5.50	0.67	1.82	0.34	0.10	0.278	0.416	3.4:1	0.448	0.176	0.624	1.758	4.76:1	54.51
BW	109-200	5.67	1.50	2.58	0.26	51.17	0.32	0.10	0.263	0.382	2.7:1	1.088	0.328	1.416	3.439	5.77:1	41.94

Table 3: Summary Table of Soil Classification Using USDA and WRB (2014) Soil Classification System.

Pedon	Depth	USDA				WRB			Size (Ha)	% coverage
No	(cm)	Order	Suborder	Great group	Subgroup	Prefix	RGS	Suffix		
1	0 – 131	Inceptisol	Udepts	Dystrudepts	Oxyaquic Dystrudepts	Stagnic Endogleyic	Cambisol	(Oxyaquic Hyperdystric	4750	9.57
2	0 – 200	Entisol	Psamments	Udipsamments	Typic Udipsamment	Haplic Hypoferalic	Arenosol	Hyperdystric	1400	2.82
3	0 – 200	Inceptisol	Udepts	Dystrudepts	Oxyaquic Dystrudept	Plinthic Endogleyic	Cambisol)	Oxyaquic dystric	19882	40.06
4	0 – 50	Entisol	Psamments	Udipsamment	Aquic Udipsamment	Haplic Endostagnic	Arenosol	Gleyic Hyperdystric	7700	15.52
5	0 – 120	Inceptisol	Udepts	Dystrudepts	Typic Dystrudepts	Haplic Ferralic	Cambisol	Chromic Hyperdystric	5950	11.98
6	0 – 200	Ultisol	Udults	Kandiudults	Typic Kandiudults	*Haplic Vetic*	Acrisol	Hyperdystric	5350	10.78
7	0 – 200	Alfisol	Udalfs	Kandiudalfs	Typic Kandiudalfs	Gleyic Vetic)	Lixisol	Arenic Oxyaqiuic	3350	6.75
8	0 – 200	Inceptisol	Udepts	Dystrudepts	Fluventic Dystrudepts	Haplic Fluvic	Cambisol	Chromic Dystric	1250	2.52

USDA = United State Department of Agriculture, WRB = World Reference Base, % Ha = Percent Coverage Soils and % COL = Percent Coverage of Land

Pedon 1corresponds to Stagnic Endogleyic Cambisol (Oxyaquic Hyperdystric) and Pedon 3 corresponds to Plinthic Endoglyeyic Cambisol (Oxyaquic Dystric) under WRB/ (FAO/ISIC/IUSS) (2014). Pedon 5 fits into Typic Dystrudept subgroup because they are moderately drained and do not have an ochric, kandic and argillic horizons with regular decrease in soil organic carbon content; while pedon 8 fit into Fluventic Dystrudept due to the cementation by organic matter and aluminum without iron. Using WRB/ (FAO/ISIC/IUSS) (2014), Pedon 5 corresponds to Haplic Ferralic Cambisol; while pedon 8 corresponds to Haplic Fluvic Cambisol (Chromic Dystric). Inceptisol in the study area covered 31832 hectares representing 64.14 % of the total land area. Inceptisols as young soils are expected in the study area because of seasonal flooding, and hence, the soils do not have sufficient time to develop because of the influx of materials from flood into the area. This is in line with the finding of Ayolagha and Onuegbu (2003) in their studies on soils of the Niger Delta.

Pedon 2 and 4 fell into the Entisol order because they have on evidence of proper soil development and lacks distinct pedogenic diagnostic horizon and have a very weak A-horozon developed from organic matter accumulation. Pedon 2 and 4 qualified to for the Psamment Suborder because they have a coarse texture and textural class of sand to loamy sand as specific depth. They fell into the Udipsamment great group because of the udic moisture regime of the study area. Pedon 2 also qualified for Typic Udipsamment because they are moderately deep and have deep ground water, but do not have lamellae within 200cm of soil surface and are not saturated with water in any layer within 100 cm of mineral soil surface for 30days or more cumulative days or 20 0r more consecutive days in normal years. This corresponds to Haplic Endostagnic Arenosol (Gleyic Hyperdystric) using

