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IMPACT OF SOIL EROSION ON LAND DEGRADATION IN UGA SOUTHEASTERN NIGERIA

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ABSTRACT
This study was to investigate the causes and hazard of soil erosion in Uga, Anambra State as the area is always having the problem of erosion. This study was carried out in some selected erosion sites in Uga. The study investigated the impact of soil erosion on land degradation and its environmental hazards in Uga Southeastern Nigeria. Two profile pits were prepared. one on severely degraded (eroded) sites and the other on less severely degraded (eroded) sites. They were morphologically described and sampled. Surface soil samples were collected from the erosion sites that were controlled at the depth of (0-25cm) and (25-50cm) to check the effect of the control on the soils. Some physical and chemical properties of the soil were determined. Morphologically, the soils were deep and well drained with no concretions or mottles. The colour variations ranged from brown (7.5YR 4/4) to dark reddish brown 7.5 R 3/3 for the profile pits. The soils varied in texture from fine loamy sand to sandy clay loam. The structures varied from hard to weak coarse crumb to friable. The Bulk Density values (B.D) were relatively high $1.4g/cm^2 - 1.6g/cm^3$. The infiltration was rapid ranging from 10cm – $150cm/^2$. Chemically they were strongly acidic and low in nutrient status. The pH was low between 3-9-5.1. Nitrogen ranged from 0.01 – 0.12%. Erosion affected significantly the phosphorus, pH and Al^{3+} Heavy metals values were low. Other forms of land degradation identified in the area were bush burning, sand quarrying, deforestation etc. Management practices such as use of organic amendments, minimum tillage and crop rotation could help in the conservation of the soils and ensure food security for further generations.

Keywords: Degradation, erosion, food security, hazards, sustainability.

INTRODUCTION
Soil degradation is the temporary or permanent lowering of the productive capacity of the soil. Soil erosion process is a serious problem confronting Uga people in Anambra State. Soil erosion by water is a major type of soil degradation, not just in Nigeria but in the tropics.

It occurs most often as a result of human activities like deforestation, overgrazing, building orientations and/or natural activities like soil types, topography, climate etc. The major causes of land degradation are as a result of land misuse and poor land management practices. Land degradation which has been defined as the loss of utility or potential utility of land or the decline in soil quality caused through misuse by humans (Barrow, 1992) is posing more threat to our future than military aggression.

The impact of environmental problems in Anambra State is very severe and needs adequate attention (Akamigbo, 1996). They have soil types and climate which accelerate erosion processes. Erosion may dissect the land by forming deep gullies. The scenario is typical in Nanka and Ekwulobia of Anambra state. (Akamigbo, 1996). Gully erosion not only reduces the land area for agricultural purposes but also threatens the building of the inhabitants of the area where it occurs. In Anambra state, studies by the task force on soil erosion control revealed that 10% of the land area is occupied by gully erosion of all types. This must have increased by now. Soil erosion affects agriculture by selective removal of plant nutrient and removal of organic matter by wind or water.

Effort made in the past to combat the problem even by the state government and the village people could not make much meaning. The erosion sites are still on the increase. The investigation carried out in the study area revealed that the most severe site studied started developing like six years back.

There is need not only to investigate the causes of the problems of land degradation but also to investigate the effect of soil erosion on agricultural production and make recommendations on how to ameliorate them in order to secure food and sustain the environment. This study is aimed at examining the nutrient status of the severely eroded, less severely eroded sites and also the controlled site.

MATERIALS AND METHODS

Study Site.

This study was conducted on two different types of erosion sites. One site was located on erosion site that was very severely eroded and the second site was on a less severely eroded site. Surface samples were collected from an erosion site that has been controlled. The area is located between latitude 5^0 56'N and 5^0 57'N and between longitude 7^0 4'E and 7^0 06'E. The area falls within the humid tropical zone of southeastern Nigeria with average annual rainfall of about 1485mm and mean annual temperature that ranges from 27 to 35^0C and rarely falls to 21^0C throughout the year. The relative humidity ranges from 40 to 92% (Badiane 2009). The vegetation of the area is rainforest with mainly grasslands. The natural vegetation of the area consists mainly of secondary forest. The major land use types in the study area are arable crop production, cash crop production and non agricultural uses such as residential, commercial and local roads.

