International Journal of Geology, Earth and Environmental Sciences ISSN: 2277-2081 (Online)
An Open Access, Online International Journal Available at http://www.cibtech.org/jgee.htm
2014 Vol. 4 (1) January-April, pp. 236-243/Chukwuocha et al.

Research Article

DETERMINATION OF THE ERODIBILITY STATUS OF SOME SOILS IN IKEDURU LOCAL GOVERNMENT AREA OF IMO STATE, NIGERIA

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ABSTRACT
Determination of soil erodibility status in four selected communities of Ikeduru LGA was conducted. Soil samples were collected randomly from Cassava farm, Bamboo field, Fallow land and sparse grassland and were analysed for moisture content, particle size distribution, textural class, organic matter content, permeability and aggregate structure using oven drying method, sieve analysis, triangular chart, and permeability/soil type table. Laboratory results were subjected to statistical analyses. Narrow variation was seen in all the particle size distribution (ranged from 25.10 – 35.15) with samples from sparse grass land vegetation having the least value (35.20), samples from cassava farm and bamboo field had their values as 35.15 and 29.40 respectively. The clay, silt and MC had a negative non-significant relationship with the erodibility status with values of correlation -.412, -.532 and -.836 respectively. While sand percentage content had a positive non significant relationship with erodibility factor ***K*** having the values of .670. OMC percentage content had a high positive significant relationship with erodibility factor ***K***, with the value of correlation as 1.000**. There was a high level of significance between clay, silt, sand, OMC, and MC with values of correlation as -.753**, -.714**, -.831**, and .955** respectively. Using regression equations and erodibility classification table the erodibility levels for the four samples locations were estimated and found to fall within the category of >0.2. This low value of erodibility factor implies that the cause of erosion in the study area may not be as a result of the soils only but could be as a result of other erosion causative factors such as rainfall intensity and duration.

Keywords: Erosion, Soil Erodibility, USLE, Particle Size, Ikeduru

INTRODUCTION
Soil erosion refers to the detachment and transportation of soil particles by water, wind ice or gravity. Water and wind are the major driving forces of erosion. The steady and slow processes that occur in nature such as geomorphologic processes cause non-destructive type of erosion, and this type is not detrimental to man's wellbeing and is wholly beyond his control. Erosion due to man's activity such as deforestation, leveling and cultivation results in accelerated erosion. Commonly speaking, and unless specifically mentioned, erosion refers to accelerated erosion (Tripathi, 2007).

While some human activities can significantly increase erosion rates, erosion is triggered by a combination of factors such as steep slopes, climate (e.g. long dry periods followed by heavy rainfall), land cover patterns (e.g. sparse vegetation) and ecological disasters (e.g. forest fire). Some intrinsic features of a soil can also subject it to erosion (e.g. a thin layer of topsoil, silty texture or low organic matter content). Erosions that have gone pass the rill stage and developed into deep gullies are generally irreversible. Soil moved by erosion carries nutrients, pesticides and other harmful chemicals into rivers, streams and ground water resources leading to pollution and siltation of surface water bodies as well as cause drastic reduction of water volume, and eventual siltation and drying up of rivers, water reservoirs and dams.

Erosion and the hazards associated with it (e.g. destruction of farmland and houses, destruction of transportation and communication systems, degradation of arable land, contamination of water supply, isolation of settlements and migration of communities), are common features in Imo State. The environmental menace caused by this problem of erosion also affects the economy of the State (Peter *et al.*, 2008)

Figure 1: A typical gully erosion feature in Ikeduru LGA

Literature Review

Soil characteristics are major contributors to an areas' susceptibility to erosion. Soil erodibility has been related to various factors such as cultivation pattern pedality and soil moisture retention characteristics (Onweremadu, *et al*., 2007), rainfall intensity (Abbas *et al.,* 2010). Based on the above Peter *et al.,*(2008) determined the erodibility indices for Owerri west in Imo State however, much work has not been done in determining the erodibility status of soils in Ikeduru LGA even though this area is noted as one of the major erosion provinces of Imo State (Amangabara, 2012).

