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ASSESSMENT OF SOIL PROPERTIES FROM SELECTED EROSION SITES IN ABIA STATE, SOUTHEASTERN NIGERIA

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Abstract: *The assessment of some soil properties of 17 erosion sites located in Aba South, Ugwunagbo, Umuahia North and Umuahia South Local Government Areas of Abia State were carried out. A reconnaissance visit was carried out with the aid of a location map of the study area to identify the areas to be studied. A combination of target and random soil survey techniques guided field studies. The morphometry of the erosion sites were measured showing length, width and depth. Top soil samples of 0-20cm were collected in each erosion site, giving a total of 17 soil samples which were air-dried and sieved. These soil samples were subjected to routine laboratory analysis and resulting data were analyzed statistically using mean and coefficient of variation. Results showed the soils were sandy having mean value of 874g/kg while clay and silt contents were low having 30g/kg and 96g/kg respectively. Bulk density of the eroded soils recorded a mean value of 1.36g/cm^3. Total exchangeable acidity content was high (1.56cmol/kg) while nutrient contents of all soils studied were low having organic matter content of 0.55%, percentage base saturation of 25.4% and ECEC of 2.09 cmol/kg as a result of the nature of the parent material and removal of surface soils.*

Key words: Erosion, Soil Properties, Land Degradation, Environment

Introduction

Soil erosion has been a major environmental problem worldwide (Nyakatawa *et al*., 2001), and an issue of great concern since the inception of civilization as it has been a subject of discussion among engineers, soil and environmental scientists. Many cases of top soil losses in the tropics are caused by intense rainfall ,soil material transport by surface run-off (Liu, *et al*., 2000; Relf, 2001) and saltation through the air (Karydas *et al*.,2014). The removal of the top soil by erosion reduces soil productivity and can irreversibly damage the land where soils are shallow (Panagos *et al*., 2014). This threatens the human life, particularly in developing countries (Anasiru *et al*., 2013). Each year, about 75 billion tons of soil material are lost due to erosion, the amount mostly comes from agricultural land (Mahmoudi *et al*.,2010).The magnitude of soil erosion by water is controlled by natural factors such as rainfall intensity and run off, soil erodibility, slope gradient, vegetation and human induced factors such as intensity of farming and construction practices. Intensive cropping uses the soil but often causes the soil on sloping land to be lost by erosion (Karydas *et al*., 2014). The sorting action of either water or wind removes a high proportion of clay and humus from the soil and leaves less productive coarse sand, gravel and stones behind. Most of the soil fertility is associated with clay and humus, these components are important in microbial activity, soil structure, permeability and water holding capacity. Thus, an eroded soil is degraded chemically, physically and biologically. Consequently, farmers need to apply more of fertilizer in order to maintain their crop productivity (Bosede, 2010).

In South-eastern Nigeria, the impact of soil erosion has been ravaging, and goes beyond the loss of fertile land. It has displaced communities, led to increased eutrophication and sedimentation in streams and rivers, clogging the waterways, which results in declining water quality and damages hydraulic structures (Idah *et al*., 2008; Ogbonna, 2012). The greatest threat to the environmental settings of south-eastern Nigeria is the gradual but constant dissection of the landscape by soil erosion by water. Although the incipient stages of soil erosion through rill and interrill are common and easily managed by the people through recommended soil conservation practices. The gully forms have assumed a different dimension such that settlements and scarce arable land are threatened (Igwe, 2012). More than 1.6% of the entire land area of eastern Nigeria is occupied by gullies. This is very significant for an area that has the highest population density 500 persons per km^2 in Nigeria (Ofomata, 1975).

The World Bank (1990) recognized three main environmental problems facing Nigeria: soil degradation and loss, water contamination and deforestation. In addition, six other problem areas were specified: gully erosion, fishery loss, coastal erosion, wildlife and biodiversity losses, air pollution and the spread of the water hyacinth (Akpokodje, 2010). Gully erosion contributes to each of the three main problems and causes damage with an annual cost to the nation, estimated at $100 million in 1990 (Ofomata 1981). Erosion rate is very sensitive to climate, agriculture and general land use which triggered the study on the assessment of soil properties from erosion sites in Abia state, Nigeria.

