FERTILITY LEVEL OF SOME DEGRADED SOILS OF IMO STATE, SOUTHEASTERN, NIGERIA

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ABSTRACT
Low fertility status of soils is a major factor limiting agricultural production in the World today but in most parts of Southeast Nigeria, low fertility status of the region is mainly attributed to improper land uses which have resulted to numerous land degradation problems and this is evident in the low yield of agricultural produce in those regions. Degraded soils of Azara Egbelu, Ngor Okpala and Awo-omamma in Imo State, South eastern Nigeria were studied with the aim of investigating the influence of degradation on their fertility status. Three pedons were dug and described according to standard procedure. Samples were collected, labelled properly and subjected to routine laboratory analyses for selected physical and chemical properties. The results showed that soils were generally acidic in all profiles with mean value ranging from 5.17 to 5.61. The exchangeable cations were low in the three profile pits. Soil organic matter was low with mean values of ranging from 4.20 g kg to 12.66 gkg. Soils of the studied sites were vulnerable to calcium and magnesium deficiencies as shown in low calcium magnesium ratio. The mean C/N ratio ranged from 4.7 to 9.5. The value obtained from the fertility indices such as Ca:Mg ratio, C/N ratio, organic matter, effective cation exchange capacity indicated low fertility and will require soil enrichment. At profile pit 1, the sand (7.29), bulk density (8.64), total porosity (12.59), moisture content (13.93), base saturation (2.87) had low percentage variations while clay (27.44), total exchangeable acid (21.1) , effective cation exchange capacity (25.64), calcium- magnesium ration (90) had moderate variation. Soil degradation rate for pH, organic carbon, base saturation, effective cation exchange capacity for soils of profile pit 2 were 1,3,1,5 while the soil vulnerability potential was 5,4,5,1 respectively. At profile pit 1, the soil degradation rate for Soil pH, Organic carbon, Base Saturation, Effective cation exchange capacity 2,1,5,5 respectively while Soil vulnerability potential was 4,3,5,1. Profile pit 3 had Soil degradation rate of 2,4,1,4 5 respectively while Soil vulnerability potential was 4,3,5,2. The ratio of the SDR/SVP for the study areas indicated that there is high susceptibility to degradation especially soil erosion. Soils of the area also indicated high vulnerability potential.

Keywords: Properties, Fertility Status, Degradation, Soil, Vulnerability, Susceptibility,

INTRODUCTION

Tropical soils are most susceptible to degradation as a result of climatic factors and the nature of their parent materials. These tropical soils are highly susceptible to degradation especially under continuous cultivation when conservation measures are not put in place (Ovie *et al.*, 2015). These frequent degradation affects the productivity and fertility status of these soils. In South-east, Nigeria the major causes of soil degradation includes soil erosion, which is as a result of high rainfall, deforestation, fragile nature of soil and farming activities as reported by Igwe, (2003). More so, as a result of not disposing waste generated from industries and house hold, agricultural waste properly soils have been polluted with toxic substances; thereby reducing their fertility level and productivity.

Soil degradation is defined as a reduction in biological and economic productive potentials of soils; rain-fed cropland, irrigated crop land or range, pasture and forested land by one or a combination of processes (Osanyande *et al.*, 2014). Degradation results when the capacity of a natural ecosystem to renew itself is restrained by regular disturbances and perturbations and this is a threat to human survival and livelihood (Abbas, 2009). According to Chris-Emenyonu *et al.*, (2011) soil erosion is one of the ecological problems ravaging the Nigeria soil landscapes especially in Southeast Nigeria. In Imo State alone over 261 gullies have been reported and documented. Apart from these gullies, waste is also improperly disposed in most part of the state especially in urban regions. These has lead to contamination of the soil by causing accumulation of toxic materials such as heavy metals and metalloids through discharges and erosion from the fast growing industries, mines, fertilizer applications, seepage, improper disposal of metal waste, herbicides, pesticides, waste water irrigation. These accumulations of pollutants inhibit the fertility of these soils hence their ability to be productive.

Soil fertility is a precursor for agricultural productivity and food security in the tropics. Soil fertility is the capacity of the soil to supply nutrients that enhance crop growth and ensure sustainable food production (Ekong *et al*., 2015). The fertility status of soils are affected by their properties because soil properties play a key role in the release of plant nutrients which are needed for plant growth and development but fertility status of these soils are being hindered due to continuous degradation of these soils. Most of these soil properties have been adversely degraded as a result of different anthropogenic and non anthropogenic activities.