Two profile pits were sited. One pit each on the severely eroded site and less severely eroded site respectively. Auger samples were collected at the depth of 0 - 25cm and 25 - 50cm depth to check the effect of the control measures on the soil, physical and chemical properties. Core samples were collected from around the profile pits for physical property analysis.

Laboratory Analysis

The samples were air dried and sieved to pass through 2mm sieve. The fine earth fraction was analyzed for the following parameters. Particle size analysis was carried out by hydrometer method.

The textural classes were determined from the USDA soil textural triangle. Bulk density was obtained by CORE method. Total Porosity was calculated from the values of the bulk density using the method described by Vomicil (1965). Soil pH was obtained in 1:25 soil/water extract of the composite samples according to Mclean (1965) method. Available P was determined by the Bray 2 extract. Cation Exchange Capacity (CEC) was determined by the NH_4OAC displacement method and exchangeable acidity by titrimetric method after extraction with 1.0N KCl (McLean, 1965). Total exchangeable bases (Ca^{2+}, Mg^{2+}, Na^+ and K^+) were determined using 1N NH_4OAC extractant method, where Ca^{2+} and Mg^{2+} were obtained on an Atomic Absorption Spectrometer; Na^+ and K^+ by flame photometer. Base saturation was calculated from TEB/CEC x 100, where TEB = total exchangeable bases. Soil organic carbon (OC) was determined by dichromate method. Soil organic matter was obtained by multiplying percentage carbon by 1.724. Total nitrogen was determined by the macro-Kjeldhal method (Bremmer 1965).

Infiltration rates were determined in the field using the double ring cylinder infiltrometer method. Heavy metals Pb, Zn, Cu and Fe were also determined. The determination was done on the top layers of each site since that is where the concentrations of the heavy metals are more and the surface sample is where arable farming is done. The concentration of individual metals was measured with atomic absorption spectrometer (AAS) after wet digestion with HNO_3 for Pb and a mixture of HNO_3 and HCL for iron (Bruce and White side, 1984).

Statistical Analysis

The statistical analysis consists of descriptive statistics and ANOVA with Duncan multiple range test. Descriptive statistics show the means of the chemical properties of different eroded soil (severely eroded, less severely eroded and eroded but controlled soil). The ANOVA compared the differences in mean among the three sites.

RESULTS AND DISCUSION

Causes of Soil Erosion in the Area.

When a man tries to modify the land for his own use, he changes and upsets the natural balance thereby resulting to erosion. One of the major causes of erosion in this place is indiscriminate building orientation which is a result of land tenure system. Land tenure system is a system of land ownership by individual which means that people are forced to use the land to build based on the shape of their land and not based on whether it will cause erosion. Other causes identified were indiscriminate removal of vegetative cover. Akamigbo (1986) said that major factors of soil erosion in Anambra state are bush burning together with indiscriminate removal of vegetative cover. The people are involved in bush burning, overgrazing, deforestation, quarrying of sand and intensive cropping. This is to combat the teeming population density of about 1500-2200 which is too much for an area of 1sqkm. The soil type of the area which is sandy soil derived from sand stone parent materials and the climate of the area explains why the area is prone to erosion. The topography of the area is another reason why the study area had erosion. The entire area is located on a slope. The people irrespective of the slope still carry out their continuous cropping on the land. Akamigbo (1996) observed that 75% of gullies in Anambra State had their origin in poorly execrated civil works which directly or indirectly concentrated runoff. This is similar to the case of the eroded but controlled site that was examined. Agricultural methods of controlling erosion should be encouraged as it enhances soil structure and also more sustainable

Soil Morphology.

