Morphology, Physico-Chemical Properties and Classification of Soils of Coastal Plain Sands in Owerri, Imo State, Southeastern Nigeria

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KEYWORDS

Classification,
Coastal Plain Sands,
Dystric Nitisols
Soil properties,
Survey,

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ABSTRACT

Assessment of soil health and fertility depends on the understanding of properties and classifications of soils. In this study, soils from Obinze, Avu, Irete, and Amakohia were examined for morphology, physical, chemical properties, and classification. Target sampling technique was used and two profiles each dug across the four study sites. A total of 37 soil samples were collected according to horizon differentiation, and analyzed in the laboratory using standard procedures. Results showed that soils were well drained, colour matrix varied from brown (2.5 YR 3/2) to red (2.5 YR 5/8), sand dominated the fine earth materials (> 600 g/kg) with clay content (109 – 308 g/kg) irregularly distributed due to eluviation. Textural classes ranged from sandy loam to sandy clay loam, bulk density ranged from 1.0 – 1.77 Mg/cm^3 with high values recorded in Amakohia. Silt/clay ratio indicated advanced weathering (< 1.0), while moisture retention capacity was low. Soil pH was moderately acidic (5.22 – 6.16), and organic carbon, nitrogen, and phosphorus levels were generally low and irregularly distributed. Exchangeable cations and cation exchange capacity varied irregularly down horizons, with low base saturation indicating low soil fertility. Soils were classified using USDA Soil Taxonomy and correlated with World Reference Base for Soil Resources. Obinze, Avu, and Amakohia soils were classified as Grossarenic Kandiudult, while Irete was Typic Kandiudult, and translates to Dystric Nitisols (World Reference Base). It is recommended that; the incorporation of crop residues and addition of organic manures will improve the properties of the soils for sustainable crop production.

INTRODUCTION

Soils of Owerri are predominantly derived from Coastal Plain Sands parent material, shaped by nearby rivers such as Nworie and Otamiri. The geological formation is Oligocene-Miocene formations, comprising acid crystalline rocks like granites, gneisses, and quartzite of the Benin formation. The characteristics of these soils in a given location are greatly influenced by its parent material (Nsor, 2017). These soils typically exhibit reddish-yellow to reddish hues, sandy clay textures, and blocky structures, with low cation exchange capacity (CEC), base saturation, and free iron oxide content (Madueke *et al*., 2021). Diagnostic horizons commonly display argillic characteristics, abundant weatherable minerals, and low silt-clay ratios (Nnabuihe *et al*., 2021 and 2022). They often have deep profiles, mainly in low-lying areas, with coarse to fine sand textures and an acidic nature. The clay fraction tends to be rich in kaolinitic clay minerals, possibly due to high rainfall and soil temperatures (Nnabuihe *et al*., 2023). These soils also support diverse agricultural crops and tree plantations such as maize, yam, cassava, fluted pumpkin, oil palm, mango, avocado, kola, as well as various shrubs and grasses (Madueke *et al*., 2020). The region faces threats from rapid industrialization and population growth, leading to unsustainable land practices and environmental issues. Hence, this study aims to assess soil properties and classify them based on USDA Soil Taxonomy (Soil Survey Staff, 2014) and FAO/UNESCO World Reference Base (2014) for sustainable crop production.

MATERIALS AND METHODS

Study sites include Obinze, which is located between Lat. 05^0 26.804^1 N and Long. 06^0 58.395^1 E on elevation of 68 m, Avu between Lat. 05^0 25.663^1 N and Long. 06^0 58.456^1 E on elevation of 66 m, Amakohia between Lat. 05^0 30.376^1 N and Long. 07^0 20.853^1 E on elevation of 58 m, and Irete between Lat. 05^0 30.118^1 N and Long. 06^0 59.784^1 E on elevation of 72 m. Obinze and Avu are mainly suburbs with fast growing metropolis, Amakohia consisted of developed residential area, while Irete consisted of clusters of industries, mostly manufacturers. Mean annual temperatures ranged from 28-31°C and annual rainfall from 2500 to 3000 mm peaking between April and November (NIMET, 2023).

Target soil sampling technique was used and two profiles each dug across the four study sites. Soil sampling involved profiles as described by Food and Agriculture Organization (FAO, 2006). Thirty-seven (37) soil samples were collected, air-dried, sieved, and analyzed for physical and chemical properties. Soil particle size distribution was analyzed using hydrometer method, as described by Gee and Or (2002). Bulk density was analyzed using Core method, as described by Grossman and Reinsch (2002). Oven-drying saturated samples method was used to determine moisture content, according to Obi (1990). pH meter was used as described by Thomas (1996) to determine soil pH. Total nitrogen was based on micro Kjeldahl digestion method (Bremmer,1996). Organic carbon was analyzed using the wet digestion method (Walkley and Black, 1934). Available phosphorus was analyzed using Bray I method (Bray and Kurtz, 1945). Exchangeable acidity was based on (Mclean, 1982) and exchangeable bases (Ca, Mg, K and Na) were extracted in 1N NH_4OAc at pH 7. Sodium and K were determined with a flame photometer while Ca and Mg were determined with atomic absorption spectrophotometer (Jackson, 1962). Cation exchange capacity was analyzed using aluminum acetate leaching at pH 7 (Blackermore *et al*., 1987). Base saturation, aluminum saturation and exchangeable sodium percent were calculated.

