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CHARACTERIZATION OF WETLAND SOILS DEVELOPED ON LIMESTONES PARENT MATERIAL IN CROSS RIVER STATE, SOUTH EASTERN NIGERIA.

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ABSTRACT

Wetland soils developed on limestone parent materials were characterized and classified. In the study, eight (8) profile pits were sunk in 3 sites within Cross River State in 2006, described and sampled according to FAO (1988) guidelines. The samples were analysed in the laboratory using routine methods. Results obtained for morphological studies and physicochemical analysis showed that the soils were generally deep to shallow, moderately well drained to poorly-drained with weak red to light grey, Dark reddish brown to reddish brown, yellowish brown in colour. The soils are weak, medium, and crumb, moderate and sub-angular blocky structure. The texture ranged from sandy loam, silt, loam, loamy sand, sandy clay and clay loam. Bulk density values ranged between 1.20 g/cm^3 and 1.85 g/cm^3 with a mean of 1.37 g/cm^3. Particle density values ranged from 2.18 g/cm^3 to 3.70 g/cm^3 with a mean of 2.74 g/cm^3. The soils showed total porosity of 50% on the average which indicated good soils for maximum plant growth. The soils are slightly alkaline to moderate alkaline in reaction. Organic matter, total nitrogen, Available phosphorus contents, calcium, magnesium, potassium, and sodium contents were rated as low to moderate. An effective cation exchange capacity value of 10.36 cmol/kg was rated moderate with base saturation values above 82 per cent for these soils. The soils were classified as Inceptisols and Alfisols.

KEYWORDS: Wetland Soil, Limestone Parent-Material, Morphological Characteristics.

INTRODUCTION

Wetland soils are hydromorphic, which is characterized by an excess of soil water at least for a short period of time (Ibanga *et al.*, 2005). The soil processes, which operate under such conditions are called gleying and ferrolysis and these are induced by water saturation if organic matter and soil temperature allow microbial activity. These soils have gleying horizons, and pseudogley horizons, where mottles and concentrations of re-oxidized compound occur. These gley or pseudogley horizons are found either near the surface or at depth depending on the fluctuating water table regime. (Ibanga *et al*, 2001). Limestones are sedimentary rocks composed mainly on carbonates, which are always in the form of aragonite, calcite and dolomite, plus small amounts of iron bearing carbonates (Peltijohn, 1975). Consolidated products of calcareous sands, limy mud and crushed shells also constitute limestone. (Anatoles, 1996). Soils derived from limestones are calcimorphic in nature being formed from calcareous parent materials on upland and slope (Bridges, 1970). Limestone deposits in Cross River State are found in Akamkpa, Biase, Odukpani and Yakurr Local Government Areas. These include impure limestone such as Marls found at new Netim and pure one found at Mfamosing. It fringes the sand stones known as “Awi formation” which again fringes the basement complex. They are found concentrated at the Southern part of Cross River State at boundary between the Calabar flank and the Precambrian Oban Massif (Akpan, 1990). These formations represent one of the oldest and major known marine carbonate sequences. They are cenomanian to mid-albian in age (Peter, 1982). Limestones are the cheapest ingredient used for agricultural liming purpose and also wetland soils support any vegetation that tolerates permanent or periodic wetness like rice, banana, Plantain, sugar cane, cocoyam, yam, early maize and vegetables production.

In Nigeria good agricultural lands are being appropriated for urban, infrastructural or industrial uses and degraded crop lands are being abandoned while other lands are being opened up for farming, often at the expense of forests. In yet other cases, marginal lands are subjected to intensive cropping. According to South-center (1997), expansion of the cultivated area should continue to play a significant role in providing increased food supplies; and Cross River State should be a part of this global move. The objectives of this study was to characterized wetland soils developed on lime stones parent material by morphologically, physico-chemically and also, to make recommendations for their better utilization.

Materials and Methods

Cross River State lies between latitudes 4° 27′ and 6° 45′ North and longitudes 7°15 and °28′ East. The climate of Cross River State is equatorial, characterized by a long wet season lasting from March to July with heavy down pours, strong wind storm, violent thunder and lightening; a short dry season known as the “August Break” usually in July or August; a short wet season between September and November to early March and climaxes between December and January during the hamattan (Dry dusty weather). (Afangide *et al.*, 2010).

