DETERMINATION OF SOIL ERODIBILITY INDICES FOR SELECTED SOILS IN SOUTHERN GUINEA SAVANNA ECOLOGICAL ZONE OF NIGERIA UNDER RAINFED AGRICULTURAL PRACTICE

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Abstract: A field experiment was conducted to determine erodibility index of selected soils in Southern Guinea Savanna Ecological zone of Nigeria. In each area, samples were taken from various depths of 0 – 10 cm, 10 – 20 cm and 20 – 30 cm, respectively for analysis in order to determine their physical properties. Textural triangle was used to carry out textural classification to determine the percentage dominance of the various textural classes of soil present in the selected areas. The Bougocous hydrometer method was used to determine the particle size distribution for the samples collected at various depths. The soil moisture content for plot A ranged between 9.04 to 9.14% while that of plot B ranged between 8.21 to 8.70%, plot C ranged between 7.83 to 8.51%, plot D ranged between 7.67 to 8.73% and plot E ranged from 8.73 to 9.05%. The permeability rate became stable for plot A at 45 min while at plot B, C, D and E was at 33, 45 min and 48 minutes, respectively. The particle size analysis indicated that the soil type in plot A is mainly sandy loam. It is concluded that the study area is less vulnerable to erosion as only fine soil particles are washed off as a result of the effect of surface runoff which is indicated by the negative erodibility indices obtained for the study area.

Keywords: Permeability, soil, structure, water, texture

Introduction

Soil is a complex mixture of minerals, water, air organic matter, gases, liquids and the countless organisms that are decaying remains of once living things (Schoonover and Crim, 2015). It forms at the surface of land, thus it is referred to as the skin of the earth. Soil is capable of supporting plant life and it is vital to life on earth. A good soil for growing most plants should have about 45% minerals (with a mixture of sand, silt and clay), 5% organic matter, 25 air, 25% water (Saxton and Rawls, 2005).

Soil is an essential input to agricultural production in Nigeria, where agricultural production is crucial to the development and livelihoods of the vast population which depend on this natural abundant resource (Duiker *et al.,* 2001). Soil erosion occurs when soil particles are detached by wind or water, transported and deposited somewhere else different from their initial position, contributing a significant amount of soil loss each year under various land condition different from their initial position (Morgan, 2005). Erosion also begins when rain or irrigation water detaches soil particles (Hann *et al*., 2006). Soil degradation under farming sometimes brings about soil erosion, sedimentation and leaching (Akilapa, 2010). Soil erosion depends on the erosivity of the rainfall and the erodibility of the soil. (Akintola, 2010) The extent of washing away of soil particles depends on the soil characteristics and type of soil particles involved, which leads to the concept of erodibility of the soil.

Soil erodibility is an estimate of the ability of soil to resist erosion based on the physical characteristics of each soil. Generally soils with faster infiltration rates, higher levels of organic matter and improved structure have a greater resistance to erosion (Dexter, 2004). A soil with relatively low erodibility factor may show signs of serious erosion, yet a soil could be highly erodible and surfed little erosion, this is because soil erosion is a function of many factors as stated in the Universal Soil Loss Equation (USLE). These factors include rainfall factor (R), soil erodibility factor (K), slope length (LS), crop factor (C) and control practice factor (P) with respect to the area. This is represented in the Universal soil loss equation as

$$A = RKLSCP \qquad 1$$

Erodibility is the resistance of the soil to both detachment and transport (Emeka, 2014). The soil erodibility factor K is a quantitative expression of the inherent susceptibility of a particular soil to erode at different rates when the other factors that affect erosion are kept constant (Ezeabasili1 *et al*., 2014). Erodibility varies with soil textures, aggregates, stability, shear strength, soil structures, infiltration capacity, soil depth, bulk density, soil organic matter and chemical constituents. Soils below the plough layers are often compact and less erodible. Rills will develop in areas where resistance bedrock is close to the surface if the parent material is unconsolidated such as sands and gravel (Morgan, 2001). The organic and chemical constituents of the soil are important because of their influence on stability of aggregates. This study aims at determining the erodibility index of the selected soils and its effect on the soil erosion.

