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Selected Properties of Two Soil Groups in Rivers State Nigeria

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Abstract:*Some physical and chemical properties of some upland and wetland soils of Rivers State Nigera were investigated to ascertain the effect of these soil forms on soil properties. 6 profile pits were sunk in Ogba/Egbema, Port Harcourt and Etche Local Government Areas of the State; each representing either an upland or a wetland soil. Samples collected from the various horizons were analyzed for selected soil properties. Results showed that the wetland soils had shallow water tables ranging from 46 to 60cm depth. The percentage of sand, organic matter, available P, total nitrogen, iron content and cation exchange capacity were higher in most locations and horizons than the at the upland soils. pH was generally acid across all locations. The mean values at the Ap horizons ranged between 5.06 to 5.87. Iron content for wetland soils, at the Ap horizon ranged between 333 to 2000mg/kg with the highest for Port Harcourt and the least for Etche.*

Keywords: *Upland soil, Wetland soil, physical and chemical properties*

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I. Introduction

Upland is generally considered to be land that is at a higher elevation than the alluvial plain or stream terrace, which are considered to be ‘’ lowland”. Wetlands can be broadly defined as marshes, swamps, bogs, and similar areas. These areas are poorly drained and retain water during rainy periods (Schlesinger and Bernhardt, 2013). They are widely distributed throughout the world and can be found in all climates. National Research Council (1995) refers to the term ‘wetland” as ecosystems that are characterized by hydric soils and plant and animal species adapted or partially adapted to life in saturated conditions. However, there are often multiple names for specific wetland types, reflecting the diversity of approaches that have been taken to wetland evaluation and classification through decades and centuries.

In Nigerian wetlands, either throughout or for most part of the year contain moisture at levels far in excess of that tolerated by most plants include among others: The mangrove swamps, the Lake Chad basin, the Kainji Lake zone, the groundwater of upland savanna sites, the interdune depressions, the valley bottoms of rivers, the floodplains andthe heavily wet areas of some of our rain forest (Onofeghara, 1990). Moses (1985) divided Nigerian wetlands into two brood categories, viz, freshwater floodplains and coastal saline swamps. A floodplain contains swamps marshes, ponds, shallow lakes and other water-logged areas of land.

The higher amounts of phosphorus obtained in the surface soils are either due to the higher organic matter or the application of phosphate fertilizers, which are sometimes in use in the areas. Although phosphorus availability increases under waterlogged condition in Africa with low level of water control, soil erosion is the only important loss mechanism beside crop uptake.Willet (1986, 1989), pointed out that the causes of increased P availability during flooding were the reducible dissolution of ferric oxides and the liberation of absorbed and occluded P.Changes on soil pH that increases the solubility of Fe, Al, and Ca phosphate and the desorption of surface P

In upland soils in tropical regions soil acidity is a major problem which can have pedogenetic (parent material, age) or anthropogenic causes (ammonia-N fertilizers). The upland soils are nevertheless considered the largest remaining potential for future agricultural development (Theng, 1991; Von Uexküll and Mutert, 1995).

Wetland soils differ from upland soils in that they are anaerobic. The absence of oxygen produces characteristics, especially differences in soil color and texture that are uniquely different from aerobic, upland soils.

Thus, the physical, chemical, and biological characteristics of anaerobic soils are important in determining the properties and functioning of wetlands.The objective of this study is to investigation and document the properties of the upland and wetland soils within the same terrain in a typical tropical environment; a case study of Rivers State Nigeria.

II. Materials and Methods

The study sites for this research were six (6) in three (3) locations, namely Ogba/Egema/Ndoni, Etche and Port Harcourt Municipal; all in Rivers State of Nigeria. The climate of Rivers State is the humid tropical type, characterized by the effect of the humid Marine Tropical (MT) air mass and dry Continental (CT) air mass with their associated South-westerly winds. The wet or rainy season usually begins about mid-March and ends mid-November with a little dry spell usually referred to as "August Break" occurring in the month of August. The dry season extend from November ending, through December to March. The distribution of the mean annual rainfall in the state is from about 2000 mm inland to over 3000 mm along the coast. The wettest months are June, July and September. January, February and March are usually the hottest months while July and September normally record the lowest temperatures. The relative humidity in the area is high, ranging from 75-95% decreasing from the coast towards inland. The entire Rivers State is in the tropical rainforest belt of Nigeria. However, the dominant vegetation is secondary which has almost entirely taken over the primary forest due to farming activities. Smallholder agriculture is a major socioeconomic activity in the area in addition to soil exploration and exploitation.For each of the Local Government Area(LGA) two sites representing upland and wetland soils were chosen as indicated in Table 1.