Erodibility is the resistance of the soil to both detachment and transport. The soil erodibility factor (K-factor) 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. For a particular soil, the soil erodibility factor is the rate of erosion per unit erosion index from a standard plot. The factor reflects the fact that different soils erode at different rates when the other factors that affect erosion (e.g., infiltration rate, permeability, total water capacity, dispersion, rain splash, and abrasion) are the same. Texture is the principal factor affecting K_{fact}, but structure, organic matter, and permeability also contribute. The soil erodibility factor ranges in value from 0.02 to 0.69 (Peech *et al*,.1947).

A soil with relatively low erodibility factor may show signs of serious erosion, yet a soil could be highly erodible and surfer little erosion (Nyakatawa *et al.,* 2001) This is because soil erosion is a function of many factors as stated in the Universal soil loss equation (USLE). These factors include erosivity factor (rainfall) (R), soil erodibility (k), slope length (LS), crop factor (C), and control practice factor (P). This is represented in the universal soil loss equation as

$$A = R\ K\ LS\ C\ P$$

The Universal Soil Loss Equation (USLE) is currently the most popular in many countries to estimate soil erosion amount. The parameters in this equation were representatives from two-thirds of the eastern U.S.

Nigeria is not an exception among the countries using the USLE. It is still the main method to estimate soil loss and is in the Technical Code of Soil and Water Conservation, and Manual of Soil and Water

Conservation as the reference for the country. However, its results are often inconsistent with the actual situation because the application conditions show great difference. Factors like rainfall erosion index, gradient, slope length, crop management and conservation practice (R, L, S, C, P) have been modified by scholars based on related data, but the soil erosion factors (SEFs) still lacks a suitable equation for local conditions. This is attributable to the limited field data and survey, and to the time-consuming process for estimating Km on site. As a result, Km is still estimated based on the basic property of soil (Huang *et al.*, 2012).

METHODS

Study Area

Ikeduru (Lat 5 "27 'N) and Long 7" 07'E is one of the twenty seven local Government Area of Imo State (LGA) of Nigeria with its headquarters is located at Iho. The LGA is made of 17 communities namely Avuvu, Atta, Eziama, Amakohia, Ngugo, Ikembara, Akabo, Abazu, uzoagba, Amaimo, Inyishi, Iho, Okwu, Umudim, Ugiri, and Eziama with each community experiencing a different degree of erosion ranging from sheet erosion to severe gully erosion. The climatic condition of the LGA is that average daily temperature is 27^{0}C. Average annual rainfall of 1750 – 2000mm while relative humidity oscillates between 71.6 – 86.6%. The soil type according to the USDA soil classification scheme is ultisol derived from the coastal plain sands (Benin Formation) (Uzoho, *et al.*, 2007). Influenced by the topography (relief is about 240m), rainfall distribution is uneven and mainly concentrates in the raining season. In addition, the undulating gradient and frail geology makes the soils of Ikeduru susceptible to erosion. How to control soil loss and reduce soil erosion is a key subject for soil and water conservation when developing these areas.