STATISTICAL ANALYSIS

Variability amongst soil properties of different profiles were estimated using the method proposed by Wilding (1994). In this, a coefficient of variability (CV), less than 15 represents low variation,16-30 (moderate variability) and greater than 30 represents high variation (Wilding *et al*.;1994).

RESULTS AND DISCUSSION

Soil morphological properties (Table 1) revealed darker surface (0-15 cm) compared to subsurface (15-200 cm) horizons. Avu soils exhibit brownish surface and reddish-brown argillic horizons, likely influenced by organic matter. Obinze soils are reddish-brown, while Irete and Amakohia vary, possibly due to material movement from drainage. Soil structure ranges from weak to strong, with Amakohia having high compaction in A horizon. Good drainage, as attributed to more macropores, was observed. Avu shows dense plant roots, especially in argillic horizons, due to perennial crop dominance. The high root concentration in Obinze could be the abundance of trees as reported by other researchers (Esu, 2010; Madueke *et al.*, 2021, Nnabuihe *et al.*, 2022).

Table 1: Morphological properties of soils of the study sites

Horizon	Depth	Matrix colour (moist)	Texture	Structure	Consistence	Boundary form	Roots	Drainage
				OBINZE I				
A	0 – 16	2.5 YR 3/3	SL	1fg	st/sp fr	Cw	m-vf, m-f, c-m	Wd
AB	16 – 41	2.5 YR 3/4	SCL	1 msbk	st/sp fi	Gs	c-vf, c-f, m-m	Wd
Bt_1	41 – 70	2.5 YR 4/6	SCL	1 csbk	st/sp, fi	Ds	f-vf , f- f, m-f	Wd
Bt_2	70 – 122	2.5 YR 4/8	SCL	1 csbk	st/sp fi	Ds	f-vf, f-f, m-m	Wd
Bt_3	122 – 200	2.5 YR 5/8	SCL	1 csbk	st/sp fi		f-vf , f-f,c- m	Wd
				OBINZE II				
A	0 – 18	2.5 YR 3/2	SL	1fg	st/sp ,fr	Cs	m-vf, m-f,c-m	Wd
AB	18 – 42	2.5 YR 3/3	SCL	1 msbk	st/sp, fi	Gw	c-vf,c-f,	Wd
Bt_1	42 – 75	2.5 YR 4/4	SCL	1 msbk	st/sp fi	Ds	f-vf,f-f,f-c	Wd
Bt_2	75 – 128	2.5 YR 4/6	SCL	1 msbk	st/sp, fi	Ds	f-vf,f-f,m-c	Wd
Bt_3	128 – 200	2.5 YR 5/6	SCL	1 csbk	st/sp,fi		f-vf,c-m	Wd
				AVU I				
A	0 – 17	2.5 YR 3/3	SCL	1fg	slp/sls, fr	Gw	m-vf,m-f,m-m,c-f	Wd
AB	17 – 53	2.5 YR 3/4	SCL	2 msbk	slp/sls fi	Cw	m-vf,m-f,m-m,f-c	Wd
Bt_1	53 – 88	2.5 YR 4/4	SCL	1 msbk	st/sls fi	Ds	m-vf,m-f,m-c	Wd
Bt_2	88 – 134	2.5 YR 4/6	SCL	1 msbk	slp/sls fi	Ds	c-vf,c-f,c-m	Wd
Bt_3	134 – 200	2.5 YR 5/6	SCL	2 msbk	slp/sls fi		f-vf,vf-f	Wd
				AVU II				
A	0 – 14	2.5 YR 3/2	SCL	1fg	slp/sls fr	Gs	m-vf,m-f,m-m,vf-c	Wd
AB	14 – 36	2.5 YR 3/3	SCL	1 msbk	slp/sls fr	Cs	m-vf,m-f,c-m,vf-c	Wd
Bt_1	36 – 67	2.5 YR 3/4	SCL	2 msbk	slp/sls,fi	Cs	f-vf,c-f,m-m,c-c	Wd
Bt_2	67 – 94	2.5 YR 4/4	SCL	1 msbk	slp/sls,fi	Ds	m-vf,m-f,m-m	Wd
Bt_3	94 – 148	2.5 YR 4/6	SCL	2 msbk	slp/sls,fi	Ds	c-vf,c-f,c-m,vf-c	Wd
Bt_4	148 – 200	2.5 YR 5/6	SCL	2 msbk	slp/sls,fi		f-vf,vf-f,vf-m	Wd
				IRETE I				
A	0 – 60	2.5 YR 4/6	SCL	2 cg	slp/sls, fi	Cs	f-c	Wd
AB	60 – 122	2.5 YR 4/8	SCL	2 msbk	slp/sls, fi	Gs	-	Wd
Bt_1	122 – 166	2.5 YR 5/6	SCL	2 msbk	slp/sls, fi	Ds	-	Wd
Bt_2	166 – 200	2.5 YR 5/8	SCL	2 msbk	slp/sls, fi		-	Wd
				IRETE II				
A	0 – 56	2.5 YR 4/6	SCL	2 msbk	slp/sls, fi	Cs	-	Wd
AB	56 – 130	2.5 YR 4/7	SCL	2 msbk	stp/p, fi	Gw	-	Wd
Bt_1	130 – 170	2.5 YR 5/6	SCL	2 msbk	slp/sls, fi	Ds	-	Wd
Bt_2	170 – 200	2.5 YR 5/9	SCL	2 msbk	slp/sls, fi		-	Wd
				AMAKOHIA I				
A	0 – 29	2.5 YR 3/2	SCL	3 msbk	slp/sls, fr	Cw	m-vf,m-f	Wd
AB	29 – 68	2.5 YR 3/6	SCL	2 fsbk	stp/slp, fi	Ds	f-vf	Wd
Bt_1	68 – 141	2.5 YR 4/6	SCL	2 msbk	slp/sls, fi	Dw	f-vf,f-f	Wd
Bt_2	141 – 200	2.5 YR 5/8	SCL	2 msbk	slp/sls, fi		f-vf,f-f	Wd
				AMAKOHIA II				
A	0 – 25	2.5 YR 3/3	SCL	2 msbk	slp/sls fr	Cs	m-f	Wd
AB	25 – 76	2.5 YR 3/6	SCL	2 msbk	st/p,fi	Ds	f-vf	Wd
Bt_1	76 – 153	2.5 YR 4/7	SCL	2 msbk	sp/sls,fi	Dw	f-vf,f-f	Wd
Bt_2	153 – 200	2.5 YR 5/8	SCL	2 csbk	sp/sls,fi		f-vf	D