Etche and Port Harcourt represent soils of Coastal Plain Sands which have dark to brown soil colour. The texture of the soil is predominantly coarse sand with clay content sometimes as much as 35%. The soil has been found to range from sand to sandy loam in the surface soil horizon with pH values of between 4.0 and 5.8 in water (Ayolagha and Onuegbu 2002). Ndoni represent soils of Sombreiro Warri Deltaic plain with texture ranging from coarse sandy loams through fine and silt loams to varying mixtures of clay. Thus, they have low permeability and have pH of between 4.4 and 5.0 (Ayolagha and Onuegbu 2002).

Soil Sample Collection

Soil samples were collected fromsix pedons sunk; two each at the three locations, the three (3) pedons at each location represent the wetlands while the other three represent the upland soils. The profiles measured (2m) long, (1m) wide and (2m) deep except where shallow water table is struck. The morphological characteristics of each pedon were described according to procedure outlined in Soil Survey Manual (Soil Survey Staff, 2010).

Table 1:Selected Study Sites

L G A	Location/ Geographic Coordinate of thePedons				
	Upland		Wetland		Parent Material
Ogba Egema	Obor 1	06°.69' 98″ E 05° 38'39″ N	Obor 2	06°.69′ 85″ E 05°.39′ 89″ N	Sombreiro Warri Deltaic plain
Port Harcourt	RSU	06°.98′46″ E 04°.80′ 96″ N	Eagle-Island	06°.98′ 74″ E 04°.79′ 17″ N	Coastal plain sands
Etche	Ozuzu	06°.99′ 81″ E 05°.14′ 92″N	Isu	06°.02′ 07″ E 05°.15′ 58″ N	Coastal plain sands

(Ayolagha and Onuegbu, 2002).

Soil Analysis

Particle size distribution was determined by hydrometer method (Bouycous,1951) as modified by Udo *et al*. (2009), Exchangeable cations (Ca, Mg, K, N) were determined by Ammonium acetate extraction procedure (Udo *et al*., 2009). Exchangeable potassium (K) and Sodium (Na) by flame photometer while Exchangeable Calcium (Ca) and Magnesium were determined by EDTA (Ethylenediaminetetracetic acid) titration. Exchangeable acidity was measured in 1 N KCl (Udo *et al*., 2009). Organic carbon was determined by the wet oxidation method (Walkley and Black, 1934) as modified by Udo et al, 2009). Total Nitrogen was determined by the Kjeldahl digestion method (Bremner and Mulvaney, 1982) as adapted by Udo *et al*.(2009), Available phosphorus was determined by the method of Bray and Kurtz (1945) as modified by Udo *et al*. (2009).

III. Results and Discussion

Results showed that, given the high-water table of the wetland soils, the sunk profile could not get to 200m depth when compared to the upland soils in the same location (Table 1). The height of the water table of the wetland soils varied with location and was in the order 46m > 60m > 63m for Etche, Ogba/Egbema and Port Harcourt respectively (Fig.2). The Ap horizon for the upland and wetland soils was 0-11cm and 0-10cm for Ogba/Egbema, 0-15cm and 0-5cm for Port Harcourt and 0-11 and 0-8cm for Etche.

The results of the particle size distribution of the upland and wetland soils of the three locations, is as shown on Table 2. The soil textures were generally loamy sand to sandy loam across the horizons in the profile. Sand content had a range of 66 -88% with a mean of 78%, 82.5%, 73.5%, 80.8%, 83.6% and 88% for Obor1, Obor 2, Port Harcourt, Eagle-Island, Ozuzu and Isu respectively. Clay content varied from 8.6 -22.6% with a very gradual increase with depth in few pedons. The highest clay content was observed in the Eagle-Island profile where clay had a range of 12 -22.6% followed by Port Harcourt upland (RSU) with a range of 8 – 22.6% and a mean of 14.1%.

