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Review of the Fertility Status of the Wetlands of the Lower Anambra River Basin for Sustainable Crop Production.

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Abstract

The Wetlands of the Lower Anambra River Basin have been subjected to continuous crop production for a long time without adequate fertility restoration strategies. There was therefore the need to re-evaluate the soils health for sustainable crop production. Soil samples were collected from the different zones of the study area and used to evaluate the soils texture, and physico- chemical properties. The results revealed that bulk density ranged from 1.3gcm^{-3} to 1.74gcm^{-3} with a mean value of 1.50gcm^{-1}, while the hydraulic conductivity values ranged from 48.0 to 120.0 cm/hr with a mean value of 72.7cm/hr. The moisture content of the soils was as high as 47.72 to 59.11%. The soils were generally strongly acidic, ranging from pH 3.39 to 4.94. The organic matter status was generally low, ranging from 0.7 to 2.53 %. The Cation exchange capacity (CEC) was also generally low. *The soils suffer multi-nutrient deficiencies. Total N was generally low in all the zones <0.15%, with a range of 0.042 to 0.14%. The available phosphorus* in most of the soils were low (<15.0mg kg), the exchangeable K had a range of 0.077 to 0.246 Cmol/kg. The exchangeable Ca had a range of 1.60 to 5.20 Cmol/kg, low to medium level, while Mg and Na had ranges of 0.80 to 3.20 Cmol/kg and 0.044 to 0.139 Cmol/kg respectively. It was concluded that the soils require conventional to minimum tillage, use of organic manures, judicious use of organic residues, liming, Bio-fertilizers and NPK fertilizers in other to sustain the soil for intensive crop production.

Keywords: Soil fertility; Wetlands; Anambra river basin; Crop production.

1. Introduction

Wetlands constitute an important ecology in Nigeria agriculture. In the south-eastern part of Nigeria, Wetlands are important resource for crop production. They are most commonly used for rice production, since the Wetlands are flooded during most parts of the year or part of the rice-growing period.

The need for all season rice production increased awareness for the importance of irrigation in sustainable agriculture. This actually spurred the federal authorities to embark on irrigation project on the Anambra river basin in the early 1980s. The ad hoc soil surveys conducted by the river basin development authorities reported by Enwezor *et al*,(1990) showed that though the soils of the basin were fast losing fertility, that they were still suitable for rice culture. An attempt is made in the present study to re-evaluate the soils to enhance their use for improved productivity and increased rice yields.

This is necessary because there is a gap in knowledge of the impact of long term land use on the productivity of the soils of the Anambra river basin. There has existed a situation of continuous application of inorganic or chemical fertilizers to enrich the soils over the years, which situation has become counter- productive; the yield of rice at the area has been on the decline instead of progressing. In fact, Olagoke, (1991) had observed that the highest average rice grain yield per hectare for irrigated, swamp, and upland fields in the area was 1.95 tons/ha. There is the fear that yield of rice in the area over time will come to zero if urgent remedy is not found. It is thought that poor soil management, the dumping of fertilizer and indiscriminate use of other agro-chemicals on the soil have adversely affected the soils properties therefore leading to reduced crop yields. The results of this study will provide information that will be beneficial to appropriate government agencies and policy makers in taking decisions on the management strategies for sustainable use of the soils of the lower Anambra River Basin. It will also assist the farmers to identify strategies that have the potential to achieve positive impacts and address the constraints of the soils in other to improve agricultural out-put. Ultimately, the report will go a long way to assist the Anambra River Basin Development Authority in land use planning and management to ensure improved soil productivity and increased crop yields.

2. Materials and methods

Location

The study covered the area of land used by the lower Anambra River Basin Development Authority for irrigated rice project (Figure 1), which spreads across the Omor, Umumbo, Umulum and Anaku farming communities. The area is situated within latitudes $5^{o}\ 43^{1}$ N and $6^{o}\ 20^{1}$N, and Longitude $6^{o}\ 36^{1}$ E and $7^{o}\ 05^{1}$E of the derived savanna ecological zone of Nigeria. The rainfall pattern in the ecological area is bimodal with peaks in July and September. The annual rainfall averages around 200 mm, while the mean minimum and maximum temperatures range from 21 – 30^{0} C. (FDALR 1985). The soil is described as Wetland and the underlying geology made up of shale parent material. The soils taxonomic classification is Typic Dystropept, Gleyic Cambisol (FAO-UNESCO legend, 1988)

