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Characterization and Classification of Soils Of Obukiyo, Oju Local Government Area of Benue State, Nigeria

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ABSTRACT

Soils of Obukiyo, Oju Local Government Area of Benue State were studied using the grid method of soil survey with a view to characterize, classify and evaluate their potentials for sustainable crop production. Four soil units were identified on the field based on soil colour, texture, surface characteristics, topography and depth to water table. Two pits were sunk in each soil unit, described and sampled for laboratory analysis. The soils were moderately deep to very deep ranging in depth from 160cm – 190cm. They were well drained to poorly drained and strongly acid to moderately alkaline in reaction (pH 4.1 – 7.8) with high base saturation. Based on these characteristics, the soils were classified as *Arenic Paleustalfs/Aeric Lixisols* (unit 1), *Aeric Endoaqualfs/EndogleyicGleysols* (Unit II), *Ustic Epiaquerts/EpiclayicVertisols* (Units III and IV)

1.0. Introduction

The knowledge of soil properties is very vital for sustainable crop production in Nigeria. Properties of soils are the soil qualities/characteristics which play an important part in the behaviour of soils and what they can be used for (Lal *et al.,* 2004). Soil properties include the physical, chemical and biological characteristics of the soil. Several physical properties such as soil structure, texture, colour, depth, consistence, density, porosity, permeability, soil inclusion and soil temperature can and do change with management (Idoga and Ogbu 2012, Pimental 2005). The general soil chemical properties often required in most basic soil survey include organic carbon, total N, available

P, exchangeable bases, pH, CEC and base saturation (Ufot, 2012). Good knowledge about the soil resources and proper use and management will guarantee sustainable crop production.

One of the best ways of soil conservation is the allocation of the soil to its most suitable use. Allocation of the soil/land to its best uses is referred to as Land use planning in which the characteristics of the land are compared or matched with the requirements of particular land use. Land use planning ensured optimum or even maximum output and at the same time guarantees minimum damage to the land resources. Here in lies the significance of soil characterization and classification (Idoga *et al.,* 2005). The overall objective of this study is therefore to characterize, classify and evaluate their potentials for sustainable crop production.

2.0. Materials and Methods

2.1. Study Area

Obukiyo lies about 2 km South East of Oju Local Government Headquarter. The area lies between latitude 06°52'N and 06°56'N and longtitude 07°37' and 07°45'E with an elevation of about 65m above sea level. he study site covers about 600 hectares of land. The area falls within the humid tropical climate. The rainy seasons start from April and last till October while the dry season covers the months of November to March.The mean annual rainfall is about 1100mm falling between April and October. The mean monthly maximum temperature is 34^0c.The area was named after river Obukiyo which rises from Andibilla Plateau. The soils were derived from sedimentary rocks of shale (clay stones). The sediment were transported from the upland, Andibilla Plateau by water and deposited on the lowland and gradually weathered into the predominantly clay soil of the area.

2.2. Field and Laboratory Studies

The area was soil surveyed using the grid method. Auger point investigations were carried out at 100m intervals along traverses cut at 100m apart on the baseline and morphological characteristics were studied. Based on differences and similarities of the morphological characteristics four soil units were identified and two profile pits were sunk in each (fig.1). The pits were described according to the guideline for soil profile description (SSS, 2014) and the samples were collected and taken to laboratory for physical and chemical analysis. The air dried, crushed and sieved (d<2mm) samples were analyzed for particle size distribution, pH, organic carbon, CEC, exchangeable bases (Ca, Mg, K and Na), total nitrogen and available P.

PSD was determined by Bouyoucos hydrometer method (Day, 1965). Soil pH was determined by electrometric methods as described by IITA (2015). Walkley- black method as described by Nelson and Sommers (1982) was employed for organic matter content. Total nitrogen was determined using the modified macro-kjeldahl method as described by IITA (2015). Bray No.1 method as described by IITA 2015 was used for extractable P. For exchangeable bases, Ca and Mg were determined by AAS while K and Na were done by flame photometer. CEC was determined by IITA (2015) procedures while B.S was calculated by summation method.

