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Fertility Evaluation of Some Wetland Soils for Rice Cultivation in the Coastal Plains Sand, Imo State, Nigeria

*Ukaegbu, E.P., Osuaku, S.K., Nnawuihe, C.O. and Irebuisi, D.C.

Department of Agricultural Science, Alvan Ikoku Federal College of Education, Owerri, Imo State, Nigeria

**Corresponding Author's Email: emekaprosper2@yahoo.com*

Abstract

Underutilization of wetland soils of the coastal plain sand of Imo State, occupying 61,223ha of land, necessitated this study which aim was to characterize the soils and evaluate their fertility for rice cultivation. High soil moisture content, even in the dry season, high base and available-P contents of the soils were their main potentials. On the other hand, high acidity, high and toxic concentrations of Fe and Mn, low CEC, low K and N were their main fertility constraints believed to hinder cultivation of the soils by small holder farmers. The contents of the parameters at surface soil are, BS, 48-85%; av.P, 14.6-110.0 mg/kg; p^H, 4-5.9; Fe, 0-233 mg/kg; Mn, 0.7-145.6 mg/kg; ECEC, 2.3-15.0 Cmol/kg; exch.k, 0.07-0.17 Cmol/kg; TN, 0.04-0.15 g/kg. Liming, planting rice varieties tolerant of Fe toxicity and N-fixing trees are some control measures noted. It is recommended that government should clear the fields, characterize the soils in detail, control water and provide appropriate management technology for cultivation of rice in the area, so as to facilitate the cultivation of the soils by small holder farmers.

Keywords: Coastal plains sand, evaluation, fertility, rice cultivation, wetlands.

1. Introduction

Wetland refers to land often situated in low-lying topography that is under the influence of water. Ojanuga, Okusami and Lekwa (1996) define it as land that is in a large part of it permanently or seasonally flooded for a considerable period of the year and that normally supports hydrophilic plants and animals. Such land has been recorded by Ojanuga, Okusami and Lekwa (2003) to be found all over Nigeria.

The wetland soils are noted to have great agricultural potentials. Akamigbo (2001) recorded the wetlands in the forest zone of Nigeria to be used for gathering of forest products, early cropping of maize in the planting season, cultivation of yam, cowpea, rice and vegetables. He however observed their underutilization in humid tropical Africa as compared with similar land that forms the backbone of food production in south and southeast Asia. Similarly, Moormann and Van Breeman (1978) noted that use of soils of wetlands is limited in areas where rice is not a major or even a minor food crop. Reasons adduced for such underutilization include prevalence of schstosomiasis and other waterborne diseases, high technical input required to control excess water, low soil pH and associated problems of low available phosphorus, high Al-saturation, Fe and Mn toxicity etc

(Ahukaemere, Eshette, Ahiwe, 2014; Akamigbo, 2001; Moormann and Van Breeman, 1978; Onyekwere, Akpan-Idiok, Amalu, Asawalam & Eze, 2001).

The wetland Soils of the coastal plains sand of Imo State are underutilized. This is most evident by the fact that no part of the location is cultivated to rice. The relative high moisture content notwithstanding, the soils rarely get cultivated in the dry season. With the current Federal Government of Nigeria policy to encourage local rice production so as to discourage imports and save ‘Foreign exchange’, it has become necessary that all cultivable wetlands in Nigeria should be put to profitable use. This requires characterizing the lands/soils for their efficient management, as Ojanuga *et al.* (1996) had recognized a general lack of exact data on their location, size and characteristics. The characterization of soils of the area has been in general terms.

This study evaluates fertility of wetland soils of coastal plains sand of Imo State. Specifically, it aims at highlighting the fertility potentials as well as limitations of the soils that need to be considered for their effective management for rice cultivation.

