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CHARACTERIZATION AND CLASSIFICATION OF CROPLAND-SOILS AFFECTED BY EROSION IN IGBUDU IKWO, SOUTHEASTERN NIGERIA

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ABSTRACT

This research was carried out in Igbudu Ikwo, Ebonyi State in Southeastern Nigeria to investigate and classify some cropland-soils affected by erosion. Three profile pits were dug and samples were collected in their horizons. The soils physico-chemical properties analyzed indicated that all investigated soils were sandy loam (SL), bulk density was high ranging from 1.51, 1.59 and 1.42 gcm^{-3}in pedons 1, 2 and 3 due to the preponderance of high sandiness, although within the acceptable levels (<1.85). Available P was medium (5 – 15 $mgkg^{-1}$) in pedon 2 and high (>15 $mgkg^{-1}$) in pedons 1 and 3. Organic matter was medium (2.0 - 4.2%) at pedons 1 and 3 and low < 2% in pedon 2 when critical limits was considered. This low organic matter content is a challenge as the soils of Igbudu Ikwo is already prone to erosion and would need high organic matter content to bind the soils particles together against disintegration by erosion processes. Sodium was very low (< 0.1 gkg^{-1}) while K was low (<0.1 – 0.3 gkg^{-1} Therefore, the inputs of K fertilizer would be necessary to enhance the productivity of the soils. Calcium and Mg were very low when critical limits were considered (<2 gkg^{-1}) and (<0.5 gkg^{-1}) for Ca and Mg respectively. Adequate soil conservation practices and improvement of soil nutrients should be adopted for the optimum productivity of the soils of Igbudu Ikwo, Ebonyi State. The pedons were classified as Arenic Kandiudults in USDA soil taxonomy and Arenic Lixisols when correlated with WRB for soil resources.

Contribution/Originality: This work is the first attempt to characterize and classify soils of Igbudu Ikwo in Southeastern Nigeria even though the area is of huge agricultural significance and under erosion threat. This study provided information on soil physic-chemical properties as well as the current nutrient/fertility situation of the soil.

1. INTRODUCTION

The erodibility of the soil is the vulnerability or susceptibility of the soil to erosion. It is a measure of a soil's susceptibility to particle detachment and transport by agents of erosion. Igwe (2003) remarked that a number of factors such as the physical and the chemical properties of the soil influence erodibility. In southeastern Nigeria, the nature and the long weathering history of the soils parent material evident in the dominance of the clay mineralogy by non-expanding clay minerals and low soil organic matter concentration due to high mineralization rates and excessive leaching of nutrients could be linked to the worsening situation. Inappropriate land use and soil management options are also a common feature of agriculture in the region. Anthropogenic factors often combine to weakened soils to produce severe gullies. The soils are hence loose and slumps under high intensive rainfall that renders them easily detachable. Some of the soils have the tendency to slake and form seals under such intense rainstorms thereby resulting in considerable runoff and soil erosion. The soil erodibility factor has since been recognized as a contributing factor to soil erosion hazard (Igwe., 2012).

Soils prone to erosion in any environment have been a serious threat to crop production. The Millennium Ecosystem Assessment (2005) identified unwise land-use choices and harmful crop or soil management practices as the major drivers of increasing soil erosion. Soil erosion has multiple negative effects on agricultural soils such as decreasing crop yields, decreasing water quality (turbidity and particle-born pollutant) and disturbed hydrological regimes such as increased flood risk due to riverbed filling and stream plugging (Lai, 2017). Soil erosion is both naturally occurring (geologic erosion) and influenced by humans (accelerated erosion). Accelerated erosion can be 10 — 100 times more damaging than geologic erosion (Live Science Staff, 2004). Example include disturbance of soil or natural vegetation by grazing livestock, deforestation, tillage and construction, each of which are heightened by high rain fall and/or steep slopes. Globally 15% of total land area is eroded (Blanco-Canqui & Lal, 2008).

