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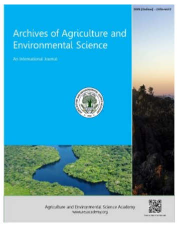

ORIGINAL RESEARCH ARTICLE

Evaluation of physical and chemical properties of some selected soils in mangrove swamp zones of Delta State, Nigeria

C. Umeri, R.C. Onyemekonwu* and H. Moseri

Department of Agricultural Science Education, College of Education, Agbor, Delta State, NIGERIA

*Corresponding author's E-mail: chukwukaraymond@gmail.com

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ABSTRACT

In the present investigation the analysis of physical and chemical properties of some selected soils of mangrove swamp in Delta State (Latitude 5^0 and 6^0 and 30' North and longitude 5^0 and 6^0, 45' east) were determined. Hence, representative soil samples were obtained from three locations *viz.,* Koko, Ozoro, Warri (Mangrove swamp) at 0-15cm and 15-30cm depths. The soil samples were analyzed for their physical and chemical properties *viz.,* soil texture (Sand, silt and clay), pH, EC, total organic carbon, available P, Na, K, Mg, Ca^+, exchangeable acidity (Al^{3+}, H^+), ECEC, OM, Zn, Pb, Fe, Cu and Mn at different study sites. The soil texture of the studied soil samples were primarily recorded as sand and loamy sand, with sandy texture at different study sites. The soils had a pH range of 5.65 to 6.40 at the surface, and were marginal in organic carbon, total nitrogen; exchangeable Ca, Mg, and ECEC, Zn, Fe, Cu whereas the contents of Mn were recorded to be adequate based on the recognized critical levels for the different nutrients. The potassium levels were found to be deficient in the soils. The pH of the soil showed a significant and positive correlation with K(r = +0.35) and Pb (r = +0.43). Total N positively correlated with the organic carbon (r = +0.92) and Fe (r = +0.63). The soils of the study area were mainly sandy loam indicating that the soils will support arable crop production. From the results of the present study it is recommended that the phosphorus and exchangeable potassium should be artificially supplemented to enhance the nutrients in the soil required for the growth and yield of the crop plants.

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INTRODUCTION

In Nigeria, soils aid tremendously in ensuring food security especially production in the production of crops of which the country spend a huge amount on its importation. The quality of soils does not depend on its ability to supply adequate nutrients alone but the nutrients must be in the right proportion as needed by plants (Ayeni and Adeleye, 2011; Umeri, 2015). A soil that supplies adequate nutrients needed by plants with favourable soil pH will produce better crops quality and yield if other conditions of growth such as biological and physical properties of the soil are favourable (Anderson, 1991; Olueh, 2014). The capability or nutrients strength of a soil to maintain and support the plant growth generally depends on its physical, chemical and biological properties which have been found to play significant roles in crop production. Researchers have reported that the nature of parent material has been found to influence development and characteristics of soils (Brady and Weil, 2005; Iloeji, 2003; Umeri *et al.,* 2016). According to Nkhuzenje *et al.* (2002) the declining soil fertility have been reported as a major limitation to increasing yields, and a threat to sustainability of crops (Lawal *et al.,* 2013; Umeri, 2015).

In order to realize the full potentials of these soils, there is the need to take the inventory of their nutrient status in the soils. This becomes necessary as information on the profile distribution of soil elements in arable crop growing soils will provide the basis for making informed decision with respect to fertilization and other soil management practices. A good knowledge of the variations of soil physical and chemical properties their interactions as it relates to micronutrient status is essential for good land evaluation which is a pre-requisite for sound land use planning (Iloeji, 2003; Lawal *et al.,* 2013; Olueh, 2014).

The broad objective of the study was to evaluate the physical and chemical properties of some selected soils in mangrove swamp soils of Delta State. The specific objectives of the present study were to evaluate the physical, chemical properties of some selected soils, to examine the micro nutrient of some selected soils and to assess the interrelationship among the nutrients of soils of mangrove swamp zones of Delta State.

