Erodibility Indices and Soil Loss from Different Land uses in Owukpa and Okaba Bioregion of Lower Coal Measures Geological Sediments of the Anambra Basin, Nigeria

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Abstract
The study on erodibility indices and soil loss from different land uses in Owukpa and Okaba bioregion of lower coal measures geological sediments of the Anambra Basin, Nigeria was conducted forested, cultivated and residential lands. Thirty-nine (39) representative soil samples were collected at a depth of 0 – 20 cm using auger, labeled and preserved to the laboratory for standard laboratory procedures. The percentage of different grain sizes Moisture content, organic carbon, organic matter content, soil pH, bulk density, particle density, porosity, soil structural index, specific gravity, particle size and permeability were verified. The three land uses were predominantly sandy soil and classified as sandy loam, moderate Permeability, low moisture and clay contents. Dispersion, Erosion, Clay and Modified Clay ratios where high, while Water Stable Aggregates was low. Cultivated land use has the highest value of erodibility factor K (0.12) and predicted soil loss was 18.22 tons/ha/yr. Residential land use value of erodibility factor K was 0.10 and the predicted soil loss of 14.80 Tons/ha /yr while forested land use K was lowest (0.08) with predicted soil loss of 11.84 tons/ha/yr. Using one way ANOVA at $p \leq 0.05$ the different land use patterns did not significantly influence erodibility factor and soil loss in the study area.

Keywords: *Owukpa and Okaba, Lower Coal Measures, Geological Sediments, Anambra Basin, soil erodibility indices and soil loss.*

1. INTRODUCTION

Soil erodibility in relation with other soil properties help in designing land management strategies to check the danger of soil erosion, environmental degradation caused by unsuitable land use (Mandal *et al*., 2010). The ability of a soil to produce some products or carry out some functions may decline with certain land uses. It has been observed that as the fertility of soil declines, soil structure weakens and the soil becomes susceptible to erosion (Adetunji, 2004). Conversely, the sustainable agricultural production, primarily regarding soil quality, is a key to guaranteeing reliable food, feed, and fiber supplies (Guerra and Botelho, 2012). Adequate and relevant information are usually necessary to accomplish such goals. Understanding the technicalities of erosion processes would thus substantially support conservation strategies toward achieving a realistic success in erosion control. The soil erosion hazards impact negatively in both urban and rural areas with serious on- and off-site environmental end products and socio-economic problems. Although soil erosion is a natural phenomenon, it often worsens by anthropogenic activities such as farming, civil constructions, and mining, among, others. The anthropogenic variations in land use have altered the properties of the Earth's surface, leading to variations in soil physico-chemical properties such as soil fertility, soil erosion sensitivity and content of soil moisture (Abad *et al*., 2014). These changes may be caused by soil compaction that reduces soil volume and consequently lowers soil productivity and environmental quality (Abad *et al*., 2014).

The agricultural industry has been reported to have increased soil erosion (Guerra and Botelho, 2012). Ayuba and Dami, (2011) viewed that all aspects of agricultural soils were inherently low in nutrients and, have a weak structure that cannot withstand the high erosive power of rain and wind thereby constituting some of most slightly fragile soils. Pressures on coal mining and misuse of agricultural lands have exerted challenges in the study area towards sustainable agricultural productivity for past few decades; these practices could not only accelerate the soil erosion but can also result in soils having low soil fertility.

Land use refers to the different ways land is utilized, depending on its physical location and economic attributes (Harvey, 1996). Among all the land uses agriculture is the most dominant from earliest times. Di Gregorio and Jansen (1998) look at land use as the arrangements, activities, and inputs people undertake in a certain land cover type to produce, change or maintain it. Land use change from non-agricultural to agricultural has led to decrease of soil organic matter which causes adverse impacts on the soil structure. This is vital in understanding factors which impose serious constraints to increased crop production under different land use types and for acceptance of suitable land management practices (Chimdi *et al.*, 2012).

Scientific information that is available on the extent to which agricultural soils are degrading as a result of land use patterns in Nigeria is insufficient. Therefore, information is needed on present and potential future land use pattern to furnish a foundation for reducing adverse effects of accelerated soil erosion. In view of the land degradation processes in Nigeria due to human interference on the natural ecosystems, it then becomes pertinent to carried out this study Soil Erodibility indices and soil losses under different land uses in the study area.

