Infiltration Characteristics and Soil Physico-Chemical Properties of Wetlands in Akwa Ibom State, Southeastern Nigeria

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Abstract

The study was conducted to evaluate some soil physico-chemical and infiltration characteristics in moderately sloping low lands, flat floodplains and undulating river terraces (wetlands) in Akwa Ibom State, Southeastern Nigeria. Average values of the infiltration parameters were generally low (except sorptivity), and were higher in the flat floodplains, followed by the river terraces and sloping lowlands. Also, the parameters varied widely both within and across the physiographic units and indicated that the soils have large water storage depth.

Introduction

Inland swamps occupy a sizeable proportion of Akwa Ibom State and other parts of southeastern Nigeria. They are flooded to depths of 0.5 to 3 m during the rainy season. In the dry season, the ground water table recedes to great depths below the surface, enhanced by evaporativity or drainage flux into the atmosphere and decreasing soil water availability for crop production. The soils are however relatively more fertile than the adjacent uplands (Hekstra and Andriesse 1983), but are generally under-utilized and little known. The need to optimize the uses of the soils for increases in food production necessitated the evaluation of their physico-chemical properties and infiltration characteristics. This study therefore evaluated some physico-chemical and infiltration characteristics of wetland soils in Akwa Ibom State, Nigeria.

Materials and Methods

The study was conducted in the wetlands occurring in the basins of the Enyong Creek in the north, and Ikpa River in the north-eastern area, between longitudes 7° 31 and 7° 56 E, and latitudes 5° 03 and 5° 27 N of Akwa Ibom State, Southeastern Nigeria. The estimated areas of the swamps is 7100 ha in the north (comprising Itu and Igwu Rivers and Enyong Creek) and about 2700 ha in the northeast (Ikpa River).

The area of study is characterized by mainly three physiographic units, namely, the undulating river terraces, flat floodplains and gently to moderately sloping lowlands of the Enyong Creek and Ikpa River basins, both of which are tributaries of the Cross River. The soils are derived from Quaternary Shale-rich and Sandstone parent materials. Soils of the river terraces are dominated by poorly to very poorly drained, sandy clay loam or silty clay loam topsoil over clayey sub-soils. They are poorly to imperfectly drained clays underlain by sandy clays at depth in the flat floodplains. Soils of the sloping lowlands are dominated by imperfectly to well drained sandy clay loam over sandy clays or clays. Some properties of the soils are shown in Table 1.

The study was conducted at Nkari, Nkana, Igwu, Mbiabet, Use and Ikpa swamps on the basis of the three physiographic units. At each location soil profile pits were dug to the depth of the ground water table. The profile pits were described and sampled according to FAO/UNESCO (1977), and soil texture was designated according to Soil Taxonomy (Soil Survey Staff, 1999). Infiltration runs were carried out adjacent each soil pit, using the double ring infiltrometer procedure. A total of twelve runs were made. From the data obtained, infiltration rate at 1 min and 2 hr, cumulative infiltration at 2 hr, and equilibrium infiltration rate and time to attain it, and sorptivity and transmissivity were computed.

The samples collected were used to determine particle size, and organic carbon; and calcium/magnesium ratio (IITA, 1979).

Results and Discussion

Results of mechanical analysis show that the soils have moderate to high silt and clay content and low sand fraction both within and among the land types (Table 1). Equally, the mechanical separates vary widely both within and across the physiographic units. Variability in the fractions increase from the sloping lowlands to the river terraces. Differences in particle size distribution across the land types were attributed to depositional processes and activities of the adjoining rivers. Soil profiles in the undulating river terraces appeared to have benefited most from unequal deposition of weathered materials.

Table 1. Some physical and chemical properties of the top 50 cm of seasonal wetlands In three physiographic units in Akwa Ibom State, Southeastern Nigeria.

