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A Study of Soil Factors in Relation to Erosion and Land Use on a Nigeria Soil.

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ABSTRACT

An assessment of the effects of erosion on the soil productivity of Agbor area of Delta State, Southern Nigeria was evaluated. The investigation involved three (3) soils (Virgin forest, Arable cropping and Traffic soils) with history of erosion. The aggregate stability, mean weight diameter (MWD) and state aggregation of soil of the area was studied, since these soils properties have direct relationship with soil erodibility. The results reveals that the soil texture was loamy sand. mean weight diameter values ranged from 0.56 mm (Traffic), 0.74 mm (arable cropping) and 1.25 mm (virgin forest). State of aggregation ranged from 12.00 mm (arable cropping), 23.00 mm (traffic) and 43.3 mm (virgin forest). Mean porosity 65.4 mm (traffic soils), 72.1 mm (arable cropping) and 77.0 mm (virgin forest). Mean aggregate stability ranged from 74.4 mm (traffic soils), 25.8 mm (arable cropping) and 48.00 mm (virgin forest). Soil organic matter mean values ranged from 0.08 g/ kg (traffic soils), 1.90 g/ kg (arable cropping) and 2.72 g/ kg (virgin forest), respectively. The results recorded for virgin forest relative to arable cropping and traffic soils in most of the soil properties evaluated is an indication that current land use practices in Agbor area contribute immensely to the accelerated soil degradation observed in the area.

1. Introduction

Erosion is one of the greatest limiting factors of soil productivity in the Southern parts of Nigeria. Erosion by water removes topsoil and nutrients, exposes a less fertile subsoil, reduces the available water holding capacity, reduces soil structural stability, causes surface sealing, and reduces soil lnfiltrability (Oyedele and Aina 1998). Soil aggregation is one of many features that characterize a soil. Soil aggregate is a word synonymous to the word 'ped', which refers to the aggregation of or arrangement of primary soil particles into larger units, which are separated from adjoining aggregates by forces, or plains of weakness (Aina, 1994). Aggregates stability is the ability of the granules or aggregates to withstands destruction by the impact of implements, rain drops, or running water so that water penetration, aeration, and the penetration to the roots are maintained at favourable levels (Baver *et al*.,1978).

The structure of a soil can be evaluated by determining the extent of aggregation, the stability of the aggregates and the nature of the pore space. These characteristics change with tillage practices and cropping system.

The high vulnerability of soils and limitations to sustainable use especially for food production are thus related to the poor soil physical regimes and dynamics which are associated with weakly developed and easily degradable soil structure. Because soil structural development and stabilization are attributed mostly to organic matter binding, loss of organic matter will lead to disaggregation and adjunct degradational processes including sub-optimal soil temperature regimes, compaction, increased susceptibility to dispersion and erosion, and reduced moisture retention potential (Aina, 1994; Ufinomue *et al*., 2014).

Soil erosion by water is a major problem with soils in the humid Southern region of Nigeria. The precursor process of particle detachment is enhanced by tillage practices which breaks down soil into finer particles thus accentuating erosion process (Aina, 1994). In a given situation, erosion is characterized by soil erodibility (soil's potential to erode), climatic (rainfall) erosivity (ability to cause erosion), landform and land use. Soil aggregate is considered a soil quality indicator that provides information on the soils ability to function as a basic components of the ecosystem, and aggregate stability may be a good indicator of erodibility of tropical soils (Aina, 1994).

Achieving a sustained management of eroded soil requires information on the magnitude of yield reduction association with soil loss and the changes in the physical and chemical properties of soil. There is also the need to identify some easily measurable soil physical and chemical properties that are sensitive to erosion. This will ensure an early detection of soil erosion and a quick response to ameloriating such soils before they are completely degraded.

Research to determine the effects of erosion on soil productivity in tropical region is limited. Partly summing and partly because of the earlier belief that the nutrients loss in eroded soils could be replaced through chemical fertilizer inputs (Mbagwu,1984). However, studies have shown that physically degraded soils do not always respond to chemical fertilizer inputs (Aina, 1994).

The objectives of this study are :(1) to determine the soil properties that are modified by erosion and (2) to evaluate the relationship between these properties.

