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CHARACTERIZATION, CLASSIFICATION AND LAND USE MANAGEMENT OF FLOOD PLAIN SOILS OF CENTRAL CROSS RIVER STATE, NIGERIA.

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ABSTRACT

The floodplain soils of Central Cross River State are extensively cultivated for food crop production and contributes nearly 60% of the agricultural wealth of the inhabitants. Knowledge of their characteristics, classification and management will enhance their productive potential and facilitate technological transfer. Profile pits were escavated in levee and backswamp locations in two communities with extensive floodplains and studied. Based on morphological and other analytical characteristics, the soils were classified according to USDA soil Taxonomy and correlated to FAO/UNESCO soil map of the world legend. Backswamp soils were classified as Vertic Tropaquepts while levee soils were classified as Typic Tropustuepts at sub-group level of the USDA soil Taxonomy. The FAO/UNESCO equivalent of these soils is Luvisol. The major limitations of these soils are high acidity (low pH), low available phosphorus and poor drainage. Backswamp soils were superior in most fertility indices assessed than levee soils. Soil pH in these soils had a high positive correlation with CEC, available phosphorous and base saturation with "r" values of 0.79, 0.76, and 0.75 at $p<0.01$ respectively. However, the relationship between CEC and erodibility index was negative with "r" value of -0.77 at $p>0.01$ significant level. The floodplain soils can be efficiently managed through the use of water control mechanisms, construction of efficient low cost drainage systems, construction of giant heaps and application of phosphatic fertilizers/NPK high in phosphorus. The backswamps can be dammed for fish farming.

KEYWORDS: Floodplain soils, classification, land use, sustainable management.

INTRODUCTION

There is an increasing need to provide more information on our wetlands especially the floodplains because of their enormous agricultural potentials. Floodplains soils are derived from alluvial deposits and are located in areas that are susceptible to flooding during the wet season and are somewhat well drained during the dry season (Carsky, 1992). Eshett (1993) remarked that the largest concentration of natural wetland occurs in Southern Nigeria where the principal geological formation consists of coastal plain sands and alluvium. Floodplains are areas within which river escapes into during flooding. These soils may be sandy as in beach deposit or derived from sandstone, but are more frequently clayey and are said to be very fertile with maximum water holding capacity (William *et al*., 1979). Brinkman and Blockhuis (1986) observed the texture of floodplain soils to range from clay to sand with the greatest variation in the texture of surface horizons. World Bank (1992) described the floodplain as flood prone, low lying slow draining area, that generally posses finer texture. Most flood plain soils are seasonally flooded.

Troech and Thompson (1993) observed that floodplain soils that are seasonally dry possess structures that range from blocky to prismatic. Ahn (1993) remarked that well drained tropical soils are usually reddish in colour, but when drainage is poor the soil colour is either bluish grey, greenish grey or neutral grey. Evans and Framzmeier (1986) noted that floodplain soils with reducing conditions produce low chroma mottle colour while better drained soils produce brighter colours.

Floodplains are the major soil resource that contribute nearly 60% of the agricultural wealth of Central Cross River State, Nigeria, and occur extensively along the Cross River bank. Regrettably, much has not been done to highlight the characteristic potentials of this natural asset. This study is intended to investigated the characteristics of floodplain soils, highlight cost effective management strategies and classify the soils in order to facilitate transfer of knowledge or experience from one plot to another.

MATERIALS AND METHODS

Site Description

This study was carried out in Central Cross River State, Nigeria. The study area lies between longitude $8^{o}00$ and $9^{o}10$ and latitude $5^{o}20''$ and $6^{o}20''$N. The geology of the area consist of cretaceous sandstone-shale intercalation and basement complex of the Eze-Aku group of the South Eastern Benue Trough and Ikom-Mamfe Embayment (Petters, 1995). The mean annual rainfall of the area ranges from 2500-3500mm per annum (Bulktrade and Investment Company Limited, 1989).

Sampling Design/Technique

The stratified random sampling technique was adopted in this study. The floodplains were stratified into backswamps and levee. A total of four profile pits were excavated in the study area. Two communities with extensive floodplains were selected for this study. In each of the communities two pits, one at the backswamp and the other at the levee were excavated. The randomly selected communities were Ovonum and

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Ediba in Obubra and Abi Local Government Areas respectively.

