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ASSESSMENT OF MICRONUTRIENT STATUS OF INLAND DEPRESSION AND FLOODPLAIN (WETLAND) SOILS IN AKWA IBOM STATE SOUTH-EASTERN NIGERIA

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ABSTRACT
The available micronutrients status of soils of two wetland types: inland depression (ID) and Floodplain (FP) were studied. Six representative soil profiles, three for each wetland type were dug, 13 and 14 soil samples, respectively were collected from each wetland type according to their genetic horizons, for laboratory analysis and interpretation. The result showed that Iron (Fe) content had a mean value of 142.62mg/kg for ID soils and 213.16mg/kg in FP soils. The mean values of manganese (Mn) were 7.43mg/kg for ID soils and 3.19 mg/kg for FP soils. Also, zinc (Zn) content had mean values of 8.50mg/kg for ID soils and 2.67mg/kg for FP soils, while copper (Cu) content had mean values, 4.30 and 2.20mg/kg for ID and FP soils, respectively. All the above values were higher than the critical values of 4.2, 0.2, 0.5 and 1.0mg/kg for Fe, Cu, Zn and Mn respectively. These excessively high values were also reflected in Fe: Mn ratio of 19.1 for ID soils and 67.5 for FP soils. Also t-test analysis showed that the content of Fe was significantly higher ($P \leq 0.05$) in FP than in ID soils, while Mn, Zn and Cu were higher in ID soils. The results of correlation analysis revealed that in ID soils, Fe, Mn, Zn and Cu had significant ($P \leq 0.05$) positive correlation with sand content (r = 0.55*, 0.58*, 0.58* and 0.64*, respectively) but negative and non-significant with clay fraction. In FP soils all the micronutrients correlated negatively with sand content but only Fe was significant with sand (r = 0.60*). Clay, on the other hand, correlated positively with Fe, Mn and Cu; and negatively with Zn, but only Fe was significant with clay (r = 0.65*).

Keywords: Micronutrients, inland depression, floodplain, wetland and southeastern Nigeria

INTRODUCTION

An essential nutrient is the nutrient without which the plant cannot complete its life cycle; its functions are primarily, that of transforming photo-energy into chemical energy (FAO, 1983) and of synthesizing a whole variety of substance which make living vegetable matter. These cannot be performed by a substitute. Micronutrients are part of these essential nutrients. Although they are needed in trace quantities, it does not affect their significance in plant nutrition. For instance, one atom of nickel would impair the biochemical advantages arising from the presence of 1,000,000 atom of nitrogen (Katyal, 2004).

This relationship among essential nutrients conforms to Leibig's law of minimum, which states that "Even if all but one of the essential nutrients is missing from the growth medium, a crop supplied with this will not be able to grow and the field may give a "barren look"

Fageria *et al*, (2002) in their review of micronutrients in crop production, maintained that micronutrient deficiencies in crop plants are widespread worldwide. They attributed this to the following:

(i) increased micronutrient demand for intensive cropping practices and adaptation demand of high yield cultivars which may have higher nutrients demand,
(ii) enhanced production of crops on marginal soils that contain low levels of essential nutrients,

(iii) increased use of high analysis fertilizer with low amount of nutrient contamination,
(iv) use of soils that are inherently low in micronutrients and reserves,
(v) decreased use of animal manure, compost and crop residues,
(vi) involvement of natural and anthropogenic factors that limit adequate plant availability and create element imbalance,

Wetland soils show high complexity in their chemical properties which are major determinants of nutrient status of soils (Udo *et al*, 2006). In soils with low pH, many elements such as zinc, aluminium and manganese may be present in toxic levels while basic cations such as calcium and potassium are fixed in such conditions.

According to Dar (2004), there is need for monitoring the micronutrient status through analysis of soils and plant tissues in farmers' fields. Farmers are unaware of hidden hunger and there is an urgent need to ensure that each farmer knows the health of the soil in order to ensure the development of agriculture.