Soil erosion rates, posing a threat to sustainable agriculture (Pimentel, 2006) productive land is less than 11% of earth's total land area (Eswaran, 2001). Yet it must supply food to the world's population (less than seven billion people). Pimentel (2006) stated that soil is being lost at a rate that is 10 to 40 time faster than soil formation and ten (10) million hectares of crop land is lost yearly to erosion. Agriculture soils account for 75% of soil affected by erosion worldwide. Soil erosion is divided up into different categories including raindrop, rill erosion, sheet erosion and gully erosion. Generally, erosion is the formation of tiny channels across a soil surface that often occurs in sloping lands. Sheet erosion is the removal of a somewhat uniform layer of soil which is attributed to the splash effect of raindrop impact and also splash effect of raindrop impact and also sheet flow. If rill erosion persists, it is likely that gully erosion will occur. Gully erosion is the process that removed large amounts of soil and result in a narrow or deep channel.

Zobeck and Van (2014) stated that sandy soils are prone to erosion and drought and it will be difficult to establish plant in this types of soil because erosion of soil by water and wind will reduces its productive potential by removing nutrients, organic matter, soil organisms, water storage capacity, root Zone depth, cutting plant growth by sand (blasting. In a dry climate, it may take 100 years to form 1mm of topsoil, but erosive force removes this in a matter of minute. Sandy soil is a free draining soil to work and warm up quickly in spring, however, it dries out rapidly and leaches nutrients when there is rain, so it requires addition of organic matter to help retain moisture and feed the plants. It's gritty to touch as it made up of large particles, so it is free draining and prone to leaching nutrients. A rolled ball sandy soil will crumble away easily (Montgomery, 2008).

Poorly structured surface soil which have little resistance to raindrop, impacts are easily broken into tiny particle. The surfaces are sealed and force rain to run off fine sand as well as dense sandy barns fall in this category. The finer the particles, the more easily they are picked up by running water (Costard, Dupeyrat, Gautier, & Carey-Gailhardis, 2003). Any cultivated soils can be susceptible but sandy soils are most at risk because they have less ability to be moved (Brady & Weil, 2016). Therefore the main objective of this study is to characterize and classify soils affected by erosion in Igbudu, Ikwo Ebonyi State in Southeastern Nigeria.

2. MATERIALS AND METHODS

2.1. Location

The study area is located at Igbudu within the Ikwo Local Government Area of Ebonyi State, Nigeria. It is bounded within latitude 6°45'N and Longitude 8°65'N on the derived Savannah Zone of the Southeastern Agro-ecological zone of Nigeria and has altitude of less than 400ft above the sea level.

The landscape of the area is undulating and location exceeds 400ft, above sea level no trend has established by previous research (Amajor, 1987) of these conical shaped hills and other residual lowland planes that spreads within the areas. The geology is mainly coastal plain sand the resulting succession comprises of Igbudu acid and rocky hills formations. Otagbara and the Ogagbo Igbudu beach serves as boundary separating them from Cross Rivers (Amajor, 1987).

Two main climate seasons exist in Igbudu Ikwo Area. are dry and rainy seasons. Rainy season may also be referred as wet season. It begins on March and ends in October and is characterized by high volume of rainfall that ranged from 2000 — 2500mm annually with high temperature and low relative humidity. The dry season begins late October and ends February and is characterized by low rainfall, high temperature and low relative humidity. The temperature in the dry season ranges from 20 - 38°C and during the rainy season, 16 28°C (Aghamelu, Nnabo, & Eze, 2011).

Many southeastern Nigerian soils are regarded as Ultisol; highly weathered and leached, infertile, fragile and weak structures which encourages erosion. Its high soil reaction leads to nutrients imbalance and toxicity (Opara-Nadi & Oranekwulu, 1988).

The vegetation of the area is characterized by grasses, trees and secondary forest consisting of few shrubs with dispersed large trees and climber (Aghamelu et al., 2011). This vegetation is also partly dominated by few oil palm trees and clusters of bamboos near the Igbudu beach.

