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CHARACTERISTICS AND CROP PRODUCTION POTENTIALS OF WETLAND SOILS FROM SOUTH EASTERN NIGERIA.

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ABSTRACT

Wetland soils formed in inland depressions and alluvial flood plains in Southeastern Nigeria were studied for their morphological, physical and chemical characteristics in order to determine their potentials for crop production. A total of seven podons were studied. A hue of 10YR was commonly observed and the soils have a low chroma in the matrix. The studied were profiles were mostly fine-textured, having a sandy clay loam of clay topsoil overlying a clay subsoil. Moderately rapid to very rapic values of saturated hydraulic conductivity were obtained in inland depressions and alluvial plains. Average values within the topsoil and subsoil of the inland depressions were 5.32m day; (cv 10%) and 3.99m day $^{-1}$ (cv 9%), respectively. Infiltration rates at 1 minute and 2 hours were moderately slow to very rapid, while cumulative infiltration at 2 hours was high. The average values were 16.0mm (cv = 36%), 2.3mm (cv=38%), and 806mm (cv 38%), for inland depressions and 10.7mm (cv=25%), 5.8mm (cv=38%) and 851mm (cv 29%) for the alluvial plains, respectively.

The soil reaction was strongly to mildly acid (pH = 4.2-6.1) and reflect the generally high amount of Al on the exchange complex. On a landform basis, the general cation distribution was Al>Ca>Mg>K>Na for inland depressions and Ca>Mg>Al>K>Na for alluvial plains. Organic matter and total N were generally low. The soils were however moderate to high in fertility status, and their occurrence in level land units with low erosion hazards make them excellent for rice paddies and wetland/dry land crop rotations for sustainable increases in food crop production in southeastern Nigeria.

Key Words: Wetlands, inland depressions, alluvial plains, characteristics, potentials, crops production.

INTRODUCTION

Arable upland soils in the Southeast as in most other parts of Nigeria are being rapidly degraded by soil erosion with attendant decline in farm productivity. Wetland soils are widespread and constitute a substantial fraction of the land resources of Southeastern Nigeria. The soils occur in lowlands of three landform types, namely, coastal plains, inland depressions, (inland basins and inland valleys), and alluvial plains (river flood plains) with coastal plains being the most extensive (Andriesse, 1986). The underlying geologic materials range from Tertiary to Quaternary (Recent).

The soils hold a great potential for sustainable increases in food production because of their high inherent fertility status, and occurrence in flat or near flat landscapes where soil erosion is not a major constraint to crop production (Guthrie, 1985). Recently, wetland soils have become important for years round cultivation, but they have little been studies and are largely underutilized or unutilized, in contrast to the Asian situation where the soils are intensively used for rice cultivation. To optimize the uses of the soils for food crop production, this paper discusses the fundamental characteristics of selected wetland soils from southeastern Nigeria.

MATERIALS AND METHODS

The study area has a humid tropical climate, with mean annual rainfall ranging from 2000mm to 3000mm. Temperature are uniformly high varying from 26 to 28°C. The climate of the area is marked by an excess of rainfall over evaportranspiration for more than six months of the year, with a reverse situation for about four months of the year (December -- March). Vegetation in the area is tropical rainforest, but much of the climax vegetation has undergone transformation into secondary forests as a result of the traditional slash-and-burn farming system.

FIELD METHOD

Seven representative soil profile pibs located at Mbiabet (1450 ha) and Nkari (2829 ha) (inland depressions) and Ikpa (2700 ha), Nkama (1800 ha) and Use (940 ha) (alluvial plains) area of Akwa Ibom State were dug, described and sampled according to soil taxonomy guidelines (Sol Survey Staff, 1994).

Saturated hydraulic conductivity below the ground-water table was determined with the Houghout anger-hole method as described in Klute (1986). A total of 51 determination were made. Soil infiltrability was determined where the water-table was deep, and close to the soil pits, as described in Klute (1986).