Key: Texture:-SL= sandy loam, SCL:- sandy clay loam, Structure:-1= weak, 2 = moderate, 3 = strong, f = fine, m = medium, c = coarse, g = granular, sbk = sub angular blocky, Consistence:- fr=friable, fi = firm, st = sticky, sls=slightly sticky, sp=slightly plastic, p=plastic, Boundary form:- c = clear, w = wavy, d = diffuse, s = smooth, g = gradual Roots:- (number): m = many, c = common, f = few, vf = very few.(size): vf = very fine, f = fine, m = medium, c = coarse, Drainage : wd=well drained

Table 2: Physical properties of soils of the study sites

Horizon	Depth (cm)	Sand	Silt	Clay	TC	SCR	BD	MC	Porosity
		g/kg			%		Mg/cm^3	%	
				OBINZE I					
Ap	0-16	762	60	178	SL	0.34	1.23	4.58	53.58
AB	16-41	772	20	208	SCL	0.10	1.41	4.98	46.80
Bt1	41-70	752	20	228	SCL	0.10	1.56	5.14	41.13
Bt2	70-122	752	20	228	SCL	0.10	1.41	5.23	46.80
Bt3	122-200	752	20	228	SCL	0.10	1.41	6.18	46.80
	Mean	758	28	214		0.15	1.40	5.22	47.02
	CV (%)	**1.06**	**57.14**	**9.16**		**64.00**	**7.47**	**10.12**	**8.39**
				OBINZE II					
Ap	0-19	741	50	109	SL	0.24	1.19	4.55	55.09
AB	19-46	782	20	202	SCL	0.10	1.38	4.23	47.92
Bt1	46-75	743	39	218	SCL	0.18	1.58	5.00	40.38
Bt2	75-128	742	30	228	SCL	0.13	1.45	6.50	45.28
Bt3	128-200	732	40	228	SCL	0.18	1.40	6.28	47.17
	Mean	748	36	217		0.17	1.40	5.31	47.17
	CV (%)	**2.33**	**28.13**	**20.74**		**28.24**	**9.00**	**17.25**	**10.08**
				AVU I					
Ap	0-17	752	20	228	SCL	0.10	1.00	5.02	62.26
AB	17-53	772	40	188	SCL	0.21	1.31	5.31	50.57
Bt1	53-88	752	20	228	SCL	0.10	1.46	5.20	44.91
Bt2	88-134	752	20	228	SCL	0.10	1.56	6.64	41.13
Bt3	134-200	692	20	228	SCL	0.10	1.60	7.50	39.62
	Mean	744	24	220		0.12	1.39	5.93	47.70
	CV (%)	**3.65**	**33.33**	**7.27**		**36.67**	**15.64**	**16.37**	**17.20**
				AVU II					
Ap	0-14	772	20	208	SCL	0.10	1.20	5.16	54.72
AB	14-36	762	30	208	SCL	0.14	1.36	5.38	48.68
Bt1	36-67	742	30	228	SCL	0.14	1.41	6.18	46.79
Bt2	67-94	742	30	228	SCL	0.14	1.48	6.72	44.15
Bt3	94-148	722	30	248	SCL	0.12	1.42	7.70	46.42
Bt4	148-200	702	50	248	SCL	0.21	1.50	8.82	43.40
	Mean	740	32	228		0.14	1.40	6.66	47.36
	CV (%)	**3.16**	**28.05**	**7.16**		**24.19**	**7.04**	**19.26**	**7.86**
				IRETE I					
Ap	0-60	782	30	188	SCL	0.16	1.72	2.68	35.09
AB	60-122	774	50	176	SCL	0.28	1.54	3.18	41.89
Bt1	122-166	756	30	214	SCL	0.14	1.70	3.29	35.85
Bt2	166-200	752	30	218	SCL	0.16	1.58	4.08	40.38
	Mean	766	35	199		0.19	1.64	3.31	38.30
	CV (%)	**1.62**	**24.74**	**8.83**		**29.19**	**4.67**	**15.16**	**7.56**
				IRETE II					
Ap	0 – 56	766	80	154	SCL	0.52	1.68	2.72	36.60

