Original Research Article

Evaluation of Soil Erodibility on the Agricultural Soil of the Central Zone of Adamawa State, Nigeria

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Soils of the agricultural central zone of Adamawa state were evaluated to ascertain the soil erodibility of the area. Soil samples were collected from three locations, namely, University farm, Federal Housing and Geriyo which represent the entire soil of the agricultural central zone. Soil samples taken from the field were taken to the laboratory for analysis to determine particle size, permeability and organic matter content of the soil. Erodibility was estimated using erodibility monograph. The results showed that average permeability values obtained ranges between 5.26 to 20.57 cm/hr. The values of the average organic matter content of the soil series were found to be 1.45, 2.05 and 2.34% of University farm, Federal Housing and Geriyo, respectively. Average erodibility values range from 0.16 to 0.24 for the entire area. The results reveal that Geriyo soil series, which has the lowest erodibility value of 0.16 is least prone to erosion of the three soil series, and therefore the best in terms of soil conservation practice. The relationship between organic matter content and erodibility , permeability and erodibility had a coefficient of determination (r^2) of 0.50 and 0.11, respectively. Statistically, using t-test the result showed that there was no significant difference between the evaluated and estimated erodibility of the soil in the area.

Keywords soil, evaluation, erodibility, permeability, organic matter

INTRODUCTION

Soil is the top layer of most of the earth's land surface consisting of the unconsolidated products of rock, erosion and organic decay, along with bacteria and fungi. It is the loose material that covers the land surface of the earth and support the growth of plants (King, 2009). In addition, he stated that soil provides anchorage for roots, hold water and nutrients, they are home to myriad microscopic minerals as well as earthworms and termites. According to Hiscox (2006), many human activities cause damage to soils. These activities include bad farming techniques, overgrazing, deforestation, urbanization construction, mining, wars, contamination, pollution and fire. But the most critical of these is soil erosion.

Soil erosion is the detachment, removal, transportation and deposition of soil particles from one point to another. Soil erosion depends on the erosivity of rainfall and the erodibility of the soil (Singh and Khera, 2008). The extent of washing away of soil particles depends on the soil characteristics, which leads to the concept of erodibility. Soil erodibility is the ability of water to detach and transport soil particles. It varies with soil texture, aggregate stability, shear strength, infiltration capacity, organic and chemical content (Levy et al., 2001). Soil erodibility is an important index used in evaluating the soil sensitivity to erosion. Its precise study and evaluation is important in understanding soil erosion regularity, predict soil loss and evaluate land productivity. According to Singh and Khera (2008), soil factor K (erodibility) represents both susceptibility of soil to erosion and the rate of runoff, as measured under the standard unit plot condition of 22.1m long with a 9 percent slope, maintained in continuous fallow, tilled up and down hill periodically to control weeds and break crusts that form on the surface of the soil. They observed that soil erodibility depends primarily on physical and chemical characteristics of the soil.

According to Reichert et al., (2001), soil physical and chemical properties affect soil stability, which is an important soil property governing erodibility. However, Roose(1996), observed that soil erodibility can be seen in relation to percentage of sand content, percentage organic matter, soil structure and permeability.

Organic matter is an important element in maintaining good physical conditions in the soil; it contains the entire soil reserve of nitrogen and significant amounts of other nutrients such as

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phosphorus and sulphur. Soil organic matter often plays a major role in aggregate stability, which affects soil erodibility (Tisdall and Oades, 1982, Oades, 1984). In addition, Singh and Khera (2008) observed that organic matter reduces erodibility because it reduces susceptibility of the soil to detachment, and it increases infiltration which reduces runoff and thus erosion.

Soils high in clay have low K values, i.e low erodibility index about 0.05 to 0.15, because they are resistant to detachment. Coarse textural soils such as sandy soils have low K values, about 0.05 to 0.2 because of low runoff even though these soils are easily detached. Medium textured soils such as the silt loam soils have a moderate K value, about 0.25 to 0.4, because they are moderately susceptible to detachment and produce moderate runoff. Soils having high silt content are most erodible of all soils. They are easily detached, tend to crust and produce high rates of runoff. Values of K for these soils tends to be greater than 0.5(NRCS-USDA, 1958).

Thus, soils are known to have been affected by erosion and the soils in the research area are not exempted. The farmers in the agricultural central zone had to fight with this menace to ensure that the land are not totally lost to erosion, especially by water, which is the principal type of erosion found the area. Lack of adequate knowledge of the erodibility of the area hindered the farmers in the area to take right and adequate soil conservation and management practices in order to minimize soil loss by erosion. Hence this study aimed to evaluate the erodibility of the soils in the agricultural central zone to enhance good soil conservation and management practices for optimum crop yield to support the ever increasing population.