MATERIALS AND METHODS

The study was carried out in the mangrove swamp of Delta State, which lies between longitude 8^0 20^1 and 8^0 30^1 East of the equator. Rainfall occurs mainly between April and October. Annual rainfall is usually between 2000mm-3000mm with an intense sunlight, which lasts for a minimum of 8 hours daily. Temperatures are high for most parts of the year, especially in the months of November to April with a mean monthly of 31°C. The annual range of temperature is thus small only varying between 3°C and 5° C. Relative humidity varies from 90% during rains to about 60% in dry season (Iloeji, 2003). There are three types of soils in Delta state. These consist of alluvial soils on the marine deposits along the coast, alluvial and hydromorphic soils on marine and lacustrine deposits found in the area close to the Niger and Benin Rivers and the feral soils on loose sandy sediments in the dry land area of the north and north east (Iloeji, 2003; Umeri *et al.,* 2016).

The climatic conditions of Delta State are similar to other parts of Southern Nigeria. There are two distinct seasons; the dry season and the rainy season (Umeri *et al.,* 2016). The rainy season starts in February and continues till the end of October. The rainfall regime shows a double maxima which is separated by a comparatively low rainfall period (dry period) in August called August Break. The length of wet season is at least seven months, i.e. about 220-250 days, with average rain days of 159. Temperatures are very high during day with cool night (Iloeji, 2003; Umeri *et al.,* 2016).

Soil preparation and analytical methods: Soil samples were collected from three (3) locations within mangrove swamp of Delta State, namely- Koko, Ozoro, Warri in Nigeria. These were chosen to reflect the differences in soil and vegetational characteristics. The surface soils (0-15cm) and sub-surface soils (15-30cm) were sampled with a tabular sampling auger. Representative soil samples were taken and bulked for each depth and location. The samples were air-dried at room temperature depending on moisture content for two (2) weeks and crushed to pass through 2mm mesh sieve. Sub-samples of soil from each location were further ground to pass through 100-mesh sieve for determination of organic matter. The rest samples were then analyzed for both physical and chemical properties of the soil.

Soil analysis: Soil samples were analyzed for physico-chemical properties as described by the International Institute for Tropical Agriculture (IITA, 1979) as follows: The particle size distribution of the soil samples was done by the Hydrometer method as outlined by Juo (1979). The pH of the soil samples was measured in water at ratio 1:1 (soil: water) by glass electrode pH meter (Mclean, 1982). The organic matter was determined by wet dichromate acid oxidation method (Nelson and Sommers, 1982). The exchangeable bases (Ca, Mg, K and Na) in the different soil samples were extracted with 0.05N NH_4OAc buffered at pH 7.0 (Thomas, 1982). The exchangeable K and Na contents of the extracts were read on EEL photometer while the exchangeable Ca and Mg were determined by titration method (IITA, 1979). Total exchangeable acidity (H^+ and Al^{3+}) in the different soils was extracted with 1 N KLC (Thomas, 1982) and determined by titration method 0.05N NaOH using phenolphthalein as indicator. The effective cation exchangeable capacity (ECEC) is the he summation of exchangeable bases and total exchangeable acidity and was taken as the effective cation exchange capacity value and determined following the standard procedures (Okalebo, Gathua and Woomer, 2002).

RESULTS AND DISCUSSION

The physical and chemical properties of the soils are presented in Tables 1 and 2, and the correlation coefficients (r) relating the nutrient elements to one another are given in Table 3. During the present study the soil texture of the selected soils at different study sites varied from sand to loamy sand. The soil samples from Koko, Ozoro and Warri sampling sites were found to be sandy at the topsoil and subsoil. Soil samples from Koko and Warri were found to be sandy at the surface and loamy sand at the sub-surface while at Ozoro it was found to be loamy sand at the surface and sandy at the sub-surface (Table 1).

The pH values of various locations ranged from 5.65 in Ozoro to 6.40 in Warri, that is, from strongly acidic to slightly acidic (Table 2). But at the subsurface, the pH ranged from 5.12 to 5.56; a similar range of moderately acidic to strongly acidic. The pH of the soils showed a decrease with depth with the exception of Warri. At the locations, mangrove swamp pH values were moderate when compared to the suggested pH level of 6-6.5 (Adeoye and Agboola, 1985) for the production of most crops.

The percentage organic carbon values showed decrease with depth. At the surface it varied from 0.49% in Ozoro to 1.15% in the soil from Koko (Table 2). At the subsurface, the value ranged from 0.29% in Ozoro to 0.48% in Koko using a critical value of 0.15% (FDALR, 2004). Koko soils had moderate organic carbon content. Ozoro, Warri, soils were low in organic carbon. The soil samples from all the sampling sites showed decrease with depth, reflecting lower content of organic carbon at 15-30cm in comparison to 0-15cm. The total N content of the soils at all the locations ranged from 0.03% in Ozoro to 0.08% in soil from Warri (Table 2) at the surface. At the sub-surface, it varied from 0.02% in Ozoro to 0.04% in soils from Koko using a critical level of 0.15% (FDALR, 2004). The locations had low total nitrogen contents.