Study Area

Abia state is located in the south-eastern Nigeria and lies between latitude $4^0 40^1$ and $6^0 14^1$N and longitude $7^0 10^1$ and 8^0 E. The state covers an area of about 5,243.7 sq.km with a population of 2,833,999 (NPC, 2006). The area is dominated by flat and low lying land, although are also characterised with undulating lands with many hills, generally less than 120m above sea level. There are nine main geological formations from south to north. These include; the Benin formation, the Bende-Ameki Group, the Nkporo shale Group, the Nsukka formation, the Igali sandstone and the Asu river Group. Abia state is characterised with distinct wet and dry seasons. Wet seasons begin in March and ends in October with a break in August. The dry season begins in November and ends in February. The mean annual rainfall ranged about 2200mm and a mean temperature of above 27^0C. The relative humidity is usually high throughout the year about 90%. The soils of Abia state fall within the broad group of ferallitic soils of the coastal plain sand and escarpment, other soil types includes alluvial soils found along the low terrace of Cross river and other rivers. The soils are particularly not fertile and are prone to leaching because of heavy rainfall. The main ecological problems in the state are sheet and gully erosion. The vegetation of the study area is ordinarily considered part of tropical rainforest dominated by oil palm (*Elaeis guineensis*). The northern part of the state has rich savannah vegetation such as the Bamboo.

Materials and Methods

Field research was conducted in four (4) Local Government Areas of Abia state, namely: Ugwunagbo, Aba South, Umuahia North and Umuahia South. Fourteen gully and three rill erosion sites were identified after a reconnaissance survey of the area. These erosion sites were measured to determine length using a 100m tape. The erosion sites were divided into

sections, measurements of width (lip and base) and depth were taken at different points as there were variations in width and depth as length increased. The measurements were summed up and divided by the total sections of each erosion site to determine the average width (lip), average width (base) and average depth. Core soil samples were collected from each erosion site to determine bulk density using the Grossman and Reinsch (2002) method. Top soil samples of 0-20cm were collected and tested for some physical and chemical properties using standard laboratory procedures. Particle size distribution was determined by hydrometer method according to the procedure of (Gee and Or, 2002). Organic carbon was determined using wet oxidation method described by (Walkley and Black, 1934; Nelson and Sommers, 1982). Exchangeable bases (magnesium, calcium, sodium and potassium). Exchangeable Na and K were extracted using 1*N* NH_4OAc using flame photometer (Jackson, 1964), while Ca and Mg were determined using ethelene diamine tetracetic acid (EDTA) (Thomas, 1988). Exchangeable acidity was determined titrimetrically (Mclean, 1982).Effective cation exchange capacity (ECEC) was calculated from the summation of all exchangeable bases and exchangeable acidity (Soil Survey Laboratory Staff, 1992).Percentage base saturation (%BS) was determined by computation.

Data collected from the study site were subjected to summary statistics such as Mean. Also, Coefficient of variation (CV) was used to estimate the degree of variability existing among soil properties in the study site. Coefficient of variation is ranked as follows; low variation ≤ 15%, moderate variation 15%≤ 35% and high variability 35% (Wilding *et al*., 1994).

Table 1 Morphometry of the erosion sites

Location Type	Erosion	Length	Av. Width (lip)	Av. Width (base) m	Av. Depth	Cross-section area (m^2)
Asa Nnetu	Gully	1.94	3.16	1.82	1.04	2.6
Alaoji	Gully	16.0	6.41	4.96	1.44	8.2
Okpuala Nnetu	Gully	3.89	3.19	1.85	0.25	0.6
Ugodo	Gully	36.0	2.58	1.28	1.01	1.9
Obohia	Gully	11.0	13.34	11.54	2.30	28.6
Ohabiam	Gully	5.26	4.16	2.61	0.30	1.0
Umugo	Gully	55.70	34.88	17.62	13.8	362.3
Umunko	Gully	3.78	3.06	2.17	0.59	1.5
Uratta	Gully	15.15	9.07	7.59	2.10	17.5
Inyila	Rill	18.0	0.25	Ns	2.28	0.57
Aba South Municipal	Gully	77.60	3.65	1.63	2.52	6.7
Aba South Municipal	Gully	3.33	2.21	1.08	0.49	0.8
Emegharibe	Rill	4.79	0.80	Ns	0.13	0.1
Okporikoro	Rill	11.02	1.27	Ns	0.31	0.4
Ubakala	Gully	167.1	5.52	3.72	3.10	14.3
Nwamu	Gully	23.70	9.42	7.89	1.88	16.3
Obohia	Gully	9.50	7.65	4.59	0.42	2.6

ns= non significant

Results and Discussion

The particle size distribution (Table 2) pattern showed that sand contents were predominant in all erosion sites having and values ranged from 755.5 to 946.5 g/kg with a mean value of 874 g/kg and a coefficient of variation of 27.9%.