The erosion had minimal effect on the morphology of the soils. The soils were derived from sandstones and are generally deep and well drained. The colour variation ranged from deep brown (7.5YR 4/4) dry to dark reddish brown (7.5 R 2/2) on the top soils and orange (2.5YR 6/6) in the sub layers in the severely eroded sites. In the less severely eroded site the colour ranged from dark reddish brown (7.5YR 3/3) in the top soil to reddish brown (10R 4/4) in the sub soil. The difference in colours of top soil and sub soil in the two sites was as a result of erosion that has washed off some soil particles. The structures of the severely eroded site ranged from medium crumb structure at the top layer to strong moderate sub-angular blocky structure in the sub layer. The less severely eroded site had weak coarse crumb on the top layer and strong moderate sub angular blocky in the sub layers. The structures of the sub layers were virtually the same but that of the top soils were different because erosion has affected it. The major differences were due to slope of the area which was 12% and 2% in the severely and less severely eroded soil. Akamigbo (1986) noted that erosion deposits detached soils in the lower area. The consistency was generally non sticky to friable in the top layers and sticky to plastic in the sub layers.

Physical Properties

Particle Size Distribution.

The particle size distribution indicated that the two profile pits and the auger samples have fine sand dominant over coarse sand. Textural classifications are Sandy clay loam, Sandy loam, and Loamy sand. This could be attributed to the type of parent material of the area (Akamigbo and Asadu, 1983). The clay content of the soils ranged from 8% to 34% (Table 1). The upper horizons had lower clay content which could be attributed to the runoff of the surface caused by high rainfall and slope. The coarse sand was decreasing with depth at 50cm in the first profile but was not so in the other samples. This could be attributed to the nature of lithology of the parent material. The samples have low silt content indicating the extent of weathering (Akamigbo, 1984). They also have higher quantity of fine sand which is due to the age of those areas as attested by their weathering index f.s/c.s (fine sand/coarse sand=73/16=4.56). In AP of UG/02 profiles, the fine sand ranges from 40-73 while the coarse sand ranges from 14-36 and it is decreasing with depth. The findings further confirm the observation of Obi and Asiegbu (1980) that the low clay and silt content of surface soil horizons in this area were attributed to the high detachability and transportability of these lighter soil materials. The low content of silt and clay is essentially due to the low content of these properties in their parent materials (Akamigbo and Asadu, 1983)

Bulk Density and total porosity

The bulk density values are relatively high. It ranged from 1.2g/cm^3-1.6g/cm^3. The value obtained from the top soils of the severely eroded soil was (1.4 g/cm^3) lower than the bulk density values of the top soil of less severely eroded site (1.6g/cm^3). This could be due to agricultural activities going on at the less severely eroded site and again as a result of soil and structure degradation. Mbagwu *et al* (1985) observed that high B.D which tends to loosen the structures is as a result of soil and structure degradation. The top soil of severely eroded soil had more O.M and so the reason for lower B.D because O.M has the tendency of reducing B.D. Increases in total porosity are often correlated with decreased bulk density. This was observed in these samples. The total porosities of the samples are moderate ranging between 39% and 54% and the values decreased with depth due to little compaction by overburden pressure of the materials on the surface. The pore space in UG/02 of 39% is less than that in UG/01 of 54%. This could be attributed to the resultant effect of intensive cultivation which leads to compaction. Compaction reduces the pore spaces and void spaces making it difficult for water to enter the soil or for plant to grow resulting to erosion.

Infiltration Rates.

The infiltration rates are rapid and moderately high in the two pedons investigated ranging from 60cm/hr to 150cm/hr (Table 1) in the two pedons. In all, the steady states were reached in about one hour. In the two cases, the infiltration rates decreased with time. The infiltration rates, as a function of time is an indication of the observed textural pattern of the soil encountered. The infiltration rates are moderate to high, which could be as a result of the nature of the parent materials, which is sandstone.

Chemical Properties

Table 2 shows that all the chemical properties were generally low in both sites and even in the auger samples. The values obtained from the less severely eroded site were higher than the ones obtained from the severely eroded site indicating that erosion has really affected the site more than the other.