The objective of this study, therefore, was to assess the micronutrient status of soils of two wetland types – inland depression and floodplain in south eastern Nigeria. This is with a view to optimizing the productivity of these soils for agricultural production.

MATERIALS AND METHODS

This study was conducted in Akwa Ibom State in southeastern Nigeria. The area lies between latitude 4°30' and 5°30'N and longitude 7°30' and 8°20'E in the rainforest zone, with a mean annual rainfall of over 3000 mm. Temperature values are relatively high, with the mean annual temperature varying between 26 and 28°C.

The soils are mainly formed from coastal plain sands and alluvial deposits. Six representative soil profiles, three each for inland depression and floodplain soils, were used. Samples were collected according to their genetic horizons. The samples were air-dried, sieved (< 2mm) and used for laboratory analysis

- Particle size analysis was determined by the hydrometer method of Bouyoucous (1951) using calgon as a dispersing agent as described by Day (1965).
- Soil pH was determined in water (1:1 soil – water suspension) using pH meter with glass electrode.
- Exchangeable cations were extracted with neutral NH_4OAC. Calcium and magnesium were determined in the extract by EDTA titration of Jackson (1962) and potassium and sodium by the use of flame photometer.
- Exchangeable acidity was extracted with 1N KCl solution and titrated with 0.05N NaOH.
- Organic carbon was determined by the dichromate wet oxidation method of Walkey and Black (1934).
- Available phosphorus was determined by Bray-1 method of Bray and Kurtz (1945).
- Available micronutrients (Fe, Mn, Zn, and Cu) were extracted with 0.1N HCl, and determined by the use of Atomic Absorption Spectrophotometer.

RESULTS AND DISCUSSION

The results of laboratory analyses of soil samples used for the study are shown in Tables 1 and 2. Particle size analysis showed that for the ID profiles, clay content generally increased while sand fraction decreased with depth and silt fraction was irregularly distributed. The result also showed that in profiles representing ID soils, most surface horizons were coarse textured (sand and loamy sand) while the subsoils were fine textured (sandy clay loam and sandy clay, Table 1). In contrast, soils of the FP wetland type were all coarse textured (sand and loamy sand) at the surface and sub-soils (Table 2). Obi (1984) had observed similar result elsewhere and noted that soils of the floodplain showed texture patterns that differed because of differences in parent materials and mode of deposition of the sediments.

The pH of all the soils were acidic, irrespective of the wetland type. Values ranged between 4.24 and 5.20 and between 4.16 and 5.20 for ID and FP soils, respectively. According to Enwezor et al, (1989) rating, organic matter content in the topsoil ranged from high (3.53%) to medium (2.23%) in FP soils while the values at similar depths in the ID soils were all high. Available P ranged between high, and low (below critical level) in the surface soils of both wetland types. For the ID soils, values ranged between 41.00 and 7.33mg/kg, while FP had values ranging between 29.99 and 3.33mg/kg, for the high and low ratings, respectively.