2.0 MATERIALS AND METHODS

2.1 Description of the studied area

The Lower Coal Measures Geological formation of Nigeria located in the Guinea Savannah ecological zone and in the middle belt of Nigeria. Owukpa in Benue state geographically lies between latitude 06^0 57' and 07^0 00'N, and longitude 07^0 38' and 07^0 42'E and Okaba in Kogi State lies 7° 23' 0'' North, 7° 44' 0'' East (i.e. between latitudes $7^0 20^1 – 7^0 43^1$N of the Equator and longitudes $7^0 22^1 – 7^0 52^1$E of the Prime Meridian) are the only land areas encompassed as the study area.

Owukpa has an estimated land mass of about 350 square km and an estimated population of about 100,000 people (Isikwe, *et al.,* 2016). 95 percent of the populace is Idoma speaking group and 95 percent of the populace in Okaba are the Igala speaking group. The coal deposit within the lower coal measures geological formation in Owukpa is over 60 million tons (Agagu *et al.,* 1985).

The climate of Owukpa and Okaba is a tropical type with distinct wet and dry seasons. According to (Isikwe, *et al.,* 2016) rainfall usually starts around April when the inter-tropical convergence zone (ITCZ) shifts towards the Anambra Basin and stops in October with an average monthly precipitation of 4 – 1100 mm (0.2 inches to 0.4 inches) in Owukpa district. The mean annual rainfall for Okaba is 1250 mm as reported by Udosen and Eshiett (2009). The mean monthly temperature ranges from 16^0C to 36^0C for both areas with the value of relative humidity ranging from 36 – 80%. The harmattan period is the coldest months which usually occur during December and January while the hottest months are in February and March. However, a slight deviation may occur in their general pattern.

Geologically, the areas are underlain by two formations: The Mamu (Early to Late Maastrichtian) and Ajali (Middle to Late Maastrichtian) formations. The lower coal measures comprise white to grey, and fine to medium-grained sandstones; shaly sandstones and sandy shales, mudstones, shale and coal measures at several horizons. The shales and mudstones often alternate with thin bands and lenses of siltstones (Ogbonnaya, 1992). Both geologies are of sedimentary formation that falls within the cretaceous system of the upper senonian age.

The Coal-bearing Mamu Formation (Lower Coal Measure) accumulated during epoch of overall regression of the Nkporo cycle. According to Okeke *et al*., (2014), the Mamu Formation occurs as narrow strip trending north-south from the Calabar Flank, swinging west around the Ankpa Plateau and terminating at Idah near the Niger River. The coal measure is found within the geological units represented by the Mamu Formation (Lower Maastrichtian) and Nsukka Formation and (Upper Maastrichtian to Danian) (Obianuju, 2005). This formation is underlain by Enugu shales (Campanian) and overlain by the false-bedded Ajali sandstones of Middle Maastrichtian age.

2.2 Field and Laboratory Studies:

ASTM D 422 - Standard Test Method for Particle-Size Analysis of Soils using sieve and hydrometer method were performed to determine the percentage of different grain sizes contained within the soil. The percentage of silt, sand, and clay were determined by taking the reading from the Plot of the grain size curve D versus the adjusted percent finer on the semi logarithmic sheet. Moisture content is determined by drying the sample to a constant weight. The water content is then expressed as the percentage, by weight, of the dry sample. Specific gravity was determined based on fine-grained soil by density bottle method as per Indian Standard: 2720 (part 111/sec 1)

– 1980 G_s measured in room temperature. Bulk density (ρd) was measured with samples taken from 0 to 20 cm soil layer using metal cylinders of approximately 100 cm^3 volume (5.02 cm in diameter and 5.05 cm in height), with thirteen replicated samples taken from each land use. The samples were weighed and dried until they reached a constant weight. Determination of soil organic content (SOC) was done using the Walkley-Black method (Walkley and Black, 1934) as modified by Allison (1965) and it was converted to organic matter content using OMC = 1.72OC. The soil permeability was also determined using constant head permeameter. Soil textural class was determined using soil textural triangle. Soil porosity was calculated using bulk density and particle density according to the equation: total porosity (%) = (1-$\rho d/\rho p$) ×100. A wet sieving method was used to determine the percentage of aggregate stability (Water stable aggregates, WSA %). However, the soil erodibility indices were determined from the result of soil physical and chemical properties data obtained from the laboratory. For this work, soil erodibility factor (K) was determined based on (Bouyoucos, 1935)

