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CHARACTERIZATION AND FERTILITY STATUS OF WETLAND SOILS IN ABIA STATE AGRO-ECOLOGICAL ZONE OF SOUTHEASTERN NIGERIA.

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ABSTRACT

Due to the increasing soil degradation of Southeastern Nigeria – with particular reference to the monumental gully erosions that now devastate the region, selected wetland soils of the region were characterized with a view towards acquiring a holistic understanding of the soils and their fertility status. Random soil survey technique was used in field sampling. Four profile pits were dug in two different towns (Uzuakoli and Ubani-Ibeku) in Abia State. Results showed that soils had clayey texture. Clay increased down the profile in all the profiles, except in profile 1 where it attained a peak value in the A_1 horizon (403 g/kg) and distributed irregularly down the profile. Bulk density was below the minimum bulk value at which root-restricting conditions will occur and increasing down the profile. Soils were well drained on the surface and poorly drained in the subsoil. The pH ranged from very strongly acidic to moderately acidic. The soils had moderate to high organic matter, low total nitrogen, low Al saturation and high base saturation. Soils had low K:Mg ratio ranging from 0.02:1- 0.51 :1. Ca/Mg ratio was high in all the wetlands with exception of wetland pit 4. Soils were deficient in available phosphorus (< 6.0 ppm). Though moderately fertile , the soils can still produce increased and sustainable crop yield if the appropriate land use and husbandry practices are adopted, with particular reference to fertilizer application.

KEYWORDS: Fertility status, Soil Characterization, Wetland soils.

INTRODUCTION

Wetlands are important aspects of the physical environment in Nigerian agriculture, comprising about 22,895 km^2 of Southeastern Nigeria (Chukwu *et al*., 2009). Wetland soils are predominantly used for production of important crops like rice, dry season vegetables, early yam species and cocoa yam. Scanty information about these soils in South eastern Nigeria has led to their mismanagement and unsustainable use. The current awareness of the usefulness of wetland soils necessitate the need for effective survey and characterization of these soils for sustainable land use. The need for a holistic understanding of wetland soils of South eastern Nigeria cannot be overemphasized, especially in the light of the devastating soil degradation and food insecurity that now bedevil the region. Characterization of soils provide useful information for assessment and monitoring of the behaviour of soils. In addition, such studies help to trace the genesis of soils as well as predict their suitability for both agricultural and non-agricultural uses. This necessitated the extensive studies on characterization of some arable soils of Nigeria (Omeke, *et al*., 2009, Ahukaemere and Akpan, 2012, Onweremadu *et al*., 2007), with little attention given to wetland soils which are of paramount importance to tropical agriculture.

The decline in wetland soils' characteristics may occur through degradation associated with flooding, depletion of soil nutrients and soil compaction (Eshett, 1987). Unsustainable soil management practices and land uses may trigger such changes and consequently lower the soil fertility- a major factor in determining soil quality. In the face of these disturbing realities, the importance of a detailed characterization of the wetland soils of South eastern Nigeria cannot be over-emphasized. Therefore, the major objective of this study was to characterize selected wetland soils in Abia State of South eastern Nigeria. The results obtained from this study would serve as management tools for sustainable wetland development and management in the region.

MATERIALS AND METHODS

Site Characteristics

Abia State lies between Latitude 4^0 49^1N and 6^0 47^1, Longitude 7^0 54^1 and 8^0 58^1E. Soils of the study areas (Ubani-Ibeku and Uzuakoli) are derived from Shale (Bende Ameki group) . The study areas have tropical climates with two seasons, the rainy season which lasts from April to October and dry season which is from mid November to March. These areas receive average rainfall of 2134 mm and daily temperature ranges from 21^oC to 34^oC. The relative humidity reaches a minimum of 60 % in January (at the peak of the dry season) and rises to 80 - 90 % in July (at the peak of the rains) (Monanu, 1975). The original vegetation of the region was the tropical rain forest (FDALR, 1985), which has however been destroyed largely through human activities.