Onwudike *et al.*, (2015) reported that decline in soil fertility and land degradation has been considered as a major constrains facing agricultural productivity in South-eastern Nigeria and that there is dearth of information on the degradation rate and vulnerability potential of soil qualities in Owerri. Therefore, this study was embarked on to with the aim of investigating the influence of degradation on fertility status of some soils of Imo State, South-east Nigeria.

MATERIALS AND METHODS

STUDY AREA

The study was carried out in three different locations namely Awo-omamma lying between 5^0 40′16.1″ N and 6^0 57′ 8.6″ E, Nguru in Ngor Okpala lying between latitude $5^0 21'$N and longitude $7^0 15'$E and and Azaraegbelu lying between latitude $5^0 29'$N and longitude $7^0 9'$E, all in Imo State Southeastern, Nigeria. Soils of the study area are all derived from coastal plain sands (Benin Formation) (Orajaka, 1975).

The Climate is humid tropical. The pattern of rainfall observed in the area is bimodal and is from April-July and September-November with a break in August usually referred to as "August break. The mean annual temperature ranges from 27-28 ^{0}C with a relative humidity ranging from 70-80 % (NIMET, 2017). It has mean annual rainfall of about 2500 mm.

FIELD STUDY

A free survey technique was used to locate the sampling areas after which a profile pit was dug at each location. The locations were geo referenced using hand-held Global Positioning System (GPS). Soil samples were collected according to FAO (2003) guideline. Samples were air-dried, crushed and sieved using 2 mm sieve and taken to the laboratory for analyses. Core samples were used to collect soil samples for bulk density determination.

LABORATORY ANALYSIS

Particle size distribution was determined in water and calgon by hydrometer method (Gee and Or 2000).The bulk density was measured using the cone method (Grossman and Renish 2002). Percentage moisture content was determined gravimetrically by oven drying the samples at 15^0C (Carter, 1993). Total porosity was determined by calculation according to the procedure of (Vomocil, 1965). The silt/clay ratio was done by computing the ratio between silt and clay. The clay dispersal ratio was calculated according to the procedure of (Middleton, 1930).Clay dispersal index was calculated according to the procedure used by Chris-Emenyonu and Onweremadu (2011).Soil pH was determined using 1:2.5 soil / liquid both in water and Kcl (Handershot *et al*, 1993).Organic carbon was determined using chronic wet oxidation method (Olsen and Somers, 1982). Organic matter was obtained by multiplying the percentage organic carbon by Van Bemmele factor of 1.724. Total nitrogen was determined by normal kjedhal method (Bremner, 1996). The total exchangeable bases were extracted using 1N NH_4AOAC . Ca^{2+} and Mg^{2+} were determined by ethylene diamine tetra acetic acid (EDTA) titration method (Thomas, 1982) and Na^+ and K^+ was determined with flame photometer (Jackson, 1962). Exchangeable acidity (EA) was determined according to the procedure of (Mclean, 1982). Effective Cation Exchange Capacity (ECEC) was calculated from the summation of all exchangeable bases and total exchangeable acidity (Blake, 1965). C/N ratio was determined by calculation using carbon and nitrogen values. Ca/mg ratio was calculated as Ca/Mg. Percentage base saturation (% BS) was calculated by the summation of the total exchangeable bases divided by the effective cation exchange capacity and then multiplied by 100.

Soil Vulnerability Potential (SVP) and Soil Degradation Rate (SDR)

Soil vulnerability potential (SVP) and soil degradation rate (SDR) was estimated using the rating scheme for degradation according to Lal (1993). For SDR, the weighting sequence was as follows 1 = none, 2 – slight, 3 = moderate, 4 = severe, and 5 = extreme. For SVP, the weighting sequence is as follows 5 = very low, 4 = low, 3 = medium, 2 = high, and 1 = very high(Lal, 1993, Akpan-Idiok,2012).

Statistical Analysis

Measured variables in the data set were analysed using classical statistical method to obtain the descriptive statistics. The vertical variation of soil properties was determined using coefficient of variation. The coefficient of variation was ranked according to the procedure of Wilding (1985). C.V. $\leq$ 15 is low variation, 15-35, is moderate variation and C.V $\geq$35 is high variation.