2. Materials and Methods

2.1. Study Area

The coastal plains sand of Imo State lies within Lat. $5^{0}15^{I}$N and $5^{0}45^{I}$N; Long. $7^{0}30^{I}$E and $6^{0}45^{I}$E. It has a population of 1,806,369, on area of 3,401.29km^{2} and average population density of 1,206 persons per km^{2} (Ukaegbu, 2014). Ofomata (1975) records the location to be in the lowland humid tropics, with rainforest vegetation and having coastal plains sand as its dominant geology. Total annual rainfall is 2,250-2500mm, having 3 dry months; with temperatures that are high all though the year. Vegetation is dominated by Oilpalms *(Elaeis guineensis)* and *Pennisetum* grass species. The wetland soils of the location of study are classified as Typic Tropaquuepts (Gleyic Cambisol) (FDALR, 1985).

The figure below is digitized geomorphology map of old Imo State, showing location of study delineated with red lines. Floodplains studied are indicated within the unit.

2.2. Field study

Some of the floodplains in the location of study were identified and sites were chosen for digging of profile pits. The sites were geo-referenced with a handheld Global positioning System (GPS). Profile pits were dug to characterize the soils. The pits were sited by the major rivers in the location of study, namely Imo, Oramiriukwa, Okatankwo, Nworie, Otamiri, Orashi, Ngbele. Profiles were described using FAO (2006) guidelines. Soil samples were taken from the horizons of the pits. Auger samples were collected from surface soils (0 – 20cm) of nearby sites to the pits and some that were far off to extend area coverage of sampling. The auger samples were specifically for the determination of contents of micro-nutrient elements.