Available phosphorus: The available phosphorus for all the locations ranged from 9.26mg/kg in Warri to 28.0mg/kg in Koko at the surface (Table 2). This ranged from low to high, while at the sub-surface, the value ranged from 22.3 at Koko to 58.8mg/kg at Ozoro and it is indicating lower content of phosphorus in the surface soils in comparison with subsurface soils. Mangrove swamp had high phosphorus content when compared to the established critical value of 17mg/kg (Agboola and Corey, 1993). The exchangeable potassium at all the sampling locations ranged from 0.05 to 0.36cmol/kg in the surface and 0.04cmol to 0.10cmol/kg in subsurface. In the surface soils, it was lowest in Koko, followed by Warri while it was highest in Ozoro. In the subsurface, the value was highest in the soils from Ozoro and Warri, based on a critical value of 0.24cmol/kg (Agboola and Ayodele, 1987), surface soils obtained from Ozoro were sufficient in exchangeable potassium while the other locations were deficient. Mangrove swamp locations were deficient in exchangeable potassium.

The exchangeable magnesium value ranged from 0.32 to 0.96cmol/kg at the surface, while at the subsurface, it ranged from 0.64 to 1.68 (Table 2). At the surface, the value was highest at Ozoro followed by Koko and Warri. Thus indicating lower magnesium at the surface in comparison to the subsurface. Based on the critical level of 1.9cmol/kg (Agboola and Ayodele, 1987), all the locations had moderate exchangeable magnesium content. The exchangeable calcium values ranged from 1.44 to 7.36cmol/kg at the surface depth, while at the subsurface it ranged from 2.401 to 4.32cmol/kg (Table 2). At the surface depth, the value was highest at Warri followed by Ozoro. The soil samples from Koko were found to be deficient in calcium compared to the established critical value of 3.80cmol/kg (Agboola and Corey, 1993). The exchangeable sodium value ranged from 0.36cmol/kg to 0.46cmo/kg at the surface depth, while at the sub-surface, it ranged from 0.40cmol/kg to 0.49cmol/kg (Table 2). At the surface, the value was highest in Ozoro followed by Warri, while the value was lowest at Warri.

Soil micronutrients: Zinc (Zn) content ranged from 43.9 mg/kg in Ozoro to 57.0 mg/kg in Koko at the surface soils and from 28.8 mg/kg in Ozoro to 58.1 mg/kg in Koko at the sub-surface soils. Iron (Fe) content ranged from 80.4mg/kg in Ozoro to 182 mg/kg in Warri at the surface soils and from 29.3mg/kg in Ozoro to 80.6mg/kg in Warri at the sub-surface. The critical value of iron and zinc have been given as 3-4.5mg/kg (Adeoye and Agboola, 1985) and 5-9mg/kg (Sillanpan, 1972), respectively. As the upper layers of the soil, the soil could be considered to be high in Fe and Zn contents. The lead content ranged from 1.24mg/kg in Koko to10.9mg/kg in Warri at the surface soils and from 0.01 in Warri to 1.82mg/kg in Ozoro at the sub-

Table 1. Physical properties of selected soils of mangrove swamp of Delta State.

Sample Location	Depth (cm)	Sand	Silt	Clay	Textural class
Mangrove swamp		g/kg			
KOKO	0 - 15	906.0	54.0	40.0	S
	15-30	846.0	64.0	90.0	LS
OZORO	0 - 15	894.0	83.0	23.0	LS
	15-30	914.0	63.0	23.0	S
WARRI	0 - 15	914.0	63.0	23.0	S
	15-30	884.0	6.3	53.0	LS

S = Sand; LS = Loamy sand

Table 2. Chemical properties of selected soils of Delta State before cropping.