3.0. Result and Discussion

3.1. Morphological Characteristics

The soils were deep ranging in depth from 160cm to 190cm. Unit I soils were well drained with high sand fraction (42.4-74.40%) at the surface A and AP horizons (Table 1). The high sand fraction is characteristics of most savannah soils and is mainly due to the nature of the parent materials, constant weathering of rocks and the downward movement of clay through the soil mass (Esu, 2005, Ethan, 2006). It also indicates an Aeolian source as the parent materials of the upper horizons and the possible occurrences of soil erosion which carried away the finer fraction in the surface horizons. The soil of units II, III and IV were poorly drained as indicated by the presence of mottles in the surface horizons and gleyed lower horizons. The poor drainage could be due to the accumulation of surface water as a result of the depressional landscape as well as the high clay fraction of the soils. Soils of unit III and IV had gilgai micro-relief in some places with cracks >2 cm. The soils were well developed, having strong to moderate coarse and medium subangular blocky structure. The good structural development could have been influenced by the high clay content of the soils. The massive lower horizons of some pedons could be due to the weight of the overlying horizons (Idoga, 1985). The soil textures were predominantly sandy clay loam especially at surface A and Ap horizons, while the subsurface horizons were sandy clay and clay in some places. The relatively high clay content (19.76%-58.26%) could be due to the alluvial parent materials as well as the nature of the underlying geology. The relative differences in clay content among the soil units could be due to slight variations in topography. The clay fraction was inconsistent in distribution pattern within profiles 1, 2, 4 and 7 but increased with depth in profiles 3, 5, 6 and 8. Though in all, the clay content were higher in the lower horizons than the upper A and Ap horizons. This is in agreement with the view that clay content generally increases with depth due to some pedogenic processes such as lessivage, eluviation, and illuviation as well as the contribution of the underlying geology through weathering (Idoga, 2002, Ugwu *et al*, 2001). The percentage silt fraction ranged from 0.0% to 36.56% with inconsistent distribution pattern with depth. This may be attributed to the differences in relief and the rate of deposition of accumulated materials brought down from the upper slope by fluvial processes into the depressional lowland. The silt content were high (15.84% to 36.56%) in profiles3 and 4. This is contrary to the popular opinion on tropical soils having low silt of less than 15% (Young, 1976). The very low silt content (0.0% -8.54%) of profiles 1,2, 5, 6, 7 and 8 may be due to excessive washing away of the soil particles by water erosion and runoff (Idoga, 2012). The soils had various colours in their surface A and Ap horizons. Soils of profiles 1 and 7 had predominantly dark brown (10 YR 3/3, 10YR 4/3 and 7.5 YR 4/3, moist) colour in their A and Ap horizons. This could be attributed to the presence of relatively high O.M which is the main colouring agent in the top soil (Ufot, 2012, Brandy, and Weil, 2014). The soils of the area experienced moderate sheet erosion with slop of 0-2%.soils of unit II with lower depression had high water level than units III and IV while that of unit I were mostly upland with very low water level