Table 1: Some Characteristics of Inland Depression soils

	Horizon Depth (cm)	Sand	Silt	Clay	pH	Org. C	TN	Av.P	EA	ECEC	BS	Fe	Mn	Zn	Cu	Textural Class
		← %				← % →		mg/kg	Cmol/kg		%	← mg/lkg →				
ID_1	0 – 18	89.5	2.0	8.5	4.80	4.26	0.06	24.32	1.92	1.92	66.0	284.39	11.60	14.30	8.40	S
	18 – 27	76.5	3.0	20.5	4.90	2.53	0.05	30.40	3.52	3.52	52.1	241.44	9.20	15.10	7.58	SL
	27 – 50	75.5	2.0	22.5	5.10	1.73	0.04	21.16	2.76	5.90	53.2	134.27	12.00	12.00	5.39	SCL
	50 – 69	71.5	4.0	24.5	5.20	1.70	0.03	40.00	2.60	7.04	63.1	259.	7.40	12.08	5.01	SCL
	69 – 88	70.5	2.0	26.5	5.20	1.42	0.02	37.80	2.40	6.48	61.7	230.18	3.40	11.60	4.93	SCL
	88 – 158	67.5	4.0	28.5	4.80	1.38	0.02	38.76	3.80	7.90	51.9	134.27	4.88	8.44	5.53	SCL
	Mean	78.1	2.8	21.8	5.00	2.16	0.04	32.07	2.85	6.72	58.0	213.99	8.58	12.25	6.14	
ID_2	0-17	87.5	4.7	7.8	4.90	4.81	0.06	41.00	2.24	5.27	57.5	102.58	6.70	8.11	5.03	S
	17-49	75.5	4.7	19.8	4.90	2.94	0.05	31.32	3.84	7.74	50.4	100.49	10.10	12.20	5.17	SL
	49-77	77.5	2.7	21.8	4.80	1.87	0.04	36.44	4.00	7.89	49.3	166.80	10.16	9.89	5.09	SCL
	77-120	77.5	2.7	19.8	4.80	1.73	0.04	37.68	3.04	6.14	50.5	130.94	9.72	3.86	5.05	SCL
	Mean	78.5	4.3	17.3	4.64	2.84	0.05	36.61	3.28	6.76	51.5	125.20	9.17	8.52	5.05	
ID_3	0-11	70.0	10.2	19.7	4.92	5.19	0.08	7.33	2.08	5.81	64.5	26.28	4.50	3.09	0.44	SCL
	11-20	64.0	10.2	25.7	4.53	2.91	0.05	7.99	2.08	5.87	64.6	127.14	1.80	1.45	0.03	SCL
	20-51	60.0	6.2	35.7	4.26	1.89	0.01	10.16	1.33	4.24	68.6	30.23	5.70	2.33	3.39	SCL
	51-83	50.7	8.0	39.8	4.24	1.19	0.01	7.33	1.30	4.23	68.2	28.44	6.89	4.49	2.43	SC
	Mean	60.2	8.7	30.2	4.24	2.80	0.04	8.21	1.70	5.04	66.4	53.02	4.72	2.84	1.57	
ID	**Mean**	**71.84**	**5.19**	**22.93**	**4.81**	**2.54**	**0.04**	**26.59**	**2.45**	**5.71**	**58.16**	**142.63**	**7.43**	**8.50**	**4.53**	