Soil pH

The soil pH was generally extremely low ranged from extremely acidic to strongly acidic for both the less severely eroded site and the eroded but controlled site with their values ranging from 3.9-5.1 in the both sites. The pH in the severely eroded site is extremely acidic with the values ranging from 4.0 - 4.1. The pH values in the less severely eroded site and the eroded but controlled site are lower than that in the severely eroded site showing that they are less acidic than the severely eroded site. The acidic level of the severely eroded soil is significantly greater than the acidic levels of the eroded but controlled and less severely eroded soil (Table 3). The high acidic level of the less severely eroded soil than that of the eroded but controlled soil could be attributed to farming activities, since there is bound to be addition of inorganic fertilizers. The high acidity in the eroded sites could also be in accordance with the findings by Akamigbo and Igwe (1990) that high acidity is recorded in many eroded soils which facilitates erosion process because the basic elements which usually influence aggregation are lost when soil reaction is in the strongly to extremely acidity of these soils. This could be responsible for high aluminum saturation and very low calcium and magnesium content of the soils (Table 2). There is equally significant difference in the aluminum and hydrogen content of these soils (Table 3). The implication is that it will take a longer time to increase the pH if a crop that is not tolerant to low pH is to be planted there. The control also helped in increasing the pH of the area.

The Organic Carbon and Total Nitrogen

The organic carbon was higher especially in the top layer of the severely eroded soil than in the less severely eroded site. It ranged from very low to high in all. The values ranged from 0.21% - 2.01% in the severely eroded site and 0.37 – 1.16% in the less severely eroded site. It was decreasing with depth except in the less severely eroded site, where may be illuviation or leaching has taken place. The rainfall intensity and cultivation have contributed to leaching of the organic carbon deeper to the last layer where the plants cannot access it. The Ap horizon of the severely eroded site recorded higher organic carbon because the place was left fallow since erosion was almost claiming the place and accumulation of plant debris increased organic matter content. Morgan (1979), regarded soils with less than 2% organic matter as erodible. The severely eroded site had more than 2% organic content on its top layer yet more severely eroded. This indicates that organic matter is not the only factor that determines erodibility. The reason for this very site being much eroded could be majorly due to slope of 12%, the soil type and the farming activities going on there.

Total nitrogen values ranged from very low to moderately low in the two soils. The values ranged from 0.01 – 0.12%. The highest value was recorded in the severely eroded soil. The values were decreasing with depth due to mineralization by high temperature and leaching since nitrogen is soluble. No significant difference between the less severely eroded soil and eroded but controlled soil because of the parent material of the area is same. This is so because the effect of the erosion on the control site is more on recovering the lost nutrients. There is the tendency that it will increase with time when it must have been fully recovered.

Exchangeable Bases, Exchangeable Acidity, C.E.C and Base Saturation.

For both soils, the severely eroded, less severely eroded and eroded but controlled sites, the exchangeable bases were generally low. Na ranged from 0.01- 0.03meq/100g of soil, K ranged from 0.01-0.12meq/100g of soil, Ca ranged from 0.1- 1.6meq/100g of soil, and Mg ranged from 0.2- 1.0meq/100g of soil. The eroded but controlled site recorded higher Mg^{2+} content than the rest of the soils. This could be the effect of the control given to the place. The low levels of this could be attributed to the texture and structure together with the environment of the study area. The control reduced the erodibility of the bases. Low exchangeable bases in erosion prone area have been confirmed by Mbagwu (1986). The exchangeable acidity is low ranging from 0.1 - 0.4 cmol/kg the values could be due to parent material of the area. The effective cation exchange capacity (ECEC) and apparent cation exchange capacity (ACEC) of the studied soils are very low and may be due to clay composition of the area. Kang and Juo (1981) referred to such soils as low activity clay soils (LAC).

The percentage base saturation values are generally low to high and ranged from 14%-73%. The high base saturation values of the soils could be attributed to properties inherited from the local parent material. Akamigbo and Asadu (1986) showed that parent materials have a strong influence on total exchangeable bases and total acidity of soils.

Available Phosphorus.

The values of available P from severely eroded site ranged from 34-53mg/kg and 42-87mg/kg in the less severely eroded soil. The values are moderate to high which could be attributed to the element being present in the parent material. The high values could be attributed to the result of inorganic fertilization by farmers in the less severely eroded and organic deposits in the severely eroded sites. The profile at the less severely eroded site had significantly higher phosphorus than the others probably due to fertilizations. However, available phosphorus is usually low in high acid soils which tend to fix phosphorus by forming insoluble aluminum phosphate (Unamba – Opara, 1990).