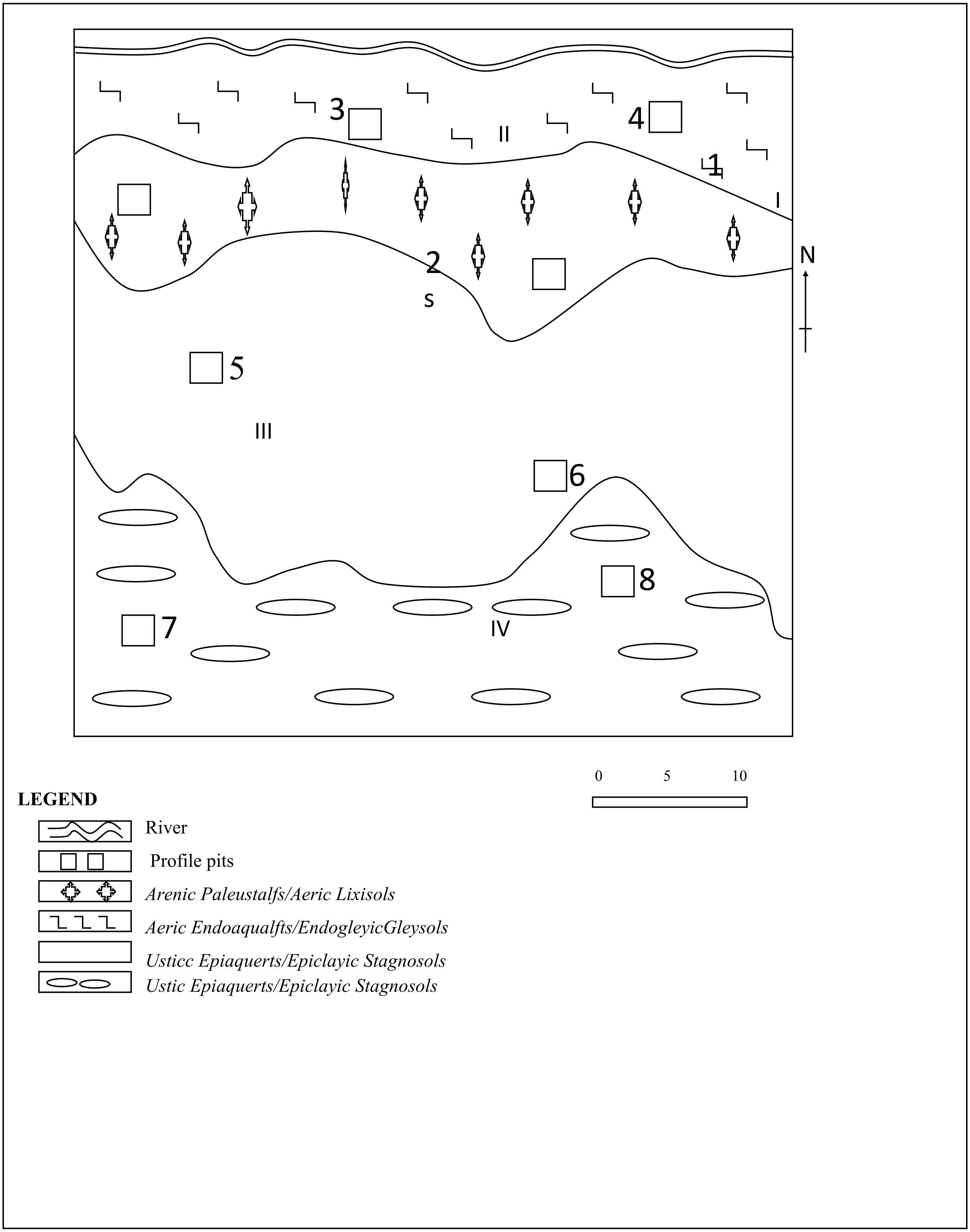

Figure 1: Soil Map of the Study Area

Table 1: Morphological Description of the Soils of Obukiyo of Oju Local Government Area

