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The Study of Soil Quality Indicators in Ibiono Ibom Area, Akwa Ibom State of Nigeria

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ABSTRACT

Soil assessment of Ibiono Ibom area of Akwa Ibom State was carried out using morphological, physical and chemical properties. Undisturbed samples were collected using core cylinder samplers at different depths and disturbed samples were also collected from the genetic horizon of the soil profiles in Ikot Usen and Ibiaku Osuk areas. Soil profiles were described using the standard soil description in the USDA 1978/1999 system. Physical and chemical parameters were analyzed using the standard laboratory procedures. Data obtained from the study were analyzed and results showed that saturated hydraulic conductivity ranged from 0.00 – 89.10 cm/hr. Bulk density, particle density and total porosity ranged from 1.20 – 1.66g/cm^3, 1.50 – 3.07 g/cm^3 and 19.8 – 56.7% respectively. Textures were generally sand to loamy sand. The impact of texture with bulk density and porosity enhances the performances of plants in the area and are indicative of moderate to high inherent soil quality. Most of the profiles have rapid permeability (mean of 17.03cm/hr and 48.88 cm/hr) and have relative greater potential to support roots. pH rating varied from extremely acid (pH 4.3) to moderately acid (pH 5.7). Organic carbon content and total nitrogen were low having ranges of 0.0390 – 1.7356% and 0.01 – 0.14% respectively. The available phosphorus content ranged from 9.54 – 27.79 mg/kg and C:N ranged from 2 to 29. The implications of the narrow C:N ratios in some of the soils reflect high levels of microbial activity and rapid decomposition of organic matter with concomitant release of nutrient elements into soil solution for plant uptake.

Key words: Soil Quality Indicators, Critical Limits, Proper Management Approaches.

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1. INTRODUCTION

Soil quality is defined as the capacity of a specific kind of soil to function within natural or managed ecosystem boundaries, to sustain plants and animals productivity, maintain or enhance water and air quality, and support human health and habitation [1]. According [2] soil quality is used when the purpose of soil is specified. [3] noted that between 1950 and 2000 over 25% of the 8.7 billion/ha of agricultural land, permanent pastures, forest and wood lands which are major sources of food, incomes and employment have been degraded with the largest being from developing countries. This according to [4] challenges the prospects for a better future of Africans and has potentials for increased conflicts over the next 25 to 30 years with obvious pressure on resources. To mitigate this, proper soil quality assessment is a necessity so as to meet the needs of the ever increasing global population. Proponents of soil quality argue that although soil scientists have long recognized the many unique and important properties and processes provided by fragile soil resources, outside the agricultural community, soils remain largely an under-valued resource [5]. Soil quality assessments are viewed as tools intended to alert users, in a manner analogous to a "consumer price index," that soil resource problems have or may be occurring.

Selection of key indicators and their critical limits which must be maintained for normal functioning of the soil are required to monitor changes and determine trends in improvement or deterioration in soil quality for various agro-ecological zones for use. Although, selection of soil indicators will vary with agro-ecological goals, the following seem to be suitable indicators for crop production in most cases; soil colour, soil texture, soil pH, organic matter content, total nitrogen, available phosphorus, carbon – nitrogen ratio, bulk density, total porosity and saturated hydraulic conductivity. This study aimed at assessment of these soil quality indicators in some areas of Ibiono Ibom through laboratory evaluation as well as comparison of the results with

interpretation guide for evaluating analytical data with a view to making modest recommendation and proper management approaches of soils in the area.