Field Work

The profile pits were dug at the most representative points of observation in each sampling location. The soil profiles were then described according to the FAO/UNESCO (1990) guidelines. Soil samples were taken from the profile for routine chemical analysis, micro nutrient analysis and determination of soil physical parameters (particle size distribution, bulk density, particle density, erodibility index).

Laboratory Analysis

The bulk density was determined by the cylindrical core method (Blake, 1965). The particle size distribution was determined by the Bouyoucos hydrometer method (Klute, 1986). Soil erodibility index was estimated by evaluating the ratio of sand and silt contents to clay content (Hudson, 1995).

The soil samples for analysis for characterization and classification were air dried, crushed and passed through a 2mm mesh sized sieve. Soil pH was determined in a 1:2.5 soil: water suspension using glass electrode pH meter. Organic carbon was determined by the dichromate wet oxidation method of Walkley and Black (Jackson, 1969). Total Nitrogen was analysed according to the macro kjeldahl method (Jackson, 1969). Available phosphorus was extracted by the Bray No. 1 procedure (Bray and Kurtz, 1945), and estimated by the molybdenum blue colour technique (Murphy and Riley, 1962). Exchangeable cations were extracted by leaching the soil with IN ammonium acetate solution (pH 7.0). Exchangeable K and Na in the extract were determined using a flame photometer while the exchangeable Ca and Mg were determined using the versonate titration method. Exchangeable H and Al were determined by the titration method from an extract obtained using IN KCl solution (McLean, 1965). The cation exchange capacity (CEC) at pH 7 was estimated using the NH_40A_C method (Jackson, 1969). The micro nutrients, free iron, manganese and aluminium oxides (dithionite Fe_20_3, Mn_2O_3 and Al_2O_3) were extracted by the dithionite-citrate-bicarbonate (DCB) solution according to the method of Mehra and Jackson (1960).

RESULT AND DISCUSSION

The soils of floodplains are derived from recent alluvial deposits, and are confined to river valleys. These soils are permanently saturated with water in the wet season but in the dry season, its moisture content is near field capacity in the sub-soil and dry in the top soil with visible cracks.

Morphological Characteristics

Under moist conditions floodplain soils are characterized by dark grey, very dark reddish grey, dark brown, reddish yellow and brown with dominant hue of 7.5 YR. Specifically soils at the backswamp positions were dark grey and reddish grey while those at the levee were dark brown, brown and yellowish brown with reddish yellow, strong brown and red mottles occurring throughout depth at the backswamps and within 50cm depth at the levee. These soils are characterized with spodic, cambic and argillic clay, loam and clay loam sub-surface diagnostic horizons due to the presence of clay skins along its pores. Floodplain soils have moderate medium sub-angular blocky, weak medium granular and strong coarse prismatic structures. This structural observation collaborates the findings of Troeh and Thompson (1993) who observed that floodplain soils that are seasonally dry, posses structures that range from blocky to prismatic.

The presence of high Na^+ content and prismatic structures suggests the possession of natric sub-surface horizons (Ibanga, 2003). The dry consistence was hard to extremely hard, although occasional soft and slightly hard consistence occurred in surface soils of levee positions. Under moist condition, the top soils consistence were very friable and friable. The sub soils were sticky-slightly plastic to sticky-plastic (Table 1). This was due to high illuviation of clay giving rise to argillic sub-surface diagnostic horizons (Esu, 1999). Few to common, very fine, fine and medium pores dominated the pedons studied. The soils were generally characterized with deep wide cracks at the backswamp and clay skins in levee pedons. The horizon boundary were either gradual, abrupt, clear or diffuse in distinctness but were generally wavy in topography (Table 1).

Physical Properties

Sandy clay, clay, loam and clay loam were dominant textures encountered in the floodplain soils. The particle size distribution was dominated by clay and silt, followed by the fine sand fraction (Table 2). This observation collaborates the findings of Akamigbo *et al*. (2001) on the fadama soils of Bauchi State. Bulk density was generally lower at the surface soil than at the sub-soil. Mean values of 1.13, 1.29, and 1.58g/cm^3 and 0.96, 0.98 and 1.23g/cm^3 were obtained for backswamp and levee positions at depths 0.025 and 75cm respectively in the floodplain soils (Table 3). The increase in bulk density with soil depth is due solely to elluviation-illuviation process which fills up coarser pores (Ogban and Ekerette, 2001). Higher values of bulk density were observed at the backswamp with lower values at the levee. This is due to the increased clay content with few fine pores at the backswamp.