2. Materials and Method.

The study was carried out in Agbor area of Delta State. Agbor is located within the co-ordinate of latitude 5^0 43'N and 5^0 30' N. The soils were described as Coastal Plain non-leached Sand, with a benchmark Classification of Oxic Tropudalf by Enwezor *et al*.,(1988). The soils were derived from Coastal soils. The vegetation cover was primarily of rainforest zone type, now modified to secondary forest by environmental factors.

2.1 Field Study.

Reconnaissance visit was made to the study area (Agbor), following these visit, random auger samples were taken. Auger samples were examined for consistency and texture. From the above physical examination of the soil, landscape and topography, the area was demarcated into blocks for this study. The blocks were within the same proximity, from the above preliminary assessment and findings, we assumed that the blocks were of same soil type (Oxic Paludalfs). Within each block three type of land use were identified. Each block was demarcated into three plots using the land use types for the demarcation; hence each plot within a block was under one of the three use types (LUTs). The land use types are cassava + maize + yam mixed cropping, traffic and natural/ virgin forest. The land use types were treatments whereas, the three different block are replicates. The split plot design was used as a layout for soil sample collection.

2.2 Soil sampling

Within each block consisting of a given land use type and within a block, 36 soil samples were taken from 0-30 cm depths and bulk for the determination of some physical, chemical properties. Similarly 36 core samples (using core samplers) were taken from all the blocks. A total of 72 samples were taken for the study.

2.3 Laboratory studies

Particle size distribution was determined by the modified hydrometer method (bouyoccous,1962). The soil bulk density was determined by core method by Black and Hartge (1986). Total Clays contents (TC) were determined from the particle size distribution. Water Dispersible Clay (WDC) was obtained without the use of chemical dispersant- Clay dispersion ratio (CDR) was computed by dividing the values of WDC by TC thus:

$$CDR = \frac{WDC\ (g\ kg^{-1})}{TC\ (g\ kg^{-1})}$$

WDC = water dispersible clay, TC = Total clays.

While dispersion ratio (DR) was determined thus;

$$DR = \frac{WDC + WDS}{TC + TS}$$

Where WDS = Water dispersible silt (g kg^{-1})
TC = Total clay obtained from chemical dispersion (g kg^{-1})
Total porosity was calculated from BD using an assumed particle density of 2.65g cm^{-3} as described by Vomocil (1965).

Hydraulic conductivity was determined by the method of Klute and Dirkson (1986). Water stable aggregates (WSA) was determined by the method of Kemper and Rosenau (1986). WSA was determined using 2.00 to 4.75mm aggregates sieves using the wet sieving procedure. Aggregates with size ranges of 4.75- 2.00mm, 2.00mm – 1.00mm, 1.0 – 0.5mm, 0.5mm- 0.25mm and ,< 0.25mm were determined.
Mean weight diameter (MWD) was calculated using the method of Van Bavel (1950) as modified by Kemper and Chepil (1965). The Mean weight diameter was computed as follows;

MWD = ∑ (i) X i

Where Xi is arithmetic mean diameter of the I = 1and I sieve openings (mm), W(i) = proportion of the total sample weight (uncorrected for sand and gravel) occurring in the fraction (dimensionless) and n = total number of size fraction.

3. Results and Discussion

The results of soil physical properties (Table 1) indicated that, mean sand values did not vary significantly. The values ranged from 800 g/ kg (virgin forest) to 860 g/kg (traffic soils). All the soil texture were classified as loamy sand, because none had sand components of < 70 g/kg. Brady (1999), stated that any soil with sand components 70 % and above falls under the broad textural class of sand. The mean clay values ranged from 50.0 g/ kg (traffic), 63.0 g/kg (arable cropping) and 76.7 g/kg (virgin forest). There were significant difference between the mean values studied (P< 0.05).

The aggregate size distribution of soils of the study area is given in Table 2. There were significant differences (P< 0.05) between the soil of the different land use types. The virgin forest soils possess more of the aggregates sizes relative to other soil use types. Across the different aggregates size, the order of contents of macro aggregate followed this trend virgin forest > arable soils < soil under traffic. The higher macro aggregates contents of forest soil may be attributed to the influence of gummy substance which are secreted by microbial and soil animals as well as the root exudates of forest plants species which have the tendencies to bind small soil micro aggregates to macro aggregate. This is in agreement with Tisdale and Oades (1982) aggregation model proposed for soils where organic matter is the major binding agent. The mean weight diameter (MWD) of the various soils which is a measure of impact of water stability/ aggregate stability of the soils were highest in forest soil with value of 120 % and 70 % which was higher than soils under traffic and arable cropping as presented in Table 2.