2. MATERIALS AND METHODS

2.1 The Study Area

The study was carried out in Ikot Usen and Ibiaku Osuk areas in Ibiono Ibom Local Government Area of Akwa Ibom State, Nigeria (Fig. 1). Ibiono Ibom is bounded by Cross River State, Itu, Arochukwu (Abia State), Abak and Ini local government area. Ibiono Ibom occupies a land mass of 2761.76sq.km, with a total population of 385,145. It consists of 9 clans, 33 groups and 193 villages. It has coordinates; $5^0$14'0' N $7^0$53'0'E / 5.23333^{0}N 7.88333^{0}E. The average temperature of the area is 25^{0}C and the area witnesses two distinct seasons which are the dry and rainy seasons and has a number of rivers and tributaries flowing within its territory. The average humidity level of Ibiono Ibom is 85% while the wind speed is at an average of 10km/h. The main ethnic group of Ibiono Ibom is the Ibibio people, who speak a dialect of the Ibibio language. The land use pattern of the area is in the order: agricultural, residential, transport, commercial and residential. Mineral resources include deposits of various stones, clay, sand and crude oil. There are forest resources such as palm trees, rubber, timber and others. The dwellers are predominantly farmers, traders and craftsmen.

2.2 Sampling Techniques/ Data Collection

Soils samples were collected from each horizon of the profiles sunk on two transect. Disturbed and undisturbed samples were collected from genetic horizons of the profiles and at different depths respectively. Soil profiles were described using the standard soil description in the USDA 1978/1999 system.

2.3 Laboratory Analysis

Saturated hydraulic conductivity was measured by the constant head perimeter technique as described [6]. Bulk density was determined by the core method described [7] where cores were dried to constant weight in an oven at a temperature of 105^{0}C. Total porosity was calculated with core samples [8]. Particle size analysis was done by hydrometer method modified [9]. The pH was determined in the laboratory using glass electrode pH meter. 1:1 soil to water ratio was used. Available Phosphorus was determined using Bray and Kurtz method [10]. Semi-micro Kjeldahl digestion method was used to determine Total Nitrogen. Total organic carbon was determined by the wet combustion method [11] as modified by Juo [9].