S = Sand; SCL = Sandy clay loam; SL = Sandy loam; SC = Sandy clay

Table 2: Some Characteristics of Floodplain soils

	Horizon Depth (cm)	Sand	Silt	Clay	pH	Org. C	TN	Av.P	EA	ECEC	BS	Fe	Mn	Zn	Cu	Textural Class
		← % →				→	%	mg/kg	Cmol/kg		%	← Mg/lkg →				
FP_1	0-15	88.8	5.9	5.2	4.81	3.53	0.09	21.99	2.08	6.37	67.4	191.82	4.34	1.33	0.82	S
	15-23	88.8	5.9	5.2	5.10	1.31	0.04	22.66	3.36	8.30	59.5	200.16	0.75	0.05	0.76	S
	23-34	94.8	2.6	2.6	5.76	1.93	0.03	9.33	1.76	4.81	63.4	204.33	0.61	1.19	0.29	S
	34-50	88.8	5.9	5.2	5.63	1.00	0.03	9.33	1.80	8.81	79.6	208.50	1.07	4.12	3.54	S
	50-68	88.8	7.9	7.2	5.70	0.99	0.03	26.60	3.04	9.26	67.2	204.35	1.12	1.29	0.89	S
	Mean	89.8	5.7	5.1	5.40	1.61	0.04	13.73	2.41	6.27	67.4	201.83	1.58	1.60	1.26	
FP_2	0-18	84.8	7.9	7.2	5.40	2.25	0.07	3.33	19.8	23.85	16.8	216.44	4.20	1.27	1.32	S
	18-39	76.8	9.9	13.2	4.16	2.21	0.06	7.33	26.60	29.80	10.7	225.18	1.26	0.29	1.69	LS
	39-87	70.8	11.9	17.2	4.20	2.11	0.05	2.66	26.00	30.90	16.1	233.52	1.01	0.61	1.45	SL
	87-198	82.8	7.7	9.2	4.36	1.97	0.06	5.33	21.80	23.91	8.8	250.20	1.24	1.54	1.17	LS
	Mean	78.8	9.4	11.7	4.49	2.15	0.06	4.66	23.70	27.14	13.1	231.34	1.93	0.54	1.17	
FP_3	0-14	86.8	5.9	7.2	4.73	3.32	0.10	29.99	4.00	7.62	47.6	208.50	5.13	5.54	1.43	S
	14-32	82.8	9.9	7.2	4.52	1.64	0.04	30.66	4.80	9.55	49.7	206.20	6.88	7.55	2.35	LS
	32-57	88.8	5.9	5.2	4.53	3.01	0.09	39.99	4.80	8.48	43.4	209.20	4.60	3.15	2.34	S
	57-96	76.8	11.9	11.2	4.62	3.75	0.10	70.66	5.40	8.99	38.3	212.67	9.21	6.81	10.57	LS
	Mean	83.8	8.4	7.7	4.60	2.94	0.08	42.91	4.79	8.66	44.7	209.14	6.46	5.76	4.17	
FP	**Mean**	**84.38**	**7.68**	**7.94**	**4.88**	**2.02**	**0.06**	**20.66**	**9.69**	**13.23**	**43.72**	**213.16**	**3.19**	**2.67**	**2.20**	

S = Sand; SCL = Sandy clay loam; SL = Sandy loam; SC = Sandy clay; LS = Loamy Sand

Generally, soil available micronutrients (Fe, Mn, Zn and Cu) were high in all the soils irrespective of the wetland type. The average values for Fe in the three ID soils examined were 213.90, 125.20 and 53.02mg/kg for ID_1, ID_2 and ID_3, respectively. These were extremely high compared to the critical values (4.5mg/kg; Viets and Linsay, 1973). Similarly, for FP, the mean values were 201.8, 231.30 and 209.10mg/kg for FP_1, FP_2 and FP_3 respectively. However, the overall mean value (213.20mg/kg) of available Fe in FP was significantly ($P \leq 0.05$) higher than (140.60mg/kg) in ID soils (Table 3). For Mn, the average values for ID (1,2,3) soils, were 8.58, 9.70, and 4.70mg/kg, respectively whereas for FP (1,2,3) soils the average values were 1.6, 1.9 and 6.5mg/kg, respectively. These were all in excess of the critical value (1.0mg/kg). Comparing the two wetland types, t-test analysis showed that the overall mean value (7.4mg/kg) of Mn in ID soils was significantly ($P \leq 0.05$) higher than (3.2mg/kg) in FP soils (Table 3).

Furthermore, the average values of available Zn for ID soils were 12.3, 8.5 and 2.8mg/kg for $ID_{(1,2,3)}$, respectively; while values for FP (1,2,3) were 1.6, 0.5 and 5.8mg/kg, respectively. Except for FP_2 (0.5mg/kg) all the soils had values higher than the critical level (0.5mg/kg). Comparing ID and FP mean Zn values showed that ID (8.5mg/kg) was significantly ($P \leq 0.05$) higher than FP mean value (2.7mg/kg).

For Cu, ID values were 6.1, 5.1 and 1.6mg/kg, respectively for $ID_{(1,2,3)}$; while values for $FP_{(1,2,3)}$, respectively were 1.3, 1.2 and 4.2mg/kg. As in the cases of Mn and Zn, the mean value (4.5mg/kg) for available Cu in ID soils was significantly higher than that of the FP soils, and they were all in excess of the critical level (0.2mg/kg).

