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Micronutrient dynamics in some wetland soils of south-eastern Nigeria

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Abstract: The inventory of profile distribution of total iron (Fe), zinc(Zn), manganese(Mn) and copper(Cu) were determined in three different soil horizons each of the wetland soils selected form Mbiabet(MB), Nkari(NK) and Nkana(NA) in Ini Local Government Area of Akwa Ibom State.

Total Fe ranged between 3.25 and 4.15 ppm. The average contents were 3.72, 3.91 and 3.62 ppm in Mbiabet(MB), Nkari(NK) and Nkana(NA) soils respectively. The total value of Zn also ranged between 2.4 and 4.9 ppm with the average content in each soil being 28.27, 17.73 and 36.53 ppm respectively. The amount of Fe and Zn in these soil profiles were strongly correlated with the clay content and high levels of organic matter of 3.70%, 2.47% and 2.5% respectively. The content clearly reflected a poor drainage conditions. In all the soil profiles Mn and Cu were detected in at least one of the soil horizons. However, Mn and Cu were not detected in the soil horizons at Nkari. Generally, the relative inventory of these micronutrients appeared to be influenced by pH, drainage pattern, organic matter and clay contents of these soils. The inventory of total values of the wetland soils considered are assessed in the light of establishing a baseline information.

Keywords: micronutrients; inventory; dynamics; wetland soils; south eastern Nigeria

Introduction

Hydromorphic soils are soils saturated with water for some periods of the year or throughout the year in some cases. They constitute vast, under exploited and sometimes undiscovered ecologies in Nigeria(Eshett, 1994).

These hydromorphic soils (wetlands soils) contain organic matter and micronutrients in various proportions. The agricultural significance of organic matter in these soils is greater than that of any other component with the exception of moisture. Its functions are to improve soil structure, root penetration and erosion resistance. It also augments cation exchange capacity, and serves as a store of nutrients which are gradually converted to forms available to plants(Young, 1976).

Micronutrient inventory of these soils vary depending on the location, soil properties and agricultural activities involved. These nutrients are needed in small amount by plants. However, (the small amount of these nutrients needed by plants not withstanding) plants show deficiency symptoms when one or few of these elements are lacking in soil.

There is paucity of literature on organic matter and micronutrient inventory in wetland soils of Akwa Ibom State. These soils are very extensive and support a dense population as they abound in almost all local government areas especially the coastal areas.

The traditional methods of restoring soil fertility through shifting cultivation with attendant fallow periods of between 3—5 years permit adequate rebuild up of organic matter which is the store house of soil nutrients including micronutrients. In addition, the use of local crop varieties did not deplete the soil severely of its organic matter and micronutrients(Kparmwang, 1994).

However, as population pressure increases, intensive crop cultivation with the use of improve crop varieties adopted, there is an imminent organic matter and micronutrient depletion(Kparmwang, 1994).

Therefore, the characterization of wetland soils to ascertain their organic matter and micronutrient status is imperative. This will enable the classification of these soils for specific purposes such as aquaculture, crop production, horticulture and so on.

1 Materials and method

A total of six soil profiles were randomly selected(Fig. 1). These covered the wetland soils in Ini Local Government Area and were represented as Mbiabet (MB), Nkari (NK) and Nkana (NA). Soil samples were collected using pedogenic horizons and taken to the laboratory for processing and analysis.

1.1 Analytical procedure

The soil samples from the field were air-dried and passed through 2-mm mesh sieve. For the analysis of organic matter, total and available content of Zn, Fe, Cu and Mn soil samples were further ground and passed through a 100 mm-mesh sieve.

Particle-size determination was done by the hydrometer method of Bouyoucos (Bouyoucos, 1951). Soil pH was measured in a 1:1 soil-to-solution suspension (Jackson, 1964). Organic carbon was measured by wet oxidation method of Walkley and Black (Walkley, 1934). Organic matter was obtained by multiplying organic carbon by 1.72 (Agboola, 1986). The soil conductivity was determined using conductivity meter.