$$K = \frac{\%SAN + \%SIL}{\%CLA} \text{------------------------------} 1$$

While the revised universal soil loss equation (RUSLE) by Schwab *et al.*, (1993) used in calculating the soil losses under standard conditions for the various sampling locations was used to predict soil losses for the various areas where soil samples were collected.

$$A = 2.24RK \text{ -------------------------------- } 2$$

Where;

A = Soil loss converted to ton/ha/yr. by multiplying by 2.24,

R = mean annual rainfall factor and K = erodibility factor (Hudson 1995).

One – way analysis of variance (ANOVA) was used to determine if land use had a significant effect on the erodibility factor and soil loss using IBM SPSS Statistics version 20. The DNMRT at $P \leq 0.05$ was used to separate the means where there was a significant difference.

3.0 RESULTS AND DISCUSSION

3.1 Results: Table 1, 2 and 3 presents the mean results of the determined Physico-chemical properties of soils, particle size distributions and soil permeability from forested, cultivated and residential land use, while, that of erodibility indices, factors, predicted soil loss and Summary of ANOVA of land use and erodibility factors/soil loss from forested, cultivated and residential land uses are presented in Tables 4, 5 and 6.

Table 1: Physico – Chemical Properties of the Soil for the Three Land Uses

Land Use	MC (%)	OC (%)	OMC (%)	pH	G_S	ρd (g/cm^3)	P (%)
Forested	12.90	0.64	1.10	6.70	2.64	1.27	58.76
Cultivated	10.40	0.62	1.06	6.50	2.68	1.35	56.22
Residential	11.13	0.59	1.02	6.40	2.68	1.40	48.73

MC = Moisture Content, OC = Organic Carbon, OMC = Organic Matter Content,
G_S = Specific Gravity, ρd = Dry Bulk Density, and P = Porosity

Table 2: Analysis of soils' grain size Distribution from the Three Land Uses

Land Use	Sand (%)	Silt (%)	Clay (%)	Soil class	Soil structure	SC
Forested	53.16	34.92	11.92	Sandy loam	Medium to C.G	3
Cultivated	57.08	33.84	9.08	Sandy loam	Medium to C.G	3
Residential	55.62	33.69	10.69	Sandy loam	Medium to C.G	3

Medium to C.G = Medium to Coarse granular and SC = Structural Code

Table 3: Soil permeability for the Three Land Uses

Land Use	Permeability rate (cm/h)	Permeability class	Permeability code
Forested	11.15	Moderate	3
Cultivated	11.61	Moderate	3
Residential	11.99	Moderate	3

Table 4: Computed Erodibility Indices for the Three Land Uses

Land Use	DR	ER	CR	MCR	WSA
Forested	0.77	0.73	8.17	7.39	3.68
Cultivated	0.81	0.89	12.78	10.63	2.62
Residential	0.79	0.80	9.66	8.56	1.38

DR = Dispersion Ratio, ER = Erosion Ratio, CR = Clay ratio, MCR = Modified clay Ratio and WSA = Water Stable Aggregate

Table 5: Erodibility Factor and Predicted Soil Loss for the Three Land Uses

Land Use	Erodibility Factor	Erodibility class	Soil loss (tons/ha/yr.)
Forested	0.08	Low	11.84
Cultivated	0.12	Moderate	18.22
Residential	0.10	Low	14.80

Table 6: ANOVA of Land Uses and Erodibility Factor/Soil Loss

Parameter	Sources of variation	Df	SS	Ms	F	Sig.