RESULTS AND DISCUSSION

The particle size distributions of the pedons are shown on table 1.Results showed that sand fractions dominated the particle size distribution but sand fraction in water was higher than that in calgon. The sand fraction ranged from 851g kg in Profile pit 3 to 857g kg Profile pit 1 and 927 g kg in profile pit 2. The high sand fraction could be attributed to the parent material dominant in the area which is coastal plain sand since the texture of the soil is highly influence by parent material over time (Oguike and Mbagwu, 2009). These results agreed with Onweremadu (2007) who observed similar textural characteristics on coastal plain soils in Owerri, Southeast Nigeria and Onwudike (2015) who observed same. The silt content ranged from 48.8g kg at profile pit 2 to 52.8 g kg at profile pit 3 and 86.8 g kg at profile pit 1 and 23.6g/k. The clay content ranged 1.54 g kg at profile pit 1, 1.85 g kg in profile pit 3 and 137.6 g kg in profile pit 2. The bulk density values ranged from 1.56 gcm^3 in profile pit

1,(Azara Egbelu), 1.85 g cm^3 Ngor Okpala in profile pit 3 and in profile pit 2 (AWO) 137.6 g cm^3 . Bulk density values obtained in all locations were much higher than the critical limit of 1.3 g cm recommended for tuber and cereal crops (Lal, 1986).Higher values obtained in AWO (137.6 g cm^3) can be attributed to various anthropogenic activities. The moisture content of the soil ranged from 17.88 g kg at Awo-omamma, 44.33 g kg in Azara egbelu and 49 g kg at Ngor Okpala. The low values could be attributed to the high sand fraction which hinders moisture retention (Chris-emenyonu *et al*, 2017).

Soil erosion is a major form of soil degradation in most regions of Imo state south Eastern Nigeria, where over 261 gullies have been recorded as at 2011.Clay dispersion ratio and clay dispersion index has been reported to be an efficient indices for predicting erodibility in some soils of South-eastern Nigeria (Chris-emenyonu and Onweremadu,2011). The CDR indicates a clear boundary between erodible and non erodible soil and CDR greater than 15% indicates

erodible and values lower than 15% indicates non-erodible in line with Middleton (1930). Mean percentage values obtained in all locations were much higher than 15% with values ranging from 72.29, 45.46 and 49.09 at Azara Egbelu, Awo-omamma and Ngor Okpala respectively. This result shows that soils of Azara egbelu were more erodible compared to the other locations.

Mean values of the clay dispersion index ranged from 17.88 at Awo-omamma, 44.33 at Azara Egbelu, and 49.00 at Ngor Okpala indicating that the soils are highly erodible and susceptible to degradation. Also Awo-omamma had a lowest value when compared to the other locations indicating that soils of Azara Egbulu and Ngor okpala has more prone to erosion compared to those of Awo-omamma using these two indices.