Horizon	Depth (cm)	Colour (Moist)	Mottling	Mottling details	Texture	Structure	Consistence	Inclusion	Boundary
Unit I Pedon 1: Arenic Paleustalfs/Aeric Lixisols									
A	0-40	7.5YR4/3	-		Sandy clay loam	3MSBK	SSW	Few Medium Roots	cs
B	40-60	7.5YR6/4	-		Sandy loam	2MSBK	SSW	Few Fine Roots	ds
BC	60-110	5YR6/6	-		Sandy loam	2MSBK	SSW	Few Fine Roots	ds
C	110-120	5YR7/6	-		Sandy clay loam	2MSBK	SSW	Few Fine Roots/hard coherent rock at 170cm	-
Unit I Pedon 2: Arenic Paleustalfs/Aeric Lixisols									
Ap	0-28	10YR5/3	-		Sandy clay loam	3CSBK	SSW	Medium Common Roots	ds
A	28-76	10YR4/2	-		Sandy clay loam	3CSBK	SSW	Few fine roots	cs
AB	76-105	10YR4/6	-		Sandy loam	2MSBK	SSW	Few fine roots	gs
B	105-115	7.5YR6/4			Sandy Clay loam	2MSBK	SSW	Few Fine roots	
Bt_1	115-180	5YR 5/4			Sandy Clay loam	2MSBK	VSW	coherent rock at 180cm	-
Unit II Pedon 3: Aeric Endoaqualfs/EndogleyicGleysols									
Ap	0-20	10YR5/6	2.5YR5/6	F3P	sandy clay loam	3CCr	SSW	Many coarse roots	cs
Bt_1	20-80	2.5YR5/2	10R5/6	M2P	Clay loam	2MSBK	VSW	Many coarse roots	ds
Bt_2	80-110	2.5YR4/3	10YR7/6	F2D	Clay loam	2MSBK	VSW	Common medium roots	ds
Bt_3	110-180	2.5YR5/4	10YR5/2	F2D	Clay loam	2MSBK	VSW	Few medium roots	-
Unit II Pedon 4: Aeric Endoaqualfs/Endogleyic Gleysols									
Ap	0-24	10YR8/6	10YR3/2	C2D	Clay loam	3CCr	VSW	Many coarse roots	ds
Bt_1	24-86	5YR5/3	10YR3/3	F2P	Sandy clay loam	2MSBK	VSW	Few fine roots	ds
Bt_2	86-118	2.5Y4/3	5YR4/3	M2P	Clay loam	2MSBK	VSW	Few fine roots	ds
Bt_3	118-190	2.5Y5/6	5YR7/1	M3P	Sandy clay loam	2MSBK	VSW	Few fine roots	-
Unit III Pedon 5: Ustic Epiaquerts/Epiclayic Stagnosols									
Ap	0-30	10YR5/6	10YR5/2	FIF	Sandy clay	3CSBK	SSW	Many medium roots	cs
AB	30-60	10YR5/8	10YR5/2	E2D	Sandy clay	3MSBK	VSW	Common fine roots	cs
B	60-75	10YR6/4	2.5Y7/6	C2P	Sandy clay	2MSBK	VSW	Few fine roots	ds
Bt_1	75-115	7.5YR5/4	5YR5/3	C2D	Sandy clay	2MSBK	VSW	Few fine roots	ds
Bt_2	115-150	7.5YR7/4	5YR7/1	C2P	Sandy clay	2MSBK	VSW	Few fine roots	ds
Btn	150-180	7.5YR5/6	2.5Y7/2	C2D	Sandy clay	2MSBK	VSW	-	-
Unit III Pedon 6: Ustic Epiaquerts/Epiclayic Stagnosols									
Ap	0-20	10YR5/4	10YR6/8	C2P	Sandy clay	3CSBK	SSW	Many fine ro	cs
B	20-50	2.5Y4/4	7.5YR6/3	F1D	Clay	3MSBK	VSW	Common fine roots	ds
Bt_1	50-100	2.5Y5/6	5YR5/4	C2D	Clay	2MSBK	VSW	Few fine roots	ds
Bt_2	100-160	2.5Y5/4	7.5YR7/1	M3P	Clay	2MSBK	VSW	Few fine roots	ds
Btn	160-180	2.5Y6/0	10YR4/2	M3P	Clay	2MSBK	VSW	Few medium concretions	-
Unit IV Pedon 7: Ustic Epiaquerts/Epiclayic Stagnosols									
Ap	0-34	10YR3/3	10YR5/6	F1D	Sandy clay	3CSBK	SW	Many coarse roots	cs
B	34-74	10YR4/3	10YR6/6	F1D	Sandy clay	3CSBK	VSW	Many coarse roots	ds
Bt_1	74-98	7.5YR5/4	10YR5/4	F2D	Sandy clay	2MSBK	VSW	Few coarse roots	ds
Bt_2	98-133	5YR6/3	10YR4/2	M2P	Sandy clay	2MSBK	SPW	Few fine roots	ds
Bt_3	133-180	2.5Y5/2	5YR4/2	M3P	Sandy clay	2MSBK	SPW	Few fine roots	-

Table 1 Cont. : *Morphological Description of the Soils of Obukiyo of Oju Local Government Area*

Horizon	Depth (cm)	Colour (Moist)	Mottling	Mottling details	Texture	Structure	Consistence	Inclusion	Boundary
Unit IV Pedon 8: : Ustic Epiaquerts/Epiclayic Stagnosols									
Ap	0-56	10YR3/4	5YR3/2	F1D	Sandy clay	3CCr	VSW	Many medium roots	cs
Bt_1	56-96	10YR4/4	2.5YR6/2	F1D	Sandy clay	3CSBK	VSW	Common medium roots	cs
Bt_2	96-126	7.5YR5/0	5YR5/2	C2P	Sandy clay	3CSBK	SPW	Few fine roots	ds
Bt_3	126-160	5YR4/8	5YR5/2	C2D	Sandy clay	2MSBK	PW	Few fine roots	-

Mottling Details:
F1F=Few fine faint, C2D=Few Common medium distinct, M3P=Many coarse prominent, C3P=Common coarse prominent
Texture
S= Sandy, C= Clay, SL= Sandy loam, SCL= Sandy clay loam, SC= Sandy clay
Structure
3CCr = Strong coarse crumbs, 2CCr = Moderate coarse crumb, 2MCr = Moderate medium crumb, 2MSBK = Moderate medium subangular blocky, 2MFBK = Moderate fine subangular blocky, 3CSBK = Strong coarse subangular blocky, 3MSBK = Strong medium subangular blocky
Consistence
SSW = Slightly sticky wet, VSW = Very sticky wet, VPW = Very sticky wet, SW = Sticky wet, NSW = Non-sticky wet, Npw = Non-plastic wet
Inclusion
C2F= Common medium faint, M2d= Many medium distinct, F1f= Few fine faint, C3d= Common coarse distinct
Boundary
ds = diffuse smooth, gs = gradual smooth, cs = clear smooth, as = abrupt smooth