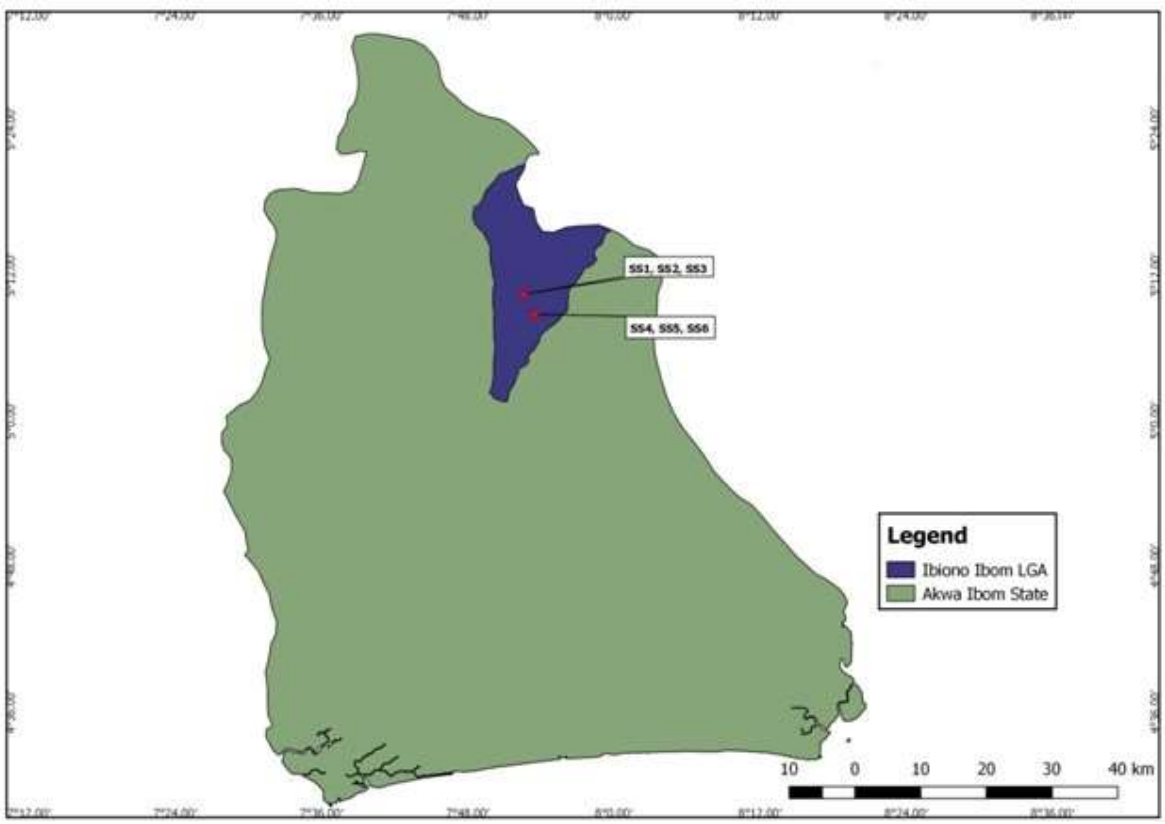

Figure 1: Map of Akwa Ibom State, showing the study area

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3. RESULTS AND DISCUSSION

3.1Morphological Properties and Soil Quality

Detailed morphological features of the various profiles studied are presented in Table 1. The soils of Ibiono Ibom area are generally deep with four of the five profiles having effective depth of 200cm and above. These deep profiles have no impermeable layer or depth to water table within 200cm. However, the shallowest effective depth was obtained in Ikot Usen 3 pedon with the effective depth of 47cm. The Ikot Usen 3 pedon was poorly drained and had relatively lower soil quality because it had ground water after the depth of 47cm. The genetic topsoil horizon in all the profiles were plow layer (Ap) and varied in depth from 0 - 10cm to 0 – 15cm with exception of Ikot Usen 1 profile (0 - 8cm) and (0- 5cm) for Ikot Usen 3 profile.

The colour at the surface horizons was predominantly very dark gray (7.5YR3/2) to very dark brown (10YR2/2) for Ikot Usen pedons and very dark gray (10YR3/1) to dark grayish brown (10YR4/2) for Ibiaku Osuk pedons. In these pedons throughout the soil matrix the hue rarely change by more than one hue column, showing the degree of uniformity in both parent material and other soil forming processes. The grayish colour of the horizon suggests low productivity. This is in line with the findings of [12][13].

The structure of the various horizons varied from medium crumb to fine crumb and fine granular at the surface. At the subsurface horizon the structure varied from fine angular blocky to medium angular blocky across the various pedons.

3.2 Physical Properties of the Soils in the Study Area

The physical properties of the soils in the pedons of the study areas are shown in Table 2 and Table 3. The soils of Ibiono Ibom area are generally sandy (Table 3). This sandy nature can be attributed to the parent materials of the area, coastal plain sands [14]. The textural class predominant in Ibiono Ibom are sand and loamy sand. Sand content had a range of (856 – 963g/kg). Silt content ranges from (60g/kg – 86g/kg) with the mean of 3.5% (35g/kg). clay content ranges from (26g/kg – 98g/kg). Though there was no definite trend, the clay content seems to increase with depth. This is because of the illuvial translocation of clay which is associated with rainfall pattern in the area. Particle density ranged between 1.50g/cm^{3}and 2.88g/cm^3 within the pedons. Generally, particle density seems to be relatively lower on the surface. This agreed with the findings of [15] who attributed increasing particle density with soil depth to the inverse relation between organic matter and increasing soil depth.

According to [16], increase in bulk density may be due to lower organic matter content. Bulk density ranged between 1.20g/cm^3 and 1.66g/cm^3 in the soils of the Ibiono Ibom area. Surface horizons had low bulk density values in all the profiles which were closer to the ideal value of 1.3g/cm^3. Generally, bulk density values increased with increase in depth of the profiles. This increase with depth may be due to compaction which resulted from over burden and less disturbance [17]. In comparison with the general relationship of soil bulk density to root growth based on soil texture [18], the bulk density values obtained in the area would not impair the ability of plant roots to penetrate the soils.