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There is uniformity of temperature ranges between 21°-32°C (Nwajiuba and Oyeneke, 2010). Rainfall ranges between 1,300-3000mm annually with relative humidity ranging from 75 to 85 percent (Okonkwo and Mbajiorgu, 2010).

The study was carried in the rainy season in 2006. Three (3) limestone areas are selected for the study, viz: Mfamosing, New Netim (Odukpani) and Abini. SThree (3) profile pits with dimension of 2.0 x 1.5 x 1.5 m were sank, each in a soil pedon. The pedons were in Odukpani (DU), Mfamosing (MF), and Abini (AB) all in southern Cross River State. The depths of each soil profile was dictated by the presence of perched water table up to 90 cm. Description and sampling were done according to the (Soil Survey Staff, 2002) guidelines. The free soil survey method of Esu (2010) was used. A total of eight (8) samples were collected from the three pedons. Soil morphological features described were colour, texture, structure, consistence, included materials and horizon boundary. Site environmental features were also recorded at each profile site Fig. 1. Samples were collected from the profile pits using hand trowels and spade employing the bottom-to-top approach. Soil samples collected from the profile pits were air-dried crushed and passed through a 2 mm-sized sieve and stored in polythene bags for the physicochemical analysis. Particle size distributions were determined by the hydrometer method using sodium hexametaphosphate (calgon) as a dispersant (Soil Survey Staff, 2002). Bulk density was determined by collecting undisturbed core samples from each identified horizon using metal cores, these was later oven-dried at 105^{0}C to a constant weight and the bulk density calculated as described by USDA-NRCS (Soil Survey Staff, 2006). Particle density was determined as described using pycnometer by (Bowles, 1992). Total porosity was determined mathematically from the result of bulk and particle density (Agbede, 2009) using this formula.