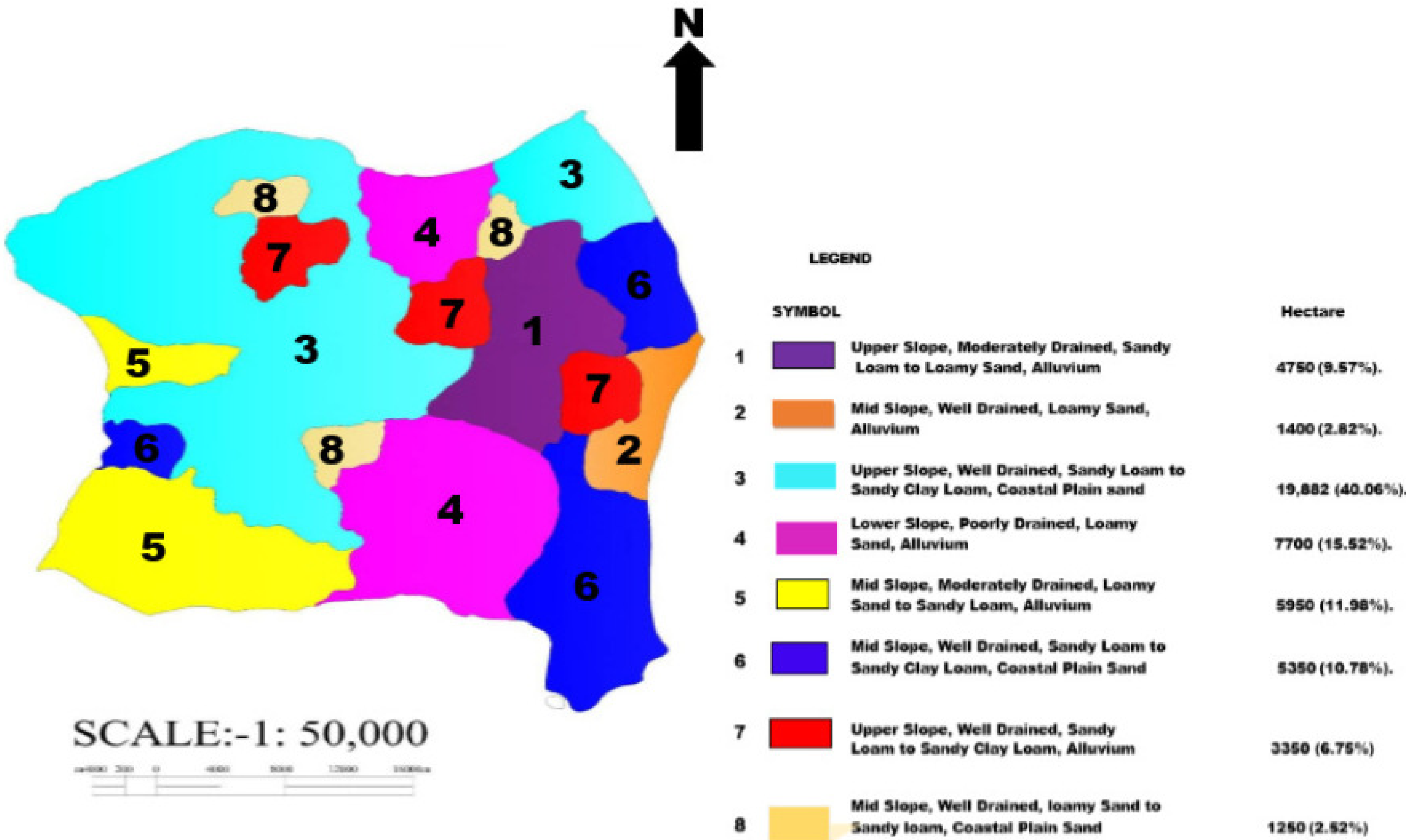

Figure 3. Soil Map of Khana LGA

WRB/ (FAO/ISIC/IUSS) (2014). Pedon 4 was further classified into Aquic Udipsammemt subgroup because they are saturated with water in one or more layers within 100 cm of the mineral soil surface in normal year for 20 or more consecutive days or 30 or more cumulative days. This also corresponds to Haplic Endostagnic Arrenosol (Gleyic Hyperdystric). Entisol in the study area covered 9,100 hectares representing 18.34 % of the total land area. Entisols are found in the area as a result of alluvial deposits from the flood plain with no evidence of soil pedogenic development characterized by their nature and properties. The results agreed with the findings of Raji (2015) who reported that the upland soils of Basement complex of Kwara State were classified as Alfisols, while soils of the valley bottom were classified as Entisols/Inceptisols. This is also in conformity with the report of Ayolagha and Onuegbu (2003). Pedon 6 qualified for the Ultisol order as they have an argillic and kandic horizon with low base saturation < 50% (by NH_4OAc), clay films easily washed due to high precipitation and notable increased in clay down the profile depth. The udic moisture regime placed them in udepts suborder. Pedon 6 fitted into the Kandiudults great group because, it is very deep with a kandic horizon and clay well distributed and does not decrease from it maximum level by as much as 20 % with a depth of 150cm from the mineral surface. Pedon 3 showed characteristics that mineral that were cardinal as they are freely drained, very deep and ground water at a moderate depth and thus, WRB/ classified as Typic Kandiudults. Using (FAO/ISIC/IUSS/WRB (2014), it corresponds to Haplic Vetic Acrisol (Hyperdystric). Ultisol of the study area occupied 5350 hectares representing 1078 % of the total land area in the study area. Ultisols were also found in the study area. This was influenced by the levees that developed over the years arising from heavy rainfall experienced in the area. Consequently, pedogenic processes of eluviation-illuviation resulting in the development of argillic-B horizons in the subsurface soils were evident. This is in agreement with Esu *et al.,* (2015) who reported that, occurrence of argillic diagnostic horizon in soils indicated the activeness of eluviation-illuviation process in soils. Pedon 7 can be classified as Alfisol order because they have a combination of an ochric and umbric epipedon and have medium to high base saturation in the soil and are saturated with water for 30 days or more in normal years. Pedon 7 belong to the Udalfs suborder due to the fact that they are more or less freely drained with udic moisture and hyperthermic temperature regime. Pedon 7 also exhibits properties that placed them