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Table 1: Morphological Features of the Soil Pedons in the Study Area

Horizon	Depth	Colour (Moist)	Texture	Structure	Consistency	Boundary	Others
Ikot Usen 1 (Summit, Cultivated land)							
Ap	0 – 8	very dark gray (7.5YR3/1)	SL	3crumb	Very Fr	cw	mfr, fmr, abundance of macro pores
AB	8 – 23	strong brown (7.5YR5/6)	LS	3gr	Fr	gw	mcr, abundance of macro pores
B1t	23 - 70	strong brown (7.5YR5/6)	LS	1ablk	Fr	gw	fcr, common macropores, activity of termites
B2	70 – 130	yellowish brown (10YR5/6)	SCL	2ablk	Fi	gw	vfr, common micropores, hardness of layer
B3	130- 200	reddish yellow (7.5YR6/8)	SCL	3ablk	Fi	gw	nr, abundance of micropores
Ikot Usen 2 (middle slope, Newly Harvested land)							
Ap	0 – 15	very dark gray (7.5YR3/1)	SL	2crumb	Very Fr	cs	mfr, fmr, abundance of macropores
AB	15 – 25	dark reddish gray (5YR4/2)	LS	2gr	Very Fr	cs	mmr, abundance of macropores
B1	25 – 65	brown (7.5YR4/2)	LS	3gr	Fr	cw	fmr, fcr, few macropores
B2	65 – 103	reddish yellow (7.5YR6/8)	LS	2ablk	Fr	gw	vfcr, common micropores
B3t	103 – 140	reddish yellow (7.5YR6/8)	SCL	3ablk	Fi	gw	vfr, abundance micropores
BC	140 – 200	reddish yellow (7.5YR6/8)	SCL	3ablk	Fi	gw	nr, abundance of micropores

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Ikot Usen 3 (Foot slope, fallow land)

Ap	0 – 5	very dark brown (10YR2/2)	SL	2gr	Fr	gs	mfr, fmr, abundance macropores
AB	5 – 15	very dark gray (7.5YR3/1)	SCL	2ablk	Slightly St	gw	mmr, common macropores, wettness
B1t	15 – 47	brown (7.5YR5/4)	SCL	3ablk	St	gw	fmr, wetness
B2	47 – 110	yellowish brown (10YR5/8)	C	3ablk	very St	gw	cvfr, water table

Horizon	Depth	Colour (Moist)	Texture	Structure	Consistency	Boundary	Others

Ibiaku Osuk 1 (Middle slope, Cultivated land)

Ap	0 – 10	dark gray (10YR4/1)	SL	3crumb	very Fr	cs	mfr, fmr, abundance of macropores
AB	10 – 39	very dark gray (10YR3/1)	LS	2gr	very Fr	cs	mmr, ffr, abundances of pores
B1	39 - 60	yellowish brown (10YR5/6)	LS	2ablk	Fr	cw	ccr, common macropores
B2	60 – 110	yellowish brown (10YR5/6)	LS	3ablk	Fr	gw	fcr, more of micrpores
B3	110 - 200	reddish yellow (10YR6/6)	LS	3ablk	Fi	gw	no root, abundance of micropores

Ibiaku Osuk 2 (Foot slope, Fallowed Land)

Ap	0 – 10	dark greyish brown (10YR4/2)	SL	2gr	very Fr	cs	mfr, fmr, abundance of macropores
AB	10 – 30	dark greyish brown (10YR4/2)	LS	2gr	Fr	gs	mmr, ffr, common macropores
B1	30 - 63	very dark greyish brown (10YR3/2)	LS	3gr	Fr	gw	mcr, abundance macropores
B2	63 - 115	dark greyish brown (10YR4/2)	LS	2ablk	Fr	gw	fmr, more of mesopores, activity of rodents
B3t	115 - 168	reddish yellow	LS	2ablk	Fi	cw	fmr, white gravels.

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BC	168 - 200	(7.5YR6/8) reddish yellow (7.5YR6/8)	LS	2ablk	Fr	gw	nr, dark reddish brown stones and white gravels

KEY: LS = Loamy Sand, SL = Sandy loam, SCL = Sandy Clay Loam, C = Clay, 1=very fine, 2= fine, 3= medium, gr= grandular, a = angular, blk = blocky, Fr = friable, Fi = firm, St= Sticky, c= clear, s= smooth, g = gradual, w = wavy, mfr = many fine roots, fmr = few medium roots, mmr = many medium roots, ffr = few fine roots, mcr = many coarse roots, fmr = few medium roots, fcr = few course roots, ccr = common coarse roots, cvfr = common very fine roots, fr = few roots, cr = coarse roots, nr = no root.