MATERIALS AND METHODS

Experimental Site

The research was conducted using the University farm, Federal Housing and Geriyo which is in the agricultural central zone. The area is located in the Gerei and Yola Noth Local Government Area, Adamawa State, within the savannah ecological zone of Nigeria. The area has two major seasons; the rain and the dry season. The rainy season lasts from the beginning of May to the end of October with annual rainfall of 958.99mm, while the dry season lasts mainly from November to the end of April. The driest months are January and February when the average minimum relative humidity is 13%. This is mainly due to the prevalent dry and desiccating northeast trade winds. The wettest months are August and September when the depth of rainfall reaches up to 25% of total annual rainfall. The relative humidity of air rises in these months to about 81% from July to September. Temperatures in the area vary; the hottest month is April with monthly average maximum temperature of 39.7°C, while the coldest months are December and January with minimum average temperatures of 16°C.

Sample Collection

Three soil samples at a depth of 20 cm designated as the sample I, Sample II and Sample III were taken from plot A, Plot B and plot C of the University farm, Federal Housing and Geriyo, respectively. A total of 9 soil samples was taken and used for the analysis to evaluate the soil. Soil samples taken from the field were collected in nylon bags and taken to the laboratory. The samples were spread and air dried in the laboratory. The samples were sieved using a 2 mm sieve.

250g of the sieved soil sample was grinded in a mortar for organic matter content determination, while the remaining parts were kept and used for particle size analysis.

Determination of Organic Matter

In line with Walkley and Blacks method, 0.50 g of each of the grinded samples was added into a conical flask. 10 ml potassium heptaoxochromate(vi) ($K_2 Cr_2 O_7$) was added into flask, then 20 ml concentrated hydrogen tetra sulphate(vi) acid(conc. H_2SO_4) was added. It was mixed thoroughly and allowed to stand for 30 minutes in a water bath to allow it to cool down. 100 ml distilled water was added into the flask and four drops of ferorin indicator was added to this solution as titrate solution.

A blank solution was also prepared without the soil sample. The solutions were titrated with Ferrous Ammonium sulphate solution. The titre values were recorded and used to find the organic carbon content of the soil expressed as;

% Organic carbon content =(B-T)ml x 0.003 x 1.33 x0.5N x 100/ weight of the soil   (1)

Where;

$\quad$ B=blank titre value
$\quad$ T=titre value for each soil sample solution
$\quad$ 0.003=Mitti equivalent of carbon
$\quad$ 0.5N= normality of $Fe(NH_4)SO_4$ used

Organic matter content was then determined from the relation expressed as;

% organic matter = % organic carbon x 1.724

$\qquad$ (2)

The values obtained is recorded for all the soil samples

Determination of Soil Textural Classification

Soil samples were taken from the fields which represent the entire agricultural central zone. Using mechanical sieve analysis as detailed by Loveday (1974), the soil textural classification of the area was determined.

Determination of Soil Permeability

The permeability test was estimated as detailed by Mittal and Shukla (1987) and expressed as

$K = C(D_{10})^2$

$\qquad$ (3)

Where;

$\quad$ K = coefficient of permeability (cm/sec)
$\quad$ C = Hazen's empirical constant. A chart value of C Varies between 41 and 146
$\quad$ D_{10} = effective diameter

The values obtained gave the permeability class of the soil samples, which was used to determine the nature and rate of flow.

Estimation of Erodibility

Using the fine sand + silt content, sand content, organic matter content, soil structure code and permeability class, the erodibility of the soil was estimated on erodibility monograph which is a standard chart for evaluating erodibility in line with Rose, 1996.   Also, regression equation was used in the estimation of the soil erodibility using all the parameters used in the erodibility monograph. The regression equation used was expressed as;

Table 1: Values of parameters for the three Soil Series in the Locations

Soil Series location	Organic Carbon (%)	Organic Matter (%)	Silt+Fine Sand (%)	Sand (%)	Soil Status Code	Permeability Class	Permeability (cm/hr)	Erodibility
University farm	0.84	1.45	25.2	81.2	3	3	5.23	0.20
Federal Housing	1.19	2.05	37.6	59.1	3	3	9.45	0.24
Geriyo	1.36	2.34	27.5	61.7	3	4	20.56	0.16

Table 2: Organic Matter, Permeability and Erodibility of the Soil Series

Soil Series location	Organic Matter (%)	Permeability (cm/hr)	Erodibility
University farm	1.45	5.23	0.20
Federal Housing	2.05	9.45	0.24
Geriyo	2.34	20.56	0.16

Table 3: Evaluated and Estimated Erodibilities of the soil series

Soil Series location	Estimated Erodibility(K_{est})	Evaluated Erodibility (K_{ev})
University farm	0.20	0.18
Federal Housing	0.24	0.20
Geriyo	0.16	0.17