into the Kandiudalf great group because they have a kandic horizon and their clay distributions does not decrease from its maximum amount by 20 % or more within 150 cm of soil surface. The pedon (7) is also placed into the Oxyaquic Kadiudalf subgroup because the soils were saturated with in one or more layers within 100cm of the mineral soil surface in normal year either for for 20 or more consecutive days or 30 or more cumulative days. This is the same as Gleyic Vetic Lixisol (Arenic Oxyaquic) in WRB/ (FAO/ISIC/IUSS) (2014). Alfisol in the study area covered 3350 hectares representing 6.75 % of the total land area. Alfisols were also found as a result of the levees crest with high clay deposit over the years. These four soil types found in the study area were greatly influenced by the parent materials, climate (rainfall) and to some extent vegetation of the area. It was also influenced by the underlying geologic material, the sedimentary rocks weathered into coastal plain sands buried under alluvium at varying degrees at different places in the study area. This is also in conformity with the observation of Mandunda *et al.* (2014) who reported that soils types are greatly influenced by the vegetation.

Conclusion

Information obtained from soil characterization and classification is key tools required to boost sustainable agricultural crop production to solve the problem of food insecurity for the teaming population of a country like Nigeria. This is because soil characterization and classification is helpful in the assessment of soil productivity. This also promotes sustainable agricultural production in an area. Adequate information on soil characterization and classification equipped the users of land with more knowledge of the soil characteristics and classes. Thus, to maintain sustainable agriculture, land use planning should be undertaken by investigating the soil through characterization and classification at both local and regional level.

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REFERENCES

Akamigbo FOR, Asadu CLA (1983).The influence of parent materials on the soils of Southeastern Nigeria. East Africa Agricultural and Forestry Journal, 48: 81–91.

Akpan-Idiok AU (2012). Physicochemical properties of degradation rate and vulnerability potentials of soils formed on coastal plain sands in southeast. Journal of Agriculture Resource 7 (7):358 – 366.

Ayolagha GA, Peter KD (2012). Effect of remediation material on physical and chemical properties of crude oil polluted Ultisol planted to soyabeans (Glycine max) in Ogoni, Niger delta, Nigeria. *Acta Agronomical Nigeriana* vol 11 No. 1 and 2.

Ayolagha GA, Onuegbu BA (2003). The soils of Rivers State in land and people of Rivers State (Eastern Niger Delta) Alagoa E.J. (ed) Research publication, Choba, Port Harcourt.