Erodibility Factor	Land use	2	0.011	0.006	2.597	0.088^{ns}
	error	36	0.079	0.002		
	Total	38	0.090			
Soil loss	Land use	2	248.470	124.235	2.597	0.088^{ns}
	error	36	1721.991	47.833		
	Total	38	1970.461			

$P \leq 0.05$

3.2. DISCUSSION

Moisture content: Moisture content results in (Table 1) shown that forested land use has the highest soil moisture content of 12.90 %, followed by residential land use (11.13%), while cultivated land use has the lowest (10.40%). The high moisture content in the forested land use may be attributed to the shade provided by the leaves and grasses from the forest which reduces evaporation or water loss or it might due to high clay content. The result is in accordance with Ayoubi, (2011) who reported that forest soils having more available water holding capacity compared to cultivated lands. Wakene (2001) also described that Cultivation degrades the soil structural aggregate, reducing the soil water retention capacity. Low moisture content in the cultivated land use maybe attributed to high sandy texture and low clay content, or it is owing to many anthropogenic activities in the cultivated land use which keep the soil surface bare. Moisture brings about the cohesion of soil particles which jointly with other soil components like organic matters form aggregates that can compete against fluid drag. Low moisture reduces the cohesion between the particles of the soil hence making them easily carried away by erosive agents such as water, thus increasing its vulnerability to erosion. In other words, the higher the antecedent moisture content, the lower the vulnerability of the soil to erosion. This finding agrees with Andreassian *et., al* (2004) who stated that a drier soil is more vulnerable to wind and water erosion than a wet soil. The moisture content in residential land use is high compared to cultivated land use. This might be as a result of more clay content in the residential land use than cultivated land use. The result shows that forested land use is less vulnerable to erosion by water than the cultivated and residential land uses. The vulnerability is in the order of forested < residential < cultivated.

Soil organic carbon (SOC) and organic matter content (OMC): The soil organic carbon varied under different land use system from 0.64 % in the forested to 0.62 % in cultivated and 0.59 % in residential (Tables 1) which translated to organic matter content of 1.10%, 1.06% and 1.02% for forested, cultivated and residential land uses respectively. The difference between soil organic carbon and organic matter content in the different land uses show clear degradation effects caused by deforestation and subsequent intensive cultivation practices which resulted in low organic carbon and organic matter content which is in accordance with the observations of Evrendilek *et al*. (2004). Studies have demonstrated that forest soils have more soil organic matter than crop land (cultivated) soils (Wang *et al*., 2008; Bonino, 2006; Breuer *et al.*, 2006; Morisada *et al.*, 2004). This shows evidently that soil organic carbon and organic matter content decreases as anthropogenic activities increases. Conversion of forest to cultivated and residential land uses causes a change in organic matter content, thus resulted in nutrient imbalances and decrease in the water holding capacity. This demonstrate that different land use systems cause difference in the levels of soil organic matter contents as reported by Fuller and Anderson (1993); Funakawa *et al.*, (1997); Sanchez *et al.*, (1983); Gebrelibanos and Mohammed (2013). According to Evans (1980) Soils with less than 2% organic carbons or 3.5 %, organic matter content can be considered erodible. The study area organic carbon is less than 2 %, and organic matter content is less than 3.5%. Therefore, the soils are erodible in nature based on (Evan, 1980) classifications of erodibility. Also, it is in accordance with Brady and Weil, (2002) who revealed that Soils with relatively low organic matter content are very vulnerable to water erosion since organic matter increases the stability of soil. Soil organic matters also have a range of impacts on water through its impacts on aggregate stability, bulk density, soil porosity and soil infiltration. A conclusion can be made that increasing soil organic matter improves aggregate stability and tends to reduce water erosion. It is in agreement with Charman and Murphy (1991) who stated that when organic matter is high, the soil will be less vulnerable to erosion because of the binding effect of organic matter and therefore less vulnerability to particle detachment hence forested land use is less susceptible to erosion compare to cultivated and residential land uses. The organic matter content is high in the forested land use compared to cultivated and residential land uses this is in accordance with Chen *et al.*, (2000), who stated that organic matter is normally highest in the forest soil comparable to constantly cultivated soil. Litters or leaves fall from trees, dead grasses, plants, and animals that are decomposed into the soil were the major contribution of soil organic matter in the forest ecosystem. The incorporation of organic residues into the soils through tillage practices and fertilizer application (organic and inorganic) at the cultivated land use might have contributed to the relatively higher level of organic matter in the cultivated land use than that of residential land use. The low organic matter content values observed in the cultivated and residential soils could probably due to the land usage as influenced by human activities.