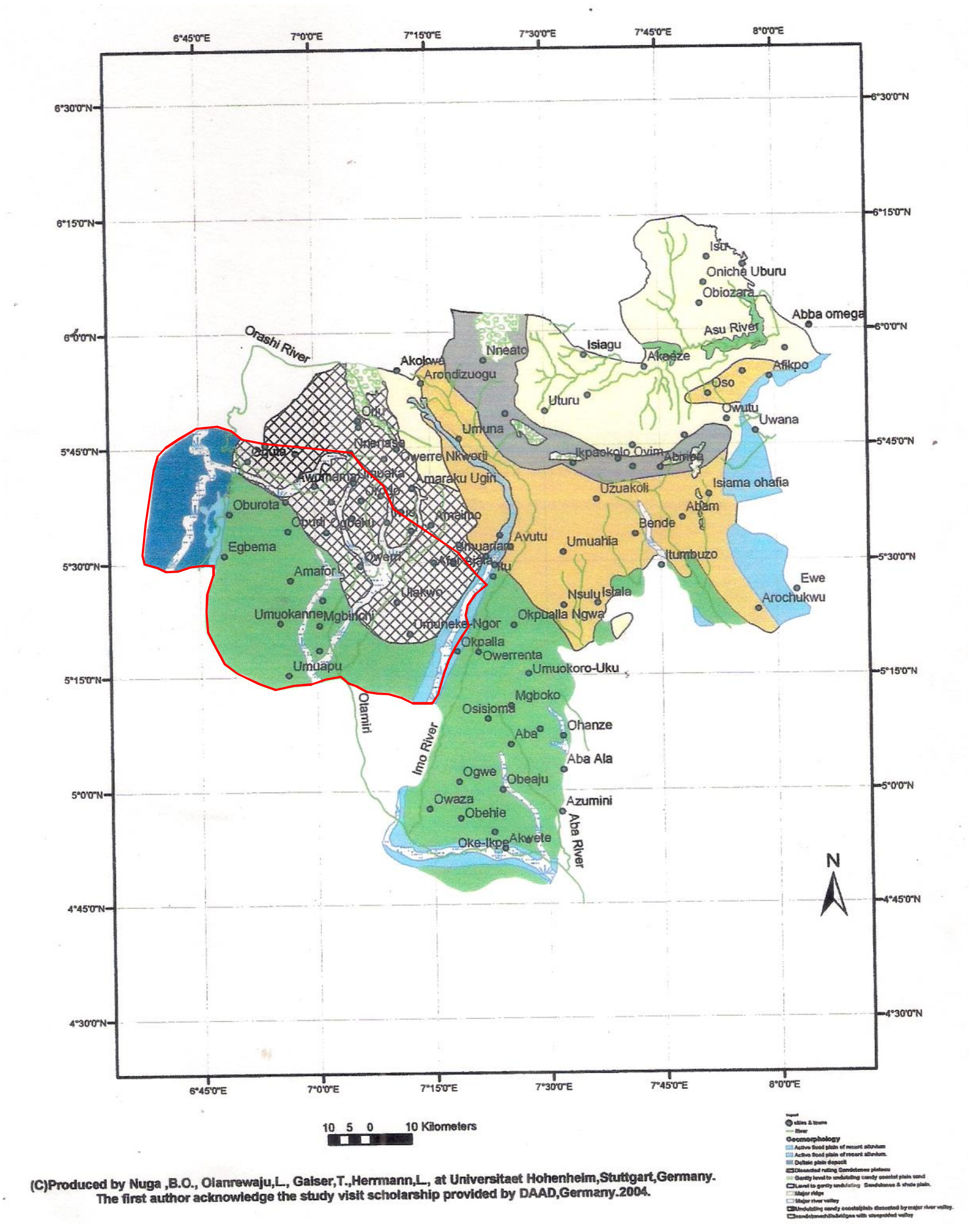

Figure 1. Digitized Geomorphology Map of Old Imo State showing location of study delineated with red lines.

Table 1: Descriptions of Sites Sampled

Profile No	Site/LGA	River	Lat.	Long.	Altitude (ht above sea level)	Slope	Land Use
1.	Olokwu Owerri-West	Otamiri	$5^{0}19^{I}$ 35.2^{II}N	$6^{0}58^{I}$ 17.3^{II}E	28m	1%	Riparian Forest, Oil palm & Rubber Plantations, cassava, maize
2.	Ngbele Oguta	Ngbele	$5^{0}40^{I}$ 52.5^{II}N	$6^{0}51^{I}$ 20.1^{II}E	33m	4%	Riparian forest, Rubber Plantation
3.	Itu Ezinihitte-Mbaise	Mpete Onumiri	$5^{0}27^{I}$ 5.2^{II}N	$7^{0}20^{I}$ 53.8^{II}E	54m	1%	Riparian forest, cassava
4.	Azaraegbu Owerri-North	Oramiriukwa	$5^{0}29^{I}$ 30.5^{II}N	$7^{0}8^{I}$ 24.1^{II}E	70m	1%	Riparian forest, maize, vegetable
5.	Amuzu Aboh-Mbaise	Imo	$5^{0}22^{I}$ 5.4^{II}N	$7^{0}18^{I}$ 56.6^{II}E	42m	0.5%	Raffia, cassava, yam
6.	Opuoma Ohaji/Egbema	Orashi	$5^{0}33^{I}$ 52.1^{II}N	$6^{0}43^{I}$ 57.6^{II}E	18m	0.5%	Cassava field.

Table 1 gives details of descriptions of the sites. The altitudes vary from 18m to 70m above sea level, while slopes range from 0.5% to 4%. Table 1 also captures Land uses at the sites of study which were Riparian forest, Oil palm-, Raffia-, Rubber-plantations, and Arable (Cassava, Maize, Yam, Vegetable) cultivation.

2.3. Laboratory analyses

Soil samples were air-dried and sieved with a sieve of 2-mm mesh size. By standard procedures as documented by Udo *et al*. (2009) the samples were analysed for the following parameters: particle sizes, pH, organic carbon/organic matter, total nitrogen, available-P, exch. Bases, exch. Acidity, effective cation exchange capacity (ECEC), base saturation. Extractable contents of micronutrients (Fe, Cu, Zn, Mn) were determined using Atomic absorption spectrometry.