The clay fraction ranged from 7.4 to 72.1 g/kg with a mean of 30.0 g/kg and a coefficient of variation of 48.2% while the silt fraction ranged from 30.0 to 189.0 g/kg with a mean of 96.0

g/kg and a coefficient of variation of 30.6% .This can be attributed to the nature of the parent material and loss of finer soil particles and organic binding agents by rain action.

Table 2 Selected soil physical properties of erosion sites

Location	Sand	Silt g/kg	Clay	T.C	B.D (g/cm^3)	Porosity (%)
Asa Nnetu	884	67.8	48.2	LS	1.26	52
Alaoji	859	102.6	38.4	LS	1.38	48
Okpuala Nnetu	861	92.4	46.6	LS	1.29	51
Ugodo	808	143.2	48.8	LS	1.48	44
Obohia	799.1	128.8	72.1	LS	1.38	48
Ohabiam	847.7	142.3	10.0	LS	1.42	46
Umugo	925	57.0	18.0	S	1.27	52
Umunko	811.1	141.1	47.8	LS	1.41	47
Uratta	946.5	40.0	13.5	S	1.35	49
Inyila	902.7	89.9	7.4	S	1.32	50
AbaSouthMunicipal	884.3	102.7	13.0	LS	1.34	49
AbaSouthMunicipal	755.5	189.0	55.5	SL	1.40	48
Emegharibe	961	30.0	9.0	S	1.29	51
Okporikoro	875	97.8	27.1	LS	1.38	48
Ubakala	894	83.1	17.5	LS	1.33	50
Nwamu	913.8	66.7	19.5	S	1.30	51
Obohia	935.6	49.6	14.8	S	1.48	44
Mean	**874**	**96**	**30.0**	**LS**	**1.36**	**49**
%CV	**27.9**	**30.6**	**48.2**		**5.7**	**2.4**

B.D=Bulk density, TC= Textural class, S= Sand, LS= Loamy sand, SL= Sandy loam

The bulk density of the erosion sites ranged between 1.26-1.48 g/cm^3 with a mean value of 1.36 g/cm^3 and a coefficient of variation of 5.7%**,** an indication of mineral soil predominance in all erosion sites. High bulk density recorded is an indication of low soil porosity and soil compaction as soils recorded 44 to 52 percentage porosity with mean value of 49% and coefficient of variation of 2.4%. Akamigbo, (1999) reported that low organic matter was responsible for increased bulk density in most soils of South-eastern Nigeria. Soil compaction is a serious form of soil degradation that results in increased soil erosion and decreased crop production by decreasing the rate at which water penetrates into the soil root zone and subsoil, thereby increases the potential for surface water pounding and water runoff (Lewandowski,1999;Idah *et. al.,*2008).It also reduces the ability of a soil to hold water and air, which are necessary for plant root growth and function, reduces crop emergence as a result of soil crusting, impedes root growth, limits soil exploration by roots and decreases the ability of crops to take up nutrients and water efficiently from soil (Voorhees,1996) . The organic matter status of the erosion sites (Table 3) were low ranging between from 0.10-0.93% and a coefficient of variation of 17.8%. The top soils which are removed by erosion inhabit most plant nutrients and organic matter, leaving soils with low nutrient status, poor structure and low water holding capacity. Organic matter content in soils should be in the range of 1.9-3.0% to attain productivity. Exchangeable basic cations (Ca, Mg, Na, and K) were low ranging between 0.38-0.69 cmol/kg and a coefficient of variation of 7.8%, which could be a result of being transported off site, also leaching could take place as soils were dominated by sand particles resulting to eutrophication. Helburg et al. (1978) and Gachene et al. (1997) reported that decline of SOM and other elements are due to their higher concentration in the surface soil, which can be easily removed and washed away by surface runoff. Total exchangeable acidity of the erosion sites were high ranging from 1.31-1.75 cmol/kg and a coefficient of variation of 6.5%, depicting acidic nature of the soils, in line with Obihara (1961) classification of soils of the zone as acid sands. The low organic matter

levels of the soils are also assumed to be part of the high acidic content. The ECEC values were low ranging between 1.69-2.25 cmol/kg and a coefficient of variation of 9.4%, high annual precipitation, small amount of basic cations in the parent material, the low buffering capacity to retain them against leaching and removal by erosion probably explain the low ECEC values recorded in the erosion sites.