Values of soil erodibility index averaged 0.9 at the backswamp and 1.8 at the levee. The levee had higher erodibility index than the backswamp, thus backswamp soils are less susceptible to erosion. This is due to variation in clay content and topographic attributes between the levee and the backswamps. This finding agrees with the work of Hudson (1995) who remarked that soil properties such as texture, structure and porosity as well as topographic features of slope length and slope angle affect erodibility of soil.

Table 1: Morphological Characteristics of Representatives pedons of soils of floodplain soils of Central Cross River State, Nigeria.

Sample No. (9)	Horizon Designation	Horizon Thick ness	Major colour (1)	Mottles (2)	Texture (3)	Structure (4)	Consistence (5)			Roots (6)	Pores (7)	Horizon Boundary (8)
							Dry	Moist	Wet			
ED/ALU/A/1	Ape	0 - 10	7.5YR4/1; Dg	7.5YR6/6; ffd, Ry	SC	2 M sbk	vh	fr	s-sp	mf	cf	aw
ED/ALU/A/2	Ba	10 – 35	7.5YR3/1; vdg	7.5YR5/6; cmd Sb	C	3 C prismatic	vh	f	s-p	fvf	ff	gw
ED/ALU/A/3	Bag	35 – 86	7.5YR5/1;G	7.5YR4/6; cmb, Sb	C	3 C prismatic	eh	f	vs-p	fvf	fvf	gw
ED/ALU/A/4	Bhg	86 – 130	7.5YR5/1;G	7.5YR4/6; mcp, Sb	C	3 M sbk	eh	vf	vs-p	fvf	fm	
OV/ALU/A/1	Ape	0 – 18	7.5YR4/1; Dg	5YR6/8; fff, Lr	C	1 M granular	s	vfr	ss-sp	cf	cm	cw
OV/ALU/A/2	Bi	18 – 48	7.5YR5/1; G	2.5YR4/8;ffd, R	C	2 M sbk	sh	fr	ss-p	cf	cm	cw
OV/ALU/A/3	Bag	48 – 65	5YR5/1;Rg	2.5YR4/8;cmd, R	C	2 M sbk	h	f	ns-np	fvf	fvf	gw
OV/ALU/A/4	Bhg	65 – 118	2.5YR6/1; Rg	2.5YR4/8; cmp, R	C	2 M skb	vh	f	s-p	fvf	ff	
ED/ALU/B/1	Ap	0 – 12	7.5YR4/6; Sb		L	1 M granular	s	vfr	ss-sp	mf	cm	aw
ED/ALU/B/2	B	12 – 41	7.5YR4/4; B		L	2M sbk	sh	vfr	ss-p	ff	cm	gw
ED/ALU/B/3	Bhg	41 – 80	7.5YR6/6; Ry	5YR4/6; fff, R	CL	3M sbk	h	f	ss-p	fvf	mm	gw
ED/ALU/B/4	Btg_1	80 – 130	7.5YR6/8; Ry	5YR4/6; cmd, R	CL	3M sbk	h	f	ss-p	fvf	mm	gw
ED/ALU/B/5	Btg_2	130 – 170	7.5YR4/6; Ry	7.5YR6/6; cff, Ry	C	3M sbk	vh	f	s-p	fvf	cm	
OV/ALU/B/1	Ap	0 – 19	7.5YR3/2; Db		CL	IF crumb	s	vfr	ss-sp	ff	cf	cw
OV/ALU/B/2	AB	19 – 53	7.5YR4/4; B		CL	IF crumb	s	fr	ss-sp	fvf	mf	gw
OV/ALU/B/3	Btg_1	53 – 80	7.5YR4/4; B		CL	2M sbk	vh	fr	ss-sp	cf	mm	cw
OV/ALU/B/4	Btg_2	80 – 139	7.5YR4/4; B		CL	3M sbk	vh	fr	s-p	cf	fm	dw
OV/ALU/B/5	Btg_3	139 - 174	7.5YR4/2; B	2.5YR5/6; cfd, R	C	3M sbk	vh	ff	s-p	fvf	fm	