Table 2: Physical and Chemical Properties of Inland Wetland Soils of Obukiyo

Horizon	Depth (cm)	Particle size dist.				Texture	pH H_2O	Org. C	Total N	Avail. P	Exchangeable Bases				TEB	EA	CEC	BS
		Sand	Silt	Clay	Clay						Ca	Mg	K	Na				
		(%)	(%)	(%)	(%)		→	(%)	←	mg/kg	→			cmolkg^{-1}	←			(%)
Unit I Pedon 1: Arenic Paleustalfs/Aeric Lixisols																		
A	0-40	70.40	7.84	7.84	21.76	SCL	7.2	1.30	0.05	3.36	1.97	1.66	0.98	0.64	5.25	0.76	5.36	87
B	40-60	72.40	7.84	7.84	19.76	SL	6.8	0.30	0.06	1.62	2.68	2.38	0.64	0.48	6.80	1.10	6.29	85
BC	60-110	79.76	0.00	0.00	20.24	SL	6.8	0.60	0.05	3.52	3.70	2.62	0.72	0.48	7.52	2.07	7.53	78
C	110-120	71.12	5.54	5.54	23.04	SCL	6.0	0.71	0.06	3.56	3.73	1.08	0.54	0.37	5.72	2.02	5.72	74
Unit I Pedon 2: Arenic Paleustalfs/Aeric Lixisols																		
Ap	0-28	74.40	4.56	4.56	21.04	SCL	6.1	1.19	0.05	3.27	1.69	1.38	0.82	0.79	4.68	1.02	4.78	82
A	28-76	70.40	6.84	6.84	22.76	SCL	6.5	0.32	0.06	1.56	2.47	1.86	0.54	0.46	5.33	1.07	5.35	83
AB	76-105	72.40	8.54	8.54	19.06	SL	5.6	1.54	0.05	2.46	3.93	2.41	0.54	0.48	7.36	2.16	7.47	77
B	105-115	69.12	4.84	4.84	26.04	SCL	5.7	1.30	0.08	4.67	2.01	1.76	0.64	0.93	5.34	2.18	5.35	71
Bt_1	115-180	62.40	5.56	5.56	32.04	SCL	5.6	0.40	0.42	4.47	1.38	2.43	0.35	0.29	4.45	2.62	4.58	63
Unit II Pedon 3: Aeric Endoaqualfs/Endogleyic Gleysols																		
Ap	0-20	50.40	28.56	28.56	21.04	SCL	4.8	2.00	0.05	3.41	2.05	2.03	0.84	0.44	5.35	3.05	5.38	64
Bt_1	20-80	43.12	27.84	27.84	29.04	CL	4.4	1.52	0.05	3.13	1.93	1.75	0.72	0.54	4.94	3.61	4.98	58
Bt_2	80-110	43.12	27.84	27.84	29.04	CL	5.6	1.50	0.04	1.45	2.07	2.04	0.75	0.54	5.60	0.76	5.73	88
Bt_3	110-180	42.42	24.54	24.54	33.04	CL	5.1	1.26	0.04	2.77	2.13	1.84	0.69	0.43	5.09	0.68	5.12	88
Unit II Pedon 4: Aeric Endoaqualf/Endogleyic Gleyols																		
Ap	0-24	42.40	24.56	24.56	33.04	CL	4.1	2.00	0.05	2.10	2.60	2.34	0.82	0.53	6.29	3.62	6.34	63
Bt_1	24-86	48.40	20.56	20.56	31.04	SCL	4.6	1.42	0.05	1.93	1.98	0.96	0.76	0.58	4.28	3.68	4.39	54
Bt_2	86-118	40.40	24.56	24.56	35.04	CL	5.0	2.13	0.06	3.73	3.36	2.73	0.52	0.64	7.25	0.77	7.34	90
Bt_3	118-190	74.40	0.56	0.56	25.04	SCL	5.0	0.40	0.08	2.84	2.69	2.48	0.73	0.64	6.54	0.68	6.72	91

Table 2 Cont. : Physical and Chemical Properties of Inland Wetland Soils of Obukiyo