Field Studies

The study was carried out in Ubani-Ibeku and Uzuakoli-Bende in Abia State in the year 2013. Total of four profile pits were dug (three in Ubani and one in Uzuakoli) in the study sites. The study sites and profile pits were geo-referenced with the aid of a hand held global positioning system (GPS).The profile pits were described using FAO, (2006) guidelines, delineation of horizon boundaries was accomplished before actual sample collection for laboratory analyses and samples were collected according to horizons. The soil samples were air dried, crushed and sieved through a 2 mm sieve mesh. A small quantity (about 10 g) of each sample was finely ground and preserved for determination of organic carbon and total nitrogen. Undisturbed soil samples for determination of bulk density were collected using core samplers.

Laboratory Soil Analyses

Soil colour was determined using Munsell colour chart while other morphological properties were determined with visual observation and hand feeling. The physical and chemical properties of the soil samples were determined using routine analytical methods. Particle size distribution was carried out by hydrometer method (Gee and Or, 2002). Bulk density was determined using the procedure outlined by Arshad *et al.*, (1996). Porosity was computed from bulk and particle density as described by Vomocil (1965). The moisture content was determined gravimetrically. Soil pH was measured electrometrically by glass electrode in pH meter in distilled water suspension using a soil: liquid ratio of 1: 2.5 (Thomas, 1996). Exchangeable bases (Ca, Mg, K, Na) were extracted with neutral ammonium acetate (NH_4OAc). Exchangeable calcium and magnesium were determined by ethylene diamine-tetraacetic acid (EDTA) titration method while exchangeable potassium and sodium were estimated by flame photometry (Jackson, 1962). Exchangeable acidity was extracted with KCl (1 N) and measured titrimetrically according to the procedure of Mclean (1982). Effective Cation Exchange Capacity (ECEC) was the sum of the exchangeable bases and the exchangeable acidity, while base saturation, was computed as the percentage of the ratio of exchangeable bases to ECEC. Aluminum saturation (Alsat), exchangeable sodium percentage (ESP) and exchangeable potassium percentage (EPP) were computed as the percentage of the ratios of exchangeable aluminum, exchangeable sodium and exchangeable potassium respectively to ECEC. Ca: Mg and K: Mg ratios were calculated from the exchangeable basic cations while C:N ratio was calculated from organic carbon and total nitrogen. Soil Organic carbon (SOC) was determined by Walkley and Black digestion method (Nelson and Sommers, 1982), organic matter was computed by organic carbon x 1.724. Total Nitrogen was estimated by micro-Kjeldahl digestion method (Bremner and Mulvaney, 1982) while available phosphorus was determined by Bray II Method (Olsen and Sommers, 1982).

Data Analysis

Data generated were subjected to coefficient of variation and correlation analyses. The coefficient of variation was ranked according to the procedure of Wilding *et al*., (1994) where Cv $\leq$ 15% = low variation, Cv >15 $\leq$ 35% = moderate variation, Cv > 35 % = high variation.

RESULTS AND DISCUSSION

Physical and Morphological Properties of Soils

The morphological and physical properties of soils are presented in Table 1. The drainage pattern of the soils ranged from well drained in the top soil to poorly drained in the deepest horizons. Variation in the drainage pattern of these horizons could be due to the differences in clay contents and soil water table, with the deepest horizons having higher clay contents than the surface horizons which invariably reduces infiltration rate (Senjobi and Ogunkunle, 2011). The structural development ranged from moderate to strong with sub-angular blocky peds. In moist state, the soils were friable, firm and very firm. They exhibited sticky and plastic consistency when wet. Soil texture ranged from clay to sandy clay loam.