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The total porosity of the soils ranges from 19.8 % - 56.7% (Table 2). All the profiles had low total porosity value between 19.8 - 31.6% at the Ap horizon (0- 20cm) with the exception of Ibiaku Osuk 2 profile which had the total porosity of 56.7% at the surface horizon. These low values are possibly due to the values of bulk densities. These soils are easily eroded due to this low total porosity under rainfall. Similarly, flooding and erosion risk of some soils of the Ogba- Egbema area to low total porosity[19].

Soil bulk density, soil porosity and particle density enable the degree of compaction and aeration of the soil[19]. The combining impact of the predominantly sand to loamy sand texture with bulk density and porosity further enhances the performances of plants in the area and are indicative of moderate to high inherent soil quality.

Data for saturated hydraulic conductivity presented in Table 2 showed a wide range of 0 – 94.72cm/hr. Water movement through sands is very rapid under saturated conditions and slow under unsaturated conditions. This can be attributed to pore size distribution and moisture retention capacity. This study shows that the infiltration of water into the soil is high, low availability of water to plant roots and high leaching losses ranges is likely to occur at the Ikot Usen 1 soil whose permeability class show very rapid. The Ikot Usen 2 and Ikot Usen 3 soils permeability classes (extremely slow after 20cm and 40cm depth respectively) is an indication of root penetration restriction. The Ibiaku Osuk 1 and Ibiaku Osuk 2 profiles have rapid permeability generally with mean of 17.03cm/hr and 48.88 cm/hr respectively. This implies that The Ibiaku Osuk 1 and Ibiaku Osuk 2 soils are well drained and have relative greater potential to support roots.

Table 2: Bulk Density, Particle density, Total Porosity and Hydraulic Conductivity of the Soils

Location	Depth (cm)	Bulk Density (g/cm^3)	Particle density g/cm^3	Total porosity (%)	Ksat. (cm/hr)	Permeability Class
IKOT USEN 1 (Summit, Cultivated Land)						
	0 – 10	1.20	1.50	19.8	89.10	Very rapid
	10 – 40	1.22	1.70	28.4	76.64	Very rapid
	40 - 60	1.26	2.04	38.1	43.53	Rapid
	60 – 80	1.43	2.46	42.0	28.36	Rapid
	Mean	*1.28*	*1.93*	*32.1*	*59.41*	
IKOT USEN 2 (Middle Slope, Newly Harvested Farmland)						
	0 – 20	1.23	1.83	32.4	38.61	Rapid
	20 – 40	1.66	2.71	38.7	0.00	Extremely slow
	40 – 60	1.50	2.35	36.3	5.35	Moderately slow
	60 – 80	1.53	2.67	40.5	0.00	Extremely slow
	Mean	*1.48*	*2.39*	*36.9*	*10.99*	
IKOT USEN 3 (Foot Slope, Fallowed Land)						
	0 – 20	1.36	1.92	29.3	42.01	Rapid
	20 – 40	1.21	2.48	51.1	41.72	Rapid
	40 – 60	1.33	3.07	56.7	0.00	Extremely slow
	60 – 80	1.45	2.88	49.6	0.00	Extremely slow
	Mean	*1.34*	*2.59*	*46.7*	*20.93*	
IBIAKU OSUK 1 (Middle Slope, Cultivated Farmland)						
	0 – 10	1.42	2.07	31.6	50.72	Rapid
	10 – 35	1.63	2.44	33.1	9.84	Moderately rapid
	35 - 55	1.64	2.25	26.7	2.90	Moderate
	55 – 75	1.66	2.42	31.3	4.66	Moderate
	Mean	*1.59*	*2.30*	*30.7*	*17.03*	

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IBIAKU OSUK 2 (Foot Slope, Fallowed Land)					
0 – 10	1.20	2.14	56.3	48.56	Rapid
10 – 20	1.26	2.55	50.6	94.72	Very rapid
20 - 45	1.36	2.27	39.9	30.30	Rapid
45 - 75	1.44	2.47	41.7	21.94	Rapid
Mean	*1.32*	*2.36*	*47.13*	*48.88*	

Source Rating: [20][18].