Sample No	% sand	% silt	% clay	Text-ure	Org.C%	Ca Cmol/kg	Mg Cmol/kg	Ca/Mg ratio	Base satn %
Gently to moderately sloping lowlands, imperfectly drained									
EN31SL	49.2	16.3	34.5	Scl	2.74	7.20	1.87	3.9	48.9
EN32SL	53.2	22.3	24.5	Scl	0.86	3.30	3.90	0.8	63.5
EN33SL	64.3	17.1	18.6	Scl	1.51	3.73	5.87	0.6	60.0
X	55.6	18.6	25.8		1.70	4.74	3.88	1.8	57.5
Se±	4.52	1.88	4.65		0.55	1.23	1.15	1.07	4.4.
CV%	14.1	17.5	31.3		56.1	45.1	51.5	104.7	13.2
Flat, floodplains, poorly drained									
EN51FP	25.1	16.0	58.9	C	2.65	16.80	13.96	1.2	80.0
EN52FP	50.0	26.4	23.6	Scl	2.13	3.10	1.20	2.6	30.7
EN53FP	41.0	27.6	31.4	Scl	1.04	9.20	4.90	1.9	68.1
[illegible]	[illegible]	33.9	[illegible]	Scl	0.52	2.93	0.53	5.5	50.0
X	39.9	26.0	34.1		1.59	8.01	5.15	2.8	57.2
Se±	5.29	3.71	8.49		0.49	3.27	3.09	0.94	10.77
CV%	26.5	28.6	49.8		61.6	81.8	120.1	67.4	37.7
Undulating river terraces, very poorly drained									
EN72RT	50.3	13.0	36.7	Sc	1.30	11.06	8.80	1.3	95.8
EN73RT	18.8	45.6	35.6	Sc	2.78	6.07	2.00	3.0	48.7
EN74RT	76.0	6.1	17.9	Sc	0.76	2.13	3.67	0.6	63.5
EN81RT	13.8	38.9	47.3	C	5.18	13.0	7.0	1.9	59.0
X	39.7	25.9	34.4		2.51	8.07	5.37	1.7	66.8
Se±	14.54	9.64	6.09		0.99	2.46	1.55	0.51	10.16
CV%	73.2	74.5	35.4		78.9	61.0	57.6	59.8	30.5

Soil texture was however fairly similar within than across physiographic units. It ranges from sandy loam to sandy clay loam in the sloping lowlands, sandy clay loam to clay in the floodplains, and sandy loam to sandy clay in the river terraces. Soil texture therefore ranges from medium to fine textured classes, with corresponding pore size distribution ranging from >0.1 mm diameter (transmission and retention pores) to <0.03 mm diameter (mainly retention pores). A physical significance of the pore size distribution is the problem of high capillary rise water from moister or wetter zones at lower depths or from the ground water table during the dry season. The capillary fringe will therefore be high and plant available water capacity (PAWC) may be adequate. However, the constant rate stage and or the profile controlled stage of evaporation will continue for a considerable length of time, and may result in deep drainage and much losses of soil water through evaporativity. This may also lead to reduced soil water storage or PAWC. The high silt content indicates abundance of weatherable minerals derived from the adjacent Sandstones and Shale hill ridges. The abundance of weatherable minerals is evidenced by the age or weatherability of the soils, which range from 27 - 150. This is equivalent to moderately weathered (16 - 50) to weakly weathered (>50) (Westin and Brito, 1969). It also indicates high soil fertility.

Organic C content varied widely both within and across the swamps (Table 1), but the variability increased from the sloping lowlands to the river terraces. Equally, organic C content had the highest mean value in the river terraces and least in the flat floodplains. The high value in the very poorly drained land type was attributed to the fact that microbial decomposition is inhibited in wet soils, due to the virtual exclusion of oxygen from the soil pores. Organic C was generally low in the soils, and C/N ratios (12 - 16) are in the range of readily decomposed and incorporated organic matter. The generally low values of organic C could be attributed to the cyclical disposition of the soils to alternate dry and wet seasons. While the wet season may reduce microbial activity, the dry season with elevated temperatures (isohyperthermic temperature regimes) enhances it, soil water not being limiting. The organic matter content of the soils is low to moderately high. The environmental implication is that carbon input to the atmosphere is greater than storage or sequestration, and may contribute the greenhouse gases.

The nutrient elements, Ca and Mg, vary widely both within and among the physiographic units, mostly in the flat floodplains (CV = 120.1%) (Table 1). The pattern of differences in mean values was similar to other parameters, that is, increases in mean values from the sloping lowlands to the river terraces. Generally, the nutrient levels were adequate, that is, greater than their critical values (Ca = 2.50Cmol/kg, Mg = 0.45Cmol/kg) in the 50cm depth zone. The nutrients were in excess of their critical levels in some soils. The observed values of Ca and Mg could be attributed to pedochemical weathering of the adjacent sandstone and shale parent materials, enchanced by cycles of alternating redox potential. The soils fluctuate between high or positive redox potential in the dry season and low or negative redox potential in the rainy season, when submergence improves the solubility of most nutrient elements in wetland soils. In terms of soil fertility, the soils would appear to require no Ca and Mg fertilization because of the seasonal flushes. Equally, being readily soluble, their toxicity and effect on nutrient balance may not arise because they can easily be lost in saturated flow. It is however advisable to carry out routine evaluation of the soils for Ca/Mg and K/Mg.