2.4. Evaluation Procedure

Generally, parameters are related to their critical values as documented in literature. But, soils were classified according to the fertility capability soil classification (FCC) system of Sanchez *et al.* (1982). Results of laboratory analyses of samples from pits were used for the soils' fertility capability classification. The conversion data as documented by Sanchez *et al.* (1982) consist of three categorical levels, 'type' (texture of plough layer or top 20cm), 'substrata type' (texture of subsoils), and 'modifiers' (soil properties or conditions which act as constraints to crop performance). The FCC units are determined by combining class designations from the three categorical levels. However, only data relevant for evaluation are presented.

3. Results and Discussion

The area of the coastal plains sand of Imo State is 3,401.29km^2, 18% of which (612.23km^2 or 61,223ha) is wet land. Flood plains are found by the banks of the major rivers as indicated in table 1. While the well drained soils are intensively cultivated, the wetlands are not. Field investigation shows they are subjected to different land uses namely, Riparian forests, Plantations of Oil palm, Rafia palm, Rubber, and Arable cultivation – cassava, yam, maize and vegetables. Non cultivation of rice as well as their (wetland) non-cultivation in the dry season underscore their underutilization. Improving usage of the wetlands requires characterization of the soils. The morphological characteristics of soils are as given in Table 2.

The morphology of soils reflects influence of water as they are generally poorly drained. This is reflected by soils' moist colours which include Reddish gray (10R$^5/_1$), Reddish brown (5YR$^4/_6$), Brownish black (5YR$^2/_1$) etc at topsoil, while Brown (7.5YR$^4/_3$), Grayish brown (7.5YR$^4/_2$), Grayish yellow brown (10YR$^5/_2$) etc at subsoil. However, due to the sandy nature of soils, faint mottling was observed mainly at subsoils of some of the profiles. Fibrous root mats were observed at some of the sites. Profile distributions of textures (e.g. Profiles 2&5) indicated lithologic discontinuities associated with floodplains. The structures of soils ranged from granular to crumb at topsoil, which changed to mainly weak medium subangular blocky at the subsoil. The consistence (moist) at topsoil varied from loose/friable to slightly sticky and plastic, while at the subsoil it is dominantly firm, slightly sticky and plastic.