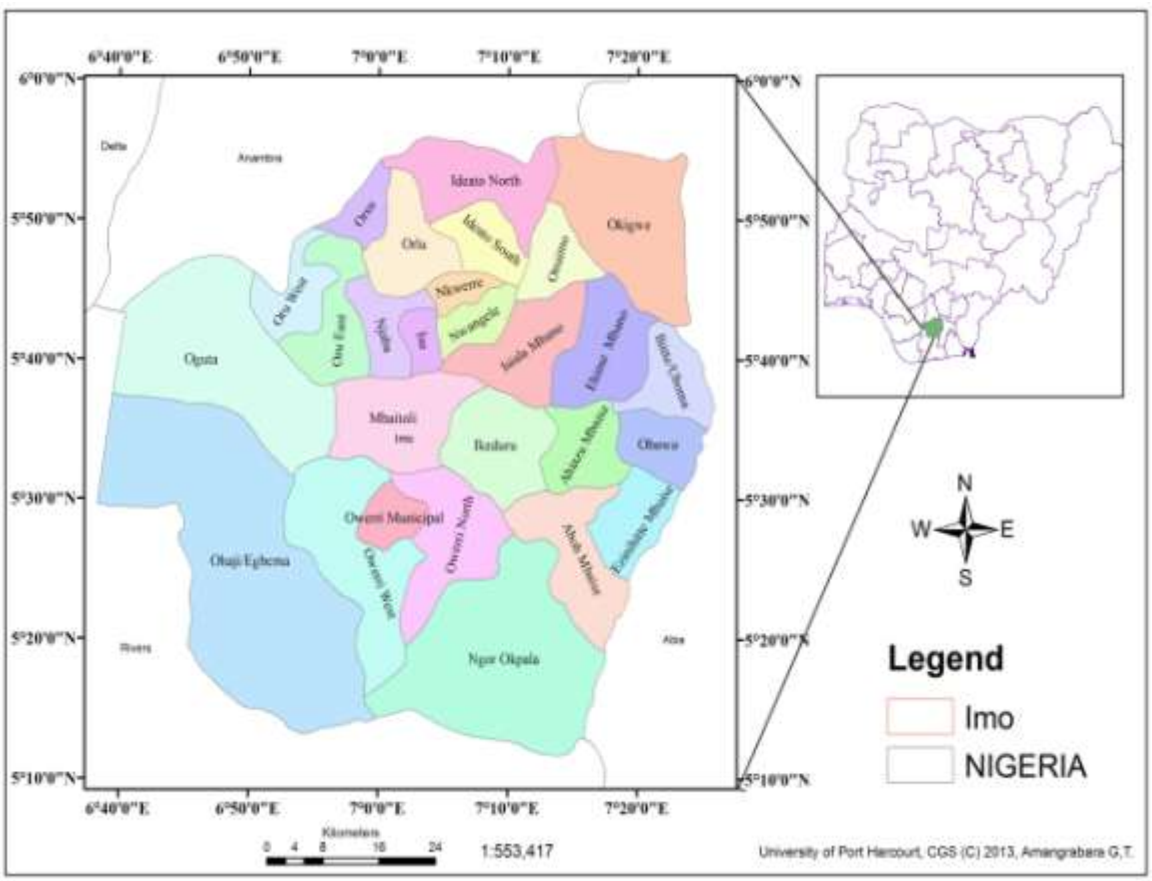

Figure 2: Map of Nigeria Showing the 27 LGAs of Imo State

Research Article

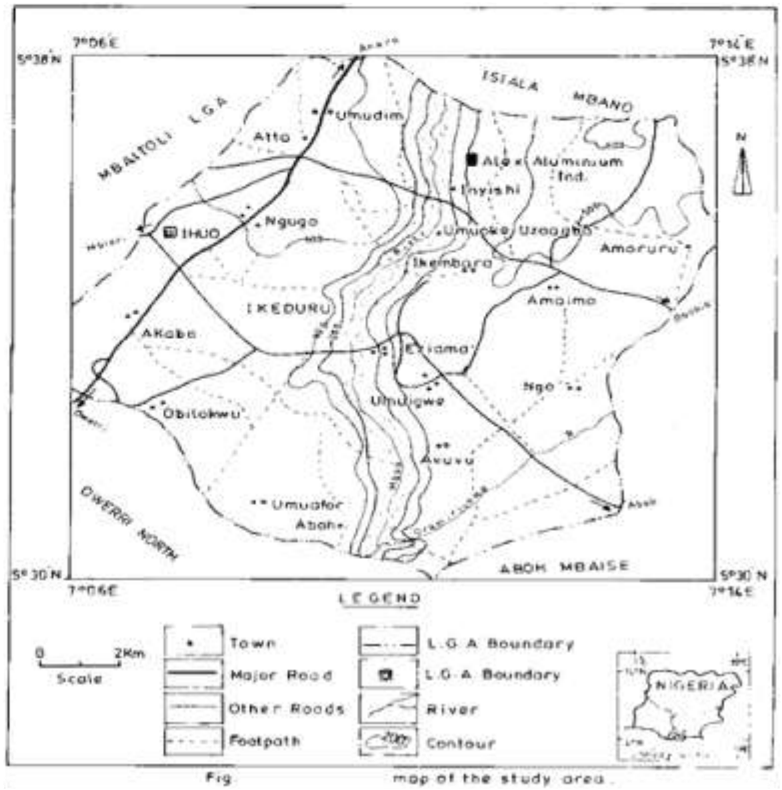

Figure 3: Map of Ikeduru Local Government Area

Aim and Objectives

The aim of this research is to determine the erodibility status of soils in Ikeduru Local Government Area to know its susceptibility to erosion and proffer suitable techniques in controlling the growing menace of soil erosion in the area. To achieve this aim, the research was guided by the following objectives