Materials and Methods

Study area

The irrigation farm of the permanent site of Federal University of Technology, Gidan Kwano Minna, Nigeria was used to conduct the study. Located along kilometer 10 Minna - Bida Road, South- East of Minna in Bosso Local Government Area of Niger State, and has a total land mass of eighteen thousand nine hundred hectares (18,900ha). The site is bound Northwards by the Western rail line from Lagos to the northern part of the country and the eastern side by the Minna-Bida Road and to the North-West by the Dagga hill and river Dagga (Musa *et al*., 2011). Table 1 shows the location for which the various soil samples were collected for analysis.

Table 1: Location of the various sample points

Location	Longitude	Latitude
A	006^0 26.499"E	090^0 31.126"N
B	006^0 26.546E"	009^0 33.128"N
C	006^0 27.521"E	009^0 32.139"N
D	006^0 27.821^{0}E	090^0 33.189"N
E	006^0 24.411^{0}E	090^0 30.316^{0}N

Sample collection

A total fifteen soil samples each were collected from the study area at depths of 0– 10 cm, 10-20 cm and 20-30 cm from the study area using a soil auger and core samplers. The distance between each of the plots where samples were collected was 10 m apart. This was determined based on the textural nature of soil observed. The soil samples were put in specimen bags and were properly labeled. This is in accordance with the works of USDA (2014). The following parameters were analyzed for:

i. Moisture content

The gravimetric method of determination of soil moisture content was used. Weight (80 g) of the soil samples collected were each oven dried at a temperature of 105^0C for 24 h after being dried at room temperature of 27^0C. The empty crucible was weighed as W_1 using the electronic weighing scale (Models: CBI-6001). The initial weight of the soil in the crucible and the crucible itself (W_2) was also determined. The sample was placed in the electronic vacuum oven (JSVO-60T) for 24 h at a constant temperature of 105^0C. After which the soil sample and the crucible was weighed as W_3. The moisture content was calculated using the following formula:

$$M_c\% = \frac{W2 - W3}{W3 - W1} \text{ x } 100 \qquad 2$$

Where M_c is the Moisture content, W_1 is the Weight of container, W_2 is the Weight of container and sample and W_3 is the Weight after oven drying.

ii. Soil bulk density

The various soil samples were initially dried at room temperature for 48 h. The mass of each empty crucible (M_1) was found; the soil samples were then transferred from the soil sample bags into the crucible and then weighed as M_2. The crucible and the soil samples were kept in the oven for 24 h at 105^0C for the moisture in the soil sample to be dried completely, after which the can and the sample of soil were removed from the oven and then reweighed as M_3. The bulk density (gcm^{-3}) was then calculated using equation 2.

$$Bulk\ Density = \frac{Mass\ of\ Oven\ dried\ soil}{Volume\ of\ core} \qquad 2$$

The porosity was then determined from the relationship between bulk density and particle density;

$$Porosity = 1 - \frac{Bulk\ Density}{Particle\ Density} \qquad 3$$

iii. Soil structure

The structure of the soil was determined by physically examining the soil samples collected using an auger and a core sampler at the stipulated depth. The relative sizes of the particles, aggregation, and the entire structure in terms of grade, form and entire structure and size were properly analyzed. This is in accordance with the works of Musa *et al.* (2012).

Table 2: Soil structure in terms of diameter of particles

Size	Angular Structure (mm)	Granular structure (mm)	Platy structure (mm)	Prismatic structure
Very fine	<5	<1	<1 (very tiny)	<10
Fine	5-10	1-2	1-2(thin)	10 -20
Medium	10 - 20	2-5	2-5	20-50
Coarse	20-50	5-10	5-10 (thick)	50-100
Very coarse	>50	>10	>10(very thick)	>100

Source: *(http://www.soils.wisc.edu)*

iv. Soil permeability

Double ring infiltrometer of outer and inner ring diameters of 600 and 300 mm respectively with both having a height of 150 mm was used to determine the rate of movement of water the soil from the inner ring. This was performed for each plot which is in accordance with the works of Musa and Egharevba (2009) and Musa *et al*. (2011). The rings were carefully driven into the soil halfway not to disturb the original formation of the soil after water was first added into the outer ring and then the inner ring. Readings were taken from the inner ring of the infiltrometer. The measurement was taken in 0, 3, 6, 9, 12, 15, 18, 21, 24, 27, 30, 33, 36, 39, 42, 45, 48, 51, 54, 57, 60 min, respectively.