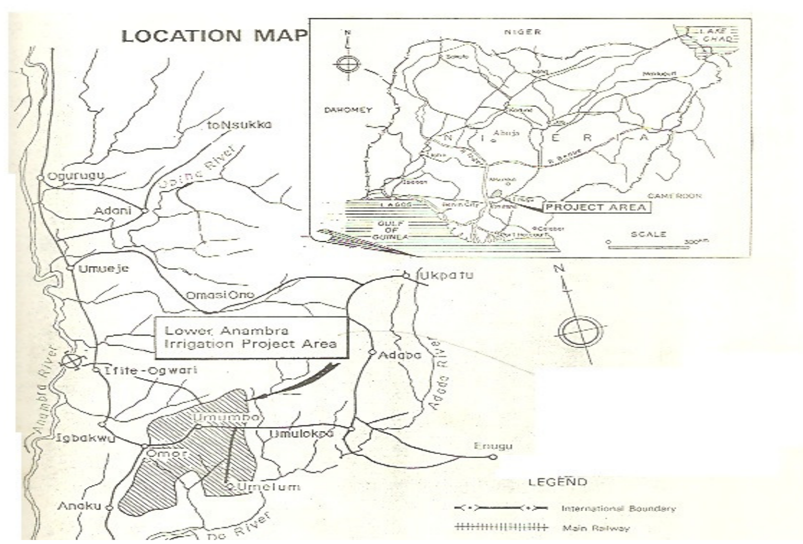

Figure 1: Location Map showing (a) Map of Nigeria indicating study area and (b) Enlarged Anambra River Basin indicating study area.

Field and laboratory work

The field map of the lower Anambra River Basin Authority (Figure 2) served as the base map for the study. The study centered on 4 major zones covering the delineated field mapping units. In the field 5 sampling sites each were chosen from the Northwest zone (W1, W2, W5,W7, W8) and the Northeast zone (E2, E4, E5, E7, E8) respectively, whereas 4 each were chosen from the Southeast (E9, E11, E13, E16) and Southwest (W11, W12, W13, W14) zones respectively , giving a total of 18 sampling areas. 20 soil samples were randomly collected with

Soil Auger from each sampling area at 0-20 cm depth, and bulked into a composite and analyzed separately for soil texture and chemical properties. 20 Soil core samples were equally collected from each sampling area out of which 10 were used to determine bulk density while the other 10 were used to determine saturated hydraulic conductivity.