AB	56 – 130	706	60	234	SCL	0.26	1.71	3.22	35.47
Bt1	130 – 170	726	40	234	SCL	0.17	1.76	3.43	33.58
Bt2	170 – 200	706	60	234	SCL	0.26	1.60	4.12	39.62
	Mean	726	60	214		0.30	1.69	3.38	36.32
	CV (%)	**3.37**	**23.57**	**16.19**		**43.61**	**3.43**	**14.87**	**6.03**
					AMAKOHIA I				
Ap	0-29	772	80	148	SCL	0.54	1.70	3.70	35.85
AB	29-68	632	60	308	SCL	0.19	1.73	4.16	34.72
Bt1	68-141	692	40	268	SCL	0.15	1.65	4.72	37.73
Bt2	141-200	672	20	308	SCL	0.06	1.68	5.13	36.60
	Mean	692	50	258		0.23	1.69	4.43	36.23
	CV (%)	**7.37**	**44.72**	**25.42**		**79.25**	**1.73**	**12.26**	**3.03**
					AMAKOHIA II				
Ap	0 -25	726	40	234	SCL	0.17	1.68	2.98	36.60
AB	25 – 76	666	40	294	SCL	0.14	1.74	3.20	35.34
Bt1	76 – 153	706	60	234	SCL	0.26	1.77	3.80	33.21
Bt2	153 – 200	646	60	294	SCL	0.20	1.71	4.88	35.47
	Mean	686	50	264		0.19	1.73	3.73	35.16
	CV (%)	**4.61**	**20.00**	**11.36**		**23.35**	**1.94**	**19.75**	**3.48**

Key: TC=textural class, BD=bulk density, SCR=silt clay ratio, MC=moisture content

Table 2 shows that soil physical properties were predominantly sandy in texture across various pedons, ranging from sandy loam to sandy clay loam (632 – 782 g/kg). This sandiness, was influenced by Coastal Plain Sands, land management, and climate, and suggested low CEC, high infiltration, and low moisture (Esu, 2010). Rapid nutrient leaching beyond rooting zones was anticipated. Increase clay content with depth resulted from soil sorting, clay migration, or erosion (argillation or lessivage). Silt/clay content (< 1.0) indicated highly weathered, ferraltic soils. Amakohia exhibited highest bulk density (1.70 - 1.77 Mg/cm³), possibly due to low organic carbon, clay accumulation, compaction from traffic / buildings, and rain impact. High moisture content in Avu may stem from organic carbon content (Anikwe, 2010).