Heavy Metals.

Lead was only identified in the severely eroded site and the value was 8.89ppm with AAS. The value is below hazardous level. Iron value was 11.7ppm for both the severely and less severely eroded site. The type of iron analyzed was Fe^{2+}. Zinc value was 5.2ppm in the severely eroded site and 4.16ppm in the less severely eroded site and 5.85ppm in the eroded but controlled site. Copper value in the severely eroded site was 1.64ppm and 0.82ppm in the less severely eroded site (Table 2). There was no cadmium identified in the area. Heavy metal components of the samples were low and these values may be influenced by the content in parent material as well as the human activities of the area. The highest concentration of these metals (Pb, Fe, Zn, Cu, Cd) are recorded in the Ap horizon of the UG/01 pedon. The higher values of these metals in the area could be attributed to the higher organic matter content of that area: because Wild (1996) said that organic matter absorbs cadmium, copper, and lead but more of lead and copper than cadmium which is evident in the study area. Soil pH generally plays an important role in the availability of metals, toxicity and leaching capability to surroundings (Chimuka et al 2005). Heavy metals are mostly more soluble and leached in acidic soils.

Erosion Control Measures

So far efforts are in progress to see that the area is rescued from the incidience of erosion hazards. Local materials like bamboo trees, elephant grasses (*Pennisetum purpurem*), diversion ditches and sand bags are used to construct barriers in the area prone to erosion. Government efforts through the Task Force on soil Erosion Control have contributed to erosion control by constructing culverts and other measures to see that erosion is combated some sites have been controlled before but due to the type of soil and topography of the area aided by anthropogenic activities of man in the area, the gully is increasing despite all the efforts to control it.

CONCLUSION

Erosion was identified as the major land degradation process in Uga town of Anambra State. There are differences in physical and chemical properties and also the heavy metal in the soils of severe degradation and less severe degradation. The soils of severe erosion recorded higher values of exchangeable acidity, %clay, %silt, heavy metals than the site with less severe erosion. The bulk density is lower than that of the less severe degradation. It must be born in mind that the soils are naturally poor in chemical attributes and degradation of land is prominent in Uga and the degradation potentials are high loss of nutrients, poor structures e.t.c. If nothing is done to it now, one day the whole land may be lost to erosion. To ensure continuous usage of the land and at the same time derive maximum returns from the land and preserve it for future use, sound conservation measures are very essential. So every Uga indigene should be encouraged to participate in the restoration of the land to avoid these stated hazards.

RECOMMENDATIONS

Government and the village should enact a law that will mandate the indigenes to use the correct building orientation to build houses and also stop quarrying of sands.

Rural Policy on agricultural land uses should be made and enforced so that there would be reduced misuse of the land.

Creation of awareness through mass education about the soils of the area will help to let the people know the implications of using it wrongly.

Soil conservation should be made a multidisciplinary course involving every discipline

Conservation team should form a monitoring team that will be visiting all corners of the town and report any case that needs urgent attention. Defaulters of conservation rules should be sanctioned. An effective engineering construction must be preceded by appropriate environmental impact assessment studies. The existing gullies should be reforested.

Table 1. Physical properties of representative profiles and auger samples

Horizon	Depth (cm)	Clay (%)	Silt (%)	Total sand (%)	Fine Sand	Coarse Sand	Textural classe	Infiltration Rates Severely eroded Time (min)	IR	Less Severely eroded Time (min)	IR	B.D g/cm^3	T.P (%)
Severely Eroded soil								2	150	3	100		
Ap	0-24	16	7	77	41	36	SL	3	100	2	150		
AB	24-42	26	1	73	57	16	SCL	2	150	3	100		
Bt_1	42-69	26	3	71	55	16	SCL	3	100	4	75	1.2	54
Bt_2	69-128	34	1	65	51	14	SCL	2	150	5	60		
Bt_3	128-165	34	3	63	47	15	SCL	2	150	4	75		
Less Severely Eroded soils								2	150	4	75		
Ap	0-13	8	3	89	73	16	Sand	4	75	4	75		
AB	13-67	11	2	87	57	30	LS	4	75	4	75	1.6	39
Bt_1	67-120	12	1	87	55	32	SL	4	75				
Bt_2	120-200	17	1	82	52	29	SC	3	100				
Eroded but controlled soils								5	60				
A1	0-25	12	1	87	58	29	LS	3	100				
A2	25-50	14	1	85	53	31	LS	5	60				
								5	60				
								5	60				
								5	60				
								5	60				

Legend: A1 and A2: Auger point controlled sites, SL: Sandy loam, IR Infiltration Rates
SCL: Sandy clay loam, LS: loamy sand, SC: Sandy Clay B.D, Bulk Density, T.P, Total porosity.