For all locations, the sand contents were higher at the wetland soils than for the upland soils. Sand contents for the weland soils was in the order 88% > 82.5% > 80.8% for the Etche, Ogba/Egbema and Port Harcourt soils respectively. Silt and clay contents were in the reverse order.

Table 2. Particle Size Distribution of Wetland and Upland Soils in the three locations

LOCATION	PEDONS	HORIZON	DEPTH(cm)	%Clay	%Silt	%Sand	Textural class
OEN(UL)	OBOR1	Ap	0-11	12.6	3.4	84	LS
		Hp	11_20	10.6	7.4	82	S L
		Bt_1	20-42	10.6	13.4	76	SL
		Bt_2	42-72	10.6	13.4	76	SL
		C	72-200	12.6	15.4	72	SL
	MEAN			11.4	10.6	78	
OEN(WL)	OBOR2	Ap	0-10	8.6	7.4	84	LS
		Bh	10_23	8.6	7.4	84	LS
		Bw_1	23-49	10.6	9.4	80	SL
		BW_2	49-60	12.6	5.4	82	SL
	MEAN			10.1	7.4	82.5	
PH(UL)	RSU	Ap	0-15	8.6	7.4	84	LS
		Bt_1	15-45	22.6	5.4	72	SL
		Bt_2	45-75	12.6	15.4	72	SL
		C	75-200	12.6	21.4	66	SL
	MEAN			14.1	12.4	73.5	
PH(WL)	E/ISLAND	Ap	0-5	14.6	3.4	82	SL
		Bt_1	5_16	22.6	3.4	74	SL
		Bt_2	16-21	14.6	3.4	82	SL
		Bh	21-30	12.6	3.4	84	LS
		Bw	30-63	12.6	5.4	82	SL
	MEAN			15.4	3.8	80.8	
ETCHE(UL)	OZUZU	Ap	0-11	10.6	3.4	86	LS
		Bt_1	11_25	10.6	3.4	86	LS
		Bt_2	25-43	10.6	3.4	86	LS
		Bt_3	43-60	14.6	5.4	80	SL
		C	60-200	14.6	5.4	80	SL
	MEAN			12.2	4.2	83.6	
ETCHE(WL)	ISU	Ap	0-8	8.6	3.4	88	LS
		Bh	8_17	8.6	3.4	88	LS
		Bw	17-46	8.6	3.4	88	LS
	MEAN			8.6	3.4	88	

KEY: UL= Upland, WL=wetland, t= Clay accumulation, p= ploughed layer, h=Illuvial humus, %= percentage, OEN= Ogba/Egbema/Ndoni, PH= Port Harcourt.

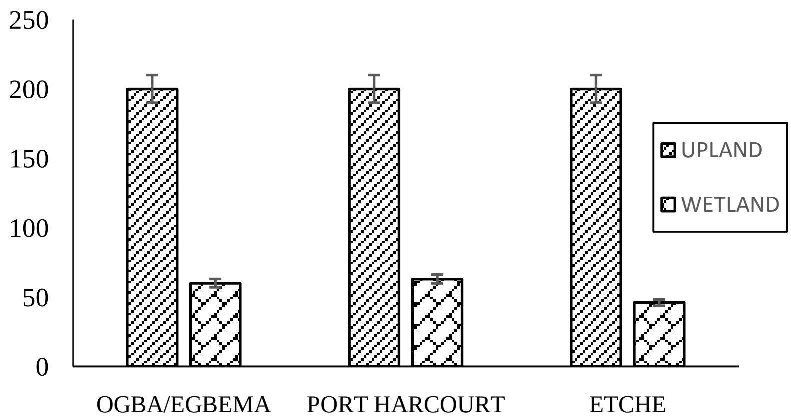

Fig. 1: Maximum depth (m) of profile sunk as affected by visible water water table at various location