Laboratory method

Soil samples were air-dried and sieved through a 2mm sieve and preserved for the various determinations. Pasticle size analysis was performed according to the Bouyoucos hudrometeer method (Bouyoucos, 1951) and Soil taxonomy (Soil Survey staff, 1974) was used to designate the textural classes. Soil pH was determined in 1:2 soil-water solution. Organic carbon was determined by the wet oxidation methods of Walkley and Black (1934), and total nitrogen by the modified Kjldahl digestion procedure. Available P was extracted by the Bray I method (Bray and Kurtz. 1945). The concentration lof P in the extracts was determined by the blue colorimetric method of Murphy and Riley (1962). Exchangeable cations were extracted with IMNH$_4$OAC (pH 7): Ca and Mg in the extracts were measured by AAS, while Na and K were estimated by flame Photometry. Exchangeable acidity was determined in IMKCI and titrating aliquots with 0.01M NAOH (McLean, 1965). Effective CEC was obtained by summatio of exchangeable basis ad exchangeable acidity (IITA 1979).

RESULTS AND DISCUSSION

Soil Morphology

The pedons were deep without imprenetrable layers, stones or hard concretions. The pedons were all mottled and gleyed (Table 1). A hue of 10YR was commonly observed, a low chrome in the matrix and generally high value mottles. The gleyed or mottled colours or soft reddish concretions (hydromorphic properties) reflect poor drainage or alternating oxidaion/reduction conditions.

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TABLE 1. Morphological and Physical Properties of the Soils

Profile	Depth	Colour (moist					Mechanical Properties		
		Matrix		Mottles		Sand	Silt	Clay	Texture
				Inland Depressions					
MB5	0-12	10YR	3/2	5YR	¾	44.6	14.8	41.2	Sc
	12-42	N	4/0	10YR	3/3	60.0	14.4	25.6	Scl
	42-69	2.5Y	5/1	10YR	6/6	46.0	5.0	49.0	Sc
	69-100	2.5YR	5/1	10YR	4/4	46.0	6.2	47.8	Sc
	100-125	10YR	5/1	7.5YR	6/8	26.0	18.8	55.2	c
				Typic Tropaquents, very poorly drained					
MRF1	0-10	2.5Y	4/2	7.5YR	4/4	61.6	25.7	12.7	cl
	10-50	7.5YR	5/2	10YR	4/1	44.6	23.4	32.6	scl
	50-80	N	6/0	2.5YR	4/6	42.0	21.4	36.6	sl
	80-120	N	6/0	7.5YR	4/4	40.1	19.4	40.5	c
	120-150	N	5/0	5YR	5/8	32.0	21.4	46.6	c
				Aeric Tropaquents, poorly drained					
NK8	0-19	10YR	4/2	7.5YR	4/4	32.6	32.0	35.4	cl
	19-39	2.5YR	5/2	7.5YR	5/6	21.6	22.0	56.4	c
	39-67	2.5YR	6/1	7.5YR	5/8	24.6	22.0	53.4	c
	67-160	2.5YR	5/1	5YR	4/6	35.0	35.0	29.2	c
				Aeric Vertic Tropofluents, poorly drained					
NAIA	0-11	10-YR	4/2			5.00		336.4	Scl
	11-32	10YR	5/2	7.5YR	5/6	23.3	53.93	70.8	C
	32-79	10YR	5/2	7.5YR	5/6	17.6	8.0	74.4	C
	79-108	10YR	4/8	2.5YR	4/8	23.8	8.0	68.2	C
	108-158	10YR	7/2	2.5YR	4/8	23.4	20.0	56.6	C
				Aeric Vertic Tropofluvent, poorly drained					
NAIIA	0-15	5YR	2/2	2.5YR	2/4	46.4	19.4	34.2	Scl
	15-27	5YR	6/2	5YR	6/8	36.4	23.4	40.2	cl
	27-57	7.5YR	6/2	7.5YR	6/8	12.2	23.0	64.8	C
	57-89	7.5YR	7/2	5YR	6/8	16.2	23.0	60.8	C
	89-115	5YR	7/2			9.8	21.4	68.8	C
				Vertic Tropofluvents, poorly drained					
US7A	0-18	10YR	4/1	5YR	4/6	42.2	18.0	39.8	Cl
	18-42	10YR	5/1	5YR	4/8	8.0	14.0	78.0	C
	42-80	2.5Y	5/1	2.5YR	4/6	6.0	12.4	81.7	C
	80-120	5YR	5/1	7.5YR	5/6	8.1	12.2	79.7	C
	120-150	5YR	4/8	2.5YR	48	4.0	6.0	90.0	C

