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Erodibility Indices under Different Land Uses in Awka, Nigeria

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ABSTRACT: Erosion problems are on the increase, worldwide, especially in the Southeastern part of Nigeria, where this problem is becoming uncontrollable. In this study, erodibility indices were studied in Nnamdi Azikiwe University, Awka, Anambra State Nigeria under four land uses (cultivated land, fallow land, bush and bare land). The land uses are located in the Agricultural and Bioresources Engineering Farm Workshop, apart from the bush, which is located close to the farm workshop. Soil samples were collected from each of the land uses at 0-25cm depth using soil auger. The soil samples were taken to the laboratory for determination of %silt, %clay, %sand and organic matter content. Soil structure, permeability, clay ratio (CR), modified clay ratio (MCR), critical level of organic matter (CLOM) and erodibility (K) index were also determined. From the result. %sand and % silt had negative correlation with k index, while % clay and organic matter content has positive correlations. The average CR and MCR obtained were 2.303 and 1.98 respectively, while CLOM of soil obtained in all the land uses were less than 5%. The result of the CLOM indicates poor soil structure and high susceptibility of erosion, while conclusion could not be drawn from CR and MCR.

KEYWORDS: soil structure, permeability, clay ratio, modified clay ratio, critical level of organic matter, cultivated land, bare land bush land, fallow land.

1. INTRODUCTION

Soil erosion is one of the most serious forms of land degradation in the world (Sohan and Lal 2001). Erodibility is the resistance of soil to both detachment and transport. Erosion is dependent on soil properties, topography, land use, rainfall intensity, surface cover and land management practices (Zund 2017). According to Ahukaemere et al 2021, soil erosion has contributed to land cover changes in Nigeria especially in Southeastern part of Nigeria. Land is one of the most important factors necessary for agriculture. Increase in food demand caused my increase in population has made agriculture an important factor in the economy of Nigeria. According to Ubuoh et al 2013, soil erosion is caused by interaction of natural and anthropogenic forces. This increase in population has led to massive clearing of agricultural lands, and improper clearing has led to destruction of agricultural lands. Agriculture in Nigeria has been hindered by land degradation, transportation of sediments and erosion. This land degradation which is as a result of soil structural damage is as a result of use of poor agricultural implements and other man-made and natural activities which leads to erosion. Water erosion is also one of the major causes of agricultural land degradation in Nigeria

There are needs to provide erodibility information which will help engineers, agriculturists and other land scientists to know the areas prone to erosion. This will enable them to adopt best management practices in clearing and controlling land for agriculture.

2. METHODOLOGY

2.1 Study Area

This research was carried out in Nnamdi Azikiwe University. Four different Land uses were used for the experiment. Three of the land uses (cultivated land, bare land and fallow land) are located in the experimental farm site of the department of Agricultural and Bioresources Engineering (ABE), Nnamdi Azikiwe University, Awka (6^0 15'11.8N to $6^0$15'5.3E latitudes and $7^0$7'118N to $7^0$7'183N) while the fourth land-use (small bush) is located outside but near the experimental site of ABE.

2.2 Soil Sample Collection

Undisturbed soil samples were collected at a depth of 0-25cm from each land use using auger. The soil samples were taken to the laboratory for soil organic matter and soil particle size determination.

2.3 Organic Matter Content Determination

5g scoops of soil was placed into a tared 20-ml beaker, this was dried for 2 hours in the oven at 105^0C. this was put inside muffle furnace at temperature of 360^0C for 2 hours, after which it was removed and dried in a dessicator to measure weight loss. This was determined using equation 3.1.

$$Organic\ matter = \frac{(wt.at\ 105^0C)(wt\ 360C)X\ 100}{wt105^0C}$$
3.1

2.4 Soil Particle Size Determination

50g of each of the soil sample was put into a 250ml beaker, and the beaker was filled with distilled water to 200ml mark. The sand was washed four times with distilled water.20ml of 25% sodium hexametaphosphate and 200ml of distilled water were added and this was allowed to stand for 16hrs (ie overnight). This was transferred into 0.2mm sieve. The particles accumulated in the sieve after sieving are the sand, while the particles that penetrated the sieve to the pan are the silt. The %clay was calculated using equation 3.2.

$$\%Clay = 100 - \%Silt + \%sand$$
3.2

2.5 Soil Structure

Four soil structure classes were considered in this work and they were assigned codes 1-4. Code 1: very fine granular (1-2mm), 2: fine granular (2-3mm) 3: medium granular (3-5mm) and 4: blocky (greater than 5mm)

2.6 Soil Permeability

Six permeabilitv classes were considered viz; 1: rapid (greater than 150mm/hr), 2: moderate to rapid (50-150mm/hr), 3: moderate (12-50mm/hr), 4: slow to moderate (5-15mm/hr), 5: slow (1-5mm/hr) and 6: very slow (less than imm/hr)

2.7 Clay Ratio (CR)

The clay ratio estimates the amount of clay that tightly binds the soil particles. It was determined for the four land-uses using equation 3.3

$$CR = \frac{\%sand + \%silt}{\%clay}$$
3.3

2.8 Modified Clay Ratio (MCR)

The modified clay ratio was determined for all the land-uses using equation 3.4

$$MCR = (\%sand + \%silt)/(\%clay + \%OM)$$
3.4

2.9 Critical Level of Soil Organic Matter (CLOM)

The critical level of soil organic matter has relationship with with aggrehate formation capability as it form resistance soil erosion (Olaniya et al 2020). This was calculated for the four land-uses using equation 3.5.