A physical significance of the preponderance of Mg is the effect of the generally low Ca/Mg ratios on the structural stability and water movement in the soils. The preponderance of Mg indicates weak soil structures because Mg enhances dispersion or deflocculation of clay, negating aggregation. In addition to the effect of the fine textural characteristic of the soil, water intake and flow may be limited, by the preponderance of micro-pores, and consequently the wetness condition of the soils. A further significance of the ratios is that they are generally out of the range of 3:1 to 4:1 considered optimum for plant growth. Ca and Mg fertilization would therefore be needed when the soils are transformed into intensively managed agro-ecosystems.

Base saturation, except in the sloping lowlands, was also variable, with values ranging from 30.7% to 95.8%. The moderately high values in most soils indicates the abundance of the basic cations on the absorption complex.

The infiltration characteristics of the soils were generally low and highly variable both within and among the land types (Table 2). Infiltration rate was low and considerable time elapsed before the equilibrium rate could be attained.

Table 2. Infiltration characteristics of seasonal wetlands in three physiographic units in Akwa Ibom State, Southeastern Nigeria.

Sample No.	Sorptivity cm min	Transmissivity cm min	Infiltration rate (cm min) 1min	2 hr	equil i	Time to equil i (min)	Cum Intake (cm)
Gently to moderately sloping lowland, imperfectly drained							
EN31/SL	1.05	0.45	1.30	0.55	0.06	80	66.0
EN32/SL	0.22	0.19	0.35	0.21	0.20	46	25.6
EN33/SL	1.54	0.36	1.45	0.50	0.13	86	60.4
X	0.94	0.33	1.03	0.42	0.13	70.7	50.7
Se±	0.39	0.08	0.34	0.11	0.04	1.25	1.26
CV%	71.2	39.6	57.7	43.7	53.8	30.5	43.2
Flat floodplains, poorly drained							
EN51/FP	0.76	1.42	1.95	1.49	1.20	106	178.4
EN52/FP	1.09	0.13	0.68	0.23	0.15	100	27.7
EN53/FP	0.31	0.22	0.38	0.25	0.20	104	29.9
EN54/FP	-0.04	0.05	0.03	0.04	0.04	73	5.0
X	0.53	0.46	0.76	0.50	0.40	95.8	60.3
Se±	0.25	0.32	0.42	0.33	0.27	7.69	39.78
CV%	93.7	142.2	110.1	132.4	135.6	16.1	132.1
Undulating river terraces, very poorly drained							
EN72/RT	3.94	0.14	0.53	0.50	0.38	92	59.9
EN73/RT	1.18	0.62	1.45	0.73	0.50	93	87.0
EN74/RT	0.60	0.53	0.83	0.58	0.43	96	69.6
EN81/RT	0.10	0.01	0.05	0.01	0.01	80	0.9
X	1.46	0.33	0.72	0.46	0.33	90.3	54.4
Se±	0.86	0.15	0.29	0.16	0.11	3.52	18.68
CV%	117.8	91.0	81.9	68.5	66.3	7.8	68.7

The low rate of infiltration and soil infiltrability may be due to the generally fine textures and predominance of micro-pores in the soils. The values of sorptivity and transmissivity are important in soil water conservation. Usually, the sorptivity term is the dominant parameter governing the early stages of infiltation. The low values of the parameter indicates low capacity of the soils to absorb rain water, the observed cracks notwithstanding. Cumulative intake is greater in dry than in moist soil, because the drier soil has a higher storage capacity. The observed values of accumulative infiltration show that the wetland soils can dry to reasonably great depths (average depth of profile pits is 150 cm). The implication of the observed values of accumulative intake is that with an average annual rainfall of about 2500 mm, the soils can only accumulate an average 55.5 mm, or 2.22% of the total annual rain water. The excess is lost as runoff with further implication for soil conservation. This study shows that wetland soils have low infiltration rate and moderately high cumulative intake. The infiltration characteristics are important soil properties affecting soil (runoff) erosion.

References

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