Texture: s = sand; si = silt, c= clay; sl =sandy loam; c = sandy clay; scl = sandy clay loam; cl = clay loam; sic = silty clay; sill = silty clay loam.

The soils were generally fine-textured, having a sandy clay loam or clay topsoil overlying a clay subsoil, and were derived from shales and collvium/alluvium quarternary (recent geological) parent materials. Pedons in Mbiabet, Nkari (inland depressions) and Nkana and Use (alluvial plains) exhibit a strong structure- forming disposition. They become sticky and plastic during the wet season and moderately hard and cracked, and may be difficult to work during the dry season, and therefore excellent rice soils byt may pose sevee constraints (wetness and poor seedbed) to the cultivation of upland crops. Pedons in Ikpa swamps (alluvial plains) are slightly sticky and slightly plastic with high organic matter content, and are perennially wet.

Saturated hydraulic conductivity (Ks) varied widely among the soils, especially in the 40cm soil depth (Fig. 1) Ks values ranged from 4.20 to 11.82m day^{-1} with an average of 7.19m day^{-1} (cv = 12%) in the top 40cm, and 0.91 to 5.44m day^{-1} averaging 3.50m day^{-1} (cv = 9%) in the subsoil. On a landform basis, inland depressional areas have lower average Ks values (5.42m day^{-1}, cv = 10%) in the topsoil and less variable with depth (3.99m day^{-1}, cv = 13% respectively) (Fig.2). However, the landforms were almost similar in subsoil. The observed Ks values were higher than expected from soil texture consideration. Overall rates were moderate to very rapid, and were attributed to a higher percentage volume of interaggregate or structural pores mainly, which remain open when wet and provided macro-contruits for water movement. Profile drainage may therefore be unimpeded, so that the poor drainage condition of the soils especially during the wet season, may be due largely to ponding from overland flows, seasonally or perennially high groundwater table and excessive inundation from the Cross River and its main tributary, the Enyong Greek systems. The drainage requirement of the wetland soils is consequently high.

Measure infiltration rate 1 minute and 2 hours and cumulative infiltration at 2 hours were generally higher than expected from these soil textures (Table 2). There were large variations within each landform as within the soil units. Infiltration rates at 1 minute and 2 hours, and cumulative infiltration at 2 hours average 16.0mm (cv=36%). 2.3mm (cv = 35%), and 806mm (cv=43%) respectively, in inland depressions. The corresponding values in alluvial plains are 10.7mm (cv=25%), 5.8mm (cv=38%), and 851mm (cv=29%), respectively. These values were moderately slow to rapid. Factors which influence intake rates include soil aggregation, natural channels or macropores, and antecedent soil moisture content. Natural continuous channels appeared to be the dominant factor in these soils. Conservation tillage involving minimum tillage with mulch may therefore be needed in these soils to reduce losses or irrigation water to deep percolation.

Table 2: Infiltration Rates and Cumulative Infiltration of the Soils

Location	Infiltration Rate Mm min − 1 at 1 min	2h	Cumulative Infiltration at 2h (mm)
Inland Depression			
Nkari (5)			
Min	4.0	1.3	256
Max	40.0	6.5	2411
X	19.0	2.6	949
CV%	70	87	92
Mbiabat (1)	1.0	0.8	92
Alluvial Plains			
Nkara (2)			
Min	15.0	2.5	870
Max	23.0	12.0	1784
X	19.0	7.3	1327
CV%	30	93	49
Use (6)			
Min	4.0	1.5	277
Max	15.0	7.5	1181
X	9.0	4.0	638
CV%	44	55	53
Ikpa (3)			
Min	0.1	0.1	9
Max	28.0	25.0	1817
X	9.0	8.0	959
CV%	169	169	168

Number in parentheses represent sample sizes.