$$Porosity = 1 - \left(\frac{bulkdensity}{particledensity}\right) x100\%$$

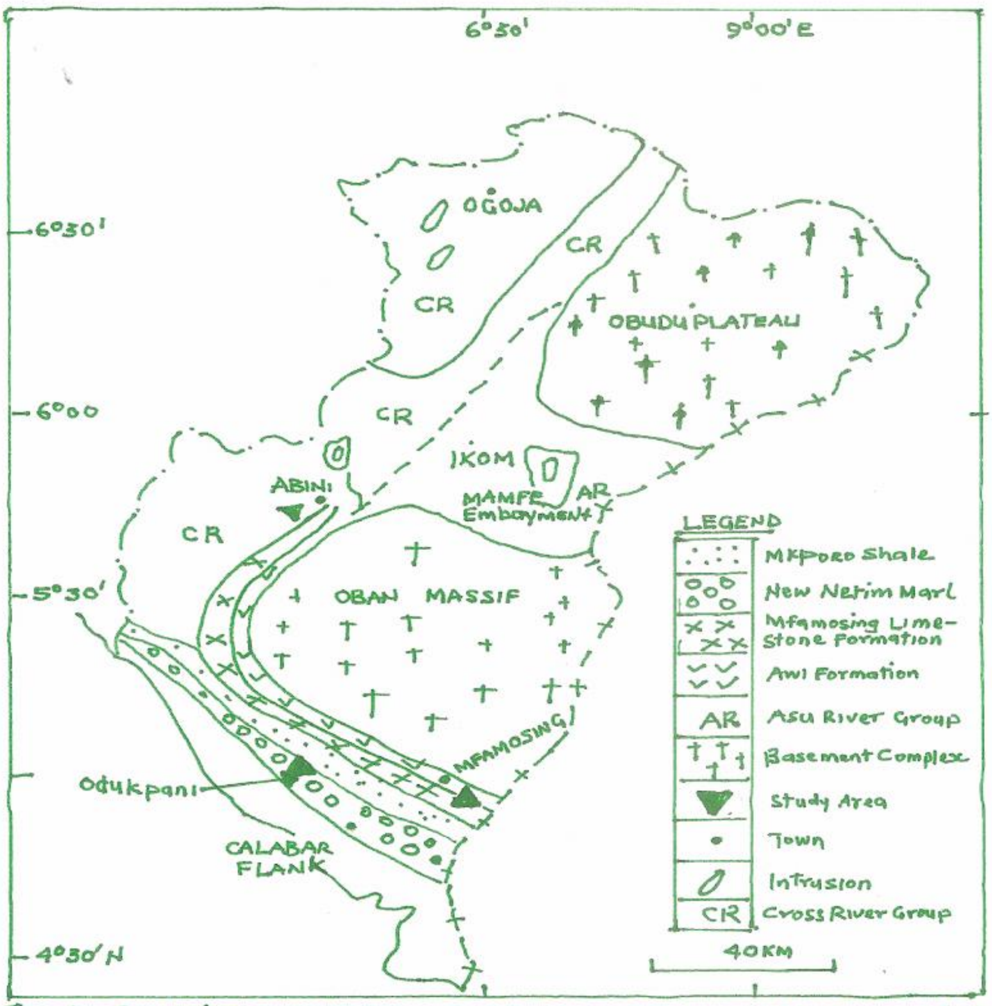

FIG 1: Geological map showing the study areas CROSS RIVER STATE, SOUTHEASTERN NIGERIA.

Soil pH was determined in 1:2 soils: water suspension ratio using a glass electrode pH meter (Thomas, 1996). Organic carbon was determined by wet combustion method of Walkley and Black as outlined by (Agbede, 2009). Organic mater determination was by multiplying the value of organic carbon by a factor of 1.724, a constant used for tropical soils (Agbede, 2009). Total nitrogen was determined on a sample sieved through 0.5mm mesh using the Macro Kjeldahl method (Isirimah *et al.,* 2003). Available phosphorus was extracted by the Bray No. 1 method (Bray and Kurtz, 1945) and P in the soil solution determined calorimetrically by the ascorbic acid method as described by (Agbede, 2009). Exchangeable Acidity: Al^{3+} and H^+ were determined by leaching the soil with 1N KCl solution and the extract titrated with standard NaOH solution (Udo *et al.,* 2009). Exchangeable cations (Ca, Mg, K and Na) were leached from the soil sample using 1N NH4 OAc (pH 7.0) buffer. The Na and K were measured with a flame photometer while the Ca and Mg were determined by EDTA titration as outlined by (Esu, 2010). Effective cation exchange capacity (ECEC) of the sample was determined by summing up the exchangeable cations plus exchangeable acidity. Percentage base saturation was obtained by expressing the sum of exchangeable cations as a percentage of the effective cation exchange capacity (IITA, 2000), using the formula:

$$BS\% = \frac{\sum(Ca+Mg+K+Na)}{ECEC} x100$$

RESULT AND DISCUSSION

Morphological characteristics of the soils were described in description sheets. Soils were deep, shallow and poorly drained with colour range from weak red (2.5YR 4/2), orange (2.5YR 7/6) and light grey (7.5YR 8/2) with grey (10YR 6/1) mottle for soil units DU. Dark reddish brown, (5YR 3/3) and light grey (7.5YR 8/2) for soil unit MF. Yellow (10YR 8/6) and yellowish brown (10Yr 5/8) for soil unit AB. The light grey (10YR 6/1) hydromophic mottles indicates the fluctuating ground water table position during the wet period of the year (Table 1), the soils are sandy loam to loamy sand in texture for surface and subsurface with weak, medium crumb, sub angular blocky structure. Moist and wet consistence was firm to very firm, sticky, very sticky and plastic to very plastic. Many fire and medium roots were observed (Table 1). These properties enhance maximum roots penetration (Esu, 2010). The mechanical analyses results of the soils indicated that they are coarse-texture (Table 2). The textural classes were sandy loam to loamy sand for both surface and subsurface. The coarse nature of these soils could be attributed to the coarse nature of their parent materials (Ibanga *et al.*, 2005) Bulk density values of these soils vary between 1.21 to 1.62 g/cm^3 with a mean of 1.37 g/cm^3 for both surface and subsurface which is ideal for agronomy practice, as it is less than the critical value of 1.45 g/cm^3. This is confirmed by Essoka (2000) who found that states bulk density less than 1.8g/cm^3 will not impede root penetration (Table 2). Particle density of these soils range from 2.42 g/cm^3 to 3.10 g/cm^3 with mean of 2.74 g/cm^3 for surface and subsurface which rated too high and greater than the critical value of 2.60 g/cm^3 for tropical mineral soils (Essoka and Esu, 2001). Total porosity values showed range between 49.80 and 50.00 % and tended to decreased with increase in profile depth (Table 2).