Table 2: Morphological Descriptions of the soils

Profile No/Location	Horizon Depth (cm)	Colour (Moist)	Mottling	Texture	Structure	Consistence (Moist)	Cutans (clay skins)	Roots	Boundary	Drainage
1. Olokwu	0-13	10R$^{5}/_{1}$	N	S	WE, FI, GR	LO, NST, NPL	-	F, M	C, S	Poor esp. at subsoil
	13-57	7.5YR$^{3}/_{2}$	N	S	WE, FI, GR	LO, NST, NPL	-	F, F	A, S	
	57-72	7.5YR$^{3}/_{2}$	N	S	MO, ME, SB	FI, NST, NPL	P, T	-	D, S	
	72-92/3	7.5YR$^{4}/_{2}$	N	S	MO, ME, SB	FI, NST, NPL	-	-	-	
2. Ngbele	0-10	5YR$^{4}/_{6}$	N	S	WE, FI, GR	LO, NST, NPL	-	F, M	A, S	Poor esp. at subsoil
	10-17	2.5YR$^{4}/_{6}$	N	LS	MO, ME, SB	FI, SST, SPL	P, T	F, F	C, S	
	17-34	2.5YR$^{4}/_{8}$	N	LS	MO, ME, SB	FI, SST, SPL	P, T	F, F	D, S	
	34-55	2.5YR$^{4}/_{8}$	N	S	WE, FI, GR	LO, NST, NPL	-	F, F	C, S	
	55-80	10YR$^{4}/_{4}$	N	S	WE, FI, GR	LO, NST, NPL	-	F, F	-	
3. Itu	0-17	7.5YR$^{4}/_{3}$	N	SL	MS, ME, CR	FI, ST, PL	-	F, C	C, W	Poor
	17-48	7.5YR$^{4}/_{4}$	N	SL	ST, ME, SB	VFI, ST, PL	B, MT	F, F	C, S	
	48-80	10YR$^{5}/_{3}$	C, M, D	SL	ST, ME, SB	VFI, ST, PL	B, MT	-	-	
4. Azaraegbelu	0-40	5YR$^{2}/_{1}$	N	SL	WM, FI, CR	FR, NST, NPL	-	F, M	C, I	
	40-63	7.5YR$^{4}/_{2}$	N	LS	WE, FI, CR	LO, NST, NPL	-	F, C	A, W	
	63-83	7.5YR$^{4}/_{2}$	F, F, F	LS	WE, FI, GR	LO, NST, NPL	-	F, F	-	
5. Amuzu	0-35	7.5YR$^{4}/_{2}$	C, M, D	CL	ST, ME, SB	VFI, ST, PL	-	F, M	C, S	Poor
	35-70	7.5YR$^{4}/_{2}$	C, M, D	SiCL	ST, ME, SB	VFI, ST, PL	-	F, F	D, S	
	70-96	5YR^{5}/1	C, M, D	SL	WE, ME, SB	FR, NST, NPL	-	F, F	D, S	
	96-140	7.5YR$^{5}/_{2}$	C, M, D	SL	WM, ME, SB	FR, NST, NPL	-	-	A, S	
	140-160	10YR$^{5}/_{2}$	C, M, D	SL	WE, ME, SB	FI, ST, PL	-	-	-	
6. Opuoma	0-23	7.5YR$^{3}/_{2}$	N	SL	MO, ME, CR	FR, SST, SPL	-	FM, M	C, S	Poor esp. at subsoil
	23-55	2.5YR$^{3}/_{3}$	N	SL	MO, ME, SB	FI, ST, SPL	T, P	FM, F	C, S	
	55-95	2.5YR$^{3}/_{4}$	N	SCL	ST, ME, SB	FI, ST, SPL	T, P	-	G, S	
	95-136	2.5YR$^{3}/_{4}$	F, F, F	SCL	ST, ME, SB	FI, ST, SPL	T, B	-	D, S	
	136-180	2.5YR$^{3}/_{6}$	M, F, F	SCL	ST, ME, SB	FI, ST, SPL	-	-		

KEY:

- **Mottling.** Abundance: N = None; M = Many; C = Common; F = Few. Size: M = Medium; F = Fine. Contrast: D = Distinct; P = Prominent; F = Faint.
- **Texture.** S = Sand; LS = Loamy Sand; SL = Sandy loam; SCL = Sandy clay loam; SiL = Silt loam; SiCL = Silty clay loam; CL = Clay loam; L = Loam; SC = Sandy clay; SiC = Silty clay; C = Clay.
- **Structure.** Grade: WE = Weak; VWE = Very weak; MO = Moderate; ST = Strong; MS = Moderate to strong. Size: FI = Fine/thin; ME = Medium; CO = Coarse/thick; FM = Fine and medium; MC = Medium and coarse. Type: BL = Blocky; AB = Angular blocky; SB = Sub angular blocky; GR = Granular; CR = Crumbly.
- **Consistence.** Moist: FR = Friable; LO = Loose; FI = Firm; VFI = Very firm; FRF = Friable to firm. Stickiness: SST = Slightly sticky; ST = Sticky; VST = Very sticky; NST = Non-sticky; SVS = Sticky to very sticky. Plasticity: NPL = Non-plastic; SPL = Slightly plastic; PL = Plastic; SPP = Slightly plastic to plastic.
- **Cutans (Clay Skins).** Quantity: P = Patchy; B = Broken; C = Continuous. Thickness: T = Thin; MT = Moderately thick; Th = Thick.
- **Roots.** Diameter: F = Fine; FM = Fine and Medium. Abundance: C = Common; M = Many; F = Few; VM = Very many; VF = Very few.
- **Boundary.** Distinctness: A = Abrupt; C = Clear; G = Gradual; D = Diffuse. Topography: S = Smooth; W = Wavy; I = Irregular.

