ANNUAL SOIL LOSS AND ERODIBILITY POTENTIALS OF SOILS UNDER DIFFERENT LAND USE TYPES IN OWERRINTA, ABIA STATE, SOUTH-EASTERN NIGERIA.

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ABSTRACT
In recent years, much of the natural vegetation (forest, and rangeland) within Abia State has been converted to various land uses. This change in land use has affected soil properties related to soil erodibility over time. The objective of this study is to predict the erodibility potential and annual soil loss of the soils of Owerrintaunder different land use types. In this study,soil samples were collected from different land use systems at different depths(0-15cm, 15-30cm and 30-45cm) in Owerrinta to estimate the annual soil loss and erodibility status of soils of the study area. The experiment was a 4 x 3 factorial in a randomized complete block design with three replications. The factors were the four land use systems (oil palm plantation, forest, arable crop land and fallow) and three depths (0-15cm, 15-30cm and 30-45cm). The properties assessed were soil organic carbon, texture and erodibility factor (k). The estimated mean annual soil losses were calculated using the revised Universal Soil Loss Equation (USLE). The erodibility factors of the soils were grouped using Olson's erodibility indices. The data obtained were subjected to analysis of variance (ANOVA), and correlation analysis. The results obtained indicate that the erodibility (K) for the land use types were 0.176, 0.131, 0.101 and 0.056 for arable farm, fallow, oil palm and forest respectively. The arable farm had the highest k value while the lowest was observed in the forest land. The grouping of erodibility status of the study area using the Olson's erodibility indices indicated that the soils of forest land (0.056) were in group I which showed low erodibility. The erodibility of the soils under fallow (0.131) and oil palm (0.101) fell in group II and the soils of the arable crop (0.174) were in group III which is very erodible. The estimated mean annual losses were 454.10 tons/ha/yr, 381.37tons /ha/yr, 311.9tons/ha/yr and 270.84tons/ha/yr for arable farm, fallow, oil palm and forest respectively. The estimated annual soil loss for the different land use increased with increase in soil depth. They were 251.19tons/ha/yr, 329.89 tons/ha/yr and 432.58tons/ha/yr for 0-15cm, 15-30cm and 30-45cm, respectively. Minimal tillage, mulching, cover cropping, and application of organic matter are highly recommended for such erosion prone soils of Owerrrinta especially in the arable crop farms.

Keywords: Erodibility factor K, USLE, Landuse systems, erodibility indices, annual soil loss

INTRODUCTION
Soil erodibility is the degree of susceptibility of the soil to erosion. It is an estimate of the ability of soils to resist or succumb to erosion, based on their physical and chemical characteristics (Ojo and Johnson, 2010). It depends on soil structure, texture and composition. There is a mutual relationship between soil erosion and parent materials based on land use types(Ozdemir and Ashkin, 2003).This work studied the erodibility of soils of Owerrinta in relation to their land uses. An in-depth study of the erodibility potentials of soils of Owerrinta under different land uses will help in adopting good soil management system. Findings from this research will boost the bank of information that will foster sustainable agricultural land uses in Owerrinta. This will also help to curb the menace of soil degradation and erosion in Owerrinta. The general objective of this study was to determine the erodibility potential of soils of Owerrintaunder different land uses. The specific objectives of the study were to predict the annual soil losses using the rainfall erosivity factor (R) and the soil erodibility factor (k) and to evaluate the effect of land uses on the erodibility of some soils of Owerrinta

Materials and Methods
Description of the study area
The study was carried out at Owerrinta in IsialangwaSouthLocal Government Area of Abia state. Owerrinta lies within latitudes 05^0 21′N to 05^0 24′N and Longitudes $07^0$32′E to 07^o42′E with mean annual rainfall of about 2226mm (*climatedata.org*.2019). The dominant parent materials is alluvium.The soils are mainly ultisols and are acidic(Chikezie*et al*, 2009). The main ecological problems inthe study area are soil degradation and erosion. The rainy season starts from March and extends to October with bimodal peaks in July and September, and a short break in August. The dry season starts in November and lasts till February.