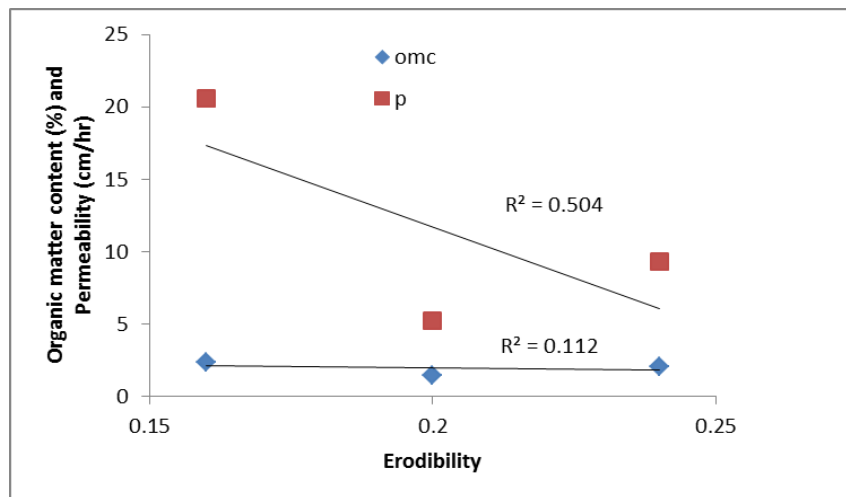**Figure 1:** Relationship between Organic matter content, Permeability and Erodibility

$100K = 2.1 \times 10^{-4}(2-OM)xM1.14+3.25(St-2)+2.5(Pt-3)$
                        (4)

Where;

K=eredibility index
OM=organic matter content (%)
St=soil structure code(very fine granular =1, block = 4)

Pt= permeability class (rapid = 1to very slow = 6)

The values obtained from the erodibility monograph and the regression will be compared to ascertain the viability of the methods.

RESULTS AND DISCUSSION

Table 1 shows the values of parameters determined from the tests carried on the soil samples collected from the three locations; University farm, Federal Housing and Geriyo, respectively.Table1 indicates that percentage organic carbon vary from 0.84 to 1.36 % and percentage organic matter vary from 1.45 to 2.34%. The highest value of organic carbon and organic matter of 1.36 and 2.34% was obtained at Geriyo while the lowest value of 0.84 and 1.45% was recorded at University farm. The result revealed that Geriyo soil series is not susceptible to erosion compared to Federal Housing and University farm soil series.

Table 1 show that University farm soil series had the highest percentage of sand that had a value of 81.2%, while the least value of 59.1% was obtained at Federal Housing soil series. However, soil structure code and permeability class of 3 were recorded for most the soil series. Geriyo soil series had a value of 4 for permeability. Table 2 shows the organic matter, permeability and erodibility of the soil series. Tables 2 indicate that University farm soil series had values of 1.45%, 5.26 cm/hr and 0.20 for organic matter, permeability and erodibility, respectively. Also, Federal Housing soil series had a value of 2.34%, 9.45 cm/hr and 0.24 for organic matter, permeability and erodibility, respectively. Table 2 also shows that Geriyo soil had percentage organic value of 2.34, 20.57 cm/hr permeability and an erodibility value of 0.16.

The result revealed that Geriyo soil series recorded the highest value of organic matter, permeability and lowest erodibility values. This means that Geriyo soil series is not susceptible to erosion followed by Federal Housing soil series while the University farm soil is susceptible to erosion. Figure 1 shows the relations of the organic matter and permeability to erodibility values of the soil series. Figure1 revealed that the organic matter and permeability influences the degree of erodibility of the soil, even though the result indicated that organic matter had more effect on erodibility which had r^2 value of 0.50. Permeability and erodibility had a correlation value of 0.11, which shows that permeability had less influence on erodibility. The value of erodibility obtained 0.16, 0.20, and 0.24 are in the range of 0.10 to 0.28 erodibility values recorded in earlier studies carried by Dion (2002). The differences may be due to difference in soil texture, permeability, climatic condition and organic matter content of the soil.

Table 3 shows the values of the evaluated and estimated erodibility of the soil series. Table 3 indicates that the estimated erodibility (K_{est}) and evaluated erodibility (K_{ev}) vary among the soil series. The estimated and the evaluated values of the erodibilities are in the range of 0.16-0.24.The values obtained indicated that the three soil series have not reached the critical stages of 0.25- 0.5 and in order to curtail the susceptibility of the soil to erosion in the near future, there is a need for erosion control measures in the areas.. Statistically, using t-test, there was no significant difference between the

K_{est} and K_{ev} for the soil series. This implied that estimated erodibility could be used to ascertain the susceptibility of an area to erosion, provided appropriate parameters are available.

CONCLUSION

University farm, Federal Housing and Geriyo soil series had erodibility values of 0.20, 0.24 and 0.16, respectively. Federal Housing soil series with the highest erodibility value is more susceptible to erosion, while Geriyo soil series with the highest percentage of organic matter and lowest erodibilty value is the best among the three soil series for agricultural practices. There was no significant difference between the erodibility values of the soil series in the three locations. There was no significant difference between the estimated erodibility and the evaluated erodibility determined for the study area.

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