Correlation analysis (Tables 4 and 5) showed that pH significantly ($P \leq 0.05$) correlated with Fe and Zn in ID soils, but not significant in FP soils. Also, available P significantly correlated with all the micronutrients in ID soils except Mn, whereas in FP soils it had significant correlation with all the nutrients except Fe. Organic matter content showed negative but non-significant correlation with all the micronutrients in ID soils, whereas in FP soils it had negative but significant correlation with Mn and positive but non-significant correlation with Fe, Zn and Cu. All the micronutrients in ID soils had positive, significant correlation (Fe, 0.55; Mn, 0.58; Zn, 0.58 and Cu, 0.64) with sand fraction but negative and non-significant correlation with silt and clay fractions. On the other hand in FP soils, Fe had significant negative correlation (-0.60) with sand and (0.65) with clay fractions. Other micronutrients had non-significant (positive or negative) correlation with all the particle sizes.

Table 3: T-test for the Equality of means of soil properties between Inland Depression and Floodplain

Soil Properties		ID mean	FP mean	Remark
pH		4.81	4.88	NS
Org. C	(%)	1.47	1.17	NS
TN	(%)	0.04	0.06	NS
Av.P	(mg/kg)	26.59	20.66	NS
ECEC	(cmol/kg)	5.71	13.23	S
EA	(cmol/kg)	2.45	9.69	S
Fe	(mg/kg)	142.63	213.16	S
Mn	"	7.43	3.19	S
Zn	"	8.50	2.67	S
Cu	"	4.53	2.20	S
Sand	(%)	71.84	84.38	S
Silt	(%)	5.19	7.68	S
Clay	(%)	22.93	7.94	S

Key:
NS – Non-significant (P ≤ 0.05)
S – Significant (P ≤ 0.05)

Table 4: Correlation between selected soil properties in inland depression

	Fe	Mn	Zn	Cu	pH	Av.P	ECEC	Org. C	Sand	Silt	Clay
Fe	1.00										
Mn	.30	1.00									
Zn	.77*	.58*	1.00								
Cu	.70*	.70*	.84*	1.00							
pH	.60*	.21	.65*	.40	1.00						
Av.P	.57*	.28	.57*	.66*	.64*	1.00					
ECEC	-.13	-.18	-.39	-.22	.36	.43	1.00				
Org. C	-.20	-.03	-.04	-.11	.11	-.17	-.33	1.00			
Sand	.55*	.58*	.58*	.64*	.59*	.59*	-.11	.52	1.00		
Silt	-.33	-.43	-.49	-.47	-68*	-.39	-0.5	-.23	-.58*	1.00	
Clay	-.43	-.40	-.43	-.45	-.53	-.43	-.15	-.72*	-.96*	.48	1.00

* Significant (P ≤ 0.05)

Table 5: Correlation between selected soil properties in floodplain

	Fe	Mn	Zn	Cu	pH	Av.P	ECEC	Org. C	Sand	Silt	Clay
Fe	1.00										
Mn	-.04	1.00									
Zn	-.19	.80*	1.00								
Cu	-.18	.68*	.63	1.00							
pH	.39	-.29	0.08	-.01	1.00						
Av.P	.19	.67*	.67*	.76*	.19	1.00					
ECEC	.18	-.30	-.43	-.14	-.63*	-.55	1.00				
Org. C	-.04	.71*	.33	.45	-.36	.54	-.04	1.00			
Sand	-.60*	-.17	-.05	-.38	.41	-.05	-.73*	-.23	1.00		
Silt	.45	.37	.24	.24	-.41	.24	.58*	.25	-95*	1.00	
Clay	.65*	.02	-.80	.26	-.38	-.08	.79*	.21	-.98*	.87*	1.00

* Significant (P ≤ 0.05)

Profile Distribution of Micronutrients

Figures 1 and 2 show the profile distribution of Fe, Mn, Zn and Cu in ID and FP soils, respectively. In ID profile, available Fe increased from 137.75mg/kg in the A horizon to 174.11mg/kg in the B horizon and then decreased to 98.88mg/kg in the C horizon. In FP profile the available Fe content consistently increased from 206.98mg/kg in the A – to 214.51mg/kg in the B- to 222.40mg/kg in the C horizon. In both ID and FP wetland types, available Mn initially decreased from A to B horizon and rose again in the C horizon. Available Zn consistently decreased with depth in ID profile while the opposite was the case in FP soils. For available Cu in the ID profile, it increased from 4.62 in A horizon to 4.85mg/kg in the B horizon and decreased to 4.34mg/kg in the C horizon, while it consistently increased in the FP profile from 1.18 to 1.95 to 4.21mg/kg in A, B and C horizons, respectively.