The major occupation of the people of Igbudu Ikwo is farming (about 50% are subsistence farmers) with food crops dominating the practice. Common crops include yam, cassava and rice. The cropping system is usually mixed; such as yam and vegetables, yam and cassava or yam, cassava and vegetables. Rice production is prevalent in most lowlands and the inland valleys. Generally, Igbudu Ikwo contributes immensely to the Ebonyi rice production and agricultural activities at this location are intense and the soils required to be replenished by constant use of fertilizers as fallow is no more a common practice for a natural nutrients restoration.

2.2. Field Work

The size of agricultural land of Igbudu Ikwo is about 40 hectares, and the area affected by arosion is about 5 hectares. A transect line was cut across the area affected by erosion and profile pits sunk at a distance of 150 – 200 m apart. Three profile pits were dug and samples collected according to their horizonations. Four samples were collected from each profile pit, with a total of 12 samples. The samples were bagged, labeled, sent to the laboratory for routine analysis of soil physical and chemical properties.

2.3. Laboratory Soil Analysis

Particles size distribution was determined by hydrometer method according to the procedure of Gee and Or (2002). Bulk density was measured by core method (Grossman & Reinsch, 2002). Porosity was computed from bulk density and particles density. Soil reaction (soil pH) was determined in 1.25 soil liquid ratios in water and 0.1N KCI (Thomas, Haszler, & Blevins, 1996). Organic carbon was determined using method described by Nelson and Sommers (1982).

Available Phosphorus was determined using Bray II method (Olson & Sommers, 1982). Total Nitrogen was determined using modified microkjeldah 1 method (Bremner & Mulvaney, 1982). Exchangeable bases (Ca, Mg, K, and Na) were determined using NH_4OAc saturation method (IITA, 1979). Calcium and Mg in solution were determined using Atomic Absorption Spectrophotometer, while K and Na were determined on a Flame Emission Photometer.

Effective Cation Exchangeable Capacity (ECEC) was determined by the summation of exchangeable cations. Percent base saturation was calculated as the sum of all base forming cations, divided by cation exchange capacity and multiplied by 100.

2.4. Statistical Analysis

Co-efficient of variation was used according to Wilding (1985) to estimate the degree of variability existing among soil properties in the study site.

Comparison was drawn from the results that were gotten from the laboratory analysis of the pedons. Co-efficient of variables was ranked according to Wilding (1985) as follows:

Level % Ranking

Co-efficient < 15 low variation

Co-efficient variation 15 — 35 moderate variation

Co-efficient > 35 and above high variation

3. RESULT AND DISCUSSION

Morphological soil properties of the soils of Igbudu Ikwo are summarized in Table 1. All the investigated soils were deep as the horizon depths were all above 120 cm. Horizon boundary characteristics revealed an abrupt horizons in A and AB of pedon 1 while its Bt1 was clear. In pedon 2, all horizons had clear horizon boundaries. Pedon 3 had boundaries that were gradual in A and AB and clear in its Bt1. Roots were distributed in the pedons as follows; common (c), many (m) and very few (vf) in horizons A, AB and Bt1 and Bt2 respectively in pedon 1. In pedon 2, roots were many in A and AB while it is very few in Bt1 and Bt2. Pedon 3 indicated a common root distribution in A horizon, few in AB and very few in Bt1 and Bt2. The few and very few roots observed in the investigated soils especially at the Bt1 and Bt2 of pedons 1 and 2 as well as greater part of pedon 3 could be as a result of the dominance of sparse vegetation on the surface of the studied soils. This situation has predisposed the soils to agents of erosion such as running water thereby tearing apart the structure and washing away the nutrient content of the soils. The sparse vegetation was as a result of anthropogenic activities such as human interference on natural vegetations. Igwe. (2012) noted that among the factors that encourage soil erosion are vegetation clearance, intensive harvesting and over-grazing leaving the soil bare. Stocking (1987) noted that vegetation acts in a variety of ways by intercepting raindrops through encouraging greater infiltration of water and through increasing surface soil organic matter and thereby reducing soil erodibility. Lal. (1983) suggests that vegetation and land use are one of the most important factors in soil erosion process in southeastern Nigeria. Therefore choosing an appropriate landuse can drastically curtail soil erosion.