Table 3: Chemical Properties for Upland and Wetland Soils

Horizon	Depth (cm)	pH	Aval. P	% O.M	% O.C	% TN	Exchangeable Bases (cmol/kg)				Al^{3+}	H^+	Fe (mg/kg)	CEC (cmol/kg)	TEA
							Ca^{2+}	Mg^{2+}	Na^+	K^+					
OBOR 1															
Ap	0-11	5.80	11.40	2.29	1.33	0.07	0.75	0.95	0.32	0.21	1.00	0.20	166.67	2.23	1.20
Hp	11-20	5.75	2.81	1.31	0.76	0.02	0.65	0.75	0.34	0.27	2.10	0.20	66.67	2.01	2.30
Bt1	20-42	5.70	0.35	1.28	0.74	0.03	0.30	0.20	0.25	0.18	2.30	0.40	33.33	0.93	2.70
Bt2	42-72	5.85	1.05	0.92	0.53	0.03	0.05	0.30	0.24	0.13	2.50	0.14	33.33	0.72	2.64
C	72-200	5.50	0.70	0.55	0.32	0.00	0.10	0.10	0.33	0.18	2.00	0.44	33.33	0.71	2.44
	Mean	5.72	3.26	1.27	0.74	0.03	0.37	0.46	0.30	0.19	1.98	0.28	66.67	1.32	2.26
OBOR 2															
Ap	0-10	6.10	35.09	4.61	2.68	0.13	0.45	0.30	0.33	0.24	1.20	1.18	1266.67	1.32	2.38
Bh	10-23	5.60	14.04	0.89	0.52	0.06	0.30	0.05	0.35	0.22	2.10	0.68	66.67	0.92	2.78
Bw1	23-49	5.75	11.40	1.48	0.86	0.01	0.13	0.17	0.27	0.16	1.40	0.58	66.67	0.73	1.98
BW2	49-60	5.80	19.30	2.71	1.58	0.01	0.80	0.07	0.29	0.16	0.80	0.46	66.67	1.32	1.26
	Mean	5.81	19.96	2.42	1.41	0.05	0.42	0.15	0.31	0.20	1.38	0.73	366.67	1.07	2.10
RSU Ap	0-15	5.80	35.96	2.39	1.39	0.02	0.90	0.55	0.32	0.22	0.60	0.90	166.67	1.99	1.50
Bt1	15-45	5.75	16.67	2.10	1.22	0.01	0.25	0.30	0.27	0.19	1.80	0.64	33.33	1.01	2.44
Bt2	45-75	5.55	7.02	1.23	0.72	0.02	0.65	0.30	0.30	0.16	1.90	0.54	33.33	1.41	2.44
C	75-200	5.20	0.70	0.61	0.35	0.00	0.80	0.10	0.28	0.15	1.70	0.72	33.33	1.33	2.42
	Mean	5.58	15.09	1.58	0.92	0.01	0.65	0.31	0.29	0.18	1.50	0.70	66.67	1.44	2.20
EAGLE-SLAND															
Ap	0-5	5.35	14.39	4.05	2.35	0.08	2.05	3.25	7.17	2.31	0.70	0.34	2000.00	14.78	1.04
Bt1	5_16	5.15	14.74	1.60	0.93	0.02	0.95	2.70	3.70	1.79	0.40	0.82	2000.00	9.14	1.22
Bt2	16-21	4.45	85.96	3.29	1.91	0.04	1.60	3.20	3.48	1.54	1.20	0.80	1266.67	9.82	2.00
Bh	21-30	5.70	84.21	0.91	0.53	0.00	0.45	1.30	0.87	0.40	0.00	0.52	333.33	3.02	0.52
Bw	30-63	4.65	78.95	17.18	9.99	0.08	7.15	11.90	8.70	2.18	5.10	5.72	3600.00	29.93	10.82
	Mean	5.06	55.65	5.41	3.14	0.04	2.44	4.47	4.78	1.64	1.48	1.64	1840.00	13.34	3.12
OZUZU Ap	0-11	5.70	19.30	2.05	1.19	0.02	2.10	3.70	0.25	0.16	0.30	0.10	166.67	6.21	0.40
Bt1	11_25	6.15	12.28	0.57	0.33	0.01	0.50	4.40	0.23	0.16	0.40	0.10	333.33	5.29	0.50
Bt2	25-43	5.95	20.18	0.44	0.26	0.00	1.30	0.05	0.26	0.15	0.30	0.20	333.33	1.76	0.50
Bt3	43-60	5.80	54.39	0.54	0.31	0.00	1.15	1.20	0.24	0.11	0.60	0.20	333.33	2.70	0.80
C	60-200	5.75	43.86	0.30	0.17	0.00	0.90	0.65	0.23	0.11	0.40	0.26	333.33	1.89	0.66
	Mean	5.87	30.00	0.78	0.45	0.01	1.19	2.00	0.24	0.14	0.40	0.17	300.00	3.57	0.57
ISU Ap	0-8	5.70	14.04	4.37	2.54	0.01	0.75	0.00	0.26	0.18	1.50	0.42	333.33	1.19	1.92
Bh	8_17	5.80	17.54	3.80	2.21	0.01	0.30	0.05	0.25	0.12	2.00	0.00	333.33	0.72	2.00
Bw	17-46	5.75	8.77	3.14	1.83	0.08	0.05	0.05	0.19	0.10	1.80	0.18	333.33	0.39	1.98
	Mean	5.75	13.45	3.77	2.19	0.03	0.37	0.03	0.23	0.13	1.77	0.20	333.33	0.77	1.97