Table 3: Particle Size Distribution

Location/ Horizons	Depth(cm)	%Sand	%Silt	% Clay	Textural Class
IKOT USEN 1 (Summit, Cultivated Land)					
Ap	0 – 8	94.6	2.6	2.8	Sand
AB	8 – 23	93.9	2.3	3.8	Sand
B1t	23 - 70	90.9	1.0	8.1	Sand
B2	70 – 130	90.6	3.6	5.8	Sand
B3	130- 200	89.6	4.3	6.1	Loamy sand
	Mean	**91.9**	**2.8**	**5.3**	
IKOT USEN 2 (Middle Slope, Newly Harvested Farmland)					
Ap	0 – 15	93.6	3.8	2.6	Sand
AB	15 – 25	93.6	3.4	3.0	Sand
B1	25 – 65	94.6	2.6	2.8	Sand
B2	65 – 103	90.6	2.6	6.8	Sand
B3t	103 – 140	87.6	2.6	9.8	Loamy sand
BC	140 – 200	86.9	8.3	4.8	Loamy sand
	Mean	**91.1**	**3.9**	**5.0**	
IKOT USEN 3 (Foot Slope, Fallowed Land)					
Ap	0 – 5	94.9	2.6	2.5	Sand
AB	5 – 15	92.9	4.5	2.6	Sand
B1t	15 – 47	85.9	4.3	9.8	Loamy sand
B2	47 – 110	85.6	8.6	5.8	Loamy sand
	Mean	**89.8**	**5.0**	**5.2**	
IBIAKU OSUK 1 (Middle Slope, Cultivated Land)					
Ap	0 – 10	93.3	3.3	3.4	Sand
AB	10 – 39	90.3	4.3	5.4	Sand
B1	39 - 60	90.3	5.3	4.4	Sand
B2	60 – 110	89.3	4.3	6.4	Loamy sand

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B3	110 - 200	90.3	4.3	5.4	Sand
	Mean	**90.7**	**4.3**	**5.0**	
IBIAKU OSUK 2 (Foot Slope, Fallowed Land)					
Ap	0 – 10	96.3	0.6	3.1	Sand
AB	10 – 30	94.6	1.6	3.8	Sand
B1	30 - 63	93.3	3.3	3.4	Sand
B2	63 - 115	96.3	0.3	3.4	Sand
B3t	115 – 168	89.3	3.3	7.4	Loamy sand
BC	168 – 200	91.3	3.3	5.4	Sand
	Mean	**93.5**	**2.1**	**4.4**	

3.3 Soil Reaction (pH)

The results in Table 4, indicate that the soils' pH rating varied from moderately acid to extremely acid. There was no definite trend of the pH values with regards to depth. Therefore this disagreed with the observation of Esu [21], who reported a general decrease in pH values with increase in depth. The top soils of Ikot Usen 1 and Ikot Usen 2 indicate very strongly acid while that of Ibiaku Osuk 1 and Ibiaku Osuk 2 indicate strongly acid. Hence, soil nutrients especially Phosphorus, Nitrogen, sulphur and some micronutrients are affected [22]. Similarly, it was reported that soil pH influences nutrient availability in the soil and Manganese (Mn) are increased with acidity while the availability of macronutrients (N,P, K and S) are reduced resulting to deficiency symptoms in some plants growing on such soils[23]. The acidic nature of Ibiono Ibom soils can be attributed to the texture of the soil and high rainfall, were elements are highly leached leading to acidity. This observation conforms to that of Chiekezie *et al.* [24].