The common land uses of the area include oil palm plantation, grassland, short duration bush fallow, forest and arable farming cultivated with cassava, maize, yam and vegetables in a mixed cropping system. Palm plantations in the study areas had underlying shrubs as undergrowth and the oil palm trees were unprunned. Plants like *Eupatorium odoratum*and*Mimosa pudica* were also found in most oil palm plantations. The common tree species found in the forest of the study areas are oil bean tree(*Pentaclethramacrophyllum*), African bread fruit (*Treculiaafricana*), bush mango

(*Irvingiagabonesis*), Africa star apple (*Chrysophyllumalbidum*) and Iroko trees (*Miliciaexcelsa*). The forests had shrubs and few grasses as undergrowth especially where the canopies are not thick. The fallow lands in the study areas are short duration fallow lands, usually less than two years. This might be due to high pressure and demand on land in these areas. The land is usually converted to arable crop land after the short fallow period. Trashing and burning of cleared bushes before cultivation is a common practice in the study areas. Crops are planted on ridges and heaps made with hoes. The arable crops are continuously cultivated on the same piece of land. Weed control using hand picking and hoes were common practices.

SOIL SAMPLING AND PREPARATION

Soil samples for the study were collected from four land uses: oil palm plantation (OP), forest (FO), arable crop (AC)and land fallow(FA) at three depths, 0-15cm, 15-30cm and 30 – 45 cm with soil auger and core samplers for the determination of soil properties in the laboratory.

LABORATORY STUDIES.

Particle size distribution was determined by Gee and Or (2002) method, using sodium hexa-metaphosphateas dispersing agent. Micro-aggregate stability was determined using the amount of silt and clay in calgon – dispersed as well as water –dispersed samples during particle size analysis described by Gee and Or (2002). Bulk Density (BD)was determined using the core method as described by Anderson and Ingram (1993). Organic carbon was determined using the wet oxidation method of Walkley and Black (1934). Soil erodibility was determined based on Wischmeier and Smith (1963) formula for the determination of erodibility index. This formula made use of some soil characteristics namely; Structural Class Index, Permeability Class Index, soil erodibility index (Organic Matter Content and % Silt + Very fine sand and % sand (i.e. 100- % clay).

Soil Structural Class Index

The soil structural class index of the soil samples were determined in the field based on Wischmeier and Smith (1963) method of erodibility determination. It was determined by taking soil clods from each plot and at each depth, and dropping them from known height of about 1.2m, watching how the clods were broken for classification as shown in Table 1 below.

Table 1: The soil structural class index of the soil samples

Soil Structure	**Class Index**
Very fine granular	1
Fine granular	2
Medium or coarse granular	3
Blocky, platy or massive	4

Source: Wischmeier and Smith (1963).

The permeability class index of the soil samples were determined based on Wischmeier and Smith (1963) method. This is done by using a cylinder infiltrometer test. In this method, each point location was tested by measuring a known quantity of water (300ml) and watching how long it takes (in minutes) to infiltrate into the soil at each depth. The time taken was then classified using Table 2 below.

Table 2: Permeability Class Indices of Soils

Time (mins)	**Soil class**	**Remarks**
1-10	1	Sandy soil
11-20	2	Sandy loam
21-30	3	Sandy clay loam
31-40	4	Sandy clay loam
41-50	5	Clayey loam
51-60	6	Clayey soil

Source: Wischmeier and Smith (1963)

The soil erodibilty index was calculated based on Wischmeier and Smith (1969) equation as follows:

$K = 2.1\times10^{-6} x M1.14(12–OM)0.0325(S-2)x0.025(P-3)$…………….eqn.1

Where, K= erodibility index of soil

OM =organic matter content, M =% silt + % very fine sand and % sand (i.e. 100 - % clay)

P = permeability class index

S = structural class index (f) erosion prediction

The annual soil loss was calculated using the revised USLE as proposed by Schwab *et al.*,(1993) for the various sampling locations as follows:

Annual soil loss A = 2.24RK ……………eqn.2

Where: A = Soil loss in tons/ha/yr

R = mean annual rainfall factor

K = erodibility index

The mean annual rainfall factor, R was obtained using Roose (1977) equation thus;

R = 0.5 H ……………………………..…eqn.3

Where:H is the mean annual rainfall in mm.

According to *climatedata.org.2019*, Owerrintahas mean annual rainfall of about 2226mm.