Horizon	Depth (cm)	Particle size dist.				Texture	pH H_2O	Org. C	Total N	Avail. P	Exchangeable Bases				TEB	EA	CEC	BS
		Sand	Silt	Clay	Clay						Ca	Mg	K	Na				
		(%)	(%)	(%)	(%)		⟶	(%)	⟵	mg/kg	⟶		cmolkg^{-1}		⟵			(%)
Unit III Pedon 5: Ustic Epiaquerts/Epiclayic Stagnosols																		
Ap	0-30	58.40	3.54	3.54	38.06	SC	5.7	1.38	0.06	1.42	1.99	0.84	0.76	0.58	4.17	3.63	4.37	53
AB	30-60	60.24	0.44	0.44	39.32	SC	7.5	0.88	0.11	1.52	1.98	1.42	0.82	0.58	4.80	2.62	4.85	65
B	60-75	53.04	6.36	6.36	40.60	SC	6.7	0.74	0.05	1.44	1.98	2.64	1.03	0.94	7.59	0.71	7.68	91
Bt_1	75-115	51.68	7.20	7.20	41.12	SC	7.0	0.97	0.06	1.26	2.99	2.32	0.94	0.82	7.07	2.24	7.07	76
Bt_2	115-150	56.40	1.50	1.50	42.10	SC	6.0	1.97	0.06	1.21	1.82	0.98	0.73	0.64	4.17	2.02	4.28	67
Btn	150-180	55.68	0.78	0.78	43.54	SC	6.3	1.56	0.04	1.26	3.38	2.41	0.84	0.58	7.21	0.76	7.22	90
Unit III Pedon 6: Ustic Epiaquerts/Epiclayic Stagnosols																		
Ap	0-20	56.40	2.62	2.62	40.98	SC	7.8	1.74	0.09	1.41	2.68	2.55	1.86	0.98	8.07	0.62	8.19	93
B	20-50	43.12	2.59	2.59	54.29	C	5.4	0.86	0.07	1.82	4.94	1.83	0.87	0.62	8.26	1.77	8.28	82
Bt_1	50-100	42.12	3.22	3.22	54.66	C	6.0	0.74	0.07	1.33	3.93	2.34	1.04	0.94	8.25	2.08	8.34	80
Bt_2	100-160	40.40	2.89	2.89	56.71	C	5.6	1.26	0.14	2.19	3.24	2.38	0.82	0.62	7.06	2.04	7.16	78
Btn	160-180	39.12	2.62	2.62	58.26	C	7.7	0.78	0.01	1.50	2.98	1.87	0.98	0.96	6.52	0.63	6.58	91
Unit IV Pedon 7: Ustic Epiaquerts/Epiclayic Stagnosols																		
Ap	0-34	58.40	2.60	2.60	39.00	SC	5.4	2.25	0.05	3.36	1.82	1.34	0.86	0.77	4.79	1.82	4.89	72
B	34-74	59.68	0.32	0.32	40.00	SC	6.5	1.02	0.05	1.57	2.94	1.86	0.93	0.56	6.29	1.74	6.29	78
Bt_1	74-98	61.12	1.65	1.65	37.23	SC	6.2	0.36	0.04	2.14	3.67	2.48	0.89	0.03	7.97	0.75	7.98	91
Bt_2	98-133	59.70	1.14	1.14	39.70	SC	5.8	1.59	0.06	6.51	2.47	1.65	0.42	0.84	5.38	2.11	5.49	72
Bt_3	133-180	35.12	7.45	7.45	39.43	SC	5.7	1.73	0.06	1.97	1.64	1.34	0.64	0.53	4.15	2.19	4.26	65
Unit IV Pedon 8: Ustic Epiaquerts/Epiclayic Stagnosols																		
Ap	0-56	57.40	2.40	2.40	40.20	SC	5.5	1.45	0.07	2.33	2.34	1.86	0.95	0.82	5.97	2.18	5.98	73
Bt_1	56-96	53.12	2.34	2.34	44.59	SC	4.9	1.45	0.06	1.66	2.78	2.02	0.41	0.36	5.55	3.02	5.67	65
Bt_2	96-126	53.40	0.61	0.61	45.99	SC	6.1	0.48	0.04	1.94	3.37	2.62	0.82	0.72	7.53	0.76	7.33	91
Bt_3	126-160	52.12	2.62	2.62	45.26	SC	5.8	0.46	0.06	2.48	3.43	2.14	1.58	0.42	7.57	2.22	7.69	77