Table 2. The Chemical properties of the representative profiles and auger samples and the heavy metal contents

Hori	Depth (Cm)	Ph	C (g/kg)	N (g/kg)	Av.P (mg/kg)	Exchangeable Bases (Cmol/Kg)				C.E.C (Cmol/kg)		B.S (%)	Exch, aci (Cmol/Kg						
						Na^+	K^+	Ca^{2+}	Mg^{2+}	ACEC	ECEC		AL^3	H^+	Pb	Fe	Zn	Cu	Cd
									Severely Eroded Soil										
Ap	0-24	4.0	2.01	0.12	53	0.01	0.06	1.6	0.4	2.8	5.4	73	0.3	0.2	8.89	11.7	***5.2***	***1.64***	***trce***
AB	24-42	4.0	0.87	0.07	37	0.01	0.03	0.4	0.2	2.2	3.44	29	0.2	0.4					
Bt_1	42-69	4.0	0.50	0.04	39	0.01	0.03	trace	0.2	1.7	2.54	14	0.2	0.4					
Bt_2	69-128	4.1	0.25	0.02	47	0.01	0.01	trace	0.6	1.8	2.92	33	0.1	0.4					
Bt_3	128-165	4.1	0.21	0.01	41	0.01	0.03	trace	0.2	1.2	1.84	20	0.2	0.2					
									Less severely eroded soil										
Ap	0-13	4.2	1.08	0.09	87	0.01	0.12	0.2	0.4	1.8	2.83	40	0.1	0.2	***trace***	***11.70***	***4.16***	***0.82***	***trace***
AB	13-67	3.9	0,62	0.05	59	0.02	0.03	0.2	0.2	1.8	2.62	24	0.2	0.2					
Bt_1	67-120	4.1	0.37	0.03	42	0.01	0.03	0.4	0.2	2.0	3.04	32	0.1	0.3					
Bt_2	120-200	4.0	1.16	0.01	76	0.01	0.02	0.4	0.2	1,5	2.43	42	0.1	0.2					
									Eroded but controlled soil										
A1	0-25	5.1	0.87	0.08	51	0.01	0.06	0.4	1.0	1.9	3.57	32	0.1	0.1	***trace***	***5.85***	***5.85***	***1.23***	***trace***
A2	25-50	4.5	0.62	0.05	42	0.01	0.04	0.1	0.2	1.6	2.25	22	0.1	0.2					

Table 3: Statistical table showing the F-values and significant values of the chemical properties analyzed.

Variable	F-Value	Eroded but controlled	Less severely eroded	Severely eroded
pH	15.444**	4.80^a	4.05^b	4.04^b
Carbon	0.009NS	0.745	0.768	0.808
Nitrogen	0.001NS	0.45	0.45	0.052
Phosphorus	3.525*	46.50b	66.00a	43.40b
Sodium	0.845NS	0.01	0.125	0.01
Potassium	0.437NS	0.05	0.05	0.032
Calcium	0.081NS	0.250	0.30	0.40
Magnesium	1.417NS	0.60	0.25	0.32
ACEC	0.206NS	1.750	1.775	1.940
ECEC	0.272NS	2.91	2.73	3.23
B.S	0.141NS	27.00	34.50	28.04
Al^{3+}	2.876*	0.100	0.125	0.200
H^+	3.092*	0.150	0.225	0.320

Legend: * and ** = P< 0.05 and 0.01 percent significant levels, NS= not significant,n=2,4,5 for eroded but controlled, less severely eroded and severely eroded respectively. D.f=1.

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