Table 3 displayed results of chemical properties at the study sites. Soil pH ranged from 5.22 to 6.16 which is moderately acidic, due to leaching of basic cations and presence of iron and aluminum ions. Organic carbon values were generally low, with highest values in Avu and Obinze, attributed to tree litter and rapid decomposition, contrasting with lower values in Amakohia and Irete due to intense land use and leaching. Avu had the highest mean total nitrogen, followed by Obinze, while Amakohia and Irete had lower values due to high mineralization, leaching, and erosion. Available phosphorus was generally low (< 1.5 mg/kg) (Landon, 1991) due to colloidal particle loss. Exchangeable bases showed low levels of Na and K compared to Ca and Mg (Kyuma *et al*., 1986; Landon, 1991). Cation Exchange Capacity (CEC) was generally low (6 - 12 cmol/kg), typical of Coastal Plain Sands (Landon, 1991), affecting nutrient retention. Percentage base saturation was low (< 60 %) (FDALR, 1990), indicating high aluminum saturation especially in Irete and Amakohia. Low Ca/Mg ratios indicated soil infertility, requiring liming to reduce acidity and replenish calcium. High aluminum saturation (< 50 %) in Irete and Obinze soils may affect plant growth. Low exchangeable sodium percent (< 2 cmol/100g soil) was attributed to intense rainfall leaching (Ogg *et al*., 2017). The USDA soil taxonomy (2006) was used to classify these soils, and correlating it with World Reference Base (WRB, 2014). Obinze, Avu, and Amakohia soils were Grossarenic Kandiudult, while Irete was Typic Kandiudult, and translates to Dystric Nitisols (World Reference Base, 2014), due to isohyperthermic temperature regime, predominant argillic and kandic horizons, low base saturation (< 35%), sandy texture, and absence of lithic contacts within 150 cm, moderately to slightly acidic (pH 5.62–6.35), with low activity clay (13.35 – 65.26%), and mixed clay mineralogy.