Porosity and hydraulic conductivity of the soils followed the same trend as MWD in soils under virgin forest being higher (P<0.05) than that of other soils. This maybe attributed to the high organic matter of the forest soils and its structural condition. These provided a better environment for soil organism, which by their activities enhance soil porosity and hydraulic conductivity. The mean values for soil organic matter was significantly different (P<0.05) between soils of virgin forest and arable cropping (Table 3).

Table 1. Particle size distribution of various land use types (LUTs).

Land Use Type	Sand g/kg	Silt g/kg	Clay g/kg	Texture
Arable Cropping	820.7	110.0	63.0	Loamy Sand
Traffic Soil	860	90.0	50.0	Loamy Sand
Virgin forest	800	123.3	76.7	Loamy Sand
LSD (0.05)	16.31	6.2	23.5	

Table 2. Effects of Land Use Type on State of Aggregation, Mean Weight Diameter, Dispersion ratio Porosity and Hydraulic conductivity

Land Use Type	State of Agg.(mm)	MWD (mm)	DR (mm)	Porosity (%)	Hydraulic Conductivity (cm/S)
Arable Crop.	23.0	0.74	0.49	72.1	109.3
Traffic	12.3	0.57	0.41	65.4	51.7
Virgin Forest.	43.3	1.25	0.39	77.0	147.3
LSD.(0.05)	8.01	0.42	NS	14.35	44.30

Key; Agg.= Aggregation, MWD= Mean Weight Diameter, Hydraulic Conduc.=Hydraulic Conductivity, Lsd= Least significant Difference

SOM is, therefore, much less in the arable cropping and traffic soil. While, the highest value (2.72 g/kg) was observed for Virgin forest as presented in Table 3.

Table 4 shows that all the Total Exchangeable base (TEB) were significantly affected (P< 0.05). This may have resulted in washing of excessive base by erosive agents. Electrical conductivity (EC) did not differed significantly (P<0.05) between the land use types.

The study reveals that the soils under traffic land use types (LUTs) and arable with same proximity are highly susceptible to problems of degradation as a results of impact of rain drop. Subjecting the soils to forest re-vegetation could help ameliorate this negative phenomenon.

Table 3. Mean effects of land use types on some chemical properties.

Land Use type	Org.C g/kg	SOM g/kg	Avail.P m/kg	TN g/kg	pH
Arable Crop.	0.98	1.90	10.59	0.10	6.83
Traffic	0.41	0.08	8.57	0.03	6.83
Virgin F.	1.71	2.72	11.49	0.10	6.62
Lsd (0.05)	0.86	0.13	4.29	0.06	0.15

Key.Org.C= Organic Carbon, SOM= Soil Organic Matter, Avail. P= Available Phosphorous, TN = Total Nitrogen, pH= Potential Hydrogen , Lsd= Least Significant Difference.

Table 4. Influence of total exchangeable bases and electrical conductivity.

L a n d U s e Type	Ca cmol/kg.	Na cmol/kg	K cmol/kg	Mg Cmol/kg	EC µS/cm	Al g/kg	H g/kg
Arable C.	3.25	0.20	0.15	1.28	24.3	1.18	3.60
Traffic	1.75	0.24	0.58	0.76	9.1	0.09	3.87
Virgin F	4.97	0.23	0.20	0.85	22.3	2.00	11.49
Lsd (0.05)	3.71	0.31	0.92	0.23	22.40	1.36	1.36

4. Conclusion

In this study, the variations in soil properties and land use types (LUTs) were dependent and were shown to be modified by erosion. The soils studied were characteristically less acidic across LUTs. Erosion imparted more significantly on arable cropping (indicated by the results of dispersion ratio) compare with VF and T. The study further revealed that, the significant difference between soils in organic carbon content was an indication that this soil property must have influence aggregation and stability of soil aggregate in the area.
Enormous problems still exist in using (misusing) the soils in the area as evident from widespread soil and land use degradation, severe erosion, loss of agricultural productivity and many environmental and soil related problems which put the fixed supply of land under continual stress.

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