The physical and chemical properties of soils are as presented in Table 3 below.

Table 3: Selected Physical and Chemical Properties of Soil

Profile No./Location	Horizon Depth (cm)	Sand (%)	Silt (%)	Clay (%)	Texture	pH	Org. C. g/kg	TN g/kg	av.P mg/kg	Exch. K Cmol/kg	ECEC Cmol/kg	BS (%)
1. Olokwu	0-13	94	2	4	S	5.3	0.9	0.15	51.0	0.09	2.3	76
	13-57	94	2	4	S	5.7	0.45	0.06	40.0	0.07	5.9	97
2. Ngbele	0-10	90	4	6	S	5.0	0.41	0.05	110.0	0.15	3.1	85
	10-17	86	2	12	LS	4.6	0.34	0.04	68.0	0.07	4.1	81
	17-34	87	3	10	LS	5.2	0.15	0.05	94.0	0.05	8.4	92
	34-55	90	2	8	S	5.2	0.30	0.06	90.0	0.38	2.8	89
3. Itu	0-17	71	15	14	SL	4.0	0.9	0.13	90.0	0.17	8.8	48
	17-48	56	20	24	SL	4.9	0.64	0.11	68.0	0.14	8.4	36
4. Azaraegbelu	0-40	76	17	7	SL	4.6	0.84	0.04	41.0	0.08	5.9	73
	40-63	86	7	7	LS	4.6	0.48	0.07	26.0	0.07	5.3	80
5. Amuzu	0-35	26	37	37	CL	4.9	0.84	0.05	14.6	0.14	15.0	50
	35-70	22	52	26	SiCL	4.8	0.64	0.16	110.0	0.17	12.7	40
6. Opuoma	0-23	76	13	11	SL	5.9	0.84	0.08	69.0	0.07	3.7	50
	23-55	68	13	19	SL	4.7	0.23	0.10	12.0	0.06	5.2	65

The documented dominance of sand in textures of soils of area of study was also found. At the topsoil the percentage of sand ranged from 26% (profile 5) to 94% for profile 1. Most ranged between 71% and 94%. At the subsurface, sand ranged between 56% and 94%. So, the soil textures at the topsoil are mainly sandy loam and sand. At the subsurface, the textures are sand, sandy loam, loamysand and silty clay loam. The soils' pH values ranged from 4.0 (profile 3) to 5.9 (profile 6) at the topsoil. While at the subsurface, the values are 4.6 (profiles 2) to 5.7 (profile 1). Organic carbon contents ranged from 0.41 g/kg to 0.90 g/kg at the topsoil. Total nitrogen contents ranged between 0.04 g/kg and 0.15 g/kg at the surface soils. Available phosphorus had values ranging from 14.6 mg/kg to 110 mg/kg at the surface soils. Exchangeable potassium had values at the surface soils ranging from 0.07 Cmol/kg to 0.17 Cmol/kg. The effective cation exchange capacity (ECEC) values at the surface soils ranged from 2.3 Cmol/kg to 15.0 Cmol/kg. Base saturation of surface soils are 48% to 85%.

Following the guides for interpretation as compiled by Adaikwu and Ali (2013): soil reaction at surface soils ranged from extremely acid to moderately acid. Using a critical value of 10 g/kg as low for OC, the parameter was low at all sites. With critical value of 2 g/kg as low, TN was low in all the soils. Having 15 mg/kg as low and >25 mg/kg as high, av.P was high in most of the soils with the exception of profile 5 which was 14.6 mg/kg. With 12 Cmol/kg as low for ECEC, the parameter was low for most of the soils, with the exception of profile 5 having a value of 15 Cmol/kg. Using the value of 40% as low, base saturation ranged from moderate to high for the soils.