Blake GR (1965). Particle density. In CA Blake (ed) "Method of soil analysis part 1. *American society of Agronomy Monograph. No. 9 pp.*

371-373.
Brady NC, Weil RR (2002). The Nature and Properties of Soils. 13th edition. Pearson Education. India.
Bray RH, Kurtz LT (1945). Determination of total and available form of phosphorus in soils. *Soil science* 59: 39 -45.
Essoka AN, Essoka PA (2014). Characterization and Classification of Obudu Mountain Teep Hillside Soils (2014). *Nigeria Int. Journal of Soil Sci. 24 (1 2014)1-12.*
Esu IE (2010). Soil Characterization, Classification and Survey HEBN Publishers Plc, Ibadan, Nigeria.
FAO/ISIC/IUSS/World Reference Base for Soil Resources (2014). International Soil classification system for naming soils and creating legends for soils map update 2015. World Soil Reports (106), FAO, Rome
Juo ASR (1979). Selected Methods for Soil and Plant Analysis. IITA Manual Series No. p.70.
Loganathan PA, Dickson AA, Isirimah NO (1984). Potassium Supply Capacity of Soils formed on different Geological deposits in the Niger Delta Region of Nigeria. *Geoderma* 65:109-120.
Mandunda LM, Samndi AM, Malgwi WB, Tarfa BD (2014). Characterization and Classification and Rice Suitability Evaluation of flood Plain Soils in Savanna Zones of Nigeria. Nig. 7. *Soil and Env. Res. Vol.13 2015, 93 – 104.*
Nwaloka CD, Lawal BA, Raji BA, Ezenwa MIS, Tsado PA (2019). Characterization and classification of soils of Mina Niger State. *International Journal of Agricultural and Rural Development pp 187 – 199.*
Obi CJ, Esu IE, Obi JC (2014). Characterization and Classification of Coastal Plain soils within Uyo Capital Territory *Nigeria. Proceeding of the 38th Annual Conference of the SSSN 10 – 14th March, 2014*
Olaniyan JO (2013). Characterization Classification and Agricultural Potential of some selected Soils of Kwara State, Nigeria. NJSS Vol. 23(1).
Oyegun CU, Ologunorisa YE (2002). Weather and Climate. In the Land and people of Rivers State: Eastern Niger Delta. Alagoa, E. J., Derefaka, A. A. (eds) Onyoma Research Publication, Choba, Rivers State Nigeria P. 18.
Peter KD, Ayolagha GA (2012). Effect of Remediation on Growth Parameters, Grain and Dry Matter yield of soybean (Glycine max) in crude oil polluted soil in Ogoniland, Southeastern Nigeria, Asia Journal of Crop Science 4:113-121.
Peter KD, Anthony UJ (2107). Effect of Land Use Types on Physicochemical Properties of Soils in Khana, Rivers State, Southern Nigeria. *International journal of Agriculture and Rural Development SAAT FUTO 2017. Vol.20 (1). 298*
Plaster EJ (1992). Soil Science and Management (2ed) New York, Delmar Publishers Incorporated Polytechnic Farm soils for arable cropping. Spectrum, 1: 36-42.
Raji BA (2015). Characterization and Classification of Some Basement Complex Soils a Kwara State, *Nigeria Journal of Soil Science.* Vol.26, 2016, pp 67 -100.
Sen TK, Nayak DC, Singh RS, Dubey RN, Maji AK, Chamuah GS, Sengal J (1997). Pedology and Edaphology of Benchmark Acid Soils of North Eastern. India Journal of Indian Society of Soils Science 45(4): 782 – 790.
Sereke F (2002). Land Evaluation for sustainable highland agriculture in N W- Thailand (Pang Ma Pha) with special respect to soil and water resources. Diploma Thesis: Su Hgart Institute for Soil Science, University of Hohenheim, p. 75.
Soil Survey Staff (2014). Key to Soil Taxanomy United State Department of Agricultural Natural Resources Conservation Service, Twelfth edition.
Thurow TL, Smith JE (1998). Assessment of soil and water conservation methods apllied to the cultivation of steep lands of southern Honduras Vetiver grass. An assessment of soil and water in Hondura.http//:www.vetiver.org HON_reshtm
Udo, E.J. and Ogunwale, J.A. (1986). Laboratory Manual for the analysis of soil, plant and water samples (2nd ed) IUP, Ibadan.
Udoh BT, Esu IE, Ibia TO, Onweremadu EU, Unyienyin SE (2013). Agricultural Potentials of het Beach Ridge soils of the Niger Delta, Nigeria. *Malasian Journal of soil Science Vol.17:17-37 (2013).*
UNEP (2010). Report on the Assessment of Crude Oil Polluted OgoniLand.
Walkey A, Black (1934). An examination of the method for determining Soil organic matter and proposed modification of the chromic acid titration method. *Soil Science 37:27-28.*