3.4 Total Organic Carbon (TOC)

The data for total organic carbon is presented in Table 4, indicate a general decrease of TOC with depth in all the profiles. Considering the Critical limits of interpreting levels of analytical parameters [25] in Table 4, the soils of the study area had low organic carbon content. The low organic carbon of the area can be attributed to continuous cropping, as well as annual slash and burn system of farming which discourages the build-up of organic matter status. These practices results in low organic matter and impaired chemical soil quality and low agricultural yield in soils of the area [26].

3.5 Total Nitrogen

Generally, total nitrogen ranged between 0.01 – 0.14%. There was a definite trend in the values of the total nitrogen, hence, the decrease in the values of total nitrogen with increase in depth. Following the rating of total N of >1% as very high, 0.5 – 1% as high, 0.2 – 0.5% as medium, 0.1 – 0.2% as low and <0.1% as very low Nitrogen status as indicated by Landon [27], the surface soils of Ikot Usen1 and Ikot Usen 3 qualify for low Nitrogen status while others qualify for very low status of Nitrogen.

From the result, low nitrogen is a limiting factor to sustainable agricultural productivity of the area [19]. Hence, resulting in the low yield from farms in the area. This can be associated to the farming system practiced in the area where organic wastes inputs is not sufficiently incorporated into the soil [28].

3.6 Carbon-Nitrogen Ratio

Carbon-Nitrogen Ratio is written as C:N and is usually a single number [29]. It is defined as the ratio of the weight of organic carbon to the weight of total nitrogen in a soil or organic matter. It is the relationship between organic matter and nitrogen content of soils. C:N of the sampling stations ranges from 06 to 29 as shown in table 10. Ibiaku Osuk 1 pedon had the lowest value with the mean value of 17 while Ikot Usen 1 soil had the highest value with the mean of 19. The implications of the narrow C:N ratios in some of the soils as shown in Table (4) reflect high levels of microbial activity and rapid decomposition of organic matter with concomitant release of nutrient elements into soil solution for plant uptake. This conforms to the observation of Akpan-Idiok [30].

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3.7 Available Phosphorus

Generally, the available phosphorus of the soils in Ibiono Ibom area ranges from 9.54mg/kg – 27.79mg/kg (Table 4). In Ikot Usen 1 soil the range was 12.35mg/kg – 27.79mg/kg, Ikot Usen 2 soil had 10.12 - 19.65mg/kg, the range of Ikot Usen 3 soil was 9.54 – 18.25mg/kg, the Ibiaku Osuk 1 had the range 11.79 – 23.02 mg/kg, Ibiaku Osuk 2 ranges from 10.12 – 24.70 mg/kg and Ibiaku Osuk 2 ranges from 14.04 - 26.95mg/kg. Following the critical levels according to Esu [25], the available P is medium to high in Ikot Usen 1 soil, Ibiaku Osuk 1 soil and Ibiaku Osuk 2 while at Ikot Usen 2 the critical level of the available P is medium and low to medium at Ikot Usen 3 soils.

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Table 4: Some Chemical Indicator Ratings of the Soils in the Study Area

Location Horizon	Depth (cm)	pH value	Rating	TOC (%)	Rating	Total N (%)	Rating	C:N	Avail. P	Rating
IKOT USEN 1 (Summit, Cultivated Land)										
[										
Ap	0 – 8	4.5	Very strongly acid	1.7355	High	0.11	Low	16	17.40	Medium
AB	8 – 23	4.3	Extremely acid	0.8775	Low	0.05	Very low	18	12.35	Medium
B1t	23 – 70	4.3	Extremely acid	0.3705	Very low	0.02	Very low	19	27.79	High
B2	70 – 130	4.3	Extremely acid	0.6825	Low	0.03	Very low	23	19.65	Medium
B3	130- 200	5.1	Strongly acid	0.2145	Very low	0.01	Very low	22	12.35	Medium
	Mean			**0.7761**		**0.04**		**19**	**17.91**	
IKOT USEN 2 (Middle Slope, Newly Harvested Farmland)										
Ap	0 – 15	4.9	Very strongly acid	1.4625	Moderate	0.10	Low	16	11.79	Medium
AB	15 – 25	4.4	Extremely acid	1.1115	Moderate	0.10	Low	12	12.35	Medium
B1	25 – 65	4.6	Very strongly acid	0.9945	Low	0.05	Very low	20	14.04	Medium
B2	65 – 103	4.9	Very strongly acid	0.4875	Low	0.02	Very low	24	14.04	Medium
B3t	103 – 140	4.8	Very strongly acid	0.6240	Low	0.03	Very low	21	19.65	Medium
BC	140 – 200	5.3	Strongly acid	0.2145	Very low	0.02	Very low	11	10.12	Medium
	Mean			**0.8158**		**0.05**		**17**	**13.67**	
IKOT USEN 3 (Foot Slope, Fallowed Land)										
Ap	0 – 5	5.7	Moderately acid	2.4960	Very High	0.14	Low	18	11.23	Medium
AB	5 – 15	5.1	Strongly acid	1.2285	Moderate	0.07	Very low	18	9.54	Low
B1t	15 – 47	4.7	Very strongly acid	0.7215	Low	0.05	Very low	14	14.04	Medium
B2	47 – 110	4.6	Very strongly acid	0.8775	Low	0.05	Very low	18	18.25	Medium
	Mean			**1.3309**		**0.08**		**17**	**13.27**	