The soils generally have clayey texture. Wetland pit 2, 3 and 4 have more clayey subsoil, a phenomenon that could be diagnostic of the existence of argillic horizons (Eshett, 1987). Similarly, in these pits the surface horizons have low clay contents compared to the subsurface horizons. Clay increased down the profile, except in pit 1 where it attained a peak value in the A_1 horizon (403 g/kg) and distributed irregularly down the profile pit (Table 1). Nevertheless, while the vertical variability was moderate in wetland pit 3, it was low in wetland pit 1, 2 and 4 respectively (Table 1). The low vertical variability of clay in these pits reveals horizons homogeneity and precludes the existence of well developed argillic horizons. Silt content of the soil was moderate ranging from 190 – 240.70 g/kg. This intermediate silt content contradicts the assertion of Akamigbo (1984) and Madueke *et al*., (2012) that soils of South eastern Nigeria are low in silt as a result of the high degree and extent of weathering and leaching they have undergone. Soil texture has an important role in the assessment of soil characteristics. The uptake capacity of soil, which is an indicator of soil fertility, depends on the texture composition of the soil. According to Loide, (2004), as the percentage of clay particles and colloids contained in the soil increases, the content of plant nutrients bound by these particles and colloids increases as well. Thus the soil’s nutrient binding capacity dictates how easily the nutrients not bound by soil particles can be washed out of the soil.

Table 1: Morphological and Physical Properties of Wetland Soils

Horizon	Sand	Silt (gkg^{-1})	Clay	Tex.	SCR	BD gcm^{-3}	MC %	TP (%)	Soil colour	Dr	Soil struct.	Con.
					Wetland profile 1 (Ubani – Ibeku)							
A1	262.00	334.00	403.00	CL	0.83	1.17	10.00	55.9	10YR3/3	ID	2 me, sb	firm
A2	422.00	214.00	363.00	CL	0.59	1.23	11.35	53.58	10YR3/2	ID	2-3, sb	firm
Btg1	442.00	174.00	383.00	SC	0.45	1.38	16.00	48.0	10YR7/3	PD	3 sb	firm
Mean	**375.30**	**.240.70**	**383.00**		**0.63**	**1.26**	12.45	**52.49**				
Cv (%)	26.3	36.6	5.22		30.8	8.59	25.28	7.74				
					Wetland profile 2 (Ubani – Ibeku)							
A1	522.00	234.00	243.00	SCL	0.96	1.18	7.99	55.5	10YR2/3	WD	2 me, sb	Fri.
A2	522.00	243.00	234.00	SCL	1.04	1.22	6.46	53.96	10YR3/2	WD	2 m, sb	Fri.
Btg1	542.00	206.00	263.00	SCL	0.78	1.38	9.77	48.0	10YR5/6	ID	2 -3 sb	Firm
Btg2	562..00	126.00	312.00	SC	0..40	1.42	9.02	46.42	10YR7/3	ID	3 sb	Firm
Btg3	522.00	166.00	312.00	SC	0.53	1.60	14.75	39.62	10YR7/2	PD	3 sb	Firm
Mean	**534.00**	**195.00**	**272.00**		**0.83**	**1.36**	**9.60**	**48.70**				
Cv (%)	3.35	25.06	13.67		27.3	12.39	32.67	13.06				
					Wetland profile 3 (Ubani – Ibeku)							
A1	362.00	414.00	223.00	L	1.86	1.19	9.00	55.09	10YR5/6	WD	2 m, sb	Firm
A2	522.00	166.00	312.00	SCL	0.53	1.25	11.35	52.83	10YR5/3	ID	3, sb	Firm
Btg1	482.00	134.00	383.00	SC	0.35	1.38	16.00	48.00	10YR5/6	PD	3 sb	Firm
Mean	**455.30**	**238.00**	**306.00**		**0.84**	**1.27**	**12. 12**	**51.97**				
Cv (%)	18.29	64.39	26.20		90.0	7.63	29.40	6.97				
					Wetland profile 4 (Uzuakoli)							
A1	132.00	260.00	608.00	C	0.43	1.21	9.19	54.33	10YR2/3	ID	2 me, sb	Firm
A2	252.00	200.00	548.00	C	0.37	1.51	9.00	43.01	5YR5/2	ID	2 ,sb	Firm
Btg1	372.00	120.00	508.00	C	0.24	1.55	10.00	41.5	2.5Y5/6	PD	3 sb	Firm
Btg2	172.00	180.00	648.00	C	0.28	1.67	15.59	36.9	2.5Y7/3	PD	3 sb	Vf
Mean	**232.00**	**190.00**	**578.00**		**0.33**	**1.48**	**11.0**	**43.94**				
Cv (%)	45.6	30.4	10.8		25.8	13.2	43.2	16.8				