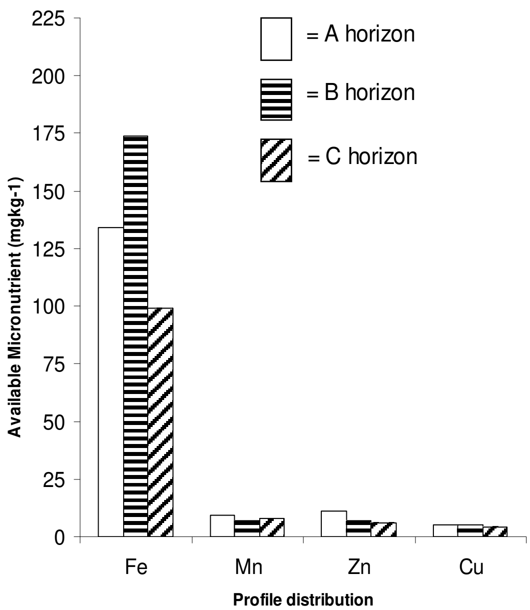

Fig. 1: Profile distribution of available Micronutrients (Fe, Mn, Zn and Cu) in Inland Depression Soils

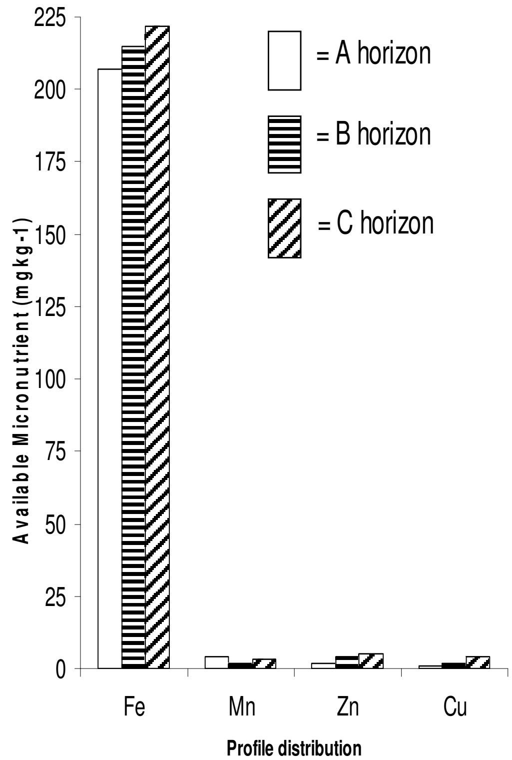

Fig. 2: Profile distribution of available Micronutrients (Fe, Mn, Zn and Cu) in Flooodplain Soils

This result has shown that available Fe is not only in excess in the wetland soils studied but also have higher concentration in the B- than the A-horizons. It has been observed that a widespread problem for rice production in regions with acid soils is iron toxicity (Somasiri, 1991). At low nutrient levels, even 30 mg Fe^{2+} may be toxic (Moormann and Van Breemen, 1978). This result has shown that in irrigated rice project, where land preparation is a major exercise, there is a tendency to further increase the already excess available Fe by removing the topsoil and exposing the subsoil. This observation has shown that in inland depression and floodplain soils in the area of study, and similar locations under acid sands of southern Nigeria (Udo and Sobulo, 1981; Akpan, 2005), micronutrient toxicities may play a major role in the reduction of crop yields

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