The result of chemical properties in (Table 3) shows pH values of 7.81 to 8.20 with a mean of 7.97 for surface and subsurface soils. This is rated as slightly alkaline to moderately alkaline in reaction (Esu, *et al.*, 2009). The organic matter, total nitrogen, available phosphorus of the soils varied between 2.38-0.83 %, 0.04-0.10 % and 13.00 - 1.08 mg/kg respectively for surface and subsurface soils. The values were rated low to very low for organic mater; very low to low for total nitrogen and medium to low for available phosphorus. Available phosphorous generally increased with depth while N and organic carbon decreased with soil depth. The mean exchangeable Ca, Mg, K, and Na contents for these soils were 7.38, 1.61, 0.66, and 0.11 cmol/kg respectively, and were rated low to moderate apart from Ca as shown in Table 3. However, Ca was high as the soil had limestone basement principally. Also percentage base saturation of 82.38 % was rated as high for these soils.

Soil classification (Table 4) was done using USDA Soils Taxonomy (soils survey staff (2003) and with approximate correlation in FAO (1988) UNESCO soil map of the world legend FAO (1988). The soils of the study areas were mainly Inceptisols and Alfisols while MF and AB met the Inceptisols. All the soils were formed under humid and continually warm environment and have aquic moisture regime for Du and MF, Udic moisture regime for AB.

Table 1: Morphological characteristics of the soils

PEDON	DEPTH CM	MUNSEL COLOUR (MOIST)	TEXTURE	STRUCTURE	CONSISTENCE	ROOTLET	BOUNDARY	INCLUSION
DU	Valley bottom soils, Poorly drained 0-2% slope							
AP	0-13	2.5yr 4/2	Sandy loam	Week, medium, SBK		Many, medium	Clear, weary	
AB	13-40	2.5YR 7/6	Sandy clay loam	Week, medium, SBK	Very firm, slight sticky, slightly plastic	Many, medium	Clear, weary	
Bt	40-60	7.5YR 8/2	Sandy clay loam	SBK	slightly sticky, slightly plastic	Few, fine	Gradual, weary	Few, stone
MF	Valley bottom soils poorly drained 0 - 2% slope							
AP	0-9	2.5YR 4/2	Sandy loam	Week, medium	Firm slightly sticky, slightly plastic	Many, medium	Clear, weary	
AB	9-39	7.5YR 5/6	Sandy clay loam	Moderate, medium, SBK	Firm, very sticky, very plastic	Few, fine	Gradual, weary	
Bt	39-90	10YR 6/8	Clay loam	Moderate, medium, SBK	Firm, very sticky, very plastic		Gradual, weary	Common, coarse iron
AB	Valley bottom soils poorly drained 0 - 2% slope							
AP	0-21	10YR 8/6	Sandy clay	Weak, medium, crumb	Firm, sticky, plastic	Few, medium	Clear, weary	
AB	21-52	10YR 5/8	Clay loam	Moderate, medium, SBK	Firm, sticky, plastic	Few, fire	-	
	*** SBK - Sub Angular Blocky**							

Table 2: Physical characteristic of the soils.