The investigated soils were all weakly structured as they have a weak grade structure, crumbs in their form and very fine in sizes. The soil consistence of investigated soils indicated non sticky in all pedons when wet except at the Bt horizons of pedons 1 and 3 where it was slightly sticky. When moist however, consistence was loose and loose to soft when dry in all investigated soils. Soil consistence is measured separately for dry, moist and wet soil because moisture content impacts how a soil responds to pressures (Rawls & Pachepsky, 2002) in the field, soil consistence is measured by testing the ease with which the soil is crushed between the thumbs and forefingers (Soil Survey Staff, 1993).

Table-1. Morphological Properties of soils of Igbudu Ikwo.

Location	Depth (cm)	Horizon boundary	Root abundance	TC	Structure			Consistence			Colour	Mottle
Pedon 1					**Grade**	**Form**	**Size**	**Wet**	**Moist**	**Dry**	**Dry and moist conditions**	
A	0 - 21	abrupt	C	LS	1	Cr	Vf	So	L	L	dry – 5yr 7/1 light gray, moist–5yr 4/1 dark gray	Fe,1,f
AB	21–40	abrupt	M	LS	1	Cr	Vf	So	L	S	dry – 5yr 8/1 white, moist – 5yr 7/1 light gray	C, 2,d
Bt1	40- 80	clear	vf	SL	1	Cr	Vf	So	L	L	dry – 5yr 6/1 gray, moist - 5yr 4/1 dark gray	C, 2,d
Bt2	80-127		Vf	SL	1	Cr	Vf	SS	L	S	dry – 5yr 4/1 dark gray, moist–5yr3/1 very dark gray	f,1, f
Pedon 2												
A	0 – 20	clear	M	LS	1	Cr	Vf	So	L	L	dry – 5yr 7/1 light gray, moist–5yr 5/1 dark gray	F,1,f,
AB	20– 45	clear	M	SL	1	Cr	Vf	So	L	S	dry – 5yr 8/1 white, moist–5yr 7/1 light gray	C,2,d
Bt1	45-86	clear	vf	SL	1	Cr	Vf	So	L	S	dry – 5yr 8/1 white, moist–5yr 8/1 white	F,1,f
Bt2	86-125		vf	SL	2	Cr	Vf	So	L	S	dry – 5yr 8/1 white, moist–5yr 4/1 light gray	F,1,f
Pedon 3												
A	0 - 23	Gradual	C	LS	1	Cr	F	So	L	S	dry – 5yr 8/1 white, moist – 5yr 6/1 gray	c,2,d
AB	23 -48	Gradual	F	SL	1	Cr	F	So	L	S	dry – 5yr 6/1 gray; moist–5yr 4/1 dark gray	F,1,f
Bt1	48- 84	Clear	vf	SL	1	Cr	Vf	SS	L	L	dry – 5yr 8/1 white; moist–5yr 8/1 white	F,1,f
Bt2	84-131		vf	SL	1	Cr	Vf	So	L	Sh	dry – 5yr 8/1 white; moist–5yr 7/1 light gray	c,2,d

Note: A = abrupt, c = clear, g = gradual, m= many, vf – very few, cr = crumb, 1 = weak, vf = very fine, So = non Sticky, ss = slightly sticky, L = loose, Sh = slightly hard, f = few, m= medium, I == fine, 2 = medium.

In pedon 1, soil colors were 5YR 7/1 light gray (dry), 5YR 4/1 dark gray (moist)in A horizon over white (5YR 8/1) (dry) to light gray (5YR 7/1)(moist) in AB horizon. Bt horizons indicated gray to dark gray colors when dry and when moist respectively. In pedons 2 color ranged from dry– 5YR 7/1 light gray, moist–5YR 5/1 dark gray at the surface horizon to dry – 5YR 8/1 white, moist–5YR 4/1 light gray down the profile, this trend also repeated in pedon 3.The gray to white colors prevalent in these soils was an indication of low organic matter content as well as other binding agents such as sesquioxides thereby further predisposing the soils to erosion (Stenberg, Rossel, Mouazen, & Wetterlind, 2010).