i. To determine the percentage level of certain physicochemical properties of soil in the area
ii. To make comparative analysis in the percentage levels
iii. To estimate the erodibility status using regression equation
iv. To input data generated from objective (i) to the regression equation, $k = 2.77M^{1.14} (10^{-7}) (12-\alpha) + 4.28 (10^{-3}) (\beta-2) + 3.29 (10^{-3}) (\gamma -3)$
v. Correlating the data generated from the analyses of the physicochemical properties of the soil to erodibility

Soil Sample Collection

Soil samples were collected from four communities in the area as follows:

Table 3.1: Soil Samples Collection Locations

Sample Locations	**Atta**	**Amamba**	**Inyishi**	**Iho**
Landuse Type	Cassava Farm (cassava plants in strips with average heights of 1m and presence of weeds)	Bamboo Field (Tall bamboo trees in clusters. Absence of weeds. Presences of structural development	Fallow land. (densely vegetated, has been left fallow over 15years)	Sparse grass land (uncultivated, sparsely vegetated. Presence of structural development

Soil samples were collected at random positions at 1metre distance apart. Four quadruple samples at 15meters depth except in fallow land where triplicate soil samples were collected. The soil samples were put in sterile polythene bags and tied very well and sent to the Institute of Erosion Studies Soil laboratory

Research Article

at the Federal University of Technology, Owerri for laboratory analysis for the determination of moisture content, particle size distribution, organic matter content, textural class, permeability class, aggregate and structural class.

For the determination of the soil erodibility: There are several methods that can be used to estimate the K-factor. 1)The use of in situ erosion plots, 2) measuring K under a simulated rainstorm, 3) nomographs relating K-factors to topsoil conditions i.e. predicting K using regression equations describing the relationship between K and soil physical and chemical properties. In situ erosion plots enable measurement of K under field conditions. They make use of a standard condition of bare soil, no conservation practice, 7^0 slope of 22m length. This approach is costly and time consuming. Measuring K under stimulated rainstorm has a major drawback in that rainfall simulators built to date can hardly recreate all the properties of natural rain. For this study, the use of regression equations describing the relationship between K and soil chemical and physical properties was adopted. The nomograph developed by Wischmeier *et al* (1971) expressing the relationship between K and soil properties is based on the following equation

$$k = 2.77M^{1.14}\,(10^{-7})\,(12-\alpha) + 4.28\,(10^{-3})\,(\beta-2) + 3.29\,(10^{-3})\,(\gamma-3)$$

Where M = (%silt + very fine sand) (100 -%clay)

α = organic matter (%)

β = structure code (very fine granular = 1, fine granular =2, coarse granular = 3, blocky, platy or massive = 4)

γ = Permeability class (rapid = 1, moderate to rapid =2, moderate = 3, slow to moderate = 4, slow =5 very slow = 6)

The soil erodibility is normally classified into the following groups; Very high >0.45, high = 0.35 – 0.45, moderate = 0.25 – 0.35, low to very low = <0.2 based on classes of values for erodibility (Bergsma et al 2010)

The results of the physicochemical analyses of the soil samples were further subjected to statistical analysis using Analysis of Variance (ANOVA) to determine the sample variation. Matlab was also used to perform homogeneity analyses on the data. Correlation analysis was also performed to determine the relationship between the physicochemical properties and erodibility