Table 3: Chemical Properties of Soils of the study sites

Horizon	Depth	pH H_2O	OC	TN	A P	Ca^+	Mg+	Na^+	K^+	TEB	Ca: Mg	H^+	Al^{3+}	CEC	B.sat	Al^{3+} sat	ESP
			(gkg^{-1})	%	($mgkg^{-1}$)	→		Cmol /100g	←			→	Cmol/100g	←	→	%	←
								OBINZE I									
Ap	0-16	5.61	0.89	0.12	0.53	1.40	0.74	0.07	0.12	2.33	1.89	0.06	0.05	6.69	34.83	2.05	1.05
AB	16-41	5.35	0.76	0.08	0.47	1.18	0.68	0.17	0.14	2.17	1.74	0.08	0.12	6.31	34.39	5.06	2.69
Bt1	41-70	5.69	0.67	0.06	0.61	1.08	1.02	0.16	0.11	2.37	1.06	0.11	0.13	5.80	40.86	4.98	2.76
Bt2	70-122	5.54	0.57	0.08	0.63	1.06	0.77	0.18	0.17	2.18	1.38	0.15	0.16	5.35	40.75	6.73	3.36
Bt3	122-200	5.44	0.28	0.04	0.71	1.12	0.86	0.12	0.19	2.29	1.30	0.13	0.21	5.47	41.86	7.98	2.19
	Mean	5.53	0.63	0.08	0.59	1.17	0.81	0.14	0.15	2.27	1.47	0.11	0.13	5.92	34.54	5.30	2.41
	CV (%)	**2.18**	**32.69**	**33.17**	**14.06**	**10.52**	**14.60**	**28.93**	**20.04**	**3.53**	**20.51**	**29.65**	**40.29**	**8.57**	**9.36**	**37.67**	**32.15**
								OBINZE II									
Ap	0-19	5.40	0.78	0.10	0.44	1.54	0.68	0.05	0.14	2.41	2.26	0.08	0.07	5.79	41.62	2.73	0.86
AB	19-46	5.64	0.72	0.07	0.48	1.13	1.04	0.12	0.10	2.39	1.07	0.08	0.05	5.85	40.85	1.98	2.05
Bt1	46-75	5.62	0.60	0.05	0.42	1.12	1.58	0.10	0.18	1.98	1.93	0.14	0.10	4.52	43.81	4.50	2.21
Bt2	75-128	5.67	0.40	0.06	0.75	1.60	0.62	0.13	0.12	2.47	2.58	0.12	0.18	5.21	47.41	6.50	2.50
Bt3	128-200	5.61	0.31	0.03	0.54	1.70	0.60	0.15	0.11	2.03	1.95	0.18	0.26	5.16	39.34	10.53	2.59
	Mean	5.59	0.58	0.06	0.53	1.31	0.70	0.11	0.13	2.26	1.96	0.12	0.13	5.31	42.61	5.25	2.11
	CV (%)	**1.72**	**31.19**	**38.59**	**22.50**	**18.68**	**53.40**	**30.96**	**21.76**	**9.17**	**25.69**	**31.62**	**59.86**	**9.14**	**6.58**	**58.43**	**29.49**
								AVU I									
Ap	0-17	5.67	1.41	0.16	0.71	1.67	0.72	0.15	0.12	2.66	2.32	0.14	0.22	6.05	43.97	7.28	2.48
AB	17-53	5.26	1.21	0.10	0.47	1.50	0.56	0.18	0.16	2.40	2.68	0.18	0.42	5.23	45.89	14.0	3.44
Bt1	53-88	5.68	0.98	0.12	0.55	1.64	0.54	0.15	0.15	2.48	3.04	0.22	0.74	5.89	42.11	21,51	2.55
Bt2	88-134	5.35	0.81	0.08	0.64	1.70	0.92	0.17	0.15	2.94	1.85	0.28	0.83	6.07	48.44	20.40	2.80
Bt3	134-200	5.22	0.63	0.06	0.63	1.68	0.43	0.21	0.17	2.40	3.91	0.31	0.86	6.12	40.67	23.50	3.43
	Mean	5. 44	1.01	0.10	0.60	1.64	0.63	0.17	0.15	2.59	2.76	0.23	0.61	5.87	44.22	17.36	2.94
	CV (%)	-	**27.48**	**34.41**	**13.74**	**4.37**	**27.04**	**13.10**	**11.16**	**7.93**	**25.25**	**27.17**	**41.21**	**5.62**	**6.21**	**35.89**	**14.22**
								AVU II									
Ap	0-14	5.71	1.52	0.18	0.51	1.74	0.81	0.12	0.14	2.81	2.15	0.16	0.24	6.04	46.52	7.48	1.99
AB	14-36	5.79	1.22	0.14	0.41	1.62	0.58	0.14	0.11	2.45	2.79	0.14	0.50	5.42	45.20	16.18	2.58
Bt1	36-67	5.63	1.00	0.16	0.52	1.65	0.64	0.52	0.11	2.92	2.58	0.31	0.78	6.14	47.56	19.45	8.47
Bt2	67-94	5.76	0.92	0.14	0.58	1.43	0.62	0.21	0.18	2.44	2.31	0.38	0.96	5.75	42.43	25.40	3.65
Bt3	94-148	5.68	0.75	0.09	0.66	1.38	0.73	0.28	0.12	2.51	1.89	0.41	0.98	5.80	43.28	25.13	4.83
Bt4	148-200	5.65	0.58	0.07	0.58	1.40	0.70	0.24	0.10	2.44	2.0	0.48	1.02	5.36	45.52	25.89	4.48
	Mean	5.70	1.0	0.13	0.54	1.54	0.68	0.25	0.13	2.60	2.29	0.31	0.75	5.75	45.09	19.92	4.33
	CV (%)	**1.00**	**30.66**	**29.46**	**14.29**	**9.02**	**11.23**	**52.78**	**20.67**	**7.50**	**13.79**	**40.62**	**38.23**	**5.02**	**3.91**	**33.16**	**48.46**
								IRETE I									
A	0 – 60	5.80	0.48	0.03	0.32	1.07	0.60	0.14	0.18	1.99	1.78	0.42	0.52	6.23	31.94	17.75	2.25
AB	60 – 122	5.90	0.41	0.01	0.25	1.14	0.73	0.15	0.18	2.20	1.56	0.18	0.60	4.91	44.81	20.13	3.05
Bt1	122 – 166	5.69	0.38	0.03	0.28	1.04	0.53	0.09	0.14	1.80	1.96	0.82	0.87	4.89	36.81	24.93	1.84
Bt2	166 – 200	5.76	0.30	0.03	0.24	1.11	0.53	0.17	0.12	1.93	2.09	0.66	1.30	5.08	37.99	33.42	3.35
	Mean	5.79	0.39	0.03	0.27	1.09	0.60	0.14	0.16	1.98	1.85	0.52	0.82	5.28	37.89	24.06	2.62
	CV (%)	**1.31**	**16.56**	**28.87**	**11.53**	**3.49**	**13.61**	**21.05**	**16.24**	**7.29**	**10.77**	**46.63**	**37.15**	**10.51**	**12.13**	**24.91**	**23.08**
								IRETE II									
A	0 – 56	5.70	0.41	0.03	0.41	1.06	0.56	0.16	0.10	1.88	1.89	0.38	0.54	4.70	40.00	19.29	3.40
AB	56 – 130	5.74	0.35	0.01	0.37	1.42	0.62	0.18	0.13	2.35	2.29	0.23	0.66	5.52	42.57	20.37	3.26
Bt1	130 – 170	5.60	0.30	0.03	0.39	1.38	0.50	0.14	0.17	2.19	2.76	0.92	0.78	5.35	40.93	21.14	2.62
Bt2	170 – 200	5.78	0.28	0.03	0.30	1.04	0.73	0.24	0.15	2.16	1.42	0.80	0.96	5.56	38.85	24.49	4.32
	Mean	5.71	0.34	0.03	0.37	1.23	0.60	0.18	0.14	2.15	2.09	0.53	0.74	5.28	40.59	21.32	3.40
	CV (%)	**1.17**	**14.78**	**28.87**	**11.20**	**14.29**	**14.16**	**20.79**	**18.47**	**7.87**	**23.66**	**53.90**	**20.97**	**6.54**	**3.35**	**9.11**	**17.86**
								AMAKOHIA I									
A	0 -29	5.96	0.66	0.04	0.38	1.28	0.48	0.19	0.18	2.13	2.67	0.66	0.74	4.74	44.94	20.96	4.00
AB	29 – 68	5.80	0.53	0.01	0.45	1.31	0.53	0.15	0.11	2.10	2.47	0.82	0.83	4.54	46.26	22.13	3.30
Bt1	68 – 141	5.87	0.50	0.04	0.37	1.08	0.64	0.26	0.14	2.12	1.69	0.94	0.98	5.23	40.54	24.26	4.97
Bt2	141 – 200	5.76	0.47	0.04	0.33	1.34	0.56	0.21	0.19	2.30	2.39	0.80	0.94	4.96	46.37	23.27	4.23
	Mean	5.85	0.54	0.03	0.38	1.25	0.55	0.20	0.16	2.16	2.31	0.81	0.87	4.87	44.53	22.66	4.14
	CV (%)	**1.30**	**13.42**	**43.30**	**11.38**	**8.15**	**10.55**	**19.80**	**20.01**	**3.71**	**15.99**	**12.27**	**10.82**	**5.27**	**5.32**	**5.45**	**14.40**
								AMAKOHIA II									
A	0 – 25	5.32	0.70	0.03	0.42	1.22	0.38	0.11	0.13	1.84	3.21	0.60	0.80	4.57	40.26	24.69	2.41
AB	25 – 76	6.08	0.48	0.03	0.48	1.40	0.41	0.13	0.12	2.06	3.41	0.82	0.87	4.38	47.03	23.20	2.97
Bt1	76 – 153	6.16	0.39	0.02	0.39	1.30	0.44	0.11	0.16	2.01	2.95	0.77	0.96	4.45	45.19	24.00	2.47
Bt2	153 - 200	6.09	0.35	0.02	0.41	1.46	0.52	0.15	0.18	2.31	2.81	0.85	0.98	4.88	47.34	23.67	3.07
	Mean	5.91	0.48	0.03	0.43	1.35	0.44	0.13	0.15	2.06	3.10	0.81	0.90	4.57	44.95	23.89	2.73
	CV (%)	**5.81**	**28.22**	**16.67**	**7.80**	**6.82**	**11.85**	**12.76**	**15.90**	**8.17**	**7.47**	**11.94**	**8.03**	**4.19**	**6.30**	**2.27**	**10.73**