3.2 The Chemical properties

The soils of the area were rated as strongly acidic to slightly alkaline in reaction with pH values ranging from 4.1 to 7.8 in H_2O (table 2). It was lowest (4.1) in the surface horizon of profile 4 and highest (7.8) in the surface horizon of profile 6. It was inconsistently distributed down the profiles. Profiles 1, 2 and 6 had high pH values on the surface than the subsoil as a result of nutrient biocycling and high percentage base saturation at the surface horizon (Idoga and Azagaku, 2005). This could also be accounted for by the direct deposition of crop and vegetable residues on the soil surface and their subsequent decomposition to release basic cations to the soil. Idoga and Ogbu, 2012 attribute the reduction in soil pH with depth to frequent crop harvesting and leaching of bases. The percentage organic carbon of the soil was low to moderately high for savannah soils and the values ranged from 0.30% to 2.25%. The high value may be attributed to the incorporation of plant and animals residues to the soil. The low soil temperature resulting from poor drainage could also encourage O.M accumulation among the poorly drained soils of Obukiyo. The low amount of O.C of profiles 1,2,5 and 8 is probably due to continue cropping for long period, bush burning, high erosive rate, grazing, harvested crop residues without replacement and very poor management activities. TN ranged between 0.01% and 0.42%. The high amount of O.C and TN in some subsoil is an indication of the young or immature nature of the soil profile due to seasonal deposit of material. The low level of N in the soils may be attributed to release from plant tissues, gaseous loss, surface runoff, leaching, climatic factors, vegetation, human activities, initial soil pH and low activities of symbiotic and non-symbiotic N-fixing bacteria. Loss of N through denitrification and volatilization may also contribute to the low level of N in the area. Available P values were very low with values ranging from 1.213 mg/kg to 6.515 mg/kg. This may be attributed to the low pH level which fixed the P and make it unavailable. It may also be attributed to the low amount of O.C, continue cropping, crop removal, erosion of P-carrying particles, P dissolved in surface runoff and leaching due to the coarse nature of the soils. The exchangeable bases were low as a result of the nature of the underlying parent materials, intensity of weathering, leaching, low activity clay, low O.M, erosion and lateral translocation of bases. Ca was the most dominant cations with values ranging between 1.38cmolKg^{-1} and 4.94cmolKg^{-1} in the exchange complex. It may be linked to the occurrence of exchange sites which have specific affinity to Ca (Idoga, 1985) or may be due to the fact that Ca is least easily lost from exchange site or has high displacement ability over other cation exchange reaction. The Mg values ranged between 0.82cmolKg^{-1} and 2.64cmolKg^{-1} while that of K and Na ranged from 0.35cmol$Kg^{-1}$to 1.86cmol$Kg^{-1}$and 0.29cmolKg^{-1} to 0.98cmolkg^{-1} respectively. These values confirmed the predominance of Ca followed by Mg over K and Na as observed by Idoga, 1985, and Ogunkunle, 1989. The CEC of the soils were low to medium with values ranging between 3.75 cmolkg^{-1} and 8.34 cmolkg^{-1}. The low CEC values indicated that the soils had low potential for retaining plant nutrient. It may also be attributed to the nature of clay minerals (kaolinite) and low O.C level of the soils. The B.S values (53% to 98%) were moderately high to very high. The high B.S is probably associated with the presence of weathered minerals which release nutrients into the soil and their alluvial nature. A general correlation exists between the B.S and its pH. As the B.S is reduced owning to the loss in drainage of Ca and other metallic constituents, the pH also is lowered in a more or less definite proportion (see Table 2 shown above).

3.3. Soil Classification

The key to soil Taxonomy (Soil Survey Staff, 2014) was used in the classification of the soils. Both field and laboratory studies of the soils indicated an increasing trend in the amount of clay with depth and high degree of soil aggregation. The clay distribution pattern showed that there were argillic horizons in all the profiles studied. The clay distribution pattern coupled with the high base status (>50%) quantified the soils of units I and II as Alfisols. Soils of unit I were well drained with Isohyperthermic soil temperature (>22^{0}c) and a limited soil moisture content but present when the conditions are suitable for plants growth (Ustic moisture regime). These features qualified the soils as *Ustalfs*. The soil had high clay content in the subsoil than topsoil, coarse redox concentration, soil colour hue of 7.5YR or redder in subsoil, value of 4 or more and chroma of 4 or more. These properties placed the soils under the great group *Paleustalfs* and further classified as *Arenic Paleustalfs* as a result of their high sand fraction (62.40% to 79.76%) throughout the horizons, extending from the mineral soil surface to the top of an argillic horizons at a depth of 50-100cm or more.