Table 4 records extractable contents of micronutrient elements for the surface soils. Fe varied from 0 mg/kg (undetected) for site 4 to 207.3 mg/kg for site 2. Cu ranged from 0.1 mg/kg to 1.2 mg/kg. Zn ranged from 0.5 mg/kg to 14.0 mg/kg. Mn content varied from 0.7 mg/kg to 145.6 mg/kg.

Table 4: Micronutrient contents of Surface Soils

S/N	Location	Fe	Cu	Zn	Mn
			mg/kg		
1.	Nworie (Alvan)	60	1.2	3.1	5.3
2.	Okatankwo (Emekuku)	207.3	1.2	14.0	24.2
3.	Mpete (Itu)	112.1	0.1	1.1	17.3
4.	Otamiri (Olokwu)	0	0.1	0.5	0.7
5.	Mgbele (Oguta)	90.2	0.6	0.9	3.0
6.	Imo (Amuzu)	72.4	0.7	6.5	145.6
7.	Imo (Amuzu)	88.3	0.1	0.6	8.8
8.	Imo (Okpala)	233.0	0.4	1.6	4.9

With critical value of 4.5 mg/kg as low and 10 mg/kg as high (Kparmwang *et. al*, 2000), Fe was high in most of the soils, with the exception of site 4 where it was not detected. With a critical value of 0.2 mg/kg (Udo *et al.,* 1979), Cu ranged from low to high. Using a critical value of 0.8 mg/kg as low (Osiname *et al.,* 1973), Zn ranged from low to high. With a value of 1.0 mg/kg as low (Lindsay and Norvell, 1978), Mn ranged from low to very high. While Cu and Zn might have been deficient in some instances, Fe and Mn (to some extent) were rather found mostly in toxic concentrations.

Table 5: Classification of Soils into FCC units

Profile No	Type	Substrata Type	Condition Modifiers													
			g	d	e	a	h	i	x	v	k	b	s	n	c	FCC Unit
1.	S	-	+	-	+	-	+	-	-	-	+	-	-	-	-	Sgehk
2.	S	-	+	-	+	-	+	-	-	-	+	-	-	-	-	Sgehk
3.	L	-	+	-	+	+	-	-	-	-	-	-	-	-	-	Lgea
4.	L	S	+	-	+	+	-	-	-	-	+	-	-	-	-	LSgeak
5.	C	L	+	-	-	+	-	+	-	-	+	-	-	-	-	CLgaik
6.	L	-	+	-	+	-	+	-	-	-	+	-	-	-	-	Lgehk

Key:

S = Sandy,	a = aluminuim toxicity,	b = basic reaction
L = Loamy,	h = acidic,	s = salinity
C = Clayey,	i = high fixation of ‘P’ by iron,	n = nitric
g = gley,	x = x-ray amorphous,	c = cat clays
d = dry,	v = vertisols,	
e = low CEC,	k = k deficient,	

The fertility capability classification units for the soils (table 5) are, Sgehk (profiles 1&2), Lgea (profile 3), LSgeak (profile 4), CLgaik (profile 5, Lgehk (profile 6). Profiles 1 and 2 are sandy at the surface and subsurface. Profiles 3 and 6 are loamy at surface and subsurface. Profile 4 is loamy at surface but sandy at subsurface. Profile 5 is clayey at surface but loamy at subsurface. Interpretations, according to Sanchez *et al.* (1982) are: S, has high rate of infiltration and low water-holding capacity; L, has medium infiltration rate and thus good water-holding capacity; C, has low infiltration rate and good water-holding capacity. So, with the exception of profiles 1 and 2, the others have good textures for rice cultivation, as it requires much moisture.