Specific gravity (G_S): Results of the specific gravity of the soil samples from the study area vary from 2.64 to 2.68. The forested land use has the lowest specific gravity of 2.64 whereas cultivated and residential land has a specific gravity of 2.68 each (Table 1). This could be as a result of the high organic matter present in the forested land use than the cultivated and residential land uses and might have encouraged infiltration and reduced surface run-off and soil loss in the forested land use. The result demonstrates that cultivated and residential land uses are more erodible than the forested land use.

Bulk density (ρd): Results of the dry bulk density of the soil samples from the study area show that forested land use bulk density is 1.27g/cm^3 is comparatively low compared to the cultivated and residential land use bulk densities of 1.35 g/cm^3 and 1.40 g/cm^3 respectively (Table 1). The differences might be ascribed to the more clay in forested land use than the cultivated and residential land uses or on available macronutrients and micronutrients in the soil. It is in agreement with Pravin *et., al* (2013) who reported that clayey soil tends to have lower bulk densities and higher porosities than sandy soils or bulk densities decrease as the total macronutrient or total micronutrient contents in the soil increases. Also, it might be due to compaction of topsoil as a result of farm machinery or intensive agricultural practices for cultivated land while high anthropogenic activities and the trampling effects in the residential land for several years. The results were in agreement with that of Islam and Weil (2000). This means that cultivation affected bulk density. Many researchers have shown that increases in bulk density as a result of forest conversion to arable land were a reflection of the extent of soil degradation that has occurred (Guilser, 2006). The implication of higher bulk density in cultivated and residential land use cause the reduction in total porosity which translates into poor aeration which may physically restrict root growth. The bulk density ranged from 1.27 g/cm^3 to 1.40 g/cm^3 for the three land uses. This is good compared to the average standard value of 1.33gm/cm^3 bulk density for ideal soil as given by Esu, (1999). The low bulk density experienced in forested land use can be attributed to the undisturbed nature of the soil structure and high organic matter content compared to cultivated and residential land uses thereby making it more stable and non-vulnerable to the forces of erosion than cultivated and residential land uses.

Porosity (P): The porosity of soils ranges from 48.73 % to 58.76 % among the three land uses. The highest porosity is observed in forested land use (58.76%), cultivated land use 56.22% and the lowest at residential land use (48.73%) (Table 1) the overall result confirmed that porosity depends on bulk density. Celik (2005) has indicated that depending upon increases in bulk density; total porosity decreased accordingly. This low porosity in the residential land use is an indication that the soil is dense and contains a low volume of voids than the cultivated and forested land uses which has a porosity of 56.22% and 58.76% respectively. The low porosity makes the residential land use prone to erosion than forested and cultivated land uses because the infiltrations will be lower which encourages runoff. The high in the porosity of the forested land use may be as the result of low bulk density and high organic carbon which translate into high organic matter content in the area. This is in agreement with Lin *et al*., (2005) who reported that the amount of organic carbon has a positive effect on soil porosity and the plant's available water capacity. This also accounts for cultivated land and residential land uses. Also, Evrendilek *et al.,* (2004) reported that conversion of grassland into cultivated land during a 12-year period increased bulk density by 10.5% but decreased total porosity by 9.1%.

Particle size distribution: The particle size analysis results indicate that most of the particles obtained from the study area (Table 2) belong to the category of fine sand and silt (0.2mm – 0.002mm). The inter-particle bonding force between these particles is low hence they are loose and hence slight force is required to detach and transport the soil particles, therefore, making the soils vulnerable to soil erosion by water. Particle size distribution of the three land uses as shown in Table 2 indicated that sand from the forested, cultivated and residential land use were 53.16 %, 57.08 %, and 55.62 % respectively. Sand content is increased with changing forest to cultivated land, this may as a result of preferential removal of silt and adding sand in soil surface by accelerated water erosion. According to Ayoubi *et al.,* (2011) Sand content is a physical parameter affected by soil erosion and, hence, can be measured and used as an indicator for assessing soil degradation under different land use systems. However, forested land use has 11.92 % clay content while cultivated and residential has 9.08 % and 10.69 % respectively Table 2. There is higher clay content in the forest land use compared to the cultivated land and residential land uses. This is in agreement with the work of Klimowicz and Uziak, (2001) and Krishnaswamy and Ritcher, (2002) which showed selective loss of clay due to forest conversion to arable (cultivable) land. By implication, forested land use is more stable, and resists soil erosion by water than cultivated and residential land uses. However, residential land use is more stable and resists soil erosion by water than cultivated land use these are in agreement with Julian and Torres, (2006) who opined that the erosion resistance of a soil is found to increase with increasing clay properties. The result of the silt shows that forested land use has 34.92 %, while cultivated and residential recorded 33.84 % and 33.69 respectively. The soil in the three lands uses fall into sandy loam class and has medium to a coarse granular structure with code 3 in soil coding. The silt content reduces as a result of anthropogenic activities (such as cultivation and trampling effect), or it may be due to location-specific as concluded by Osakwe and Igwe (2013) in their study. The size of particle mostly eroded is about 0.1mm (Bryan 2000) hence the reduction in silt content might result due to erosion that detached and transports it away.

