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Physioco-chemical Properties of Erosion Site in Abakaliki Southeastern Nigeria

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Abstract: *The experiment to determine the physioco-chemical properties of erosion site in Abakaliki Southeastern Nigeria was carried out in 2016. Samples were collected form gully, sheet and rill erosion site in Alhaji Sulaman Street while the control was collected at non-erosion site at Azugwu. The experiment was laid out in complete Randomized Design (CRD) with four treatments and five (5) replications. The treatment used are as follows T_0 = control, T_1 = Sheet erosion site, T_2 == Rill erosion site and T_3 = Gully erosion site. Data generated from laboratory result were subjected to statistical analysis of variance and mean that was significant was separated using Fisher's least significant difference (F-LSD). The result of the experiment showed lower values in physiochemical properties of erosion prone sites when compared to that of control. Nitrogen in T_3 (Gully erosion site) was lowest when compared to other location relative to the control. Phosphorus content was highest in control and lowest in gully erosion site. Organic carbon and organic matter high in control followed by sheet (T_1), Rill (T_2) and the lowest was in T_3 (Gully). Exchangeable base (Ca, Mg, K, and Na) in erosion sites were lower than that of control. Thus erosion processes affect soil physioco-chemical properties negatively.*

Keywords: *Control, degradation, deposition, dynamic, washing*

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I. Introduction

Soils are one of earth's essential natural resources, yet they are often taken for granted. Most people do not realize that soils are living, breathing and support nearly all terrestrial life. Soil erosion is the wearing a way of field's soil by natural physical force of water and wind or through forces associated with farming activities such as tillage. Erosion whether it is by water, wind or tillage involves three distinct actions: soil detachment, movement and deposition. National Soil Erosion-Soil Productivity Planning Committee (1981) concluded that for many soils, soil erosion is occurring at higher rate than formation resulting to losses in soil productivity. Erosion of this precious source has been a problem to farmers because of poor farming decisions. Soil erosion is one form of soil degradation which causes soil compaction, low organic matter, loss of structure, poor lateral drainage and Salinization (Frye et al., 1982). Research findings on the relationship between soil loss and productivity indicated that erosion causes considerable deterioration in soil fertility and crop yields (National Soil Erosion-Soil Productivity Research Planning committee 1981). The erosion hazards cause a loss of available plant nutrients and organic matter, degradation of soil structure, decrease rooting depth and decreased soil storage capacity for crop production, which is based on the quality of the soil physical, chemical and biological properties. According to Lal and Singh (1998), soil degradation process with reference to productivity encompasses physical, chemical and biological degradation. Soil physical degradation can affect crop growth and yield by decreasing root depth, available water and nutrient reserves and soil erosion can lead to yield loss by affecting soil organic carbon, nitrogen, phosphorus and potassium contents and soil pH. Chemical degradation is caused by the processes of nutrient depletion and/or loss of organic matter, acidification and toxic aluminum, salinization and industrial and mining activities.

Erosion is mostly found in all major ecological zones of tropical Africa (Lal, 1985). For instance, erosion rates of 10-40 ha per a year are common on crop land (Lal, 1985). Soil erosion in a particular climatic zone with particular soil land use depends on physiochemical properties of that particular soil. Such manifested through interrelated by nomadic herding in terms of overgrazing mechanical operations on the soil, deforestation, subsequent intensive cropping, prior drainage, impeded plant root growth, excessive runoff and accelerated erosion.

This study aimed at the determination of selected physioco-chemical properties of erosion site in Abakaliki Southeastern Nigeria.

II. Materials And Method

2.1 Study Area

Abakaliki is the capital of Ebonyi State. It is located on Latitude 6^o 19^1N and Longitude 8^o 6^1 E and in a derived savannah of the South East agro-ecological zone of Nigeria. It occupies an area of approximately 5,939 square kilometer with estimated population of 141,438 people according to the 2006 Nigeria census. The economy of the town is based on Agriculture, informal services and small scale industries. Abakaliki has a tropical climate with distinct dry and wet seasons characterized by the prevalence of the moist South Westerly Monsoon winds that result in heavy rainfall spread between April, July and August, October periods and dry season within November to March. The minimum and maximum temperatures of the area are 27^oC and 31^oC respectively. The relative humidity of the area is between 60 to 80 percent. The area has an annual rainfall range of 1700 - 2000mm and the soil of the area belongs to the order Ultisol classified as typic Haplustult (Federal Department of Agriculture and Land Resources 1985).