The colour differences between the surface and sub-surface layers reflects biological processes notably those influenced by the soil organic matters, the surface horizons have darker colour than the corresponding sub-surface horizons as a result of relatively higher soil organic matter content. White to gray colour of soil is as a result of salts accumulation in arid and sub-humid regions where the evapo-transpiration less than the precipitation there is an upward movement of water and soluble salts in the soil (Bradv & Weil, 2006).

Table-2. Physical properties of Soils of Igbudu Ikwo.

Location	Depth (cm)	Sand%	Silt %	Clay%	SCR	TC	BD g/cm³	Porosity%
Pedon 1								
A	0-21	80.24	5.0	14.76	0.34	LS	1.42	46.42
AB	21- 40	78.24	6.0	15.76	0.38	LS	1.50	43.40
Bt1	40 – 80	76.24	5.0	18.76	0.26	SL	1.51	43.01
Bt2	80– 127	72.24	7.0	20.76	0.33	SL	1.61	39.25
Mean		76.76	5.7	17.5	0.32		1.51	43.01
Cv (%)		4.5	16.7	15.7	11.1		5.2	5.9
Rank		LV	MV	MV	LV		LV	LV
Pedon 2								
A	0 – 20	81.24	6.0	12.76	0.47	LS	1.36	48.68
AB	20 – 45	70 .24	14.0	12.76	1.09	SL	1.42	46.42
Bt1	45 – 86	70.24	15.0	14.76	1.01	SL	1.48	44.15
Bt2	86– 125	69.24	10.0	20.76	0.48	SL	1.71	35.47
Mean		72.74	11.25	15.26	0.76		1.59	40.00
Cv (%)		7.8	36.6	8.0	21		4.8	12.3
Rank		LV	HV	LV	MV		LV	LV
Pedon 3								
A	0 – 23	79.24	4.0	16.76	0.23	LS	1.38	47.92
AB	23 – 48	77.24	5.0	17.76	0.28	SL	1.40	47.16
Bt1	48 – 84	78.24	7.0	16.76	0.4	SL	1.42	46.42
Bt2	84– 131	70.24	10.0	19.76	0.50	SL	1.48	44.15
Mean		76.24	6.5	17.76	0.35		1.42	46.42
Cv (%)		5.1	40.7	4.7	14		3.0	3.0
Rank		LV	HV	LV	LV		LV	LV

Note: SCR = Silt clay ratio. TC = Textural class, BD = Bulk density, LS = Loamy sand, SL = Sandy loam, CV = Coefficient of variation, LV = low variability, MV = moderate variation, HV = High variability.

The physical properties of soils of Igbudu Ikwo in Ebonyi indicated that texture ranged from loamy sand to sandy loam in all investigated soils, suggesting that there was preponderance of sand in the studied soils Table 2. Highest sand occurred in pedons 1 followed by pedons 3 and the lowest occurred at pedon 2. Mean sand were 76.76, 72.74 and 76.24% in pedons 1, 2 and 3 respectively. Also mean silt distribution was16.7, 36.6 and 6.5 % in pedon 1, 2 and 3 respectively. Silt had no particular trend in pedon 1 while it increased in pedon 2 and 3. Clay content increased down the profile in all pedons having means of 17.5, 15.26 and 17.76% in pedons 1, 2 and 3 respectively. The consistent clay increase down the profile in all investigated pedons was due to clay movement down the profile suggesting illuviation and formation of argillic horizons in Bt horizons. The mean silt clay ratio recorded were 0.32, 0.76 and 0.35 for pedons 1, 2 and 3 respectively. Ugwa, Orimoloye, Kamalu, and Obazuaye (2017) reported that old parent materials usually have silt / clay ratio < 0.15 while the index > 0.15 was indicative of young parent material and value of = 0.15 is indicative of moderately weathered soils. Also, Ikemefuna (2010) rating the soil degradation rate and vulnerability potential of soils reported that if the silt/clay ratio is 5, it implies none, 3 is moderate, 2 is high while 1 is very high. These suggest that soils of Igbudu Ikwo, had attained advanced stage of weathering, highly weathered and highly leached which characterized most soils in the Southeastern Nigeria (Schoeneberger, Wysochi, & Benham, 2012); (Soil Survey Staff., 2014). It is therefore essential to minimize these limitations by choosing appropriate crops and good management practices. Cover crops, application of organic manures as well as minimum tillage are some of such practices.