Table 1: Physical Properties of the studied areas

Samples In water		**Depth Cm**	**Sand**	**Silt**	**Clay g/kg**	**BD g/cm^3**	**TP %**	**MC g/kg**	**CDI**	**CDR**	**TC**
AZ	A	0 – 30	859.6	102.8	37.6	1.71	35	263	31.97	82.39	LS
AZ	AB	30 – 50	799.6	42.8	157.6	1.39	48	177	66.33	74.11	LS
AZ	Bt_1	50 – 80	789.6	132.8	77.6	1.43	46	243	32.66	67.78	LS
AZ	Bt_2	80 – 101	819.6	42.8	137.6	1.62	39	232	51.42	62.12	LS
AZ	Bt_3	101 – 120	809.6	112.8	77.6	1.56	41	232	39.27	76.04	LS
MEAN			**815.6**	**86.8**	**97.6**	**1.54**	**41.8**	**229**	**44.33**	**72.49**	
CV			7.29	41.65	50.19	8.64	12.59	13.93	32.86	8.72	
Ranking			L	H	H	L	L	L	M	L	
AWO	Ap	0 – 38	919.6	62.8	17.6	97.6	35	961	18.03	61.66	S
AWO	Bt_1	38 – 72	899.6	72.8	27.6	137.6	32	795	20.06	58.92	S
AWO	Bt_2	72 – 114	939.6	32.8	27.6	137.6	31	770	20.06	40.16	S
AWO	Bt_3	114 – 144	929.6	42.8	27.6	137.6	40	770	20.06	36.97	S
AWO	Bt_4	144 – 171	949.6	32.8	17.6	137.6	36	103	11.17	29.58	S
MEAN			**927.6**	**48.8**	**23.6**	**137.6**	**34.8**	**680**	**17.88**	**45.46**	
CV			2.72	58.10	16.4	5.32	10.24	48.85	21.53	31.03	
Ranking			L	H	M	L	L	H	M	M	
NG	AP	0 – 14	969.6	12.8	17.6	1.69	36	233	30.56	27.54	S
NG	AB	14 – 25	839.6	102.8	57.6	1.81	32	343	67.75	46.32	LS
NG	Bt_1	25 – 37	929.6	52.8	17.6	1.91	26	686	14.97	53.99	S
NG	Bt_2	37 – 50	869.6	22.8	107.6	1.92	28	685	78.19	49.09	Ls
NG	Bt_3	50 – 71	869.6	72.8	57.8	1.87	29	372	53.53	68.49	Ls
MEAN			**895.6**	**52.8**	**51.64**	**1.85**	**30.2**	**464**	**49**	**49.09**	
CV			**5.89**	**69.58**	**5.08**	**4.86**	**12.91**	**45.02**	**53.24**	**30.08**	
Ranking			**L**	**H**	**L**	**L**	**L**	**H**	**H**	**M**	

Pit 1 AZ = Azeraegbelu , pit 2 AWO=Awo-omamma, pit 3 NG = Ngor Okpala, SCR = silt clay ratio,MC = moisture content, Bd = Bulk density, TC = Textural class,TP = Total porosity,CDI =clay dispersal index,CDR = Clay dispersal ratio,M =moderate, H =High,L=low

CHEMICAL PROPERTIES

Chemical makeup of soils affects the resistance of soils to forces generated by agents of erosion (Chris-emenyonu and Onweremadu. 2011). The results of the chemical properties are shown on Table 2. Soil pH influences plants nutrient availability, the pH values of the soils ranged from strongly acidic (5.17) at Azara Egbelu, to moderately acidic (5.61) at Ngor Okpala (Lal, 1993, Akpan-idiok 2012) and is similar to those obtained by Chris-Emenyonu and Onweremadu (2011) in erosion degraded soils of Awo-omamma. Soil acidity contributes to low fertility of soils because of the high concentrations of Al, Fe, Mn, and H which affects the availability of basic cations hence restricting crop growth. Soil acidity affects soil microbes abundance especially earthworm and other biological activities, this is evident in the slow breakdown of organic materials in the soil and this might have attributed to the low value of exchangeable bases and organic matter obtained in the study locations. The exchangeable cations were low in the three locations, exchangeable Ca, Mg, K and Na in Azeraegbelu falls within the range of 0.002 – 3.2 Cmol/kg, Awo-omamma 0.001 – 3.8 Cmol/kg and Ngor Okpala was 0.002 – 3.2 Cmol/kg. Criteria used by FDALR(1985) was used in attempt to classify exchangeable calcium , with less than 2.0 cmol kg^{-1} (very low),2.0 – 5.0 cmol kg^{-1} (low) and 5.0 – 10.0 cmol kg^{-1}(moderate). K and Na recorded the lowest value in the three locations (0.001 – 0.03) cmol/kg respectively this can be attributed to the acidic nature of the soils, low organic matter content among others. Also the low exchangeable bases can be attributed to high rainfall which accelerates run-off and leaching down the subsoil this conforms to the work of Onwudike *et al* (2015) who obtained the similar results in soils of South-Eastern Nigeria.

Generally, soils of the studied site are vulnerable to calcium and magnesium deficiencies as they show low calcium-magnesium ratios. According to Landon (1984), a decrease in Ca/Mg ratio to a level below 3 results to the unavailability of calcium and magnesium and all three locations had values less than 3. The mean C/N ratio ranged from 4.7 to.9.5. Exchangeable Al and H recorded the lowest value (0.1 – 0.6cmol/kg).