The organic matter content of the upland soils could be as a result of continuous cropping in the area. The annual slash and burn system of farming which generally practiced in the area further discourages the build-up of organic matter status. These activities result in low organic matter and reduce chemical soil quality and low agricultural yield in soil of area (Assefa, 1978, Yihenew, 2002).Generally, organic matter content decreased with increasing depth in most pedons. This could be due to the vegetation attributes of the study area.

The Total Nitrogen content were generally low, across all location and horizon (Table 3). Landon's (1991) rating of nitrogen content is as follows: > 1% as very high, 0.5 – 1% high, 0.2 – 0.5% medium, 0.1-0.2% low and < 0.1% as very low nitrogen status. However, the wetland soils had higher values than the upland soils. The Nitrogen content is lower in continuously intensively cultivated and highly weathered soils of the humid and sub-humid tropics due to leaching. The higher organic matter level as reflected in (Table 3), the higher the soil nitrogen, this might be attributed to the positive relationship between organic matter and nitrogen in soils. Similar organic matter and total nitrogen relationship have been reported for other soils of the Niger delta by Isirimah (1986).

The available phosphorus at the Ap horizon was higher at the wetland soil of the Ogba/Egbema soil (35.09 mg/kg) than at the upland soil(11.4mg/kg). The trend was, however, different for the Port Harcourt and Etche soils (table 3). The critical level of available P (by Bray 1) was 20mg/kg.

The iron contents were significantly larger in the wetland soils at the Ap horizon than in the upland soils all the other horizons down the profile. Willet (1986, 1989), pointed out that the causes of increased phosphorus availability during flooding were the reducible dissolution of ferric oxides and the liberation of absorbed and occluded phosphorus.

The cation exchange capacities (CEC) for surface soils of the upland and wetland areas were generally low; Obor1 (2.23 cmol/kg), RSU (1.99 cmol/kg), Ozuzu (6.21 cmol/kg) and Obor2 (1.32 cmol/kg) and Isu (1.19 cmol/kg) respectively. The highest CEC value was obtained in Port Harcourt wet land soil (Eagle Island) with a significantly different mean of 13.34 cmol/kg when compared to all the other soils. The considerable higher clay content in the soils of Eagle Island may have contributed to its relatively higher CEC in the soils. The total exchangeable acidity had a reverse trend with the CEC.

IV. Conclusion

The results of the physical and chemical properties analyzed in this study, collaborates the fact that anaerobic conditions in wetland soils makes them differ in characteristics from those of upland soils. These findings, therefore, will inform decisions on management of these soils.

Wetland soils differ from upland soils in that they are anaerobic. The absence of oxygen produces characteristics, especially differences in soil color and texture that are uniquely different from aerobic, upland soils

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