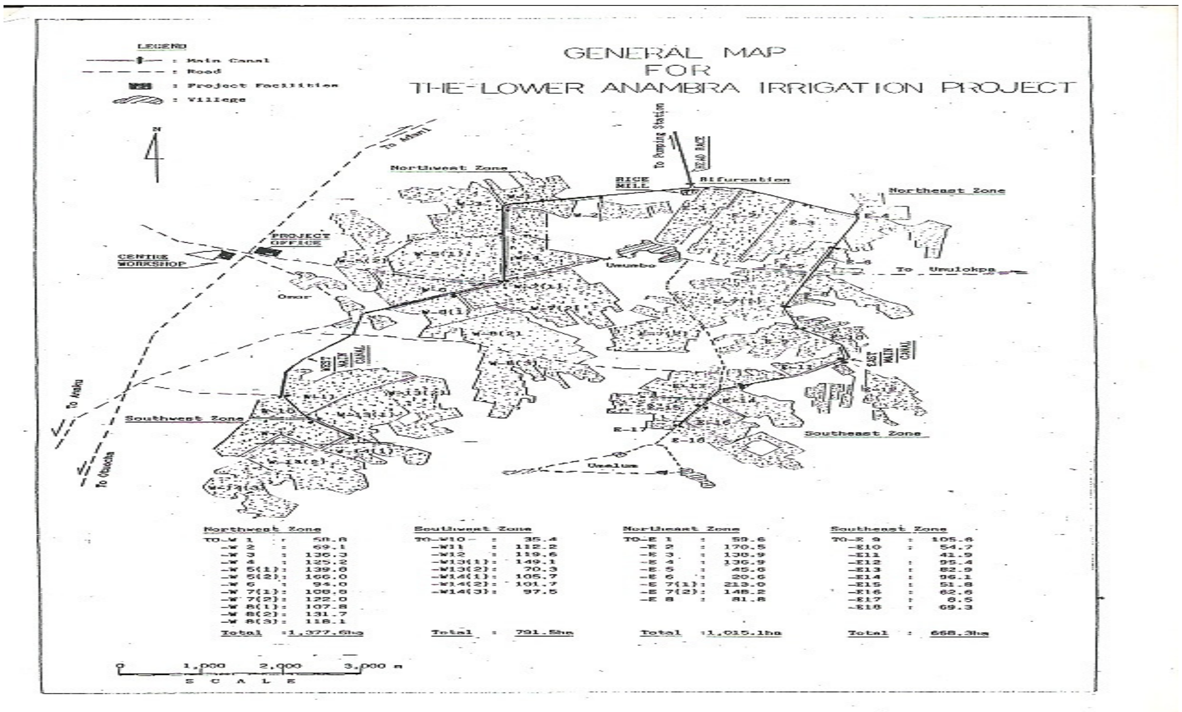

Figure 2: The field map of the Study Area showing the sampling sites.

Soil samples were processed and analyzed using the procedures of IITA, (1979) whereas soil textural classification was based on the standard procedures (Soil survey staff, 1990).

Data Analysis

The data generated were statistically analyzed, using coefficient of variability as outlined in Genstat,(2004).

3. Results and discussion

Table 1 shows the result of the soil texture, whereas the physical parameters; Bulk Density, Total Porosity, Hydraulic conductivity and moisture content of the study area are presented in table 2. The textures of all the samples are generally silty. This is confirmed by the high amount of silt particles, which ranged from 63.1 to 87.10% compared to that of sand and clay which had a range of 2.90 to 18.90% and 3.39 to 26.0% respectively.

Bulk density ranged from 1.3gcm^{-3} to 1.74gcm^{-3} with a mean value of 1.50gcm^{-1} bulk density. The bulk density of the study area did not vary so much, but the values obtained showed an ideal situation for good water retaining ability, although too high for root penetration. The high structural stability could be explained by high presence of sesquioxide concretions, use of heavy equipments, and vehicular and human traffics. Similarly the porosity did not differ significantly among the samples with a range of 34.0 to 52.0%. The hydraulic conductivity had a wider variability among the different sites with values that ranged from 48.0 to 120.0% and a mean value of 72.7cmhr^{-1}. The observed poor physical condition of the soils is a pointer to the fact that the soils require structural modifications to improve the suitability for sustainable agricultural purposes. Conventional tillage is therefore recommended at field capacity, in other to avert compaction and unduly high structural stability which otherwise would impede root penetration and nutrient mobility.

The moisture content of the soils is high at 47.72 to 59.11%. This high water holding capacity is determined in large measure by the texture of the soils. The fine texture of the soils (high silt and clay percentage) hold more water than if the soils were coarse textured. This has confirmed the high level of soil moisture content in all the study sites. The movement of moisture and air through the soil though will be dependent on the porosity of the soil which is influenced markedly by the soil structure and particle sizes.

Chemical properties

The soils had mottled surface, descriptive of iron toxicity. This condition is attributable to cyclic oxidation reduction of iron compounds associated with fluctuations of water table that contains dissolved iron products or organic matter mineralization as shown in Table 2.

pH, Exchangeable Acidity (EA), Organic Matter (OM) and Cation Exchange Capacity (CEC)

There were no marked variations among the pH values of the paddy soils, ranging from pH 3.39 to 4.94. The soils of the paddy fields are therefore generally strongly acidic. These pH values were below the critical value of pH 5.0 recommended for the production of most crops in the soils of the Southeastern Nigeria, (Enwezor *et al*., 1990). Low pH values (< 5) could be due to Al saturation in soil solution (Soil Survey Staff, 2003), which was evident in this study. This could also be a consequence of continuous use of inorganic fertilizers particularly Nitrogen based fertilizers in the area. The Introduction of mineral fertilizers probably influenced farmers to abandon traditional soil fertility management systems in the area. This is because they are more convenient to handle and apply, little quantities are required and they increase crop yields significantly due to their high solubility and nutrient content (Venture and Watanabe, 1992). The levels of the exchangeable acidity (EA) in the soil varied a great deal, (1.12 to 4.24 Cmol(+) kg^{-1}) with a mean of 4.0 Cmol(+)/kg.$^{-1}$ This is higher than the level of 2.0 Cmol(+)/kg^{-1} considered critical level for Al toxicity in soils of Southeastern Nigeria (Njoku *et al*., 1987). The soils organic matter status is generally low, ranging from 0.7 to 2.53 %, perhaps due to land use and frequent burning. The soils have been subjected to poor land use, continuous cropping, and seasonal bush burning. Soils in the derived savanna are prone to frequent bush burning which are likely to favour quicker oxidation of organic matter. All these account for the low percentage organic matter in the soils.