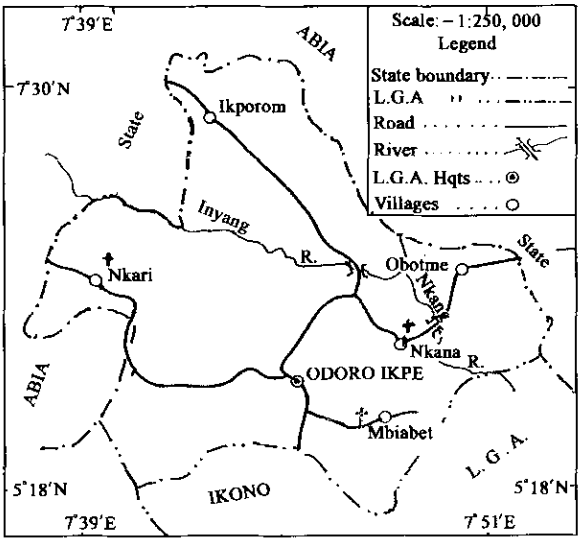

Fig. 1 Part of Ini Local Government Area showing sampling sites(+)

Extract for the determination of exchangeable bases and Zn, Fe, Mn and Cu was prepared using 0.1M HCl as described by Baker and Amacher(Baker, 1982).

Potassium(K) and sodium(Na) in the extract were determined by flame photometry. Ca and Mg were determined by the EDTA titration method (Jackson, 1964). Exchangeable activity(EA) was measured with 1 mol/L HCl and titratable acidity was measured by the method of McClean (McClean, 1965).

The effective cation exchange capacity(ECEC) was taken as the sum of exchangeable bases(EB) and exchangeable acidity(EA)(Kamprath, 1970).

Zn, Mn, and Cu were determined using model 919 UNICAM atom absorption spectrophotometer. Fe was determined colorimetrically using the orthphenanthroline method(Jackson, 1969).

2 Results and discussion

The physical and chemical properties of the soils are shown in Tables 1 and 2. The soils in Mbiabet (MB), Nkari(NK) and Nkana (NA) have relatively high sand and clay fractions but low in silt. In all the profiles, the clay tends to accumulate in the subsoil (B-horizon). The silt/clay ratio is < 1 in all the profiles. The low silt/clay

Table 1 Mean values of some physical properties of the wetland soils

Depth, cm	EC, ds/m	Coarse sand	Find sand	Silt	Clay	Texture
		%				
Mbiabet (MB)						
0—15	0.0834	66.1	14.2	5.4	22.6	* SCL
15—30	0.0834	65.8	14.2	5.4	22.6	SCL
30—45	0.0802	65.5	16.2	5.4	22.6	SCL
Nkari(NK)						
0—15	0.0786	56.6	16.6	5.9	12.2	* LS
15—30	0.0781	55.0	15.8	5.9	11.0	LS
30—45	0.2050	55.3	16.6	5.7	11.6	LS
Nkana (NA)						
0—15	0.1033	57.2	14.3	5.5	20.7	SCL
15—30	0.0615	65.0	14.6	5.9	20.1	SCL
30—45	0.1470	58.8	15.6	5.4	21.7	SCL

Notes: SCL-sandy clay loam; LS-loamy sand ratio, according to Udo(Udo, 1976) indicates teralitic pedogenesis.

Table 2 Mean values of some chemical properties of the wetland soils

Depth, cm	PH (H_2O)	Org.M, %	Org.C, %	Ca	Mg	Na	K	EA	ECEC	BS
				mg/100g						
Mbiabet(MB)										
0—15	4.48	3.70	2.14	6.00	5.20	1.30	1.53	5.44	19.41	72.06
15—30	3.94	0.82	0.48	3.20	4.80	0.13	0.12	11.04	9.9	42.77
30—45	5.62	2.97	1.72	19.60	25.60	0.17	0.38	1.12	46.7	97.61
Mkari(NK)										
0—15	5.58	0.29	0.17	17.2	21.60	0.21	018	0.96	40.15	97.61
15—30	5.34	2.47	1.43	12.4	13.20	0.31	0.24	4.96	30.93	82.96
0—45	4.91	0.24	0.14	4.80	17.20	0.12	0.07	1.12	23.31	95.20
Nkana(NA)										
0—15	4.94	2.59	1.50	4.40	4.80	0.74	0.11	7.68	18.81	59.17
15—30	4.96	1.12	0.65	3.20	6.40	0.12	0.09	15.04	24.85	39.48
0—45	4.77	0.91	0.53	2.40	4.80	0.12	0.07	12.64	20.03	36.89

Notes: EC——electro conductivity; org. M——organic matter; org. C——organic carbon; EA——exchangeable acidity; ECEC——effective cation exchange capacity; BS——base saturation

All the soils were acidic with pH mean value ranging between 4.48 and 5.58. The organic matter content was relatively high in poorly drained Mbiabet(MB) and Nkana(NA) soils, the values in these soils ranged from 1.12% and 3.70% in the surface horizons. The values of Nkari soil ranged between 0.29% and 2.50%.

2.1 Total iron(Fe)

The ranges and mean values of Fe contents in various horizons are summarized in Table 3. Nkari has the highest, 3.91 ppm, followed by those of Mbiabet and Nkana, respectively 3.71 ppm and 3.61 ppm. The total Fe in the surface soils is strongly correlated with the clay content. This clearly reflects the drainage conditions of the profiles.