RESULTS

Table 4.1: Soil Physical properties under varying Landuse in Ikeduru LGA

Sample	Landuse	Clay %	Silt %	Sand %	OMC %	MC %	P	AS	Remark
M1	Cassava Farm	5.9	15.5	53.4	1.7	20.0	3	2	sandyloam
M2	Cassava Farm	6.2	19.4	51.3	1.5	19.8	3	2	sandyloam
M3	Cassava Farm	3.8	15.6	57.0	1.7	19.8	3	2	sandyloam
M4	Cassava Farm	5.6	17.0	52.1	1.3	21.5	3	2	sandyloam
Mean		**5.4**	**16.9**	**53.4**	**1.6**	**20.3**	**3**	**2**	
B1	Bamboo Field	14.0	14.4	40.3	1.0	27.9	4	4	sandysilt
B2	Bamboo Field	14.8	17.1	42.5	0.9	27.6	4	4	sandysilt
B3	Bamboo Field	16.3	13.7	40.7	1.0	25.8	4	4	sandysilt
B4	Bamboo Field	15.6	16.3	50.2	1.2	28.3	4	4	sandysilt
Mean		**15.2**	**15.4**	**43.4**	**1.0**	**27.4**	**4**	**4**	
C1	Fallow grassland	4.5	27.0	44.9	1.5	21.9	3	2	Loam
C2	Fallow grassland	4.7	23.4	45.9	2.0	15.4	3	2	Loam
C3	Fallow grassland	3.8	27.3	42.8	1.9	18.8	3	2	Loam
Mean		**4.3**	**25.9**	**44.5**	**1.8**	**18.7**	**3**	**2**	
S1	Sparse grassland	28.5	12.4	41.3	1.2	46.2	5	3	Sandyclay
S2	Sparse grassland	27.9	12.5	31.9	0.8	46.6	5	3	Sandyclay
S3	Sparse grassland	26.3	11.8	45.4	1.0	34.1	5	3	Sandyclay
S4	Sparse grassland	27.5	12.1	33.5	0.7	39.1	5	3	Sandyclay
Mean		**27.6**	**12.2**	**38.0**	**0.9**	**41.5**	**5**	**3**	

NOTE: *M = Atta Soil Samples, B = Amamba soil samples, C = Inyishii soil samples, S = Iho samples. OMC = organic matter content, MC = Moisture content, P = Permeability, AS Aggregate structure*

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Table 4.2: Correlation of some soil parameters and Erodibility in Ikeduru LGA

	Clay	Silt	Sand	OMC	MC	K
Clay Pearson Correlation Sig. (2 tailed) N	1 .000 19	-.754** .001 19	-.714** .000 19	-.831** .000	.959** .000 19	-412 .588 4
Silt Pearson Correlation Sig. (2 tailed) N	-.754** .000 19	1 19	.233 .315 19	.752** .000 19	-.698** .001 19	-.532 .468 4
Sand Pearson Correlation Sig. (2 tailed) N	-.714** .001 19	.234 .315 19	1 19	.637** .003 19	-.707** .001 19	.670 .330 4
OMC Pearson Correlation Sig. (2 tailed) N	-.831** .000 19	.752** .000 19	.637** .003 19	1 19	-.782** .000 19	1.000** .164 4
MC Pearson Correlation Sig. (2 tailed) N	.959** .000 19	-.698** .001 19	-707** .001 19	-782** .000 19	1 19	-.836 .164 4
K Pearson Correlation Sig. (2 tailed) N	-.412 .588 4	-532 .468 4	.670 .330 4	1.000** .000 4	-.836 .164 4	1 4

***, Correlation is significant at the 0.01 level (2 tailed).*
OM, MC (as defined in table 4.1 above), K = erodibility Status.

Table 5.3: Standard Erodibility Indices

Group	***K***-Factor
I	0.0 – 0.1
II	0.11 – 0.17
III	0.18 – 0.28
IV	0.29 – 0.48
V	0.49 – 0.64

Source (Peter et al., 2008)

Table 5.4: Description of the erodibility status of the soil location

SAMPLE Group	***K*** – Factor	Nature of Soil
M	0.07	Well drained soils having fine granular substrata and sandy loam texture
B	0.06	Partially drained soils in sandy silt material
C	0.07	Graded loams and silt, loam
S	0.05	Poorly graded moderately fine and textured soil and poorly drained

Note: M= Cassava farm samples (Atta), B= Bamboo field samples (Amamba), C = Fallow land samples (Inyishi), S = Sparse grassland Samples (Iho)

DISCUSSION

Moisture Content, Textural Class, permeability & Aggregate Structure

From Table 5.1 above, the mean moisture content (MC) for each of the landuse in the study area varied from 18.7% (Fallow grassland) to 41.5% (Sparse grassland). The percentage MC was seen to be higher in soil samples from sparse grassland compared to soil samples from other locations in the study area. This could be attributed to the high clay content in the area. Clay soils generally have high water retention

Research Article

capacity. Soil samples from Fallow land had the lowest percentage MC and this is attributable to the particle size distribution, having a lower percentage of clay.