KEY:

1. COLOUR: Dg = Dark gray, vdg = very dark gray, G = grey, Rg = Reddish gray, Sb = strong brown, B = Brown, Ry = Reddish yellow, Db = Dark brown, Lr = light red, R = red.
2. MOTTLES: ffd = few fine distinct, cmd = common medium distinct, mcp = many coarse prominent, fff = few fine faint, cmp = common medium prominent, cff = common fine faint, cfd = common fine distinct.
3. TEXTURE: SC = sandy clay, C = clay, L = loam, CL = clay loam.
4. STRUCTURE: 1 = weak, 2 = moderate, 3 = strong, F = fine, M = medium, C = coarse, sbk = sub- angular blocky.
5. CONSISTENCE: vh = very hard, eh = extremely hard, s = soft, sh = slightly hard, h = hard, fr = friable, f = firm, vf = very fine, vfr = very fiable, s – sp = sticky-slightly plastic, s – p = sticky plastic, vs – p = very sticky-plastic, ss – sp= slightly sticky-slightly plastic, ss-p = slightly-stick-plastic, ns-np = non sticky, non plastic.
6. ROOTS: mf = many fine, fvf = few very fine, cf = mmon fine, ff = few fine.
7. PORES: cf = common fine, ff = few fine, fvf = few very fine, fm = few medium, cm = common medium, mm = medium, mf = many fine,
8. BOUNDARY: aw = abrupt wavy, gw = gradual wavy, cw = clear wavy, dw = diffuse wavy
9. A = Backswamp, B = Levee, ED = Ediba, OV = Ovonum

Table 2: Particle size analysis and soil erodibility index of Floodplain Soils of Central Cross River State, Nigeria.

Sample No.	Horizon Designation	Horizon Depth (cm)	Clay %	Silt %	Fine sand %	Coarse sand %	Total sand %	Textural class	Soil erodibility index
ED/A/1	Ape	1 – 10	51	4	24	21	45	SC	1.0
ED/A/2	Ba	10 – 35	51	25	18	6	24	C	1.0
ED/A/3	Bag	35 – 86	57	15	19	9	28	C	1.8
ED/A/4	Bhg	86 – 130	53	19	20	9	29	C	0.9
OV/A/1	Ape	0 – 18	48	11	23	18	41	C	1.1
OV/A/2	Bi	18 – 48	51	9	25	15	40	C	1.0
OV/A/3	Bag	48 – 65	56	14	20	10	30	C	0.8
OV/A/4	Bhg	65 – 118	58	16	17	9	26	C	0.7
Mean			**53**	**14**	**21**	**12**	**33**		**0.9**
ED/B/1	Ap	0 – 12	27	29	17	27	44	L	2.7
ED/B/2	B	12 – 41	27	29	22	22	44	L	2.7
ED/B/3	Bhg	41 – 80	31	27	21	21	42	CL	2.2
ED/B/4	Btg	80 – 130	33	37	19	11	30	CL	2.0
ED/B/5	Btg_2	130 – 170	46	25	19	10	29	C	1.2
OV/B/1	AP	0 – 19	32	27	20	21	41	CL	2.1
OV/B/2	AB	19 – 53	31	29	18	22	40	CL	2.2
OV/B/3	Btg	53 – 80	34	26	23	17	40	CL	1.9
OV/B/4	Btg_2	80 – 139	38	24	20	18	38	CL	1.6
OV/B/5	Btg_3	139 - 174	42	22	17	19	36	C	1.4
Mean			**34**	**28**	**18**	**19**	**38**		**1.8**
Grand mean			**44**	**21**	**20**	**16**	**36**		**1.4**

Key: SC = Sandy clay, C = Clay, L = Loam, CL = Clay loam, ED = Ediba, OV = Ovonum, A = Backswamp, B = Levee.

Table 3: Bulk and particle densities at specified depths of floodplain soils of Central Cross River State.