2.2 Field Method

Preliminary survey of the study area was done and sheet, rill and gully erosion sites at Alhaji Sulaman Street were selected for the study. While a non-erosion site at Azugwu was used as control. Five replicate samples of both core and auger sample were collected. Auger soil samples were collected at 0 – 20cm depth. Soil auger samples were used for determination of chemical parameters and particle size distribution while core samples were used for physical parameters.

2.3 Laboratory Analysis

The following physical parameters were determined:

- Bulk density was determined using the method described by Blake and Hartage (1986)
- Total porosity was determined according to the method described by Obi and Ebo (1995).
- Aggregate stability was determined as described by Kemper and Rosenau (1986).
- Particle size distribution was determined using hydrometer method Gee and Bunder (1979).
- Mean weight diameter was estimated by the wet sieving techniques as described by Kemper and Rosenau (1986).
- Dispersion ratio was determined as described by Kemper and Rosenau (1986).

Chemical parameters determined were as follows:

- Organic Carbon was determined using procedures described by Nelson and Sommer (1982).
- Soil pH was determined using glass electrode pH meter (Mclean, 1982).
- Total Nitrogen determined using modified Kjeldahl digestion procedure (Bremmer and Mulvaney, 1982).
- Available phosphorus was determined using procedure described by Olsen and Sommers (1982).
- Exchangeable bases was determined using procedure described by Chapman (1982).
- Effective Cation Exchange Capacity was calculated as the sum of the exchangeable bases (Chapman, 1982).

2.4 Statistical Data Analysis

Data that was collected was subjected to analysis of Variance (ANOVA) in a CRD and mean that was significant was separated using Fisher's least significant difference (F-LSD) as recommended by SAS Institute Inc. (1999).

III. Result And Discussion

3.1 Soil Texture

The texture of the soil studied is as presented in Table 1. The soils studied are sandy soils. Sandy soils are poor in soil nutrients. The poor in nutrient might have been attributed to washing and carrying away of soil nutrients by runoff water.

Table 1: Texture of the soils studied

Site	Sand %	Silt %	Clay %	Texture
T_0	60.8	21.4	17.8	Sandy
T_1	72.8	11.4	15.8	Sandy
T_2	64.8	19.4	15.8	Sandy
T_3	80.8	3.4	15.8	Sandy
Mean	69.8	13.9	16.3	
SD	8.87	8.22	1.00	

T_0 represent control T_1 = Sheet erosion site T_2 = Rill Erosion site T_3 = Gully Erosion site.

3.2 Physical properties of the erosion sites studied

Physical properties of the erosion sites studied are shown in Table 2. The result shows that the mean weight diameter analysis in the sites are 2.63mm, 1.94mm, 2.01mm and 2.95mm for sample T_0, T_1, T_2, and T_3

respectively. The result further showed that there was a significant difference ($P<0.05$) in the mean weight diameter level among the sites, the highest value was observed in sample T_3 while the least value was obtained in T_1. Aggregate stability level was significantly ($P<0.05$) different among the sites studied. The highest value was observed in sample T_0 while the least is in sample T_1 and T_3. However, the Table showed that there is no significant difference between sample T_1 and T_3. The Aggregate stability level decreases in the following order $T_0 > T_2 > T_1 = T_3$. The dispersion ratio level was not statistically significant ($P<0.05$) among the different sample. Furthermore the highest value was observed in sample T_0 and T_1 while the lowest was obtained at sample T_3. The dispersion ratio decrease in the following order $T_0 = T_1 > T_2 > T_3$. The lower values of the parameters studied in erosion sites than control mighty be attributed to loss of clay and colloids due to preferential removal of fine particles from the soil surface (Fullen and Brandsma, 1995). The loss of clay influences soil tilth and consistency. Exposed subsoil is often of massive structure and harder consistency than the aggregated surface soil (Lal, 1988).

Table 2: Physical Properties of the Erosion Sites Studied

Site	Means weight diameter (mm)	Aggregate stability (%)	Dispersion ratio (%)
T_0	2.63	41	0.75
T_1	1.94	35	0.75
T_2	2.01	40	0.72
T_3	2.95	35	0.68
FLSD (0.05)	0.0212	2.12	NS

T_0 = control T_1 = Sheet erosion site T_2 = Rill Erosion site T_3 = Gully Erosion site.