Table 3 Selected soil chemical properties of erosion sites

Location	O.M	Ca^{++}	Mg^{++}	K^{+}	Na^{+}	TEB	TEA	ECEC	B.Sat
	%	cmol/kg							%
Asa Nnetu	0.43	0.07	0.08	0.06	0.17	0.38	1.31	1.69	22.5
Alaoji	0.69	0.08	0.05	0.08	0.22	0.43	1.53	1.96	21.9
Okpuala Nnetu	0.52	0.17	0.16	0.13	0.19	0.65	1.60	2.25	28.9
Ugodo	0.35	0.10	0.04	0.05	0.29	0.48	1.44	1.92	25.0
Obohia	0.47	0.20	0.07	0.14	0.28	0.69	1.75	2.44	28.3
Ohabiam	0.26	0.18	0.13	0.09	0.24	0.64	1.52	2.16	29.6
Umugo	0.49	0.12	0.04	0.07	0.15	0.38	1.71	2.09	18.2
Umunko	0.87	0.08	0.11	0.06	0.18	0.43	1.40	1.83	23.5
Uratta	0.10	0.16	0.13	0.12	0.20	0.61	1.46	2.07	29.5
Inyila	0.96	0.09	0.18	0.13	0.27	0.67	1.59	2.26	29.6
Aba South Municipal	0.75	0.16	0.07	0.09	0.14	0.46	1.62	2.08	22.1
Aba South Municipal	0.89	0.14	0.08	0.05	0.14	0.41	1.73	2.14	19.2
Emegharibe	0.54	0.11	0.16	0.04	0.21	0.52	1.49	2.01	25.9
Okporikoro	0.46	0.19	0.12	0.08	0.23	0.62	1.55	2.17	28.6
Ubakala	0.93	0.13	0.18	0.07	0.16	0.54	1.68	2.22	24.3
Nwamu	0.23	0.07	0.09	0.11	0.28	0.55	1.70	2.25	24.4
Obohia	0.36	0.09	0.14	0.10	0.30	0.63	1.49	2.12	29.7
Mean	**0.55**	**0.13**	**0.10**	**0.09**	**0.21**	**0.53**	**1.56**	**2.09**	**25.4**
%CV	**17.8**	**19.3**	**16.4**	**13.0**	**11.5**	**7.8**	**6.5**	**9.4**	**8.8**

OM = Organic matter, Ca=Calcium, **Mg**= Magnesium, **K**=Potassium, **Na**= Sodium, **TEB**=Total exchangeable bases, **TEA**= Total exchangeable acidity, **ECEC**= Effective cation exchange capacity, **BS**= Base saturation.

The result of the percentage base saturation obtained from the erosion site ranged between 18.2-29.7%, below 50% which is the separating index between fertile and infertile soils. These values confirm the presence of acidity in the soil solution. The coefficient of variation was low ranking 8.8%, which shows that all erosion sites were affected. The varying low fertility status of the erosion sites is directly proportional to the age of the erosion site, intensity of erosion and amount of soil lost.

Conclusion

Soil erosion is a major problem of great concern in Southeastern Nigeria. Based on the morphometry of the erosion sites studied, it is obvious that tonnes of soils have been lost which reduces the availability of land for agriculture and other uses. Soils lost are washed into water bodies as sediments causing pollution. Analysis of the eroded soils shows a drastic decline in the fertility level of the soil due to the removal of activity clay and silt which affects the productivity of such soils for agricultural purposes. Soil erosion can be checked through early detection. Also reforestation, afforestation, conversation tillage, strip cropping, terracing and other engineering methods can be adopted to curb erosion and in the reclamation of degraded lands.

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