SCR = Silt clay ratio, BD = Bulk density, MC = Moisture content, TP = Total porosity, ID = imperfectly drained, 2 = Moderate, 3 = Strong, me = Medium, CL = Clay loam, SC = Sandy clay, SCL = Sandy clay loam, C = Clay, L = Loam, Dr = Drainage, Con = Consistency, Vf = very firm, WD = well drained, PD = poorly drained, Sb = Sub-angular blocky, Cv = Coefficient of variation, Cv $\leq$ 15% = Low variation, Cv > 15 $\leq$ 35% = Moderate variation, Cv >35 $\leq$ 100% = High variation, Generally, the silt-clay ratio of the soils was low (0.33-0.84) indicating the advanced stage of weathering of the parent material from which the soils are developed. The bulk density ranged from 1.26 g/cm^3 in profile pit 1 to 1.48 g/cm^3 in profile pit 2 respectively. In all the profiles, bulk density increased with depth and was below the value quoted as the minimum bulk density at which root-restricting conditions will occur (1.75 – 1.80 Mg/m^3). The low bulk density showed that the soils were not compacted (Esu and Ojanuga, 1986).

Chemical Properties

The chemical properties of soils are shown in Table 2. Soils were strongly to moderately acidic with average pH ranging from 5.31 to 5.52. Soil pH fluctuated irregularly with depth in all the wetland soils studied. Strongly to moderately acidic soil reaction is characteristic of soils of South eastern Nigeria and it is the consequence of the acidic nature of the parent rocks, coupled with the influence of the leached profile under high annual rainfall condition (Eshett *et al.*, 1990). More so, acidic condition of the wetland soils under study could be attributable to greater oxidation of anions like sulphides and nitrites leading to soil acidification. Soil pH showed low variation (Cv < 15) (Table 2) in all the pedons . Calcium and organic matter had significant negative relationship with soil pH (r = - 0.615, r = - 0.535) (Table 3). This may be due to the production of organic acids during organic matter mineralization in the soil. Similarly, Igwe *et al*., (2005) reported negative relationship between soil organic matter and pH in soils formed on the River Niger floodplain in Nigeria.

The soil organic matter content ranged from 19.80 to 29.00 gkg^{-1} and decreased down the profile. Donahue *et al.*, (1990) reported that most arable soils contain 1 – 5 % organic matter, which is mostly within the top 25 cm of the soil, and that this small amount can modify soil physical properties and strongly affect its chemical and biological properties. Moderate to high variation was recorded in the vertical distribution of organic matter, indicating the heterogeneity in horizon distribution of organic matter. Results of correlation analysis showed that organic matter had significant ($P \leq 0.05$) correlation with bulk density (r = - 729), clay (r = 0.575), Ca (r = 0.643) and TEB (r = 0.597) (Table 3). The significant positive relationship between clay and organic matter could be attributed to small pore spaces - characteristic of fine textured soils which is effective in retaining sufficient water and nutrients. Total Nitrogen was generally low (0.20 - 1.43 gkg^{-1}). The low nitrogen concentration is a common phenomenon in the soils of South eastern Nigeria and is as a result of the high nitrogen losses occurring in these soils through the leaching of nitrates, as well as the rapid mineralization of organic matter under the isohyperthermic soil temperature regime (Eshett, 1987; Eshett *et al.*, 1990). Similarly, Onweremadu *et al*., 2007 reported low nitrogen in Wetland Soils of Zarama, Bayelsa State, Nigeria. The soils were deficient in available phosphorus (< 6.0 ppm). The low available phosphorus concentration is however, a widespread phenomenon in the humid tropical soils of South eastern Nigeria and could be attributed to the high phosphate fixation capacity of these soils (Idigbor *et al.*, 2009).