Soils of unit II had endosaturation conditions, found at lowland with high water level and thickness of 20 cm or more within 75 cm of the soil surface along with Isohyperthermic temperature regime and aquic moisture regime, thus classified as *Endoaqualfs.*They had one or more horizons between the A and Ap horizons or a depth of 25cm from the mineral soil surface, deeper than 75 cm, colour hue of 10YR or redder (2.5Y), value of 4 or more (moist), chroma of 2 or more (moist) and no redox concentrations, hence subgrouped as *Aeric Endoaqualfs*.

At the other hand, soils of units III and IV had vertic properties. Their heavy clay content (≥30 %) throughout a thickness of 15 cm or more, low organic carbon (≤25 %), very sticky consistence, and coarse surface structure placed the soils as *Vertisols*. The aquic conditions of the soils as evidenced by the dominant matrix hue of 10YR or reddish (2.5Y) and the presence of mottles within 20cm of the mineral soil surface, further qualified these soils as *Aquerts*.

These soils possessed swelling and shrinkage properties (gilgail micro relief) and showed evidence of episaturation in addition to the influence of ground water and therefore classified as *Epiaquerts*. The presence of cracks that opene and close periodically and were 2cm or more wide and deeper than 50cm as well as the dominant colour hue of 10YR or yellow (2.5Y), value of 3 or more, chroma of 4 or more subgrouped these soils as *Ustic Epiaquerts*.

3.4. Classification According to World Reference Base

The soils had higher clay content in the subsoil than the topsoil as a result of pedogenetic processes (eluviations and illuuviation) leading to an argillic horizons. Soils unit I had evidence of argillic B horizons with CEC Less than 24cmol (+) kg^{-1} clay and high base saturation greater than 50% in all the B horizons. These features qualify the soil as *Lixisols* (FAO-WRB, 2014). They were classified as *Aeric Lixisols* because of the sandy clay loam texture and coarse surface structure.

Soils of unit II were classified as *Endogleyic Gleysols* due to the sign of endosaturation condition along with sandy clay loam and clay laom topsoils and subsoils respectively. The floodplain were strongly saturated with ground water and they had gleyic colour pattern, yellowish (10YR, moist) colour in topsoils and greyish (2.5YR, moist) or reddish (2.5Y, moist) in the subsoils.They had coarse surface structure in a layer, 30cm or more thick, between 50cm and 100cm from the mineral soil surface.

Soils of units III and IV were very heavy clay soils (≥30%) with perched water table showing redoximorphic features caused by surface water. They were periodically wet with mottles from the topsoils to the subsoils, stagnic colour pattern and found in lowland area, flooded environment with low fertility status.These features placed the soils as *Stagnosols.* Thesesoils were further classified as *Epiclayic Stagnosols* as a result of the presence of cracks,≥2 cm wide on topsoils, low CEC, organic carbon,total N, moderate pH level and high clay content in a layer, 30cm or more thick, within 50cm of the soil surface.. A summary of the soil classes of Obukiyo wetland is given below in Table 3.

Table 3: Summary of Soil Classification

Soil Units	Profiles	Taxanomic Classes
I	1 and 2	*Arenic Paleustalfs/Aeric Lixisols*
II	3 and 4	*Aeric Endoaqualfs/ Endogleyic Gleysols*
III	5 and 6	*Ustic Epiaquerts/ Epiclayic Vertisols*
IV	7and 8	*Ustic Epiaquerts/ Epiclayic Vertisols*

4.0. Conclusion.

Based on the physical, chemical, biological and morphological features of the soils, the argillic horizons and high BS, soils of unit I and II were characterized and classified as *Alfisols*. Unit I soils were separated as *Ustalf*s due to it ustic moisture regime. The high sand fraction grouped them as *Paleustalfs and Arenic Paleustalfs/Aeric Lixisols*. Unit II soils had endosaturation and were separated as *Endoaqualfs*. They had colour hue of 10YR or redder (2.5Y), value moist of 4 or more, chroma of 2 or more (moist) and no redox concentration, hence further subgrouped as *Aeric Endoaqualfs.* Units III and IV soils were grouped as *Vertisols* as a result of their high clay content, low organic carbon, very sticky consistence and coarse surface structure. The aquic conditions and the presence of mottles within 20cm of the mineral soil surface qualified them as *Aquerts*.They were further classified as *Epiaquerts* as a result of their gilgail micro relief and episaturation and subgrouped as *Ustic Epiaquerts* due to the presence of cracks 2cm wide from the surface to at least 50cm deep during the dry period of the year.

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