CONCLUSION

Soils derived from Coastal Plain Sands are predominantly sandy, ranging from sandy loam to sandy clay loam. Soil reaction was moderately acidic; organic matter, total nitrogen, base saturation and CEC were low; aluminum saturation and exchangeable sodium percent were low. The soils of Obinze, Avu, and Amakohia were classified as Grossarenic Kandiudult, while Irete was Typic Kandiudult, and translates to Dystric Nitisols (World Reference Base). The soils of Obinze and Avu can support agricultural production if properly managed, while soils of Amakohia and Irete can support limited range of crops due to their properties and will require sustainable land management to avoid degradation. It is recommended that; the incorporation of crop residues and addition of organic manures will improve the properties of the soils for sustainable crop production.

REFERENCES

Anikwe, M.A.N (2010). Carbon Storage in Soils of Southeastern Nigeria under different management practices: *Carbon Balance and Management Journal*: 5:5-8.

Blackmore, L. C., Searle, P.L. and Dialy, B.K. (1987). Methods for chemical analysis of soils: *Sci. Rep. 80N.Z. soil Buareu, Lower Hutt New Zealand*.

Bray, R.H and Kurtz, L.T. (1945). Determination of total organic and available forms of phosphorus in soils. Soil Sci. 59:22-229. Brian Murphy brian.amaroo@bigpond.com

Bremner, J. M. (1996). Nitrogen total: Sparks, D. L., (ed) In: methods of soils analysis, parts, chemical method. *2nd ed, SSSA book series* No 5, SSSA, Madison, WI, 1085 — 1125.

British Geological Survey pp: 1- 2.

Esu, I.E. (2010). Soil Characterization, Classification and Survey. *Principles of Soil Classification.* (9):119-156.HEBN Publishers Plc, Ibadan. ISBN 978 978 081 373 4.

FAO. (2006). Guidelines for Soil Description (4th ed.). Food and Agriculture Organization of the United Nations.

Federal Department of Agriculture and Land Resources (1990). The Reconnaissance Soil Survey of Nigeria. Soil Rept. Vol. 1. Pp: 338 – 339.

Gee, G. W. and Or, D. (2002). Particle size analysis in: Dane, J. H., Topp, G. C., (eds.). Methods of Soil analysis part 4, physical methods. *Soil Sci. soc. Am book series, No 5 ASA and SSSA* Madison .1:255 -295.

Grossman, R. B. and Reinsch, T.G. (2002). Bulk density and linear extensibility in: methods of soil analysis part 4. Physical methods. Dane, J. H. and G. C. Topp (Eds) soil science soc. *Am. Book series* no. 5. ASA and SSA Madison, WI, pp: 201 – 228.