Exchangeable Calcium was generally moderate as values were higher than the critical value of 2 cmolkg^{-1}. Exchangeable magnesium was low except in wetland pit 4 with mean value higher than the critical value of 1.2 cmolkg^{-1}. This could be attributed to the acidic nature of the parent rocks. Potassium concentration was low (< 0.6 cmolkg^{-1}). Madueke *et al*., 2012 attributed the low potassium concentration in the soils of South eastern Nigeria to the fact that there is generally a low potassium reserve in acid soils. This may be due to the highly mobile nature of exchangeable potassium relative to calcium and magnesium and its consequent massive loss through leaching (Madueke, *et al*., 2012). Generally, soils of the study area suffer from potassium deficiency, and even more than from magnesium deficiency. Exchangeable potassium percentage (EPP) was also low. Low EPP observed across the wetlands studied could be consequence of low potassium reserve of these soils. Sodium concentration was generally low (< 1.05 $cmolkg^{-1}$). As such, none of the soils can be classified as sodic or alkaline soils. Calcium (Ca) was the dominant cation followed by magnesium (Mg) in all the wetlands investigated. The trend of distribution of calcium and magnesium in the soils investigated was similar to the findings of Lawal *et al*., (2012), who also reported Ca as the dominant cation in some hydromorphic soils of Nigeria Wetland soils under soil had average K:Mg ratio of 0.02:1- 0.51 :1 , which indicates excessive predominance of magnesium in relation to potassium, which is also the case with magnesium-poor soils (Loide, 1999).