The high sand content of the soils of Igbudu Ikwo may have resulted due to the lithology or parent materials of the area which is coastal plain sand. However, parent material influences the susceptibility of soils to erosion processes. This is manifest directly by the resistance of the denuded bed rocks exposed to the flow of water and affected by the character of parent materials whose properties are given by the bed rock. The direct effect of bedrock is also manifest in the properties of the soil forming parent materials which conditions the principal properties. Some geological materials are vulnerable than others to aggressive energy of the rainfall and runoff. High erosion risks match with units of weak unconsolidated geological formations. This is more pronounced when such geological units coincide with medium to long and even very long slopes with marked gradients (Igwe., 2012).

Bulk density increased down the horizons in all pedons of the area while there was a decrease in porosity down the profile. Mean bulk density were 1.51, 1.49 and 1.42g/cm^3 and mean porosity were 43.01, 40.00 and 46.42% all in pedons 1, 2 and 3 respectively.

The chemical properties of soils of Igbudu Ikwo, Ebonyi State are as shown in Table 3. Soil pH distribution ranged from moderately to slightly acidic in all pedons, the mean pH were 5.32, 5.28, 5.2 in pedon 1, 2 and 3 respectively. Organic carbon, organic matter and total Nitrogen all decreased down the horizons n all profiles of the studied soil. Mean organic carbon were 1. 201, 1.102 and 1.190%, mean organic matter were 2.0715, 1.968 and 2.05% while mean total nitrogen (TN) were 0.125, 0.114 and 0.693% in pedons 1, 2, and 3 respectively. Organic matter was medium (2.0-4.2%) at pedons 1 and 3 and low < 2.0% in pedon 2 when critical limits was considered according to Tabi et al. (2012). This low organic matter content is a challenge as the soils of Igbudu Ikwo is already prone to erosion and would need high organic matter content to bind the soils particles together against disintegration by erosion processes. Available P increased down the profile in pedon 2, 3 and decreased in pedon 1, mean available p were 33.8, 13.66 and 27.32mg/kg in pedons 1, 2 and 3 respectively. Available P was medium (5-15 mg/kg) in pedon 2 and high (>15 mg/kg) in pedons 1 and 3 Tabi et al. (2012). Tabi et al. (2012) noted that high available p content is as a result of optimum pH medium which was slightly and moderately acidic compared to pH dependent or very high pH which could lead to p fixation in arable soil. Sodium (Na) and Potassium (K) levels on the investigated soils were low as means of 0.05, 0.7 and 0.06 and 0.138, 0.158 and 0.167 gkg^{-1} recorded for Na and K respectively in pedons 1, 2 and 3 falls below the acceptable limits. Na was very low (< 0.1 gkg^{-1}) while K was low (<0.1 – 0.3 gkg^{-1}) according to Tabi et al. (2012) therefore, the inputs of K fertilizer would be necessary to enhance the productivity of the soils. Calcium (Ca) had means of 1.15, 0.58 and 0.8 gkg^{-1}. Magnesium (Mg) results in the sampled sites were recorded as 0.49, 0.30 and 0.35 gkg^{-1}for pedon 1, 2 and 3 respectively Calcium and Mg were very low when critical limits were considered; (<2 gkg^{-1}) and (<0.5 gkg^{-1}) for Ca and Mg respectively (Abu & Malgwi, 2011).