The Cation exchange capacity (CEC) is generally low, depending on organic matter and clay contents. The CEC was less than 16 Cmol (+)/kg, the value considered as critical for sustainable crop production in the area. This confirmed similar reports by Chukwu and Chude, (1997) and Chukwu, (2007) on the Umumbo-Adani soil association which the soils of the study area represent. Since clay mineralogy affects CEC, the general low CEC could be due to presence of low activity clay. Uehara, (1978) had also reported that low CEC values suggest that the soils have low activity clays

Primary nutrients

The soils suffer multi-nutrient deficiencies particularly N, P and K. Total N was generally low in all the locations <0.15%, with a range of 0.042 to 0.14%.This condition should call for much concern because N is the most critical nutrient element for rice nutrition and production. The available phosphorus in most of the soils were low (<15.0mg /kg), while in few locations the available P values were at medium level (15 – 25mg /kg) going by the recommendation of Enwezor et al., (1990) for crop production in soils of the Southeastern Nigeria. Total N, available P and exchangeable K are low owing probably to the observed low organic matter status, acidity, nutrient mining by plants, and perhaps due to nature of parent material. The mineralization of organic P is also considered insignificant in hydromorphic soils (Udo, 1985). This low level of the primary soil nutrients may also be attributed to the high moisture level and the texture of the soil which may encourage mobility of these nutrients and disposed the elements to leaching.

Exchangeable bases

The basic cautions; K, Na, Ca and Mg were relatively low to medium levels. The exchangeable K had a range of 0.077 to 0.246 Cmol(+)/kg, whereas mainly <0.2 Cmol(+)/kg is the critical level of K in soils of the zone. The exchangeable Ca had a range of 1.60 to 5.20 Cmol(+)/kg, low to medium level, while Mg and Na had ranges of 0.80 to 3.20 Cmol(+)/kg and 0.044 to 0.139 Cmol/kg^{-1} respectively. There is therefore an apparent fluctuation in the soils content of basic nutrients which is inclined to deficiency. This situation could again be attributable to low organic matter status, leaching, high acidity and low cation exchange capacity. There is the inevitable need to improve on the soils buffer capacity by the introduction of organic manures and return of crop residues as management strategies in other to stem the loss of soil nutrients.

Fertility Inferences and Recommendations.

The soils could support intensive rice production with application of Lime, and N P and K fertilizers. Also use of organic manures, Bio-fertilizers and total return of crop residues is essential to maintain the productivity of the soils. Azolla could be introduced as a Bio-fertilizer substitute for or supplement to mineral fertilizers which are usually scarce and costly in the country. Chukwu, (2007) had actually found the wetlands of the area suitable for the growth of Azolla.He pointed out that Azolla when used as an N-biofertilizer for wet land rice has the ability to fix atmospheric N in symbiosis with N2-fixing blue green alga *Anabaena azollae*. It also reduces loss of NH4-N by volatilization (Chu and Bo-qi, 1988). Azolla is also normally enriched by trace k from irrigation water which the rice can also take advantage of. The Azolla – k may be released for rice plant uptake was reported by FAO, (1988), to have the efficiency equivalent to that of fertilizer – k. This FAO report equally confirmed that Azolla could by these processes increase gain yield of rice.

Table 1: Soil Texture

Study Sites	Sand %	Silt %	Clay %	Textural Class
NW1	12.9	73.1	3.45	Silt Loam
NW2	8.9	75.1	3.39	Silt loam
NW5	6.9	83.1	4.94	Silt
NW7	8.9	65.1	26	Silt Loam
NW8	6.9	75.1	4.17	Silt Loam
NE2	2.9	87.1	10	Silt Loam
NE4	8.9	79.1	12	Silt Loam
NE5	10.9	79.1	10	Silt Loam
NE7	6.9	77.1	4.15	Silt
NE8	12.9	77.1	10	Silt Loam
SE9	16.9	63.1	20	Silt loam
SE11	18.9	71.1	4.73	Silt Loam
SE13	6.9	83.1	10	Silt
SE16	18.9	71.1	10	Silt Loam
SW11	12.9	73.1	14	Silt Loam
SW12	16.9	69.1	14	Silt loam
SW13	14.9	73.1	12	Silt Loam
SW14	12.9	77.1	4.06	Silt
Mean (X)	11.46	75	8.93	
CV	30%	7%	60%	