PEDON	Horizon	Depth cm	Bulk density	Particle density	Porosity	Clay	Silt	Sand	texture
			g/cm^3	g/cm^3	%	%	%	%	Sandy loam
DU	AP	0-13	1.21	2.42	50.00	4	28.70	67.30	
	AB	13-40	1.33	2.66	50.00	11	24.70	64.30	Sandy loam
	Bt	40-60	* ND	* ND	* ND	11	25.70	63.30	Sandy loam
	Mean		***1.27***	***2.54***	***50.00***	***8.66***	***26.33***	***64.63***	
MF	AP	0-9	1.33	2.68	50.30	3.00	23.70	73.30	Sandy loam
	AB	9-39	1.45	2.90	50.00	19.00	21.70	59.30	Sandy loam
	Bt	39-90	* ND	* ND	* ND	41.00	13.70	45.30	Clay loam
	Mean		***1.39***	***2.78***	***50.00***	***21.00***	***19.70***	***59.30***	
	AP	0.21	1.33	2.66	50.00	49.80	15.50	38.00	Sandy loam
AB									
	AB	21-52	1.55	3.10	50.00	45.10	14.80	45.80	Sandy loam
	Mean		***1.44***	***2.88***	***50.00***	***47.45***	***19.70***	***41.90***	
	Grand Mean		***1.37***	***2.74***	***50.05***	***22.99***	***21.06***	***57.08***	
	**** ND – Not Determined***								

Table 3: Chemical characteristics of the soils

Pedon	Horizon	Depth (cm)	pH	Org C %	Org M %	TN %	Av P mg/Kg	Ca (cmol/Kg)	Mg	K	Na	EA cmol/kg	CEC cmol/kg	ECEC cmol/kg	BS %
DU	AP	0-13	7.81	1.26	2.17	0.10	8.37	8.00	0.40	0.12	0.08	1.88	8.50	10.48	82.0
	AB	13-40	8.02	0.68	1.17	0.06	4. 38	7.80	0.80	0.11	0.09	2.08	8.80	10.88	81.0
	Bt	40-60	8.04	0.88	1.52	0.01	13.00	7.40	0.40	0.12	0.10	1.04	8.02	9.06	89.0
	Mean		***7.98***	***0.94***	***1.62***	***0.57***	***5.25***	***7.73***	***0.53***	***0.12***	***0.90***	***1.67***	***8.44***	***10.16***	***84.0***
MF	AP	0-9	8.00	0.90	1.55	0.07	2.37	8.40	0.60	0.12	0.09	2.0	9.21	11.21	82.0
	AB	9-39	7.99	0.39	0.67	0.07	2.87	6.60	6.60	0.11	0.08	2.51	7.39	9.95	74.0
	Bt	39-90	7.87	0.28	0.48	0.02	1.25	10.60	0.80	0.11	0.09	2.0	11.6	13.6	85.0
	Mean		***7.95***	***0.53***	***0.90***	***0.53***	***2.16***	***7.80***	***2.67***	***0.11***	***0.80***	***2.17***	***9.36***	***11.55***	***83.3***
AB	AP	0-21	8.06	1.31	2.26	0.08	2.02	5.20	1.50	04.2	0.18	1.92	7.30	9.22	79.0
	AB	21-52	7.99	0.75	1.29	0.08	1.08	5.00	1.80	0.38	0.19	1.08	7.38	8.45	87.0
	Mean		***8.03***	***1.03***	***1.78***	***0.08***	***1.55***	***5.10***	***1.10***	***0.40***	***1.00***	***1.50***	***7.34***	***8.34***	***81.0***
	Grand Mean		**7.97**	**0.81**	**1.39**	**0.06**	**4.42**	**7.38**	**1.61**	**0.66**	**0.11**	**1.81**	**8.53**	**10.36**	**82.38**

Table 4: Soil taxonomic classification

SOIL UNITS	USDA SOIL TAXONOMY	FAO/UNESCO SOIL LEGEND
DU (Odukpani Pedon)	Aeric Endoaqualfs	Eutric Gleysols
MF (Mfamosing Pedon)	Typic Dyustradepts	Plinthic Acrisols
AB (Abini Pedon)	Typic Dyustradepts	Dystric Cambisols

CONCLUSION AND RECOMMENDATIONS

The present study of soils developed from limestone parent material in Cross River State, southeastern Nigeria indicates that their morphological and physico-chemical characteristics strongly reflect the nature of the environment in which the soils are formed. The low to moderate fertility status of the soils are reflective of the parent material and hydromorphic nature of the soils environment, which increases the reactions (alkalinity) of the soils and also inhibit some plant nutrients availability. Due to low fertility status of these soils, farmers should adopt a fertilization programme to improve on the fertility status of the soils for intensive crop production. Crop residues should also be incorporated in to the soils during tillage operation to conserve and improve on the organic matter status of the soils.

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