Sampling location	Depth (cm)	pH H_2O	EC	Total N	OC	Av P	Na (Exchangeable)	K (Exchangeable)	Mg (Exchangeable)	Ca (Exchangeable)	Al^{3+} (Exchangeable)	H^+	ECEC	OM	Zn (Available)	Pb (Available)	Fe (Available)	Cu (Available)	Mn (Available)
					%	mg/kg						cmol/kg		%	mg/kg				
Mangrove swamp																			
KOKO	0 - 15	5.88	8.85	0.08	1.15	28.02	0.36	0.05	0.64	1.44	0.90	7.40	10.6	19.9	57.0	1.24	122	7.46	1.20
	15-30	5.56	67.3	0.04	0.48	22.3	0.40	0.04	1.68	2.40	2.60	2.80	9.92	8.3	58.1	1.43	37.4	3.61	1.88
OZORO	0 - 15	5.65	43.7	0.3	0.49	18.2	0.46	0.36	0.96	4.80	1.00	1.90	9.48	5.0	43.9	0.81	80.4	3.81	4.40
	15-30	5.12	36.6	0.02	0.29	58.8	0.45	0.10	0.80	3.84	1.00	3.50	9.49	48.1	28.8	1.82	29.3	2.34	0.36
WARRI	0 - 15	6.40	12.3	0.07	0.86	9.26	0.45	0.24	0.32	7.36	0.00	3.80	15.3	14.9	55.4	10.9	182	1.02	0.36
	15-30	5.40	10.0	0.03	0.45	32.6	0.49	0.10	0.64	4.32	1.00	2.70	9.25	7.6	48.64	0.01	80.6	13.7	0.30

Av. P- Available phosphous; EC- Electrical conductivity; ECEC-Effective cation exchange capacity; OM-Organic matter

Table 3. Correlation coefficients (r) matrix showing the relationship among physical and chemical properties of some soils in Delta State before cropping.

	pH	EC	Total N	OC	Av P	Na	K	Mg	Ca+	Al	H+	ECEC	OM	Zn	Pb	Fe	Cu	Mn	Sand	Silt	Clay
pH	1	-0.399	0.120	0.174	0.031	0.260	0.351	-0.140	0.125	-0.18	-0.161	0.027	0.042	0.152	0.434*	-0.173	0.118	0.183	0.209	-0.415*	-0.013H
EC			0.016	-0.020	0.031	0.260	-0.137	0.365	-0.106	0.103	-0.117	-0.194	-0.028	0.200	-0247	0.119	-0.247	0.033	-0.055	0.328	-0.183
Total N				0.979**	0.115	0.042	-0.175	-0.273	-0.259	-0.197	-0.201	-0.222	0.629**	0.491	0.034	0.635**	-0.118	0.073	0.249	-0.201	-0.179
OC				0.110	0.061	-0.211	-0.198	-0.198	-0.241	-0.134	-0.230	-0.216	0.628**	0.496*	0.015	0.567**	-0.084	0.009	0.61	-0.216	0.164
Av P						0.079	0.004	-0.475*	-0.0290	-0.018	-0.068	-0.328	0.418	-0.093	-0.064	0.282	0.056	-0.249	0.349	-0.281	-0.340
Na							0.044	-0.241	0.208	0.121	-0.307	0.005	0.318	0.063	0.209	-0.092	0.542**	0.397	-0.462*	0.096	0.440*
K								-0.219	0.085	-0.302	-0.240	-0.353	-0.321	-0.120	0.508*	0.116	-0.197	0.061	0.072	-0.279	-0.250
Mg									0.140	0.421	0.060	0.303	-0.204	0.006	-0.314	-0.445*	-0.082	0.377	-0.190	0.183	0.095
Ca+										-0.062	0.178	0.516*	-0.134	0.125	0.429*	-0.288	0.001	0.234	0.123	0.045	-0.16
Al											-0.952	0.069	-0.091	0.011	-0.346	-0.237	0.047	0.457**	-0.420	0.324	-0.409
H+												-0.671**	-0.207	-0.259	-0.36	0.017	-0.005	-0.204	0.242	-0.119	-0.135
ECEC													-0.094	-0.150	0.195	-0.205	0.089	-0.104	-0.017	-0.064	0.100
Zn														0.219	-0.003	0.284	-0.024	-0.099	0.124	-0.065	-0.77
Ph															0.195	-0.004	-0.023	0.148	-0.022	0.113	-0.091
Pb																0.197	-0.219	-0.175	0.105	-0.257	-0.151
Fe																	-0.121	-0.302	0.146	-0.123	-0.228
Cu																		0.100	-0.380	-0.011	0.482
Mn																			-0.272	0.210	0.184
Sand																				-0.656*	-0.786**
Silt																					0.301
Clay																					1.00

EC- Electrical conductivity; OM-Organic matter; Av. P-Available phosphorus; ECEC- Effective cation exchange capacity *, **- Significantly different at P=0.05 and P=0.01 level, respectively.

surface soil. Copper content ranged from 1.02mg/kg in Warri to 7.46 in Ozoro mg/kg in the surface soils and from 2.34mg/kg in Ozoro to 13.7mg/kg in Warri at the sub-surface soils. The values were low when compared to the average critical level of 6.35mg/kg (Chude and Obigbesan, 1980).