3.3 Chemical Properties of the Erosion Sites Studied

The results of soil pH, available P, total N, organic C and organic Matter of erosion sites studied showed significant ($P<0.05$) differences in pH among the sites. The highest pH value was observed at sample T_3 while the least value was obtained in sample T_0. The pH of T_3 was higher than pH in T_0, T_1 and T_2 by 38, 11 and 50%, respectively. The highest phosphorous level was obtained from T_0 while the least was obtained in T_3. Available P in T_0 was higher than that of T_1, T_2, T_3 by 46, 28 and 119%, respectively. The highest N level was obtained from T_0 while the least was obtained at T_3. Nitrogen decreased in the following order $T_0 > T_1 > T_2 > T_3$. Control recorded the highest organic carbon of 2.67% while that of erosion sites ranged between 0.9 in gully erosion site to 2.55% in sheet erosion site. The order of decrease in organic matter was $T_0 > T_1 > T_2 > T_3$. According to Lal and Singh (1998) soil erosion can lead to nutrient loss by affecting soil organic carbon, nitrogen, phosphorus and potassium contents and soil pH which is supporting the study.

Table 3: pH available P, total N Organic C and Organic Matter of Erosion Sites studied

Site	pH	P ($mgkg^{-1}$)	N (%)	OC (%)	OM %
T_0	5.8	56.5	0.28	2.67	4.6
T_1	7.2	38.7	0.14	2.55	4.39
T_2	7.6	44.2	0.13	2.18	3.76
T_3	8	25.7	0.1	0.9	1.55
FLSD 0.05	0.21	2.12	0.0212	0.212	1.84

T_0 = control T_1 = Sheet erosion site T_2 = Rill Erosion site T_3 = Gully Erosion site.

Table 4 showed shows exchangeable bases, exchangeable acidity and effective cation exchange capacity of erosion sites studied. The Table also showed significant ($p<0.05$) changes in all the parameters studied with an exception in K which is non-significant. The highest Ca value was obtained in T_0 while the least was obtained in T_3. The Ca value in T_0 was higher than Ca in T_1, T_2 T_3 by 29, 50 and 100%, respectively. The order of decrease Mg value was $T_0>T_1>T_2>T_3$. Control had the highest Na value of 0.19 $Cmol_{(+)}Kg^{-1}$ while that of erosion sites ranged between 0.0.09 – 0.14 $Cmol_{(+)}Kg^{-1}$. The exchangeable Acidity (EA) of the four locations were 0.16 $Cmol_{(+)}Kg^{-1}$ for T_0 whereas T_1, T_2 and T_3 recorded 0.72, 0.30 and 0.32 $Cmol_{(+)}Kg^{-1}$, respectively. The highest ECEC value of 11.63 $Cmol_{(+)}Kg^{-1}$ was observed in Control. This observed ECEC in control was higher than ECEC in T_1, T_2 and T_3 by 13, 31 and 51%, respectively. Erosion reduces the fertility status of soils (Morgan, 1986; Williams *et al.* (1990). Soil chemical constraints and nutritional disorders related to erosion include: low ECEC, deficiency of major plant nutrients (N, P, K,) and trace elements (Lal, 1988; Fullen and Brandsma, 1995). Sharpley and Smith (1990) reported that the mean annual loss of total P in runoff from P fertilized watersheds is equivalent to an average of 15 %, 12 %, and 32 % of the annual fertilizer P applied to wheat, mixed crop and grass, and peanut-sorghum rotation practices respectively. Lal (1988) reported extensive loss of N in eroded sediments.

Table 4: Exchangeable Bases, Exchangeable Acidity and Effective Cation Exchange Capacity of Erosion Sites studied (Cmol $_{(+)}$Kg^{-1})

Site	Ca	Mg	K	Na	EA	ECEC
T_0	7.2	4.0	0.08	0.19	0.16	11.63
T_1	5.6	3.6	0.07	0.10	0.72	10.09
T_2	4.8	2.8	0.09	0.14	0.30	8.13
T_3	3.6	2.4	0.08	0.09	0.32	6.49
FLSD (0.05)	0.212	0.212	NS	0.0212	0.0202	2.5

***T_0* = control *T_1* = Sheet erosion site *T_2* = Rill Erosion site *T_3* = Gully Erosion site.**

IV. Conclusion

The results showed that the erosions sites are of poor qualities and cannot support crop production in it native form. For it to be use for crop production the erosion in such soil need to be controlled and organic fertilizer, mulching, plant nutrients applied.

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