	Bulk Density (g/cm^3)			Particle density (g/cm^3)		
	0cm	25cm	75cm	0cm	25cm	75cm
OV/A	1.27	1.31	1.60	2.54	2.62	3.20
ED/A	0.99	1.26	1.55	1.98	2.52	3.10
Mean	1.13	1.29	1.58	2.26	2.57	3.15
OV/B	0.99	0.85	1.24	1.98	1.70	2.48
ED/B	0.93	1.10	0.99	1.86	2.20	1.98
Mean	0.96	0.98	0.12	1.92	1.95	2.23
Grand mean	1.05	1.14	1.35	2.09	2.26	2.69
SD	0.13	0.18	0.25	0.26	0.36	0.49
CV %	12.6	15.8	18.3	12.7	15.9	18.4
SE ±	0.07	0.09	0.13	0.13	0.18	0.25

KEY: A = Backswamp, B = Levee, ED = Ediba, OV = Ovonum

Chemical Characteristics

The soil reaction in the floodplain soils ranged from pH 3.9 – 5.5 averaging 4.9 and 4.3 rated very strongly acid and extremely acid for backswamps and levees respectively. Values of organic carbon ranged from 5.9 – 23.4g/kg averaging 13.3g/kg and 13.0g/kg and rated medium for both backswamp and levee topographic positions respectively. Total nitrogen ranged from 0.4 – 2.4g/kg averaging 1.1g/kg at both backswamp and levee position of the floodplains. These values were rated medium.

Among the exchangeable cations, sodium ranged from 0.18 – 0.24 cmol/kg averaging 0.22 cmoI/kg and rated medium for both backswamps and levee. Exchangeable potassium ranged from 0.05 – 0.49 cmol/kg averaging 0.31 and 0.11 cmol/kg and rated high for backswamps and low for levee positions. The high K value at the backswamps may be due to the increased organic matter deposition. This agree with the findings of De-Alwis and Pluth (1976), who remarked that organic matter content enhances the adsorption of cations.

Exchangeable calcium ranged from 0.8 – 19.1 cmol/kg averaging 15.2 and 2.5 cmol/kg and rated high for backswamps and medium for levee. The high calcium value at the backswamp is the direct consequence of enhance deposition of organic matter and weathered materials from basement complex rocks, high in basic cations and occurring around the upper course of cross river. This observation collaborates the findings of Akamigbo *et al.,* (2001).

Exchangeable Magnesium values ranged from 1.2 – 13.2 cmol/kg averaging 10.5 and 2.2 cmol/kg rated high for backswamp soils and low for levees. This result agrees with the findings or Raji *et al.,* (2001) who reported that magnesium is generally moderate in content but high in the backswamp soils.

Cation exchange capacity values ranged from 2.5 – 33.0cmol/kg averaging 26.2 cmol/kg at the backswamp soils and 5.0 cmol/kg at the levees. Cation exchange capacity are high in the backswamp soils and low at the levees soils. The high cation exchange capacity at the backswamp is due to the increased clay and organic matter contents. The high CEC values of the backswamp collaborates the findings of Esu (1989) for some alluvial soils in Nigeria.

Values of available phosphorus ranged from 5.0 – 38.8mg/kg averaging 16.4mg/kg for the backswamps and 12.4mg/kg for levee soils. These values are rated medium for both backswamp and levee soils. However top soils of floodplains had high values of available phosphorus (Table 4). This may be due to increased organic matter deposition and mineralization in the floodplain soils.

Base saturation in the floodplain soils ranged from 31.0 – 97.1% averaging 89.1% for backswamps and 42.2% for levee soils. These values are rated high for backswamp soils and low for levee soils.

Floodplain soils exhibit moderate to high levels of dithionite Fe and Al oxides especially in the dry season (Table 5). Values of Fe_20_3, Al_20_3 and Mn_20 averaged 28.4, 4.5, and 9.0g/kg; and 2.4, 0.5 and 0.2g/kg for backswamp and levee soils respectively. This finding agrees with the observation of Mohr *et al*., (1972) who remarked that hydromorphic soils are usually enriched with Fe due to deposition of Fe compound. Consequently the very poorly drained status of backswamps increases their micronutrient status compared to levee and other upland soils.