Organic matter decreased with increase in the depth of the profile, low organic matter content of the soil indicate poor micro aggregation there making soil vulnerable to erosion (Lal, 1990) whereas soil with high organic matter will be resistant to soil crusting and compaction, have high fertility status but since sandy soils have low organic matter content, little or no swelling and shrinkage and high leaching of nutrients and pollutants leading to soil degradation (FAO 1998). This is often considered the single most

important indication of soil fertility status (Roming *et al*., 1995, Vance, 2000, Doran 2002).
The percentage total nitrogen was generally low, this is typical of soils derived from coastal plain sands (Chris-emenyonu and Onweremadu,2011, Chris-Emenyonu *et al*,2017 and higher total N content grain size fractions of the topsoil could be due to the high organic matter content of the topsoil Uzoho et *al*., 2016). The effective cation exchange capacity was low; it ranged from 1.09 – 76 cmol/kg with the higher occurring in FUTO Farm. The low effective cation exchange capacity content of these soils reminded that the adsorption capacity of these soils was humus dependent. It can also be attributed to leaching process due to high intensity of rainfall (Okalebo *et al*., 1993)

TABLE 2: Chemical Properties of the studied areas

Samples		Depth	pH Kcl	OM	TN	Av. P	Ca	Mg	K	Na	TEA	TEB	ECEC	BS	Ca/Mg	C/N
				g/kg	%	Mgkg	⟶				Cmol/kg	⟵		%		
AZ	A	0 – 30	5.10	24.08	0.12	0.91	0.64	3.2	0.02	0.01	0.5	3.87	4.37	88.56	0.2	11.84
AZ	AB	30 – 50	5.19	12.73	0.079	0.7	1.04	3.2	0.03	0.01	0.6	4.28	4.88	87.70	0.3	9.34
AZ	Bt$_1$	50 – 80	5.15	12.04	0.070	3.08	2.56	3.2	0.002	0.01	0.7	5.8	6.5	89.23	0.8	9.97
AZ	Bt$_2$	80 – 101	5.20	6.19	0.048	3.29	0.08	2.67	0.003	0.01	0.5	2.67	3.17	84.23	0.03	7.48
AZ	Bt$_3$	101 – 120	5.22	8.25	0.053	0.21	0.88	3.2	0.01	0.01	0.4	4.1	4.5	91.11	0.28	9.04
MEAN			**5.17**	**12.66**	**0.074**	**1.64**	**1.04**	**3.1**	**0.01**	**0.001**	**0.54**	**4.14**	**4.68**	**88.17**	**0.32**	**9.53**
CV			0.93	54.74	37.84	87.62	89.4	7.65	92.3	30.4	21.1	27.03	25.64	2.87	90	16.6
Ranking			L	H	H	H	H	L	H	M	M	L	M	L	H	M
FUTO	Ap	0 – 38	5.22	8.25	0.080	2.66	1.12	3.2	0.01	0.01	0.6	4.39	5.0	87.8	0.4	5.99
FUTO	Bt$_1$	38 – 72	5.25	5.85	0.051	2.73	1.12	3.2	0.001	0.01	0.7	3.33	4.0	83.25	0.4	6.65
FUTO	Bt$_2$	72 – 114	5.27	1.72	0.042	1.12	0.8	3.2	0.004	0.01	0.8	4.01	4.8	83.54	0.3	2.38
FUTO	Bt$_3$	114 – 144	5.25	2.41	0.039	4.27	3.8	3.2	0.001	0.004	0.6	7.01	7.6	92.24	1.2	3.59
FUTO	Bt$_4$	144 – 171	5.30	2.75	0.032	1.89	0.48	3.2	0.02	0.01	0.5	3.71	4.2	88.33	0.2	5
MEAN			**5.26**	**4.20**	**0.049**	**2.53**	**1.46**	**3.2**	**0.01**	**0.01**	**0.64**	**4.48**	**5.12**	**87.03**	**0.5**	**4.72**
CV			0.55	65.83	38.78	46.28	91.30	0	80	30	17.19	32.56	28.12	0.04	80	36.86
Ranking			L	L	H	H	H	-	H	M	M	M	M	L	H	H
NG	AP	0 – 14	5.39	14.10	0.086	1.54	2.24	3.2	0.02	0.004	0.1	5.46	5.56	98.20	0.7	9.51
NG	AB	14 – 25	5.57	9.63	0.072	0.56	0.08	0.2	0.01	0.004	0.8	0.29	1.09	26.61	0.4	7.76