Table 2: Chemical Properties of Wetland Soils

Hor.	pH	OM	TN	Av. P	Ca	Mg	K	Na	TEB	H	Al	EA	ECEC	BS	Al.sat	ESP	EPP	CN	Ca/Mg	K/Mg
	(w)	gkg^{-1}	gkg^{-1}	(ppm	←	←	←	→	$cmolkg^{-1}$	←	←	←	→	→	(%)	←	←			
									Wetland Profile 1 (Ubani – Ibeku)											
A1	5.44	36.00	0.40	2.80	3.56	0.30	0.01	0.04	3.91	0.05	0.70	0.75	4.66	83.9	15.02	1.02	0.22	525	11.87	0.03
A2	5.59	23.00	0.30	4.27	1.54	0.46	0.01	0.03	2.04	0.60	0.86	1.46	3.50	58.3	24.57	1.47	0.29	440	3.35	0.02
Btg1	5.53	18.00	0.30	5.60	2.14	0.76	0.01	0.02	2.91	0.64	0.88	1.52	4.43	65.7	19.86	0.69	0.23	347	2.82	0.01
Mean	**5.52**	**25.70**	**0.30**	**4.22**	**2.41**	**0.51**	**0.01**	**0.03**	**2.95**	**0.43**	**0.81**	**1.24**	**4.19**	**69.3**	**19.82**	**1.06**	**0.25**	**437**	**6.01**	**0.02**
Cv(%)	1.45	36.2	29.6	33.2	43	45.1	12.1	33.3	31.7	76.7	12.1	34.45	14.64	19.0	24.10	37.0	15.4	20.4	98.71	50.00
									Wetland Profile 2 (Ubani – Ibeku)											
A1	5.45	32.00	0.30	2.17	2.32	0.34	0.01	0.02	2.68	0.06	0.54	0.60	3.28	81.7	16.46	0.75	0.31	613	6.82	0.03
A2	5.64	19.00	0.30	4.90	2.18	0.42	0.01	0.02	2.62	0.04	0.80	0.84	3.46	75.7	23.12	0.76	0.29	367	5.19	0.02
Btg1	5.57	16.00	0.30	5.60	1.98	0.28	0.01	0.02	2.28	0.60	0.88	1.48	3.76	60.6	23.40	0.88	0.27	300	7.07	0.04
Btg2	5.46	16.00	0.20	1.40	2.06	0.76	0.01	0.01	2.84	0.05	0.86	0.91	3.75	75.7	20.48	0.35	0.27	470	2.71	0.01
Btg3	5.41	16.00	0.20	2.17	2.36	0.38	0.01	0.02	2.77	0.60	0.86	1.46	4.23	65.5	20.33	0.72	0.24	470	6.21	0.03
Mean	**5.51**	**19.80**	**0.20**	**3.25**	**2.18**	**0.44**	**0.01**	**0.02**	**2.64**	**0.27**	**0.79**	**1.06**	**3.69**	**71.8**	**20.76**	**0.69**	**0.28**	**444**	**5.60**	**0.03**
Cv(%)	1.73	35	14.9	57.6	7.5	43.2	0.00	2.00	8.3	11.6	18.0	37.18	9.76	11.9	13.47	29	9.45	26.7	31.6	43.91
									Wetland Profile 3 (Ubani – Ibeku)											
A1	5.37	43.00	0.40	4.90	3.06	0.28	0.01	0.02	3.37	0.26	0.03	0.29	3.66	92.1	0.820	0.59	0.27	618	10.93	0.04
A2	5.39	24.00	0.30	7.56	2.66	0.30	0.01	0.01	2.97	0.30	0.40	0.70	3.67	80.9	10.90	0.34	0.27	467	8.87	0.03
Bt1	5.54	14.00	0.20	3.57	2.58	0.20	0.01	0.01	2.80	0.40	0.50	0.90	3.70	75.7	13.51	0.36	0.27	420	12.9	0.05
Mean	**5.43**	**27.00**	**0.30**	**5.34**	**2.77**	**0.26**	**0.01**	**0.01**	**3.05**	**0.32**	**0.31**	**0.63**	**3.68**	**82.9**	**8.41**	**0.43**	**0.27**	**502**	**10.90**	**0.04**
Cv(%)	1.7	54.6	45	38	9.3	19.2	0.00	6.00	9.00	22.5	79.9	49.34	0.57	10.1	79.68	32.3	0.00	20.6	18.49	25.00
									Wetland Profile 4 (Uzuakoli)											
A1	5.40	55.00	2.7	3.81	3.60	2.40	0.23	0.19	6.42	0.20	0.20	0.40	8.82	94.1	2.91	2.15	0.11	11.8	1.50	0.1
A2	5.33	44.00	2.1	1.09	5.20	3.60	0.37	0.24	9.41	0.10	0.60	0.70	10.1	93	5.93	2.38	0.10	12.0	1.44	0.11
Bt1	5.24	12.00	0.6	1.31	1.60	1.00	0.66	0.03	2.69	0.50	0.20	0.70	3.39	79.3	5.89	0.88	0.29	11.6	1.60	0.66
Bt2	5.27	6.80	0.3	0.52	1.20	0.60	0.69	0.06	1.95	0.20	0.10	0.30	2.25	86.6	8.88	2.67	0.44	13.0	2.00	1.15
Mean	**5.31**	**29.00**	**1.43**	**1.68**	**2.90**	**1.90**	**0.49**	**0.13**	**5.12**	**0.25**	**0.28**	0.53	**6.14**	**88.3**	**5.90**	**2.02**	**0.24**	**12.1**	**1.64**	**0.51**
Cv (%)	1.30	80.3	81.3	86.00	64.1	72.2	46.0	77.7	67.7	63.5	80.6	26.20	63.50	7.70	41.3	39.1	71.6	5.2	15.4	99.60

Hor. = Horizon, ECEC = Effective Cation Exchange Capacity, EA. = Exchange Acidity, ESP = Exchangeable Sodium Percentage, EPP = Exchangeable potassium Percentage, Ca = Calcium, Mg = Magnesium, K = Potassium, Na = Sodium, w =Water, OM. = Organic Matter, TN = Total Nitrogen, Av. P = Available Phosphorus, Al = Aluminium, Al. sat = Aluminium saturation, H = Hydrogen, Cv = Coefficient of variation, Cv $\leq$ 15% = low variation, Cv > 15 $\leq$ 35% = moderate variation, Cv >35% = high variation