Correlation in floodplain soils

The relationship between pH (H_20) and cation exchange capacity, available phosphorus and base saturation were linear positive with high correlation coefficients "r" of 0.79, 0.76 and 0.75, all at ($p < 0.01$) respectively. Organic carbon had a high positive linear relationship with total nitrogen and available phosphorus with correlation coefficient "r" of 0.93 and 0.76 respectively. Cation exchange capacity had a high positive linear relationship with soil pH, base saturation and clay content with correlation coefficient "r" of 0.79, 0.97 and 0.82 at $P<0.01$, the relationship between CEC and erodibility index was negative with "r" value of -0.77 ($P>0.01$). This implies that as CEC increases, soil erodibility index decreases. Soils with low erodibility index have high CEC. The relationship between erodibility index and CEC, base saturation and clay content was high negative with correlation coefficient "r" of -0.77, and -0.98 at $P>0.01$ respectively.

Table 4: Some Chemical properties of Representative pedons of Floodplain Soils of Central Cross River State, Nigeria.

Sample No.	Horizon Design a-tion	Horizon Depth cm	pH (H_20)	pH KCl	Org. C	O. M	Total nitrogen	Na^+	K^+	Ca^{2+}	Mg^{2+}	CEC	ECEC	Al^{3+}	H^+	Avail. P
					← $Mgkg^{-1}$	gkg^{1-}	→	←				cmol/kg			→	
ED/A/1	Ape	0 – 10	5.5	4.2	21.1	36.4	1.8	0.24	0.46	17.6	8.4	26.7	27.5	Trace	0.8	33.8
ED/A/2	Ba	10 – 35	5.2	4.0	7.0	12.1	0.7	0.24	0.26	18.0	10.0	28.5	30.7	“	2.2	14.9
ED/A/3	Bag	35 – 86	4.4	3.3	7.4	12.8	0.6	0.24	0.20	14.8	11.0	26.2	29.0	“	2.8	11.9
ED/A/4	Bhg	86 - 130	4.2	3.2	5.9	10.1	0.6	0.24	0.26	10.2	6.8	17.5	27.9	“	10.4	5.0
OV/A/1	Ape	0 – 18	5.3	4.1	23.4	40.3	1.9	0.21	0.49	19.1	13.2	33.0	36.3	“	3.3	28.6
OV/A/2	Bi	18 – 48	5.1	3.8	15.1	26.0	1.1	0.23	0.32	17.2	11.5	29.3	31.9	“	2.6	15.1
OV/A/3	Bag	48 – 65	4.8	3.5	13.2	22.7	1.0	0.19	0.26	13.6	12.3	26.4	28.5	“	2.1	12.2
OV/A/4	Bhg	65 – 118	4.3	3.4	13.0	22.4	1.0	0.18	0.21	11.4	10.4	22.2	23.4	“	1.2	9.4
Mean			4.9	3.7	13.3	22.9	1.1	0.22	0.31	15.2	10.5	26.2	29.4	“	3.2	16.4
ED/B/1	Ap	0 – 12	4.3	3.4	23.1	39.9	2.0	0.24	0.15	3.4	2.6	6.4	13.6	Trace	7.2	19.9
ED/B/2	B	12 – 41	4.1	3.2	14.5	24.9	1.4	0.24	0.05	2.0	1.8	4.1	9.3	“	5.2	7.0
ED/B/3	Bhg	41 – 80	4.3	3.4	7.4	12.8	0.8	0.18	0.10	1.4	1.4	3.1	8.7	“	5.6	10.0
ED/B/4	Btg_1	80 – 130	4.3	3.4	5.9	10.1	0.4	0.24	0.10	3.0	2.8	6.1	14.5	“	8.4	10.0
ED/B/5	Btg_2	130 – 170	4.5	3.4	5.9	10.1	0.6	0.24	0.10	3.6	3.8	7.7	16.1	“	8.4	11.9
OV/B/1	Ap	0 – 19	4.6	3.5	24.2	36.7	2.4	0.22	0.17	3.9	2.7	7.0	15.3	“	8.3	22.1
OV/B/2	AB	19 – 53	4.1	3.2	17.1	22.8	1.7	0.19	0.11	2.8	2.5	5.6	11.7	“	6.1	14.4
OV/B/3	Btg_1	53 – 80	4.4	3.4	12.8	11.3	0.5	0.21	0.13	2.4	1.6	4.3	10.7	“	6.4	11.1
OV/B/4	Btg_2	80 – 139	4.1	3.3	10.1	11.1	0.6	0.21	0.08	1.9	1.2	3.4	8.5	“	5.1	9.5
OV/B/5	Btg_3	139 - 174	3.9	3.4	9.3	9.2	0.4	0.20	0.06	0.8	1.4	2.5	7.9	“	5.4	8.3
Mean			**4.3**	**3.4**	**13.0**	**18.9**	**1.1**	**0.22**	**0.11**	**2.5**	**2.2**	**5.0**	**10.6**	“	**6.6**	**12.4**
Grand Mean			**4.5**	**3.6**	**13.2**	**20.9**	**1.1**	**0.22**	**0.21**	**8.9**	**6.4**	**15.6**	**20.0**	“	**4.9**	**14.4**
SD			**0.5**	**0.3**	**6.2**	**10.9**	**0.6**	**0.02**	**0.14**	**6.7**	**4.4**	**11.1**	**9.4**	“	**2.9**	**7.3**
CV%			**10.1**	**8.7**	**47.1**	**52.4**	**55.4**	**10.2**	**67.1**	**75.5**	**68.8**	**70.9**	**88.8**	“	**58.9**	**50.9**
SE ±			**1.1**	**0.1**	**1.5**	**2.6**	**0.1**	**0.005**	**0.03**	**1.6**	**1.0**	**0.7**	**2.2**	“	**0.7**	**1.7**