Permeability: The results of permeability range from 11.15 to 11.99cm/h (Table 3), thus permeability code of 3 at every land uses which shows that permeability class index is moderate according to Idah *et., al* (2008). Forested land use was more permeable (11.15 cm/h) compare to cultivated and residential land use (11.61cm/h and 11.99cm/h) respectively. This show that forested land use is less eroded compared to cultivated and residential land use. This might as a result of high organic matter content, low dry bulk density and particle density in forested land use which translated to high porosity. The moderate permeability in the three land uses suggests that the pore-pressure is also moderate consequently the shear strength of the soil indicated that the soil vulnerability to water erosion is moderate.

Dispersion Ratio: Among different land uses dispersion ratio was the lowest under forest and residential land uses 0.77 and 0.79 respectively and highest under-cultivated land use 0.81 (Table 4). According to the criterion of Middleton (1930); soils having dispersion ratio > 0.15 are erodible in nature. In soils of eastern Nepal, Chakrabarti (1990) reported that susceptibility to erosion is significantly related to the dispersion ratio. This indicates that the soils from the three land uses are vulnerable to erosion because of their high values of dispersion ratio using the above criteria. Kukal *et al.*, (1993) observed that the soils under forest land use were more stable as compared to the soils under cultivation and they ascribed it to the higher organic carbon content resulting in more stability of soil aggregates. The low dispersion ratio from the residential land use might be as a result of high clay content. The soils under forest cover had higher water retention, infiltration rate and lower dispersion ratio hence more stable.

Erosion Ratio: The results show that erosion ratio (ER) in cultivated land use is the highest 0.89; follow by residential land use 0.80 and lowest in forested land use 0.73 (Table 4). This is in agreement with (Dabral *et al.*, 2001, and Singh and Khera 2008) who observed that low value of erosion ratio in the forest soils compared to other land uses. These values can be considered high compared to standard values given by Kahlon and Khera (2005). According to Kahlon and Khera

(2005); soils having erosion ratio > 0.10 are erodible in nature hence the value show that all the soils from the three land uses are erodible in nature.

Clay and modified clay ratio: The values of clay ratio (CR) and modified clay ratio (MCR) were the highest among different land uses and were in the order of cultivated (12.78) > residential (9.66) > forested (8.17) and Cultivated (10.63) > residential (8.56) > forested (7.39) for clay and modified clay ratios respectively (Table 4). This show that there is an increase in resistance to erosion in forested land use than residential and cultivated land uses while residential land use has high resistance to erosion than cultivated land use. This is in agreement with Singh and Khera, (2008) who revealed that when clay ratio in the soils decreases it show the resistance to soil erosion by water increases. The low value of clay and modified clay ratios in the forested land use compared to other land uses could as a result of high clay and organic matter content in the forested land use. The clay ratios were higher than modified clay ratios, which might be due to the inclusion of organic matter in the denominator in case of modified clay ratios. Generally, from this study forested land use has lower value of soil erodibility indices than cultivated and residential land uses while residential land use has lower soil erodibility indices than cultivated land use hence cultivated land use is more erodible than all the three land uses.