NG	Bt_1	25 – 37	5.52	8.25	0.069	1.61	0.8	3.2	0.01	0.004	0.9	4.01	4.91	81.67	0.3	6.94
NG	Bt_2	37 – 50	5.76	8.60	0.052	1.4	0.96	3.2	0.002	0.004	0.6	4.17	4.77	87.42	0.3	9.60
NG	Bt_3	50 - 71	5.80	5.85	0.046	0.56	0.88	3.2	0.002	0.004	1	4.09	5.09	80.35	0.3	7.37
MEAN			**5.61**	**9.29**	**0.065**	**1.13**	**0.99**	**2.6**	**0.01**	**0.004**	**0.7**	**3.60**	**4.28**	**74.85**	**0.4**	**8.24**
CV			**3.05**	**32.58**	**24.6**	**46.81**	**78.8**	**0**	**70**	**O**	**50.86**	**54.06**	**42.29**	**37.23**	**43.25**	**15.04**
Ranking			**L**	**M**	**M**	**H**	**H**	**-**	**H**	**-**	**H**	**H**	**H**	**H**	**H**	**M**

AZ = Azeraegbelu , pit 2 FUTO = Federal university of Technology Owerri, pit 3 NG = Ngor Okpala,, OC = Organic Carbon, OM = Organic Matter, TN = Total Nitrogen, AV.P = Available phosphorus, Ca = Calcium, Mg = Magnesium, K = potassium, Na = sodium, Al = Aluminium, H = hydrogen , TEA = Total Exchangeable Acids, TEB = Total Exchangeable Bases, ECEC = Effective Cation Exchange Capacity, BS = Base Saturation, Ca/Mg = Calcium-Magnesium ratio, C/N = Carbon nitrogen ratio

Fertility index of the Studied Area.

Table 3 showed results of the fertility index of studied locations . Generally results obtained revealed low level of fertility indices studied. Carbon/ nitrogen ratio was low at all locations (range, 4.72-9.53) as all the values were less than the separating index of 25 (Paul and Clark, 1989). Calcium-Magnesium ratio was low (0.32-0.5) compared with a normal range of 3:1-5:1 for productive soils (Landon, 1991), also Landon (1984) reported that a decrease of Ca/Mg ratio to a level below 3, results to the unavailability of calcium and phosphorus. Effective Cation Exchange Capacity (ECEC) values were low below the range of 3.03-5.52 cmolkg by (FPDD, 1990) for productive soils. This very low to low effective cation exchange capacity of these soils indicates low capacity of these soils to retain nutrient elements. Base saturation was high at all profiles with percentage values of 88.17% (Azaraegbelu), 87.03% (Awo-omamma) and 74.85% (Ngor okpala), this is similar with the findings Chris-emenyonu *et al* (2017) on soils of Awo-omamma .With these mean percentages basic nutrients must have occurred in available forms in soil solution in spite of the low cation reserves in the soils. Organic matter was low at all locations. Soil organic matter is often considered the single most important indication of soil fertility status (Roming *et al*., 1995, Vance, 2000, Doran 2002). The environment of Eastern Nigeria is characterized by high temperature and relative humidity conditions that favour rapid decomposition and mineralization of organic matter. This could explain the low levels of organic carbon in the soils (Chikezie *et al*., (2010).