KEY: ED = Ediba, OV = Ovonum, A = Backswamp, B = Levee.

Table 5: Dry Season Mean Values of Dithionite Extractable $Fe_2 0_3$, $Mn_2 0_3$ and $Al_2 0_3$ of Representative pedons of Floodplain Soils of Central Cross River State, Nigeria.

Pedon	$Fe_2 0_3$	$Mn_2 0_3$	$Al_2 0_3$
	←	g/kg	→
ED/A	20.2	8.4	0.4
OV/A	36.6	9.6	0.6
Mean	28.4	9.0	0.5
ED/B	3.7	2.8	0.2
	5.3	1.9	0.1
Mean	4.5	2.4	0.2
Grand mean	16.5	5.7	0.3
CV%	80.57	59.07	63.33
SE ±	0.67	1.69	0.10

KEY: A = Backswamp, B = Levee, ED = Ediba, OV = Ovonum

Taxonomic classification of flood plain soils

The soils under investigation were classified according to the USDA soil taxonomy (Soil Survey Staff, 1994) and correlated with the FAO/UNESCO legend of World Reference Base (WRB) system (FAO/UNESCO, 1974). The low pH, high cation exchange capacity (High fertility), presence of argillic, spodic and cambic sub-surface diagnostic horizons, existence of poorly developed horizons as evident in the absence of C-horizons of the flood plain soils, qualified classifying these soils as inceptisols (Soil Survey Staff, 1994). The soils of the back swamps occur under aquic soil moisture regime with a hyperthermic soil temperature regime, hence these soils can be classified as Aquepts at the sub-order level. Their occurrence under tropical climatic conditions permits their placement as tropaquepts in the great group level. In view of their characteristic fine texture and cracking nature, backswamp soils can be classified at the sub-group level as Vertic Tropaquepts. The levee soils occur under ustic moisture regime with a hyperthermic temperature regime hence these soils can be classified as ustuepts in the sub-order level. Their occurrence under tropical conditions and wide spread status in Central Cross River State, enables the levee soils to be classified Typic Tropustuepts at the sub-group level. The Federal Department of Agricultural Land Resources (FDALR, 1990) classified similar soils as Fluvepts or inceptisols. The FAO/UNESCO legend or World Reference Base system classification of Vertic Tropaquepts and Typic Tropustuepts is Luvisol.

CONCLUSION

Flood plain soils are unique in their characteristics. These unique attributes are greatly influenced by the dynamic nature of their water table, depositional and mineralization pattern. The backswamp soils are superior in most of the fertility indices assessed and thus are more fertile than the levee soils. The productive potentials of the flood plain soils can be enhanced through the installation of adequate drainage systems and cultivation of water tolerant crops like swamp rice in rainy seasons. Adequate liming and application of phosphatic or NPK fertilizers are also recommended.

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