Water stable aggregate: Percentage of water stable aggregates > 2 mm (WSA) were in the order of forest (3.68) > cultivated (2.62) > residential (1.38) (Table 4). The result shows that forested land use has more water aggregate stability than the other land uses. With this low number of WSA, the resistance of the soils to erosion is considerably reduced in cultivated and residential land uses thus increasing their vulnerability to erosion. The study is in agreement with Vaezi and Bahrami (2014) who revealed in their study that soils that have a lower percentage of water-stable aggregates and a lower infiltration rate have a propensity to have a higher vulnerability to erosion.

Effect of Land Use on the Erodibility Factor and Loss of the Soil of the Formation

From the result of erodibility factor (K) calculated (Table 5), cultivated land use are more erodible having the highest K value of 0.12 with moderate erodibility class, the result is in agreement with Ghaderi and Ghoddusi (2005) that soil erodibility increase by the increase of sand to silt ratio. The result is also in agreement with Ayuba and Dami, (2011) who revealed that agricultural soils are inherently low in nutrients and, have a poor structure that cannot withstand the high erosive power of rain and wind; as a result, constituting some of most marginally fragile soils. The high erodibility factor (K) values could be attributed to the increase of sand to silt ratio in the cultivated land use which has provided low binding and inter-binding forces which decrease cohesion of soil particles and make the soil vulnerable to water erosion. The residential land use has K value of 0.10 with low erodibility class. The least predicted losses were found in soils from forested land use with a K value of 0.08 with low erodibility class. These results agree with Ghasemi and Mohammadi (2003) which stated that increasing the percentage of clay and organic matter would decrease soil erodibility. These low erodibility factor (K) values could be attributed to the more clay and organic matter content present in the forested land use which has provided higher binding and inter-binding forces that increase the cohesion of soil particles and helps in resisting detachability of soil by water and in residential it may be due to high clay content. This result agrees with Murthy (2003) that the erosion resistance of soil particles is found to increase with an increasing clay proportion. The statistical analysis (Table 6) showed that the land use did not significantly affect the erodibility factor. This might be as a result of anthropogenic activities in the cultivated and residential land use interfered with practice of agriculture (that is by applying conservation technique such as organic and inorganic fertilizer in cultivated land use and erosion control measure put in places in some of the residential land use by planting trees and the application of laterites which has high clay content) in the study area. From the results of the predicted soil losses in the three Land uses in (Table 5) and using the standard erodibility indices as given by Idah *et al.* (2008) cultivated land use having the highest value of K and has the highest predicted soil losses of 18.22 tons/ha/yr. while Residential and Forest areas were having the Lower value of K with predicted soil losses of 14.80 tons/ha/yr. and 11.84 tons/ha/yr. respectively. An analysis of the result using ANOVA in (Table 6) showed that the land use did not significantly affect the soil loss. This might be as a result of forested land use converted to cultivated and residential land uses using proper practices to securing organic matter and soil stability (application of conservation technique), that did not easily cause soil erosion.

4.0 Conclusion

The results from these analyses shows that

1. The soils from the three land uses are predominantly sandy soil and classified as sandy loam with the
 structural code of 3.

2. The top soils in the study area are intrinsically low in nutrients and, have a poor structure that cannot withstand the high erosive power of rain thereby constituting some of most marginally fragile soils.

3. The soils permeability was moderately permeable with class code 3.

4. The soil moisture content and clay content are also found to be low which is an indication that the soil is loose, has little or no binding properties to make the soil particles cohesive, hence less vulnerable to the forces of water erosion. The moisture content was high in the forested land use than the other land uses these shows that the forested soil is more stable than cultivated and residential land use.

5. Dispersion ratio (DR), Erosion ratio (ER), clay ratio (CR), Modified Clay ratio (MCR) were high, while Water Stable Aggregates (WSA) which can offer resistance to the shearing force of water was low which suggests that soils from the three land uses are vulnerable to water erosion.

6. Erodibility factor (K) was determined and Annual soil losses was predicted with cultivated land use having erodibility factor K value of 0.12 which is moderate based on K value classification and predicted soil loss was 18.22 tons/ha/yr. while residential and forested land uses were having low K values of (0.10) and (0.08) with predicted soil loss of 14.80 tons/ha/yr. and 11.84 ton/ha/yr. respectively.

7. The different land use patterns did not significantly influence erodibility factor and soil loss in the study area.

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