Table-3. Chemical Properties of Soils of Igbudu Ikwo

Location	Depth (cm)	pH (H_2O)	OC %	OM %	TN %	C/N Ratio	AviaP (Mg/Kg)	Ca ←	Mg	K	Na	TEB (g/kg)	AL^{3+}	H^{3+}	TEA	ECEC →	BSat %	ALS %
Pedon 1																		
A	0 –21	5.28	1.283	2.212	0.133	9.64	38.7	1.03	0.52	0.166	0.05	1.77	0.21	0.41	0.52	23.18	76.07	33.87
AB	21-40	5.38	1.203	2.074	0.124	9.70	33.1	1.21	0.43	0.131	0.03	1.80	0.51	0.48	0.99	2.79	65.05	51.52
Bt1	40- 80	5.20	1.201	2.071	0.125	9.60	39.8	1.28	0.48	0.127	0.08	1.97	0.56	0.39	0.95	2.92	68.017	58.94
Bt2	80-127	5.32	1.119	1.929	0.166	9.64	23.6	1.09	0.53	0.129	0.04	1.79	0.43	0.61	1.04	2.83	63.03	41.34
Mean		5.32	1.2015	2.0715	0.125	9.65	33.8	1.15	0.49	0.138	0.05	1.83	0.42	0.47	0.875	7.93	68.04	46,41
Cv		1.9	4.1	5.6	5.6	2.5	21.9	9.8	9.3	13.4	43.2	5.0	36.2	21.0	21.1	128.2	8.4	ND
Rank		LV	LV	LV	LV	LV	MV	LV	LV	LV	HV	LV	MV	MV	MV	HV	LV	ND
Pedon 2																		
A	0 - 20	5.06	1.144	1.972	0.118	9.69	18.6	0.52	0.38	0.131	0.06	1.09	0.96	0.52	1.48	2.57	43.04	64.86
AB	20-45	5.01	1.105	1.905	0.114	9.69	16.8	0.63	0.32	0.122	0.08	1.15	0.72	0.86	1.58	2.73	42.01	45.56
Bt1	45-86	5.26	1.073	1.884	0.113	9.67	15.2	0.72	0.29	0.163	0.07	1.25	0.69	0.82	1.51	2.76	45.05	45.69
Bt2	86-125	5.80	1.084	1.869	0.114	9.50	4.04	0.48	0.22	0.169	0.06	0.93	0.14	0.71	0.85	1.78	52.00	16.47
Mean		5.28	1.102	1.968	0.114	9.62	13.66	0.58	0.30	0.158	0.07	1.105	0.62	0.72	1.35	2.46	45.52	43.15
CV		6.8	2.4	3,5	2.3	2.7	52.1	18.5	22.0	15.9	14.2	12.1	55.3	20.9	25.0	18.7	66.7	ND
Rank		LV	LV	LV	LV	LV	HV	MV	MV	LV	LV	LV	HV	MV	MV	MV	HV	ND
Pedon 3																		
A	0 - 23	5.32	1.367	2.357	0.141	9.69	33.7	0.98	0.46	0.192	0.03	1.66	0.29	0.46	0.75	2.41	69.08	38.66
AB	23 - 48	5.61	1.273	2.195	0.132	9.64	20.9	0.78	0.42	0.173	0.05	1.42	0.173	0.05	0.82	2.37	66.07	42.66
Bt1	84-84	5.03	1.103	1.902	0.144	7.65	30.1	0.92	0.39	0.164	0.07	1.55	0.26	0.56	0.82	2.37	650.04	31.70
Bt2	84-131	5.10	1.018	1.755	1.105	0.92	32.6	0.69	0.32	0.155	0.07	0.49	0.59	0.78	1.21	1.99	61.04	24.35
Means		5.2	1.190	2.05	0.693	6.7	27.32	0.80	0.35	0.167	0.06	1.28	0.32	0.46	0.09	2.28	65,30	34.39
Cv		5.0	13.3	13.3	13.6	10.5	19.8	39.8	38.5	9.2	36.0	21.0	15.1	4.3	13.2	8.7	5.1	ND
Rank		LV	LV	LV	LV	LV	MV	HV	HV	LV	HV	MV	LV	LV	LV	LV	LV	ND

Note: OC = Organic carbon, OM = Organic matter, TN = Total Nitrogen, aviaP = Available Phosphorous, TEB = Total exchangeable base, TEA = Total exchangeable Acidity, Mg = Magnesium, Ca = Calcuim, AL – Aluminum, = NA = Sodium, H = Hydrogen, pH = Potential Hydrogen, ECEC = Effective Cation Exchangeable Capacity, B. sat = Base Saturation, LV = Low variability, MV = Moderate Variability, HV = High Variability, CV = Coefficient of variation, ASat = Aluminum Saturation, C/NR = Carbon Nitrogen Ratio. ND= not determined.