Table 3: Fertility Indices of the studied areas

	HORIZONS	**Depth**	**C/N**	**Ca/Mg**	**BS %**	**ECEC Cmol/kg**	**OM k/kg**
AZARAEGBELU	A	0 – 30	11.84	0.2	88.56	4.37	24.08
	AB	30 – 50	9.34	0.3	87.70	4.88	12.73
	Bt_1	50 – 80	9.97	0.8	89.23	6.5	12.04
	Bt_2	80 – 101	7.48	0.03	84.23	3.17	6.19
	Bt_3	101 – 120	9.04	0.28	91.11	4.5	8.25
	Mean		**9.53**	**0.32**	**88.17**	**4.68**	**12.66**
	SDV		**1.582**	**0.288**	**2.533**	**1.200**	**6.93**
	CV		**16.600**	**90**	**2.873**	**25.641**	**54.74**
	Ranking		**M**	**H**	**L**	**M**	**H**
AWO-OMAMMA	Ap	0 – 38	5.99	0.4	87.8	5.0	8.25
	Bt_1	38 – 72	6.65	0.4	83.25	4.0	5.85
	Bt_2	72 – 114	2.38	0.3	83.54	4.8	1.72
	Bt_3	114 – 144	3.59	1.2	92.24	7.6	2.41
	Bt_4	144 – 171	5	0.2	88.33	4.2	2.75
	Mean		**4.72**	**0.5**	**87.03**	**5.12**	**4.20**
	SDV		**1.744**	**0.4**	**3.738**	**1.446**	**2.77**
	CV		**36.95**	**80**	**4.30**	**28.24**	**65.95**
	Ranking		**H**	**H**	**L**	**M**	**H**
Ngor Okpala	AP	0 – 14	9.51	0.7	98.20	5.56	14.10
	AB	14 – 25	7.76	0.4	26.61	1.09	9.63
	Bt_1	25 – 37	6.94	0.3	81.67	4.91	8.25
	Bt_2	37 – 50	9.60	0.3	87.42	4.77	8.60
	Bt_3	50 – 71	7.37	0.3	80.35	5.09	5.85
Mean			**8.24**	**0.4**	**74.85**	**4.28**	**9.29**

SDV	**1.239**	**0.173**	**27.87 1**	**1.810**	**3.03**
CV	**15.04**	**43.25**	**37.24**	**42.29**	**32.62**
Ranking	**M**	**H**	**H**	**H**	**M**

Profile pit 1 = Azeraegbelu , profile pit 2 = Demonstration farm, profile pit = Ngor Okpala, C/N = Carbon nitrogen ratio, Ca/Mg = Calcium-Magnesium ratio, BS = Base saturation, ECEC = Effective Cation Exchange Capacity, OM = Organic matter

Results of the relationship among selected soil physical and chemical properties are shown on Table 4. Results revealed that soils of Azaraegbelu had high variation in pH,organic matter, and silt, moderate variations in effective cation exchange capacity, carbon/nitrogen ratio and clay and low variation in Base saturation, sand content, bulk density, total porosity and moisture content while Awo-omamma recorded high variations in organic matter, Available Phosphorus, carbon/nitrogen ratio, silt and moisture content and soils of Ngor Okpala recorded high variations in effective cation exchange capacity, Base saturation, silt, and moisture content, moderate variations in organic matter content, carbon/nitrogen ratio and clay, low variations in pH, bulk density, total porosity, sand and available phosphorus.

The soils studied are of same lithology dominant, therefore the variations in chemical properties recorded can be attributed to alteration in chemical equilibrium resulting from some management practices such as tillage and fertilizer applications while those observed in physical properties can be attributed to their lithology.

Table 4: Variability among the Physical and Chemical Properties of soil in the studied locations

AZARAEGBELU		pH(KCl)	OM	Av.P	ECEC	C/N	BS	SAND	SILT	CLAY	BD	TP	MC		CLAY	BS
	MEAN	5.17	12.6	1.64	4.68	9.53	88.17	741.6	468	211.6	1.54	41.8	229			
	%CV	0.93	54.7	87.62	25.64	16.6	2.87	7.29	41.65	27.44	8.64	12.59	13.95			
	RANKING	H	H	H	M	M	L	L	H	M	L	L	L			
AWO-OMAMMA																
	MEAN	5.26	4.20	2.53	4.48	4.72	87.03	837.6	28.8	133.6	1.73	34.8	680			
	%CV	0.55	65.8	46.28	32.6	36.9	4.30	2.72	58.10	16.4	5.32	10.24	48.85			
	RANKING	L	H	H	M	H	L	L	H	M	L	L	H			
Ngor Okpala																
	MEAN	5.61	9.29	1.13	4.28	8.24	74.8	857.6	40.8	101.6	1.85	30.2	464			
	%CV	3.05	32.5	46.81	42.29	15.04	37.23	3.54	72.29	30.02	5.72	12.91	49.19			
	RANKING	L	M	L	H	M	H	L	H	M	L	L	H			

CV: Coefficient of variation, BD: Bulk density, TP: Total porosity, MC: Moisture content, ,ECEC- Effective cation exchange capacity, Avail.p- Available Phosphorus, TP-total porosity, OM-Organic matter.