$$CLOM = \frac{OM}{Clay + Silt}$$
3.5

2.10 Soil Erodibility (K) Index

The soil Erodibility index or the K factor is defined as the rate of soil loss per unit of R (rainfall erosivity index based on 30 min rainfall intensity energy causing erosion) on a unit plot and indicates the relative ease at which the soil is detached and transported (Olaniya et al 2020). According to Okoro et al 2022, soils with higher k values are more prone to erosion than those with lower k values. This was determined for the four land-uses using equation 3.6

$$100K = \frac{2.1M^{1.14}\,(10^{-4})(12-OM) + 3.25(s-2) + 2.5(p-3)}{7.59}$$
3.6

Where K = erodibility factor in t ha h (ha MJ mm) $^{-1}$

OM – Organic matter content (%)

M = particle size parameter = %Silt + %sand)*(100-%clay)

S = Soil structure class

P= Permeability class

3. RESULTS AND DISCUSSION

3.1 Particle Size Distribution

From table 3.1, the highest sand value of 66.586% was obtained in bare land, while the least value of 47.974 was obtained in bush land. Sand was negatively correlated with erodibility for all the land uses in table 3.2. The values of sand are in the range of bare land >fallow land>cultivated land>bush land. For silt, the highest value of 23.593 was obtained in cultivated land, while the least value 0.834 was obtained for bare land. The values of silt are in the range of cultivated land>fallow land>bush land >bare land. Sols with 40-60% silt are highly likely to be eroded (Morgan 1995), soils with silt are highly erodible. Silt was negatively correlated with erodibility index in table 3.2 and no land use in the four land uses studied contained high percentage of silt. For clay the highest value of 60.743 was obtained in bush land, while the least value of 19.402 was obtained in cultivated land. Clay was positively correlated with erodibiliy index (table 3.2). According to Olaniya et al 2020, soil with 9-30% clay is taken as the most erodible. From the result in table 3.1, only cultivated land falls within the range of clay with high erodibility. The values for clay are in the range of bush land>fallow land>bare land>cultivated land.

Table 3.1 Particle Size Distribution

Land-use	Particle Size (%)				
	Sand	Silt	Clay	OM (%)	K-Index
Bush land	47.974	8.717	60.743	5.835	0.13
Fallow land	57.304	10.023	32.673	2.980	0.028
Cultivated land	56.985	23.593	19.402	4.395	0.052
Bare land	66.586	0.834	32.580	4.475	0.041

Table 3.2 Correlation of K index with the determinant factors

	K-index	Sand	Silt	Clay	OM
K-index	1				
Sand	-0.78931	1			
Silt	-0.02601	-0.358	1		
Clay	0.8475	-0.647	-0.460	1	
OM	0.898	-0.477	-0.081	0.6569	1

3.2 Organic Matter Content

Organic matter binds the soil and reduces the risk of erosion. The result of organic matter content for the four land uses is presented in table 4.1. Bush land has the highest value of organic matte content with a value of 5.835%, while fallow land has the least value of 2.980. the result of the organic matter content is in this order; bush land >bare land>cultivated land>fallow land. Organic matter content had positive correlation with erodibility index (table 4.2

3.3 Soil Erodibility Index

The soil erodibility factor ranges from 0.02 to 0.69 (Goldman et al 1986)**.** From table 4.1, the soil erodibility values were 0.13, 0.028, 0.052 and 0.041 for bush land, fallow land, cultivated and bare land respectively.

3.4 Clay Ratio and Modified Clay Ratio

According to Bryan (1968), minimum of 10% clay is required for meaningful interpretation of clay ratio. In this study, the percentage of clay for all the land-uses were >10%, because of this, they were considered for estimation of clay ratio. Bushland with highest clay content of 60.743% has lower clay ratio of 0.933, while cultivated land with lowest clay ratio of 19.402 has the highest clay ratio of 4.15. The average value of clay ratio for the land-uses is 2.303

Modified clay ratio also followed the same trend as clay ratio. Bush land has the lowest modified clay ratio of 0.851, while cultivated land has the highest value of 3.386. The average modified clay ratio for the land-uses is 1.98.

3.5 Critical Level of Organic Matter

According to Pieri 1991, CLOM less than or equal to 5% shows loss of soil structure and there is high susceptibility of erosion, 5-7% is moderate, while greater than 9% indicates stable soil structure. The critical level of organic matter in the studied land uses ranged from 0.069-0.136.

4. CONCLUSION

The average values for clay ratio and modified clay ratio are 2.303 and 1.98 respectively. This indicates that the land uses studied are liable to be eroded.

The values of critical level of organic matter of the soil samples in all the land-uses studied were < 5% and this means the areas studied have the possibility of loss of soil structure and this means there is possibility of erosion. All the samples in the study had clay content values greater than 10%, but conclusion could not be drawn because of lack of standard for erosion proneness (Olaniya et al 2020).

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