Jackson, M. C (1962). Soil chemical analysis, *prentice Hall Inc., New York*, USA pp 498.

Kyuma, K., Rosaki, T. and Juo, A.S.R. (1986). Evaluation of the fertility of the soils. In: Juo, A, S, R and Low (ed). The Wetland Soil and Rice in Sub-sahara Africa. *Proceeding in International Conference of Wetland Soil Utilization for Rice Production in Sub- sahara Africa*.

Landon, J.R. (ed.) (1991). Booker Tropical Soil Manual: *A handbook for Soil Survey and Agricultural Land Evaluation in the tropics and subtropics*, John Wiley and Sons Inc, 605, Third Avenue, New York, USA, pp.474

Madueke, C.O., P.C Nnabude; Okore, I.K., Onunwa, A.O., Maduekeh, E.C., Okafor, M.J., Nnabuihe, E.C., Nwosu, T.V. (2020). Evaluation of soils on a toposequence formed from the Coastal Plain Sands of the Imo River Basin, Southeastern Nigeria. NJSS. 31:2: 1-9

Madueke, C.O., Okore, I.K., Maduekeh, E.C., Onunwa, A.O., Okafor, M.J., Nnabuihe, E.C., Nwosu, T.V. (2021). Characterization and Land Evaluation of three tropical rainforest soils derived from the coastal plain sands of Southeastern Nigeria. *Agro-science: Journal of Tropical Agriculture, Food, Environment and Extension. Vol. 20 (2): April 2021.*

Mclean, E. V., (1982). Aluminium. In page, A. L., Miller, R. H., Keeney, D. R., (eds). Methods of soil analysis, part 2, Am. Soc. Agron Madison *WL*. 978 - 998. Methods: L. D. sparks (eds) *SSSA book series* 159 — 165.

Nigeria Meteorological Agency Nigeria (NIMET) (2023). Climate Weather and Water Information for sustainable development and safety, *Annual Climatic Report*.

Nnabuihe, E.C. Onweremadu, E.U.; Madueke, C.O.; Nwosu, T.V.; Okafor, M.J.; Ibeh, C.U. and Nwaiwu, C.J. (2021). Characterization and Classification of floodplain soils of different geomorphic surfaces along Onumirikwa River Ulakwo Owerri Southeastern Nigeria.Paper presented at the *45th Annual Conference of the Soil Science Society of Nigeria proceedings 2021 held at BOWEN university Iwo Osun State Nigeria march 15th – 19th 2021. Colloquia 45 (2021):312-318.*

Nnabuihe, E.C., Onweremadu, E.U., Uzoho, B.U. and Aririguzo, B.N (2022). Characterization, Classification and Suitability Evaluation of Floodplain Soils of Abakaliki for Arable Crop Production. International Journ. of Agric. and Environmental Research Vol 08:01, 114 -136. January - February, 2022. https://doi.org/10.51193/IJAER.2022.8108.

Nnabuihe, E.C, Madueke, C.O, Osujieke,D.N., Chukwu, E.D., Obasi, S.N., Okafor, M.J., Onunwa, A.O., Okore, I.K. (2023). Mineralogical composition and Distribution in Selected Floodplain Soils of Southeastern Nigeria. International Journ. of Agric., Food and Biodiversity. Vol 02:01: 16-23. 01/10/2023.

Nsor, M.E. (2017). Pedogenesis, Classification and Management Implications of Soils Derived from Nanka Sands of False bedded Sandstones Lithology in Orumba North L.G.A, Southeastern Nigeria. Proceedings of the 41st Annual Conf. of SSSN. pp: 195 – 204.

Obi, M.E., (1990). Soil Physics: *A compendium of lectures*. University of Nigeria Nsukka, Nigeria, Nsukka Nigeria, pp: 330.

Soil Survey Staff (2014). *Keys to Soil Taxonomy.11th ed.* USDA, NRCS, Washington DC. Pp: 267-286.

Thomas G. W., (1996). Soil pH, soil acidity. In: Methods of soil analysis part 3. Chemical methods L. D. sparks (eds) *SSSA book series* 159 — 165.

Walkley, A. and Black, C.A. (1934). Determination of Organic matter. Soil Sci. 37:29 – 38.

Wilding, L.P., Bouma, J. and Boss, D.W (1994). Impact of Spatial Variability on Interpretative Modeling. In: Bryant R.B. and R.W. Arnold- Quantitative Modeling of Soil Forming Process. *SSSA Special Publ.*, *No*. 39: 61-75.

World Reference Base (2014). International soil classification system for naming soils and creating legends for soil maps. World Soil Resources Reports 106, Global Soil Partnership, International Union of Soil Sciences, and Food and Agriculture Organization of the United Nations, Rome, 182 http://www.fao.org/3/a-i3794.pdf.