v. Particle size analysis

The hydrometer method was used to determine the particle size analysis. 80 g of soil sample from a 2 mm sieve was poured in a conical flask. 50 ml of Sodium hexametaphosphate was added to the soil sample in the flask after which 100 ml of distilled water was added. This is in accordance with the works of Di Stefano *et al.* (2010); Neyshabouri *et al.* (2011) and Centeri *et al.* (2015). The solutions were carefully stirred to allow for a good particle in a 1000 ml measuring cylinder. The solution was then allowed to stand for 24 h.

After about a minute the hydrometer was introduced into the cylinder and allowed to stabilize before the reading was taken. The solution was kept for about 2 h after which another reading was taken. The temperature readings were taken for each of these two processes. The first reading of temperature (T_1) and hydrometer (H_1) were used to calculate the percentage sand content, while the second reading of temperature (T_2) and hydrometer (H_2) were used in calculating the percentage clay content. This is in accordance with the work of Akilapa (2010) and Akintola (2010). A correction factor in relation to the temperature was added to the hydrometer readings giving new values of H_3 and H_4, respectively (Akintola, 2010).

$$\%\ Sand = \frac{H_3\ X\ 100}{Weight\ of\ Soil}$$

$$\%\ Clay = \frac{H_4 x\ 100}{Weight\ of\ soil}$$

$$\%\ Silt = 100 - (\%\ sand + \%\ Clay)$$

Results and Discussion

Table 3 shows the results of the moisture content of selected study areas. This shows that the average moisture content of the plots A, B, C, D and E ranges from 7.950 to 9.067%.

Table 4 to 7 presents the results for the water intake rate for the selected plots of the study area. The results showed that gotten it was observed that plot B permeates more than plots A, C, D and E. Tables 4 to 8 showed that the permeability rate became stable at 45 min for plots A, B, and D while plots C and E were stable at 33 and 48 min, respectively and eventually they all tends to a steady state.

Table 3: Soil moisture content of plots A, B, C, D and E

S/N	Samples	Soil depth (cm)	Weight of Container + sample (g)W2	Weight after oven dry(g) W3	Moisture content %	Average moisture content %
1		0-10	150.360	140.041	9.033	
2	A	10-20	150.374	139.918	9.144	9.067
3		20-30	150.253	139.934	9.025	
4		0-10	150.939	140.897	8.598	
5	B	10-20	150.695	140.678	8.705	8.507
6		20-30	150.294	140.789	8.217	
7		0-10	150.450	140.567	8.574	
8	C	10-20	150.630	140.894	8.415	8.275
9		20-30	150.821	141.698	7.837	
10		0-10	150.197	140.689	8.232	
11	D	10-20	149.852	140.053	7.673	7.950
12		20-30	150.198	140.987	7.946	
13		0-10	150.764	140.673	8.732	
14	S5	10-20	150.675	140.251	9.050	8.926
15		20-30	150.568	140.238	8.997	

Table 4: Permeability rate of soil at plot A

S/N	Time elapsed (min)	Initial reading (cm)	Water intake (cm)	Cumulative water intake	Permeability (cm/hr)
1	0	15.00	-	-	-
2	3	13.04	1.96	1.96	39.20
3	6	10.82	2.22	4.18	22.20
4	9	9.90	0.92	5.10	6.13
5	12	8.90	1.00	6.10	5.00
6	15	7.85	1.05	7.15	4.20
7	18	7.50	0.35	7.50	1.17
8	21	7.01	0.49	7.99	1.40
9	24	6.80	0.21	8.20	0.53
10	30	5.40	1.40	9.60	2.80
11	33	5.09	0.31	9.91	0.62
12	36	4.85	0.24	10.15	0.44
13	39	4.50	0.35	10.50	0.58
14	42	3.50	1.00	11.50	1.54
15	45	3.10	0.40	11.90	0.57
16	48	2.89	0.21	12.11	0.28
17	51	2.62	0.27	12.38	0.34
18	54	2.41	0.21	12.59	0.25
19	57	2.00	0.41	13.00	0.46
20	60	1.90	0.10	13.10	0.11