The available manganese content of the soil ranged from 0.36mg/kg in Warri to 4.40mg/kg in Ozoro for surface soils. These values were low when compared to the established critical values of 10.3-15.7mg/kg (Ayanlaja, 1983). Inter-relationships among the nutrients revealed that pH had a positive and significant correlation with potassium and lead ($r = +0.351$ and $r = +0.434$) at 5% level and a negative and significant correlation with silt ($r = - 0.415$). Organic carbon showed a positive and significant correlation ($r = +0.567$ and $r = +0.496$) at 5% level with Fe and Zn, respectively. An analysis of soils in the area of study showed that they ranged from sand to loamy sand. During the present investigation the textural class of the soil is accounted for the low clay and silt contents in the soil samples of the study sites. This indicates that the rate of water infiltration in these soils may be high and, consequently, that the water holding capacity of these soils may be low. These properties could predispose soils to erosion, particularly, that mangrove swamp in Delta state is high. The infertile nature of the soil could lead to low crop yields, if fertilizers are not applied; and resource poor farmers will be unable to meet crop demands. Therefore the entire soils are required to maintain the fertility of the soils and modify or improve on them (Agboola and Unamma, 1991). The low ECEC (Table 2) may be due to leaching. Mangrove swamp of Delta State is a high rainfall area. The soils were acidic with low total nitrogen, available phosphorus, exchangeable potassium and calcium.

The southwestern Nigerian soils have been reported to be mostly sandy and loamy sand owing to the nature of parent materials which are predominantly sedimentary (Agboola and Unamma, 1991, Olueh, 2014). Soils become acidic as a result of organic matter decomposition and by the addition of ammonum (NH_4) nitrogen fertilizer. The ions of hydrogen (H^+) produced by these processes and they displace the calcium, magnesium and potassium from the surface or sub surface of the soils. These free salts are then leached from the upper regions of the soil profile by water moving downward through the soil (Naidu *et al.*, 1990).The mean pH was 5.2 in Mangrove swamp. This is suitable for crop production in Nigeria (Lawal *et al.,* 2013).The nutrient status of the soils was generally low with most of the nutrients having concentrations below the critical limits. Organic carbon content was sufficient at both locations according to the critical value of 1.0% recommended by Agboola and Ayodele (1987). Total N, available P and exchangeable K were marginal at mangrove swamp based on the recommendation by FDALR (2004). Calcium and Mg was deficient at all locations (Lawal *et al.,* 2013, Umeri, 2015).

Conclusions

The determination of the physical and chemical properties of some selected soils and its correlation coefficients (r) were the principal objective of this study. The study was conducted at Mangrove swamp in Delta State. Soil analysis to determine the levels of plant nutrients in the soils was carried out. Consequently, the results from this study could be summarized as follows: Soils of the area of study were mainly sandy loam. The results of the present investigation indicated that the soils of the different study sites *viz.,* Koko, Ozoro, Warri (Mangrove swamp) in the Delta State of Nigeria had proper pH, and with marginal nitrogen, exchangeable calcium, magnesium and ECEC and indicated that the soils are slightly low in the nutrient contents. While these soils were sufficiently supplied with micronutrients; especially, zinc, lead, iron, copper and manganese at all the selected sampling sites. Nevertheless, these soils are quite deficient in the available phosphorus and exchangeable potassium. The inter-relationships as per the correlation statistics among the nutrients revealed that pH had a positive significant correlation with potassium and lead ($r = +0.351$ and $r = +0.434$) at 5% level and a negative and significant correlation with silt ($r = -0.415$). Therefore, form the outcome of the present investigation it can be recommended that should be artificially fertilized with phosphorus and exchangeable potassium to enhance the nutrients in the soils essential for the growth and yield of the agricultural crops.

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