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Location Horizon	Depth (cm)	pH value	Rating	TOC (%)	Rating	Total N (%)	Rating	C:N	Avail. P	Rating
IBIAKU OSUK 1 (Middle Slope, Cultivated Land)										
Ap	0 – 10	5.5	Strongly acid	0.7605	Low	0.05	Very low	15	21.33	High
AB	10 – 39	5.5	Strongly acid	0.6240	Low	0.03	Very low	21	10.12	Medium
B1	39 - 60	5.1	Strongly acid	0.2925	Very low	0.01	Very low	29	19.65	Medium
B2	60 – 110	5.3	Strongly acid	0.1365	Very low	0.01	Very low	14	24.70	High
B3	110 - 200	5.6	Moderately acid	0.0585	Very low	0.01	Very low	06	18.53	Medium
	Mean			**0.3744**		**0.02**		**17**	**18.87**	
IBIAKU OSUK 2 (Foot Slope, Fallowed Land)										
Ap	0 – 10	5.2	Strongly acid	1.4820	Moderate	0.10	Low	17	15.99	Medium
AB	10 – 30	4.8	Very strongly acid	1.3065	Moderate	0.10	Low	16	14.04	Medium
B1	30 - 63	4.9	Very strongly acid	0.9555	Low	0.05	Very low	19	14.04	Medium
B2	63 - 115	5.3	Strongly acid	0.4290	Low	0.03	Very low	14	14.04	Medium
B3t	115 – 168	5.2	Strongly acid	0.1755	Very low	0.01	Very low	18	26.95	High
BC	168 – 200	5.5	Strongly acid	0.1505	Very low	0.01	Very low	14	14.04	Medium
	Mean			**0.9165**		**0.06**		**16**	**16.52**	

[Source of Rating [25][31]

TOC = Total Organic Carbon, N= Nitrogen, P= Phosphorus, C:N = Carbon – Nitrogen Ratio

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4. CONCLUSIONS

Generally, most of the soils of Ibiono Ibom area have excellent physical conditions which includes; it well drained nature, although the chemical condition is poor. The indicators range varied considerably from very low to high. Saturated hydraulic conductivity ranged from 0.00 – 89.10 cm/hr. Bulk density, particle density and total porosity ranged from 1.20 – 1.66g/cm^3, 1.50 – 3.07 g/cm^3 and 19.8 – 56.7% respectively. Textures were generally sand to loamy sand, TOC and TN varied from very low to high generally, while other indicators such as available P. varied from medium to high. The low organic carbon and Nitrogen of the area can be attributed to continuous cropping, as well as annual slash and burn system of farming which discourages the build-up of organic matter. These practices result in low organic matter and impaired chemical soil quality and low agricultural yield in soils of the area. Based on the results of this study, soils within Ikot Usen 1, Ibiaku Osuk pedons are more suitable for agriculture than soils within Ikot Usen 2 and 3 pedons.

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