NW=Northwest;NE=Northeast;SE=Southeast;SW=Southeast

Table 2: Soil Physical Properties

Study Sites	Bulk Density(cm^3)	Total Porosity(%)	Hydraulic Conductivity(cm/hr)	Soil Moisture(%)
NW1	1.5	43	69	55.06
NW2	1.53	44	113	51.47
NW5	1.43	46	116	52.37
NW7	1.3	51	68.03	57.27
NW8	1.57	40.8	82	55.29
NE2	1.42	46	56	53.45
NE4	1.58	40	74	52.84
NE5	1.5	43	54	48.73
NE7	1.48	44	62.05	53.36
NE8	1.42	46	120	59.11
SE9	1.74	34	78.05	49.48
SE11	1.6	40	44	51.17
SE13	1.48	44	48	49.61
SE16	1.38	48	46.05	47.72
SW11	1.64	39	65	51.63
SW12	1.45	45	63.04	50.12
SW13	1.27	52	45.07	55.35
SW14	1.69	36	105	49.06
Mean	1.50	43.43	72.68	52.39
CV	8%	10%	34%	6%

NW=Northwest;NE=Northeast;SE=Southeast;SW=Southeast

TABLE 3: Soil Chemical Properties

Study Sites	pH (H_2O)	P Mg/kg	N (%)	OC (%)	OM (%)	Ca	Mg	K	Na	EA	ECEC	BS
						←			Cmol/kg		→	
NW1	4.94	9.5	0.14	1.28	2.21	5.20	4.00	0.118	0.044	1.12	10.48	89.30
NW2	4.73	18.6	0.14	1.39	2.4	5.20	4.00	0.133	0.122	1.44	10.90	86.79
NW5	4.15	16.8	0.098	1.47	2.53	4.40	3.20	0.108	0.087	1.68	9.48	82.20
NW7	4.17	15.6	0.084	1.21	2.09	4.00	3.2	0.102	0.139	1.44	8.88	83.80
NW8	4.34	11.5	0.112	1.39	2.4	4.40	2.4	0.128	0.104	1.12	8.15	86.30
NE2	4.79	11.1	0.084	1.06	1.83	4.00	2.00	0.082	0.078	2.32	8.48	72.60
NE4	4.34	10.8	0.084	1.1	1.9	2.80	1.60	0.123	0.078	1.68	6.28	73.30
NE5	4.17	85	0.112	1.1	1.9	4.40	1.60	0.082	0.061	2.56	8.70	70.60
NE7	4.13	19.5	0.098	1.06	1.83	2.80	1.60	0.113	0.104	1.60	6.22	74.20
NE8	4.06	9	0.126	1.06	1.83	3.6	1.6	0.156	0.070	1.60	7.03	77.20
SE9	4.07	19	0.098	1.03	1.77	4.00	2.8	0.077	0.061	3.6	10.54	65.83
SE11	3.92	12.9	0.112	0.99	1.71	3.2	1.20	0.102	0.052	2.48	7.03	64.80
SE13	3.95	19.3	0.07	0.99	1.71	2.4	0.80	0.246	0.078	1.44	4.96	71.10
SE16	3.78	16.6	0.042	0.4	0.7	2.4	0.80	0.118	0.070	1.68	5.07	66.80
SW11	3.66	19.7	0.07	0.77	1.33	2.40	0.80	0.128	0.087	1.84	5.26	64.90
SW12	3.81	10.5	0.098	0.99	1.71	1.6	0.8	0.087	0.113	2.80	5.40	48.20
SW13	3.45	8.2	0.084	0.92	1.58	2.00	1.2	0.067	0.052	4.24	7.56	43.90
SW14	3.39	23.5	0.091	0.95	1.65	2.00	0.80	0.108	0.061	2.96	5.93	50.10
MEAN (x)	4.1	18.73	0.0968	1.04	1.84	3.38	1.91	0.116	0.081	2.088	7.58	70.662
CV	10%	88%	24%	22%	22%	32%	56%	33%	31%	40%	25%	18%

NW=Northwest;NE=Northeast;SE=Southeast;SW=Southeast **Conclusion**

The present knowledge about the fertility status of the soils of the lower Anambra River Basin will facilitate the development of appropriate management strategies for improved soil productivity and increased rice yields. The results have shown that the soils of the paddy field of the lower Anambra River Basin Authority evaluated are deficient in most chemical attributes, therefore requires soil amendments for sustainable productivity. The physical properties of the soils are also identified to require some structural amendments in other to support the adequate utilization of the soil for rice production. Conclusively, the soils require conventional to minimum tillage, use of organic manures, judicious use of organic residues, liming, Bio-fertilizers and NPK fertilizers in other to sustain the soil for intensive crop production.

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