Table 5: Infiltration rate of soil at plot B

S/N	Time elapsed (min)	Initial reading (cm)	Water intake (cm)	Cumulative water intake	Permeability (cm/hr)
1	0	15.00	-	-	-
2	3	12.95	2.05	2.05	41.00
3	6	10.50	2.45	4.50	24.50
4	9	9.80	0.70	5.20	4.67
5	12	8.50	1.30	6.50	6.50
6	15	7.01	1.49	7.99	5.96
7	18	6.22	0.79	8.78	2.63
8	21	5.60	0.62	9.40	1.77
9	24	4.90	0.70	10.10	1.75
10	30	4.35	0.55	10.65	1.10
11	33	3.92	0.43	11.08	0.95
12	36	3.40	0.52	11.60	0.95
13	39	3.00	0.40	12.00	0.67
14	42	2.79	0.21	12.21	0.33
15	45	2.10	0.69	12.90	0.99
16	48	1.60	0.50	13.40	0.67
17	51	1.42	0.18	13.58	0.23
18	54	1.02	0.40	13.98	0.47
19	57	0.50	0.52	14.50	0.58
20	60	0.41	0.09	14.59	0.09

Table 6: Permeability rate of soil at plot C

S/N	Time elapsed (min)	Initial reading (cm)	Water intake (cm)	Cumulative water intake	Permeability (cm/hr)
1	0	15.00	-	-	-
2	3	13.09	1.91	1.91	38.20
3	6	11.20	1.89	3.80	18.90
4	9	9.22	1.98	5.78	13.20
5	12	8.89	0.33	6.11	1.65
6	15	7.01	1.88	7.99	7.52
7	18	6.60	0.41	8.40	1.37
8	21	6.01	0.59	8.99	1.69
9	24	5.60	0.41	9.40	1.03
10	30	4.97	0.63	10.03	1.26
11	33	4.01	0.96	10.99	1.75
12	36	4.00	0.01	11.00	0.02
13	39	3.35	0.65	11.65	1.00
14	42	3.02	0.33	11.98	0.47
15	45	2.77	0.25	12.23	0.33
16	48	2.06	0.71	12.94	0.89
17	51	2.00	0.06	13.00	0.07
18	54	1.08	0.92	13.92	1.02
19	57	0.51	0.57	14.49	0.60
20	60	0.44	0.07	14.56	0.07

Table 7: Permeability rate of soil at plot D

S/N	Time elapsed (min)	Initial reading (cm)	Water intake (cm)	Cumulative water intake	Permeability (cm/hr)
1	0	15.00	-	-	-
2	3	11.98	3.11	3.11	62.20
3	6	11.00	0.89	4.00	8.90
4	9	10.28	0.72	4.72	4.80
5	12	10.00	0.28	5.00	1.40
6	15	9.46	0.54	5.54	2.16
7	18	9.04	0.42	5.96	1.40
8	21	8.54	0.50	6.46	1.43
9	24	7.68	0.86	7.32	2.15
10	30	7.01	0.67	7.99	1.34
11	33	7.00	0.01	8.00	0.02
12	36	6.08	0.92	8.92	1.53
13	39	5.96	0.12	9.04	0.18
14	42	4.24	1.72	10.76	2.46
15	45	4.10	0.14	10.90	0.19
16	48	3.85	0.25	11.15	0.31
17	51	2.66	1.19	12.34	1.40
18	54	2.05	0.61	12.95	0.68
19	57	1.01	1.04	13.99	1.09
20	60	0.05	0.96	14.95	0.96

Table 8: Permeability rate of soil at plot E

S/N	Time elapsed (min)	Initial reading (cm)	Water intake (cm)	Cumulative water intake	Permeability (cm/hr)
1	0	15.00	-	-	-
2	3	13.82	1.18	1.18	23.60
3	6	11.26	2.56	3.74	25.60
4	9	10.79	0.47	4.21	3.13
5	12	9.86	0.93	5.14	4.65
6	15	8.83	1.03	6.17	4.12
7	18	7.79	1.04	7.21	3.47
8	21	6.52	1.27	8.48	3.63
9	24	6.01	0.51	8.99	1.28
10	30	5.66	0.34	9.34	0.68
11	33	5.03	0.63	9.97	1.15
12	36	4.68	0.35	10.32	0.58
13	39	4.35	0.33	10.65	0.51
14	42	3.92	0.43	11.08	0.61
15	45	3.00	0.92	12.00	1.23
16	48	2.80	0.20	12.20	0.25
17	51	2.00	0.80	13.00	0.94
18	54	1.56	0.44	13.44	0.49
19	57	1.07	0.49	13.93	0.52
20	60	0.99	0.08	14.01	0.08