The low exchangeable bases as observed in all pedons may be due to increased weathered and leaching which characterizes mostly tropical soil (Onweremadu, 2006). The ECEC of the soils of the area was low indicting a low content of basic and acidic cations. Also, the illuviation of coastal plain sand and parents materials has encouraged intense leaching of exchangeable cation in these soils (Brady & Weil, 2007). Total exchangeable bases were low and decreased down the profiles in all the soils of the areas. Mean TEB were 1.83, 1.105 and 1.28g/kg in pedons 1, 2 and 3 respectively. Total exchangeable acidity were low and exchangeable, Al were in trace amount especially in pedon 3. Mean TEA were 0.42, 0.62 and 0.32g/kg in pedons 1, 2 and 3 respectively. Mean ECEC were 7.93, 2.46 and 2.28 gkg^{-1} in pedons 1, 2 and 3 respectively. Base saturation was highest in pedon 1 where it recorded mean of 68.04% compared to 45.52 and 65.30% recorded in pedon 2 an d 3 respectively.

3.1. Variability of Analyzed Soils

Sand, clay, bulk density, soil pH, organic carbon, organic matters, total Nitrogen, potassium, total exchangeable Bases and Base saturation exhibited low variability (LV) when subjected to the statistical analysis using coefficient of variation. while Sodium (Na), Silt, Al, H, TEA, Ca varied moderately (MV) available P and ECEC had high variability (HV). It can be seen from the result that silt is the only physical properties that recorded moderate variability while available P and effective cation exchangeable capacity are the only chemical properties that recorded high variability. These are among the determinants factor for soil fertility (Brady & Weil, 2007).

3.2. Soil Classification

The taxonomic classification of the studied soils was done using the USDA soil taxonomy and correlated with World Reference Base (WRB) for soil resources. Investigated soils were deep and extend beyond 125 cm in the three pedons. Isohyperthermic soil temperature regime placed the investigated soils on the suborder of Tropepts. The temperature regime and percentage base saturation were considered at the subgroup level in the soil taxonomy. A base saturation (by NH_4OAc) of more than 60 percent or more at a depth between 25 and 75 cm from the mineral soil surface at Pedons 1 and 3, while a base saturation (by NH_4OAc) of less than 60 percent or more in one or more horizons at a depth between 25 and 75 cm from the mineral soil surface or directly above a root-limiting layer occurred in pedon 2. Soil Survey Staff. (2014) placed soil moisture regime as Udic. The low amount silt/clay ratio suggests advanced stages of weathering and highly leached soil which is a characteristics of Utisols, there was high sandy distribution and irregular clay movement down the horizons in pedons 1, 2 and 3 resulted to formation of argillic horizons in Bt horizons.Therefore pedons were classified asArenic Kandiudults in USDA soil taxonomy and Arenic Lixisols when correlated with WRB for soil resources.

4. CONCLUSION

The classification of soils affected by erosion in Igbudu Ikwo, Ebonyi State, revealed that the soils of the area were dominated by sandy soil fractions. The silt clay ratio was very low, low indicating that soils of the area were highly leached and highly weathered which are characteristic of most soils in tropical regions according to USDA soil classification. Soil pH was slightly or moderately acidic. Organic carbon, organic matters and total Nitrogen were low. The low exchangeable bases observed in all pedons may be due to increased leaching which characterized most soil of the tropics. ECEC of the soil were low in all pedons, this may be as a result of the coastal plain sand parent materials which has encouraged intense leaching of exchangeable cations in these soils. Soil pH, organic carbon, organic matters, total nitrogen were chemical properties that recorded low variability while others are moderately variable. Almost all the physical properties varied lowly (LV) except silt which exhibited high variability. All pedons of the studied areas were classified as Arenic Kandiudult according to USDA soil taxonomy and Arenic Lixisol when correlated with WRB for soil resources.

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