Table 3: Correlation matrix

Property	%BS	Al	OM	Av. P	BD	Ca/Mg	Ca	Clay	ECEC	pH	TEB	TN
%BS	1											
Al	- 0.83*	1										
OM	0.86*	0.30 ns	1									
Av. P	0.256ns	-0.60*	0.01 ns	1								
BD	- 0.3 ns	0.586*	- 0.73*	-0.3 ns	1							
Ca/Mg	0.567*	0.04ns	0.652*	-0.28ns	0.129 ns	1						
Ca	0.633*	-0.52*	0.643*	-0.01ns	-0.33ns	-0.42ns	1					
Clay	0.459*	0.29 ns	0.575*	-0.1ns	0.135ns	0.640*	0.430	1				
ECEC	0.34 ns	-0.54*	-0.01 ns	-0.1ns	0.313ns	-0.06ns	0.457*	0.606*	1			
pH(w)	0.193ns	0.26ns	-0.535	0.14ns	- 0.03ns	0.19 ns	-0.62*	-0.09ns	- 0.235	1		
TEB	0.487*	-0.88*	0.597	-0.57*	- 0.26ns	-0.3 ns	0.942*	0.948*	0.594*	-0.62*	1	
TN	0.447*	0.300	0.968	0.08 ns	- 0.69*	0.145ns	0.685*	-0.2ns	0.15 ns	-0.50*	0.66*	1

Ns = not significant, * = significant at 5%, Several researchers have indicated soil's potassium-to-magnesium ratio (K:Mg) as an important factor in soil liming and soil fertility evaluation (Döring, 1974; Loide, 2004). Döring, (1974) further suggested that a K:Mg ratio of 3:1, or a little wider, is a favourable ratio for plants. Ca/Mg ratio was rated high in all the wetlands with exception of wetland pit 4. High Ca-Mg ratio recorded in these soils may be attributed to the texture of the soil. According to Loide (2004), the Ca-Mg ratio of clayey soils are always high as far as plant nutrition is concerned. He further pointed out that on the average, loamy and clay soils contained more Ca-Mg ratio than sandy soils. Generally, the Ca-Mg ratio obtained in wetlands 1, 2 and 3 were high when compared with 3-5:1 (normal range) reported by Landon (1991). According to the report of (New South Wales (NSW) Agriculture, (2002), some agronomist used 4 to 6 as a bench mark for the ratio of the exchangeable Ca to Mg. They claim that this bench mark must be achieved to ensure healthy soil and therefore optimum agricultural production. Loide, (2004), reported that the concept of Ca/Mg ratio is dominant force in shaping lime and fertilizer recombination.

Aluminium saturation ranged from 5.90 % to 20.76 %. Sanchez (1976) reported that there is less than 1.0 ppm aluminium in the soil solution when aluminium saturation is less than 60 %, but rises sharply when aluminium saturation increases beyond 60 %. As such, due to the low aluminium saturation (< 60%) in the soils, there is little risk of aluminium concentration attaining toxic levels. Exchangeable sodium percent (ESP) which identifies the degree to which the exchange complex is saturated with Na was very low ranging from 0.43 to 2.02%. Low ESP observed across the studied soils may be a consequent of low sodium content, rainfall pattern and the acidic conditions of the soils. As rain water percolates, it dissolves and washes down Na cations which may accumulate in ground water, implying that the amount of sodium in ground water may be proportional to the amount of soluble Na cations leached out of top and sub-soils. This is consistent with the report of (Dupriez and Deleener, 1992) that rain water falling on the surface of a field causes soils to hardly be associated with any saltiness. ESP levels of 15% is associated with pH values of 8.5 and above.

CONCLUSION

The study revealed that the nutrient status of the wetland soils studied was intermediate with exception of available phosphorus. Soils were acidic with low K/Mg ratio – soil condition that encourages liming. Consequently, with appropriate land use and husbandry practices, these soils can still produce increased and sustainable agricultural yield, with particular reference to adequate lime and phosphate fertilizer application. Indeed, as far as food security and environmental sustainability are concerned, optimum attention should be given to the wetland soils in different parts of the nation

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