Table 9: Soil particle size and textural classification result of the study areas

		Particle Size				
Plots	**Samples**	**Depth (m)**	**% Sand**	**% Silt**	**% Clay**	**Textural Class**
A	1	0 – 10	81.24	10.56	8.20	Loamy sand
	2	10 – 20	79.13	11.96	8.91	Loamy sand
	3	20 – 30	74.53	14.98	10.49	Sandy loam
B	1	0 – 10	78.39	13.24	8.37	Sandy loam
	2	10 -20	75.96	13.98	10.06	Sandy loam
	3	20 – 30	73.97	15.99	10.04	Sandy loam
C	1	0 – 10	82.98	9.26	7.76	Loamy sand
	2	10 – 20	78.98	11.37	9.65	Sandy loam
	3	20 -30	75.77	13.79	10.43	Sandy loam
D	1	0 – 10	80.44	11.32	8.24	Loamy sand
	2	10 -20	77.88	12.57	9.55	Sandy loam
	3	20 – 30	74.87	16.55	8.59	Loamy sand
E	1	0 – 10	83.09	9.56	7.35	Loamy sand
	2	10 – 20	78.90	12.98	8.12	Loamy sand
	3	20 – 30	74.98	15.70	9.32	Loamy sand

Table 9 shows the results of the soil aggregates for the selected plots within the study areas. The obtained results were used to determine the various types of soils that existed in the study area. Table 9 also showed the percentage sand, silt and clay content of the soil which was determined according to the depth of 0 to 30 cm. This is in accordance with the works of Oguike and Mbagwu (2015); Ezeabasili *et al*. (2014) and Alzlan *et al*. (2012).

The results of the soil aggregates for the various plots studied are presented in Table 10. Soil aggregation is essential for the resistance to erosion and its influence on the capacity of the soil to remain productive (Hann and Morgan, 2006). Table 11 shows the statistical analysis of the maximum and minimum limits of the various parameters considered while Table 12 indicates the calculated erodibility indices of the various plots at varying depths.

Table 10: Soil aggregates results of the study area

Sample	Plot	Depth (cm)	Bd (gcm^{-3})	Pd (gcm^{-3})	P (%)	OM (%)
1	A	0-10	1.138	1.45	57	4.6
2		10-20	1.067	1.26	59	3.9
3		20-30	1.055	1.86	60	3.6
4		0-10	0.986	1.80	62	4.0
5	B	10-20	0.881	1.61	66	3.8
6		20-30	0.929	1.53	64	3.5
7		0-10	0.890	1.44	66	4.5
8	C	10-20	1.045	1.39	60	3.8
9		20-30	0.938	1.40	64	4.2
10		0-10	0.984	1.28	62	3.6
11	D	10-20	0.913	1.45	65	3.9
12		20-30	0.951	1.52	64	3.6
13	E	0-10	0.930	1.40	64	4.2
14		10-20	0.894	1.37	66	3.8
15		20-30	0.889	1.22	66	3.4

Mc = Moisture Content; Bd = Bulk density; Pd= Particle density; P = Porosity; OM = Organic matter.