Data Analysis

The laboratory data were statistically analyzed using a 4 x 3 factorial in a randomized complete block design with three replications. The factor A was the four land uses (oil palm plantation, forest, arable crop land and fallow) and factor B the three depths (0-15cm, 15-30cm and 30-45cm). Fisher's Least Significant Difference (LSD) was used to separate significanttreatment means. Simple linear correlation was carried out on selected soil chemical and physical properties, erodibility indexand annual soil loss for the different land use studied.

RESULTS AND DISCUSSION

Erodibility Factor of Soils ofOwerrintaUnder Different Land Uses

The erodibility factors (k) of the soils are shown in Table 3 below. The erodibility (K) of the land use types were 0.176, 0.131, 0.101 and 0.056 for arable farm, fallow, oil palm and forest respectively. The arable farm had the highest erodibility factor (k) compared to other land uses. The high erodibility of soils under arable crop production might be due to continuous cropping which reduces organic matter contents and stability of the soil structure. This is in line with the observation of Balesdent*et al*, (2000) who opined that the continuous and intensive tillage operations of arable land coupled with low vegetative cover that exposed them to intense heat could lead to loss of organic matter, leaching of essential nutrients and high erodibility. The lowest erodibility (K) was found in soils of the forest lands. The low erodibility of the forest soils may be due to frequent return of biomass via litter fall, high ground cover and little or no disturbance of the soil. This confirms the finding of Holland (2004) who reported that little or no disturbance to the top soil and good vegetation cover were effective in soil organic matter conservation and improved soil structure which reduced erodibility and soil degradation. According to standard erodibility indices by Olson (1984), the soils of the arable farm belong to group III which is erodible, fallow and oil palm belong to group II which is moderately erodible and forest soil belong to group I. The erodibility of the soil in terms of depth were 0.096, 0.134, and 0.115 for 0-15cm, 15-30cm and 30-45cm, respectively.

Table 3: Average Erodibility factor (k) of the soils of Owerrinta

Depth	Fallow	Arable Farm	Forest	Oil Palm	Mean
0-15	0.141	0.101	0.062	0.081	**0.096**
15-30	0.141	0.210	0.085	0.100	**0.134**
30-45	0.110	0.211	0.021	0.121	**0.115**
Mean	**0.131**	**0.174**	**0.056**	**0.101**	**0.115**

Table 4: Standard erodibility indices

Group	K factor	Nature of soil
1	0 - 0.1	Permeable gracia outwash well drain soils having stony substrata
II	0.11 – 0.17	Well drained soils in sandy grade free material
III	0.18 – 0.28	Graded loams and silt, loam
IV	0.29 – 0.48	Poorly graded moderately fine and textured soil
V	0.49 – 0.64	Poorly graded silt or very fine sandy soil, well and moderately drain soils.

Source: Olson (1984)

The estimated soil losses of the different land use studied are shown in Table 5 below. The estimated mean annual losses were 454.10 tons/ha/yr, 381.37 tons/ha/yr, 311.91 tons/ha/yr and 270.84 tons/ha/yr for farm, fallow, palm and forest respectively. The relative higher annual soil loss in the arable farms might be due to the higher erodibility factor K of the soils compared to other land uses. The estimated annual soil loss increased with increase in depth. They were 251.19tons/ha/yr, 329.89 tons/ha/yr and

432.58tons/ha/yr for 0-15cm, 15-30cm and 30-45cm, respectively. This is indicative that the soils will be more susceptible to erosion if they lose their top soils. From the standard for the soil erosion risk classification shown below (Table 6) the soil losses are extremely high for all the land uses.