The condition modifier 'g' was recorded in all the soils, which were either waterlogged at the time of sampling or had mottles ≤ 2 chroma. Quality indicates good soil moisture regime for rice production. Some of the soils have good soil moisture content even in the dry season. Ukaegbu and Onweremadu (2012) had recorded, at a site in Imo river floodplain (Lat. $5^{0}22^{I}$ 5.4^{II}N & Long. $7^{0}18^{I}$ 56.6^{II}E) by January (2/1/2007) at the peak of dry season, moisture content of 37.28% by weight at topsoil (0 – 25cm) and 39.73% at subsurface (25 – 50cm). This is greater than the moisture retained at field capacity (8.3% to 15.4% by weight) for some 'Acid sand' profiles as reported by Babalola and Obi (1981). This underscores the potentials of the soils, yet they are rarely cultivated in the dry season. On the other hand, this quality is a major reason for the low total nitrogen (TN) content of the soils. Osunde *et al.* (2001) noted that shallow ground water or flooding in inland valleys provide conditions for losses of N. They further noted leaching, volatilization and denitrification as the major path ways for N loss. This however is controlled by fertilizer application as well as incorporating into the floodplains N-fixing trees such as *Azolla spp* and *Sesbania spp*.

The condition modifier 'e' signifying low CEC was found in most soils with only the exception of profile 5. This implies low ability to retain nutrients, mainly K, Ca and Mg. The soils therefore would require heavy applications of these nutrients and N, which applications have to be split. There is also potential danger of over liming.

Half of the soils had 'h', while the other half had 'a', thus signifying moderate to very strong soil acidity. There is thus potential for Al-toxicity as well as Fe and Mn – toxicity as indicated by the high concentrations of both micro-nutrients shown by table 4. A significant negative correlation between root length of maize and Fe had been recorded in the location (Ukaegbu, *et al.,* 2012). Similarly, exchange acidity (Al+H) had a significant limiting effect to the growth of the maize crop. The high content of Fe agrees with Osunde *et al.* (2001) and Udo (2003) who noted that continuous water logging of soils of valleys and presence of decomposable organic matter provide anaerobic conditions that favour the reduction of Fe^{3+} to plant available Fe^{2+} often in amounts that are in excess of crop requirements. Controlling the soils acidity requires liming. However, Osunde *et al.* (2001) reported the development by IITA of rice varieties that are tolerant of Fe toxicity.

The condition modifier 'i' was encountered only in profile 5. This signifies high P-fixation capacity by iron. Only this profile had 'c' type. The relative sandy textures might have contributed to the high phosphorus contents of soils as it does not encourage fixation. Profile 5 had the least av.P content. This agrees with Osunde *et al.* (2001) who also noted that phosphorus availability increases under water-logged conditions. This high content of av.P is however in contrast with findings of Ahukaemere *et al.* (2014) and Onyekwere *et al.* (2001) who, in any case, had worked on different flood plains. The modifier 'k' which refers to low ability of soils to supply potassium, was found with virtually all the soils. It is associated with soils' parent materials which are noted to be deficient in K-reserves. This limitation is taken care of by fertilizer application as earlier noted.

The not so fertile conditions of the soils had earlier been observed by Aghimien and Aduayi (2004) who reported wet soils formed on basement complex rocks to have better fertility status than those on sedimentary coastal plains sand. This is probably part of reasons for underutilization of the wetlands by the local farmers most of who are resource poor.

Variations in characteristics of the wetland soils are attributed to their varied ecological conditions which Akamigbo (2001) had noted to bring about differences in hydrologic regimes, lithology, morphogenesis etc. So, detailed mapping and characterization of the soils is therefore necessary to develop appropriate management technologies for sustainable cultivation of the soils by small-holder farmers.

4. Conclusion

Relative infertility of studied soils occasioned by high soil acidity, high and toxic concentrations of Fe and Mn, low CEC, and low contents of TN and K are some of the reasons for their underutilization. Liming, planting rice varieties tolerant of Fe toxicity and N-fixing trees are some control measures noted. Government intervention to detailedly characterize the soils, and provide appropriate management technology, especially for rice cultivation, will facilitate the use of the soils by small holder farmers. This will increase food production in the area as the relative high moisture contents of the soils, even in the dry season, is yet to be fully exploited.

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