Table 5 shows that Soil degradation rate for pH, Organic carbon, Base Saturation, Effective cation exchange capacity, for soils of Profile pit 2 were 1,,3,1,5 respectively while Soil vulnerability potential was 5,,4,5,1. Soils of Profile pit 1 the soil degradation rate for Soil pH, Organic carbon, Base Saturation, Effective cation exchange capacity 2,1,5 5 respectively while Soil vulnerability potential was 4,,3,5,1. Soils at Profile pit 3 had Soil degradation rate of 2,4,1,4 5 respectively while Soil vulnerability potential was 4,3,5,2. The ratio of the SDR/SVP for the study areas indicated that there is high susceptibility to degradation. Soils of the area also indicated high vulnerability potential. The SDR/SVP for Base Saturation in all three locations extreme degradation and vulnerability potential while pH in Profile pit 1 and Profile pit 2 showed moderate degradation and vulnerability potential and Severe in Profile pit 3. Effective cation exchange capacity in all three locations had low degradation and vulnerability potential. This shows that there is low availability of basic cations in the studied areas. This can be as a result of the parent material (coastal plain sand) and high precipitation which causes soil erosion in the study area. Similar results were obtained by Onwudike (2015) on soils of Owerri, south eastern Nigeria.

Table 5: Rating Scheme for Soil Degradation Rate and Soil Vulnerability Potential of selected Soil Properties

Study Area	Properties	Mean	SDR	SVP	SDR/SVP
	OC	7.34	2	4	2/4 Slightly
Profile pit 1	pH in KCL	5.17	3	3	3/3 Moderate
	ECEC	4.68	1	5	1/5 low
	BS	88.1	5	1	5/1 extreme
	OC	2.44	1	5	1/5 low
Profile pit 2	pH in KCl	5.26	3	4	3/4 moderate
	ECEC	5.12	1	5	1/5 low
	BS	87.03	5	1	5/1 Extreme
	OC	0.64	2	4	2/4 Slightly
	pH in KCl	5.61	4	3	4/3 Severe
Profile pit 3	ECEC	4.28	1	5	1/5 low
	BS	74.8	4	2	4/2 High

For SDR, the weighting sequence is as follows 1 = none, 2 – slight, 3 = moderate, 4 = severe, and 5 = extreme. For SVP, the weighting sequence is as follows 5 = very low, 4 = low, 3 = medium, 2 = high, and 1 = very high according to Lal (1993) and Akpan-Idiok (2012).

Critical Limits

OC	Class
< 0.4	Very low
0.4 – 1.0	Low
1.0 – 1.5	Moderate
1.5 – 2.0	High
> 2.0	very high

pH	Class
< 4.5	Extremely acidic
4.5 – 5.0	Very strongly acidic
5.1 – 5.5	Strongly acidic
5.6 – 6.0	Moderately acidic
6.1 – 6.5	Slightly acidic
6.6 – 7.5	Neutral

ECEC	Class
< 6.0	Very low
6 – 12	Low
12 – 25	Moderate
25 – 40	High
> 40	Very high

Lal (1993) and Akpan-Idioik (2012).

Conclusion

The study revealed that the soils had low fertility status and were vulnerable to degradation. Soils were dominated by grain size soil fraction with high porosity, strongly to moderately acidic, low organic matter content and generally low in other plant nutrient level. The ratio of the SDR/SVP for the studied areas indicated that there is high susceptibility to degradation. Soils of the area also indicated high vulnerability potential. The SDR/SVP for base Saturation in all three locations revealed extreme degradation and vulnerability potentials. However Effective cation exchange capacity in all three locations had low degradation and vulnerability potential. The fertility index of the studied soils revealed that all the soils had low fertility index and therefore in other to enhance agricultural productivity, the soils will require external source of nutrient enrichment. Also to combat high degradation rate and vulnerability potential of these soil and also to enhance the fertility status of the soils apart from nutrient enrichment there is need to lime the soils, plant acid tolerant plants , limit the use of inorganic fertilizes but in-cooperated organic method of fertilizer, protect the soil surface by planting cover crops . Results of clay dispersion ratio and clay dispersion index indicated that the soils are highly erodible, therefore waste should be disposed properly to prevent blockage of drainage path ways and also conservational tillage should be used to minimize runoff and soil erosion.

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