The textural class permeability from the above table showed that sparse grassland and bamboo fields have higher values of soil permeability than those from Cassava farm and fallow land. The permeability therefore is slow; this is because the soil in the area has a high percentage of clay compared to others. The soils from the Cassava farm and Fallow land fell into moderately rapid category of permeability having a higher percentage of sand particles. Soil Aggregate structure indicates that fallow land and cassava farm have the minimum values while Bamboo field have the maximum values.

On particle size distribution in the different land uses, it was observed that sand dominated across the different land uses. The high value of the sand fraction compared to the silt and clay fractions is typical of soils of Southeastern Nigeria formed largely from the coastal plain sands (Chris-Emenyonu and Onweremadu, 2011). Higher clay content was seen in sparse grassland while minimum clay content was seen in fallow land (4.3%) and cassava farm (5.4%), the percentage of sand was higher in Cassava farm (53.4%) and lowest in Sparse grassland (38.0)

Generally, the percentage organic matter content was low in all four communities. However the lowest value recorded in the sparse grassland (0.9%) while the Fallow land recorded a higher value of 1.8%. low organic matter content implies poor macro aggregate disruption making soil vulnerable to erosion (Rattan, 1990) this explains the high significant correlation between organic matter and erodibility in the study area

Relationship among erodibility Indices with selected Soil Properties

The correlation relationships of erodibility status of the sampled soil (Table 5.2) showed that Clay (-412), Silt (-532), and MC (-.836) had negative non-significant relationships with the erodibility status, while Sand percentage content (.670) had a positive non-significant relationship with erodibility status. OMC had a high positive significant relationship with the erodibility status with the value of correlation 1.000**. There was a high level of significance between Clay, Silt, Sand, OMC, and MC with values of correlation = -.754**, -.714**, -.832**, .959** respectively.

From the analyses, the erodibility status is low falling in >0.2 category in erodibility classification according to Peter *et al.*, (2008). The soil erodibility varied from 0.05 to 0.07 (table 5.4) with samples from fallow land and Cassava farm having higher values of susceptibility as a result of their high sandy content. Sandy soils are known to have low cohesive force and are prone to detachment and transportation by water and wind. High sandy soil content encourages high rate of permeability of water into soil, which induces landslide and erosion. Iho and Amamba Communities have higher clay content and lower erodibility factor because of the binding and interbinding forces that help in resisting detachability of soil by water. Igwe (2005) examined erodibility in terms of the clay content indicating that soils with low clay fraction are most susceptible to erosion.

Conclusions

The determination of erodibility status of soils in some communities in Ikeduru LGA was conducted and from the various results obtained, it showed that the soils under the various land uses in these communities are mainly sandy soils. The regression equation used in the computation of the erodibility status revealed that cassava farm and fallow land have the highest erodibility indices of 0.07 followed by bamboo field and sparse grass land with 0.05. soil samples with higher percentage of sand has higher erodibility status and those with high clay content having lower erodibility status and it can be concluded that Particle size distribution is a major finger print on the erodibility indices of soil in the study area.

However, the overall result of the research conducted in Ikeduru LGA showed that erodibility status is generally low. This implies that the extensive erosion in the LGA is not as a result of the soil but may be some other factors of erosion such as rainfall intensity and duration, land use practice, land cover and management practice. According to Nyakatawa *et al.*, (2001) soil with relatively low erodibility factor may show signs of serious erosion, yet a soil could be highly erodible and suffer little erosion. This is because soil erosion is a function of many factors as stated in the universal soil loss equation. Susceptibility to soil erosion is complex.

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