Table 11: Result of statistical analysis

Samples	MC	BD	PD	Porosity	Organic Matter
Plot A	9.07 ± 0.07^{d}	1.08 ± 0.45^{b}	1.52 ± 0.31^{a}	58.67 ± 1.53^{a}	4.033 ± 0.51^{a}
Plot B	8.51 ± 0.26^{bc}	0.93 ± 0.52^{a}	1.65 ± 0.14^{a}	64.00 ± 2.00^{b}	3.77 ± 0.25^{a}
Plot C	8.28 ± 0.39^{ab}	0.95 ± 0.79^{a}	1.41 ± 0.03^{a}	63.33 ± 3.06^{b}	4.17 ± 0.35^{a}
Plot D	7.95 ± 0.28^{a}	0.94 ± 0.36^{a}	1.41 ± 0.12^{a}	63.67 ± 1.52^{b}	3.72 ± 0.22^{a}
Plot E	8.9 ± 0.17^{cd}	0.90 ± 0.22^{a}	1.33 ± 0.96^{a}	65.33 ± 1.15^{b}	3.82 ± 0.42^{a}

Means± standard deviation with the same letters in a column are not significantly different at 50% level of probability. Where a and b represent no significant difference (NS), ab, bc and cd represents Least significant difference (LSD) in the data.

Erodibility index

Table 12: Erodibility index of the selected plots

Plots	Samples	Depth (cm)	Erodibility index (K)
A	1	0-10	-71.14
	2	10-20	-80.58
	3	20-30	-83.22
B	1	0-10	-79.68
	2	10-20	-80.84
	3	20-30	-85.12
C	1	0-10	-72.98
	2	10-20	-81.26
	3	20-30	-74.82
D	1	0-10	-85.61
	2	10-20	-79.93
	3	20-30	-85.24
E	1	0-10	-77.75
	2	10-20	-82.83
	3	20-30	-87.32

The rate of movement of water within the various study locations indicated a rapid rate of movement of water into the soil which indicates the level of dryness of the soil in the study area. Thus, the level of permeability of water into the soils was observed to be high at the initial stage and within a few minutes the rate of movement of water slowed down. This is similar to the works of Musa and Egharevba (2009) were they used the rate of movement of water through the various pore spaces to determine the type of soil existing within the same study area. It has been established by several researchers (Leonard *et al*., 2006; Boardman, 2006; Anikwe and Ubochi, 2007; Andoh *et al*., 2012) that low moisture reduces the cohesiveness among the particles hence making them freely dispersible by water and other erosion agents, thereby making it susceptible to erosion (Doerr and Walsh, 2001; Lunt *et al*., 2005; Diamond and Thoas, 2013).

Soil permeability could be related to the nature of shrubs and grasses which grew within the various study areas as the roots tend to create pore spaces within the soil. The top soil of plot B was observed to be dryer than other plots of the study area as observed from the intake rate of water. Coarse grained sandy soils have been established to have large spaces between each grain which allow water to move through it. However, permeability of water into the soil is dependent on several factors such as soil texture, pore size, soil structure, soil metric potential, initial soil water content and soil vegetation (Al-Janobi *et al*., 2010). If the quantity of water within the soil surface is less than the permeability capacity, the water will permeate freely through the soil also if the rainfall intensity at the soil surface occurs at a rate that exceeds the permeability capacity pounding will occur and then runoff over the ground surface will occur which will eventually bring about the washing away of the soil particles. This also reflects that cumulative permeability shows a rapid increase in volume of water permeated within a short period of time, which decreases to a nearly linear rate over a period time due to the level of saturation of the soil pore spaces. Researchers have shown that sandy soil has a higher permeability rate than clay soil under identical conditions (Runbin, 2011). The initial steady follow rate of water observed within the study area could be linked to the geological formation of the study area. This is in line with the study of Musa and Egharevba (2009). Soil erodibility is the susceptibility or vulnerability of the soil to erosion which is a function of soil texture, soil structure, soil permeability and organic matter content (Kim *et al*., 2011).

The rate of moisture movement affects nutrients stability and water distribution into the soil. Hence, soil nutrients distributed in the rooting zone depending on the soil properties are easily leached out. The ability of soil to store water depends on the soil pore spaces, as water moves faster through macro- pores (sandy soils) than the micro-pores (clay soil). This study showed that rate of storage of water within the soil pore spaces is determined size of pores in such soils.

Soil organic matter (SOM) is the component of the soil that consists of plant and animal residues at various stages of decomposition, cells and tissues of soil organisms and substances synthesized by soil organisms. The SOM for the various plots varied greatly as it ranges from 3.95 to 5.00% for the five plots studied. This implies that increase in SOM means increase in the permeability level of the soil. This is also in accordance to the works of Leonard *et al*. (2006), Lipiec *et al*. (2006) and Savadogo *et al*. (2007).