Table 5: Estimated soil losses of soils of Owerrinta

Depth	Fallow	Arable Farm	Forest	Oil Palm	MEAN
0-15	368.25	263.03	210.43	163.08	**251.19**
15-30	287.45	548.72	261.29	222.10	**329.89**
30-45	488.41	550.55	340.81	550.55	**432.58**
MEAN	**381.37**	**454.10**	**270.84**	**311.91**	**337.89**

TABLE 6: STANDARD FOR THESOIL EROSION RISK CLASSIFICATION

EROSION RISK CLASS	RATE OF EROSION (t/ha/yr)
Very low	<5
Low	5-10
Low medium	10-15
Medium	15-20
High medium	20-25
High	25-35
Very high	35-50
Extremely high	50

Source: Revised Universal Soil Loss Equation (RUSLE)

Correlation of some soil parameter with erodibility

Table 7 below shows the correlation between some physical parameter of the soil and erodibility factor K and estimated soil loss. Organic matter correlated negatively with bulk density and soil erodibility. This shows that an increase in organic matter will decrease the bulk density and subsequently soil erodibility. Therefore a decrease in organic matter will lead to increase in bulk density and increase in erodibility of the soil. This agrees with the finding of Zhou *et al.*,*(*2012) that soil with high bulk density has low infiltration and are more susceptible to erosion due to high runoff. Organic matter correlated positively with saturated hydraulic conductivity K.sat, and soil permeability. This shows that an increase in Organic matter will increase Ksat and permeability of the soil thereby reducing soil erosion (Zhou *et al.*,2012).

There is a positive significant relationship between percentage clay and bulk density of the soil. This shows that the higher the clay content, the higher the bulk density. Percentage clay shows a negative relationship with soil permeability andKsat, which means that an increase in percentage clay will reduce soil infiltration capacity. The table also showed a negative relationship between erodibility and clay percentage. This implies that an increase in clay content will lead to a decrease in erodibility of the soil. These observations are attributed to the binding power of soil clay and its ability to improve soil aggregate stability. This result is in line with the findings of Evans A. C. (1980) who examined erodibility in terms of the clay content, indicating that soils low in clay fraction are most susceptible to erosion. Soil permeability and Ksat strongly correlated negatively($p \leq 0.01$) with soil erodibility. This shows that an increase in soil permeability will reduce the erodibility of the soils

Table 7: Correlation of selected soil chemical and physical properties with soil erodibility

PROPERTY	1	2	3	4	5	6	7
1). OM(%)	-						
2). Clay (%)	0.073	-					
3). Bulk density	-0.123**	0.108*	-				
4). Ksat	0.336**	-0.222**	0.131	-			
5). Soil permeability	0.233**	-0.734**	-0.186*	0.472**	-		

6). Estimated soil loss	-0.292**	-0.024	0.145**	-0.124	-0.291**	-	
7). Erodibility k	-0.169*	-0.094	0.186*	0.007	-0.253**	0.884**	-

* Correlation is significant at the 0.05 level (2-tailed), ** Correlation is significant at the 0.01 level (2-tailed).

CONCLUSION AND RECOMMENDATIONS

In this study the erodibility potentials and the annual soil loss of the soils under different land uses in OwerrintainAbia state was predicted. The study was carried out on soil of four different land uses (arable land, forest, fallow, and oil palm) at three soil depths (0-15cm, 15-30cm and 30-45cm). Soil samples were subjected to laboratory analysis.The soil erodibility factor k was calculated based on Wischmeier and Smith (1969).The annual soil loss was calculated using the revised USLE as proposed by Schwab *et al*.,(1993).The erodibility factors of the soils were grouped using Olson's erodibility indices. The result indicated that soils under arable crop production had the highest erodibility while the soil under the forest land use had the lowest erodibility. The soils under arable crop production also had the highest annual soil loss while that of forest and oil palm had the lowest.The grouping of erodibility status of the study area using the Olson's erodibility indices, indicated that the soils of forest land (0.056) were in group I which showed low erodibility. The erodibility of the soils under fallow (0.131) and oil palm (0.101) fell in group II and the soils of the arable crop (0.174) were in group III which is very erodible. The estimated mean annual losses were 454.10 tons/ha/yr, 381.37tons /ha/yr, 311.9tons/ha/yr and 270.84tons/ha/yr for arable farm, fallow, oil palm and forest respectively. The estimated annual soil loss for the different land use increased with increase in soil depth. Base on the study, the soils of Owerrintawere mostly affected bythe arable crop land use which involves the continuous cropping on the same piece of land. This therefore calls for public enlightenment on the erosion status of Owerrintaby the government. The adoption of sustainable agricultural land use practices like crop rotation, cover cropping and use of organic matter are also recommended since they are reported to have reduced erodibility potentials and annual soil losses.

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