Table 3 Profile ranges and mean values of total Fe, Zn, Mn and Cu expressed in ppm in selected Akwa Ibom State wetland soils

Depth, cm	Fe, ppm	Zn, ppm	Mn, ppm	Ca, ppm
Mbiabet(MB)				
0—15	4.15	49.60	2.00	35.00
15—30	3.75	29.60	1.60	15.00
30—45	3.25	5.60	ND	10.00
Nkari(NK)				
0—15	4.15	2.80	ND	ND
15—30	4.10	2.40	ND	ND
30—45	3.50	30.00	6.00	15.00
Nkana(NA)				
0—15	3.85	48.80	2.00	10.00
15—30	3.55	30.80	1.20	30.00
30—45	3.45	30.00	0.10	15.00

Notes: ND-not detected

The values are high for well drained profiles of Nkari with a mean value of 3.91 ppm but low for the poorly drained soils of Mbiabet and Nkana with mean values of 3.71 ppm and 3.61 ppm respectively.

Normal concentration of Fe in soils varies widely from 0.7 to 55 ppm, the average Fe level in soils is estimated at 3.8 ppm(Tisdale, 1985). The pattern of pH value for Nkari clearly follows Fe distribution pattern, but in poorly drained profiles of Mbiabet and Nkana, distribution patterns are different.

2.2 Total zinc (Zn)

The soil profiles differed widely in their total Zn composition as shown in Table 3. For all the profiles the value ranged between 2.4 and 49.6 ppm. Soils of Mbiabet(MB) and Nkana(NA) ranged between 5.6 and 49.6, 30.0 and 48.8 ppm respectively, while Nkari(NK) soil ranged between 2.8 and 30.0 ppm. The corresponding means were 28.3, 11.7 and 36.5 ppm.

Although, there was no regular vertical pattern of distribution within the profiles, it tended to accumulate in the surface soils particularly in MB and NA. The range of values obtained is comparable with those reported by some workers. In some western Nigerian soils, Osiname *et al*. (Osiname, 1993) obtained a range of 8 to 39 ppm and mean value of 19.1 ppm. In Nova Scotia, a higher range of 104 to 175 ppm with a mean of 492 ppm was reported by McClean and Langille(McClean, 1976). In USA Karim and Sedberry(Karim, 1976) reported a range between 7 and 150 ppm for selected Louisiana soils.

Total Zn was strongly correlated with clay content but weakly with organic matter with mean value of 1% in NK. Hence the factors which largely control total Zn content are the clay minerals and the free oxides. Karim and Sedberry(Karim, 1976) had indicated a strong relationship with clay minerals.

2.3 Total manganese(Mn)

The soil profiles show wide values of total Mn as indicated in Table 3. For MB, Mn was not detected in one horizon while in NK it was only detected in the deepest horizon(30—45 cm). For all the profiles the values ranged between 1.6 to 2.0 ppm and 0.1 to 2.0 ppm for MB and NA respectively, their corresponding means were 1.2 and 1.1 ppm.

Although, there was no regular vertical pattern of spread of Mn within the profile, there was strong correlation with higher clay, Cu, Zn and organic matter contents.

2.4 Total copper(Cu)

The distribution of total Cu in the various profiles is shown in Table 3. The ranges of total Cu in these soils were 10 to 35 ppm, 0 to 15 ppm and 10 to 30 ppm for MB, NK and NA respectively. The corresponding mean values were 17 ppm, 5 ppm and 18.3 ppm. The contents of the total Cu varied considerably in NK, it was not detected in two of the horizons.

The values obtained agree with Osiname *et al*.(Osiname, 1976), Karim Sedberry and Miller(Karim, 1976). Total Cu was strongly correlated with clay content, and the free oxides of Fe and Mn, but not with organic matter of 1.0%. The relationship with clay content agrees with the works of Karim *et al*.(Karim, 1976) and Osiname *et al*.(Osiname, 1973).

The strong correlation with clay content and lack of relationship with the organic matter indicate a greater contribution of total Cu from the mineral component composed to that of the organic fraction of the soil (Udo, 1979).

In this study, it appears all the soils(using only surface soil values) would be regarded as being Fe, Zn, Mn and Cu sufficient. The results, however, show that the wetland soils of MB, NK, NA were rich in Fe and Zn but less pronounced in Cu and Mn contents.

However, this study was limited to the inventory of total values of these micronutrients. Further work is necessary for the determination of extractable and critical levels of these micronutrients in the area of study.

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