Values of the soil textural and aggregates obtained were placed in the soil textural triangle to indicate the classification of the soil within the study area. This is similar to the works of Gajic *et al*., (2006) and Musa *et al*. (2012). It was further observed that most of the study areas were loamy sandy soils which have a characteristic nature of retaining water more than other types of soil particles. The results obtained from the Bougocous hydrometer method showed that plot B had highest percentage of sand content compared to the other plots of the study area. It was also observed that Plot C had a higher percentage of sand content than plot D while plot E is basically made up of Loam soil. The percentage of sand of each soil sample for plot A ranges between 74.53 and 81.24% while that of plot B ranges from 73.97 to 78.39%, plot C ranged from 78.976 to 82.98%, while plots D and E ranges from 77.88 to 80.44% and 78.91 to 83.09%, respectively. The clay content of plot B was found to be higher than those of plots A, B, C and E, while the sand content of Plot B was lower than that of the other plots. The results generally showed that the percentage sand content for the various plots reduced gradually from the top soil to the depth of 30 cm while the silt and clay contents were observed to be increasing. This is similar to the results obtained by studies carried out by Alzlen *et al*. (2012); Ezeabasili *et al*. (2014) and Oguike and Mbagwu (2015). This result shows that plot B is most suitable for agricultural crop production activities than other plots analyzed, according to the work of Afolabi *et al.* (2014) as it stores for use by plants.

The soil aggregate results indicated that the highest bulk density was observed at plot A which indicates the presence of much farming activities being carried out. This ranges between 1.055 and 1.138 gcm^{-3}. This is closely followed by plot C which ranged between 1.045 and 0.938 gcm^{-3} while plots B, D, and E ranges between 0.986 to 0.881 gcm^{-3}, 0.984 to 0.951 gcm^{-3} and 0.930 to 0.889 gcm^{-3}, respectively. The observed values of the measured bulk density throughout the study areas were fairly constant. Areas where major differences were observed are linked to the percentage of soil composition in the various study areas. It has been reported by several researchers (Li, 2003; Stiles *et al*., 2003; Lu *et al*., 2004; Neff *et al*., 2004; Hupp *et al*., 2008) that areas with high percentage sand composition experience high bulk density. The particle density was observed to have a similar trend when compared with the bulk density for the various plots; with plot A having the highest value closely followed by plot B. The free flow of water into the soils was expected to be high at locations where there exist high organic matter content but the reverse was the case as the geological formation of the area varies greatly (Hakansson and Lipiec, 2000). This is similar to the works of Musa and Egbrevba (2009).

The soil erodibility factor K is a quantitative description of the inherent erodibility of a particular soil; it is a measure of the susceptibility of soil particles to detachment and transport by rainfall and runoff. Erodibility index of selected study areas erodes at different rates when other factors affecting erosion (permeability, total water capacity, dispersion, rain splash and abrasion) are kept constant (Lipiec *et al*., 2006). Using the universal soil loss equation, the various erodibility indexes for the various plots were determined. It was observed that most of the calculated erodibility indexes were negative which means that the soil is highly not erodible. This is similar to the work of Gajic *et al.* (2013).

Conclusion

The effect of erodibility index of the selected soils on erosion of the study locations in the Southern Guinea Savannah Ecological zone of Nigeria was carried out. The results showed that the rate of permeability of water into the soil was relatively fast at the initial stage and after a few minutes, limited rate of water permeability was observed. The soil physical properties had significant effect on the erodibility parameters of the soil to a large extent as most of the soils were sandy loam in nature. The results further shows that the particle size analysis soils in the study area are mainly Sandy loam which makes them less susceptible to erosion as the rate of permeability of water into the soil is slow. The double ring infiltrometer used in computation of the permeability rate shows that plot B permeates more movement of water than the other plots which could be linked to the soil particles and its organic matter content. It is therefore concluded that the soil within the study area have poor erodibility indices as a result of their poor permeability rate. This leads to the pounding of water in the study area and later, the occurrence of an almost surface runoff during which fine soil particles are carried away as a result of the movement of water across the soil surface which invariably causes erodibility of the soil.

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