Chemical Properties

Table 3 shows that the reaction of the soils is strongly to mildly acid (pH_{H2O}=4.2-6.1) and reflect the amount of exchangeable Al on the absorption complex. Soil acidity was however uniform among the pedons irrespective of landform types. The exchangeable cations were predominantly Ca, Al, and Mg, and the dominant cation sequence was Al>Ca>Mg>K>Na. On a landform basis, pedons formed in inland depressions except pedon MB5, have a sequence of Al>Ca>Mg>K>Na, whereas those formed in alluvial plains have variable sequences. On the average, the sequence is Ca>Mg>Al>K>Na.

The ECEC for all soils varies from about 4.74 to 46.04 $Cmolkg^{-1}$ soilo. Soils formed in alluvial sediments have the highest values (Table 3). The soils are moderately high in base status and similar in distribution to ECEC. Exchangeable Al, except for pedon MB5 was generally high and reflects the high acidity of the soils. High exchangeable Al is usually associated with actively weathering profiles. However, these high vales of exchangeable Al (soil acidity) were associated with the quaternary shales and sandstones and the derived coluvium and alluvium parent materials. This appears supported by the equally high organic matter content in the profile; organic matter form very strong complexes with Al and deceases its activity in the soil. Organic carbon is generally low and decreases with depth. The distribution of total nitrogen was similar to organic carbon. The C/N ration was below 10 in pedon US7A, and above 18 in pedons NK8, NAIA and NAIIB. It range of well decomposed, and completely incorporated organic matter, occur throughout the profile. Values above 18 indicate partial organic matter incorporation, which may be associated with the soil's hdromorphism that inhibits organic matter decomposition and mineralization. Available phosphorus levels were very low and are attributed to the low absolute values on the soils. The nutrient status indicates that responses to nitrogen, phosphorus and potassium containing fertilizers are likely.

CONCLUSION

This paper discusses the characteristics of selected wetland soils from Southeastern Nigeria. The soils are moderate to high in inherent fertility status and suitable for the expansion of crop production systems on intensive and sustainable basis. The soils are excellent for rice paddies as well as the cultivation of arable upland crops with the possibility of increased crop yield per unit area to feed the growing population.

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TABLE 3: CHEMICAL PROPERTIES OF THE SOILS

Profile NO.	Depth (Cm)	$P^H H_20$	Ca	Mg	K	Na	Al^{3+}	H^+	ECEC	Base Satn	Org. C %	Total %	Bray P-I Ugg^{-1}
			Exch Bases (Cmolkg^{-1})				Exch acidity						
Inland Depressions													
Typic Vertic Tropaguents very poory drained													
MB5	0-12	5.9	2.00	1.60	0.89	0.18	0.96	0.60	6.23	75.0	2.38	0.20	4.9
	12-42	4.8	7.00	1.00	0.67	0.17	0.60	1.32	10.76	82.2	2.70	0.22	2.3
	42-69	4.6	4.00	1.00	0.26	0.16	0.48	1.08	6.98	77.7	1.87	0.16	4.3
	69-100	4.5	2.00	0.60	0.27	0.19	0.84	0.84	4.74	64.6	1.40	0.12	2.7
	100-125	4.5	3.00	0.60	0.73	0.18	0.72	0.96	6.15	72.7	1.27	0.19	2.7
Typic Propaquents, very poorly drained													
MRFI	0-10	4.8	2.60	2.00	0.12	0.10	5.28	4.08	14.18	34.0	2.63	0.21	2.3
	10-50	4.5	3.60	0.40	0.11	0.25	6.36	5.16	15.88	27.0	1.62	0.13	2.0
	42-69	4.4	5.60	4.30	0.11	0.10	6.24	6.72	23.07	43.8	1.58	0.13	24.3
	80-120	4.5	2.60	1.60	0.10	0.18	4.44	5.25	14.17	31.6	1.42	0.13	8.3
	120-150	4.6	1.60	1.60	0.42	0.49	6.84	6.72	17.67	23.3	1.39	0.12	6.7
Aeric Tropaquents, poorly drained													
HK 8	01-9	4.8	4.80	2.80	0.56	0.16	99	3.15	16.46	50.5	1.66	0.08	9.3
	19-39	4.7	6.40	2.40	0.53	0.14	5.04	3.12	17.63	53.7	0.59	0.03	4.3
	39-67	4.77	8.00	4.40	0.45	0.27	11.76	7.44	32.32	40.6	0.84	0.04	4.3
	67-87	4.7	6.40	2.40	0.08	0.38	17.40	15.96	42.62	21.7	0.84	0.04	4.4
Alluvial Plains													
Aeric Tropofluvents very poorly drained													
IEIO	0-19	4.4	3.20	0.20	0.19	0.11	2.76	2.64	9.10	40.7	0.40	0.03	4.4
	19-37	4.2	280	0.40	0.20	0.17	4.44	2.88	10.89	38.8	0.43	0.04	4.9
	37-70	5.5	3.60	0.80	0.19	0.12	5.28	4.08	14.07	33.5	0.11	0.02	2.7
	70-100	5.8	3.00	1.00	0.23	0.16	7.56	7.20	19.15	22.9	0.14	0.02	2.7
	100-130	5.9	2.00	0.06	0.53	0.16	6.24	8.52	18.05	18.2	1.80	0.05	3.3
Aeric Vertuc Tropofluvents, poorly drained													
NAIA	0-11	4.8	2.40	14.40	0.16	0.08	1.60	0.40	19.04	89.5	4.00	0.20	43.0
	11-32	5.0	6.40	13.60	0.15	0.08	3.60	1.20	25.03	80.8	0.70	0.04	47.0
	32-79	4.6	6.20	15.60	0.15	0.08	4.00	6.00	32.03	68.8	0.51	0.03	10.0
	79-108	4.5	6.00	17.80	0.16	0.09	5.60	4.4	33.65	71.5	0.35	0.02	5.0
	108-150	4.3	8.40	3.00	0.16	0.09	5.60	1.20	18.45	63.1	0.35	0.02	70
Aeric Vertic Tropofluvents, poorly drained													
NAHB	0-15	4.3	4.00	5.60	0.18	0.10	6.40	3.60	19.88	49.1	2.09	0.10	3.0
	15-27	4.5	4.20	9.80	0.18	0.12	5.60	0.80	20.70	69.1	1:3	0.07	4.0
	27-57	4.7	5.60	4.60	0.16	0.12	4.00	0.80	15.28	68.6	0.97	0.05	14.0
	57-89	4.7	6.20	4.80	0.20	0.12	4.40	2.00	17.72	63.9	0.62	0.03	6.0
	89-115	4.6	6.60	17.20	0.18	0.29	7.20	2.00	33.47	72.5	0.44	0.02	11.0
Vertic Tropofluvents, poorly drained													
US7A	0-18	5.1	18.00	15.60	0.14	0.09	2.40	2.28	38.51	87.8	4.79	1.43	33.0
	18-42	4.8	15.60	12.32	0.12	0.12	6.72	4.08	38.96	72.3	0.60	1.73	6.0
	42-80	4.8	6.40	3.62	0.10	0.04	9.60	5.76	24.52	37.4	0.15	0.43	3.0
	80-120	4.8	22.80	5.40	0.20	0.24	9.36	8.04	46.04	62.2	0.36	1.07	4.0
	120-150	4.8	16.00	6.54	0.20	0.4	6.60	3.96	37.74	80.6	0.20	0.52	3.0