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Determination of Erodibility Index (K) Of Soil in Michael Okpara University of Agriculture, Umudike

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-----ABSTRACT-----
The Wischmeier and Smith (1963) formula was used to determine the erodibility indices of soil samples from five randomly selected locations in Michael Okpara University of Agriculture, Umudike (MOUAU). This formula made use of some soil characteristics namely, organic matter content, permeability class index, Structural class index , percent silt + very fine sand and percent sand (100 - % clay).These parameters were investigated and used to determine the erodibilty index, k at various locations. Location B has the highest K value of 0.07, while location E has the lowest K value of 0.03. Locations A, C, D have equal K value of 0.05. The mean K value was therefore calculated to be 0.05, which is the erodibilty index of MOUAU soil. The soils were analyzed to have greater proportions of sand to silt and clay thus, found to be erodible, comparing the erodibility indices obtained with the standard erodibility indices provided by Olson (1984).The average annual soil loss in tons/ha was also estimated for each location to confirm the area that is more prone to erosion. Location B has the highest soil loss of 165.14 tons/ha/yr, while location E has the lowest soil of 70.78tons/ha/yr. The soil losses at locations A, C and D are equal and are 117.96tons/ha/yr. Provision of adequate soil conservation structures, drainage facilities, wind breakers or shelter belts was recommended to protect the first 60cm depth within these areas from wind and water erosion especially, as the soils have proved to be erodible.

KEYWORDS: *Determination, erodibility, index, soil*

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I. INTRODUCTION

Soil erosion and its associated problems have become a matter of concern in our society today. Water erosion is a hydrological phenomenon which washes away soils, depletes plant nutrients and consequently reduces crop yield. This erosion causes sedimentation on low lands, reservoirs canals, water courses and rivers.
Rainfall as an erosive factor cannot be used along to predict soil erosion effectively without a good knowledge of the erodibility of soil, which has been described as the principle parameter of erosion. Benneth (1926) said that soils which are resistant to erosion have good structure and are easily permeable. They also have profiles with few genetic horizons and are mechanically homogenous. In this work, soil samples from different locations in Michael Okpara University of Agriculture, Umudike (MOUAU) were collected, analyzed and used to determine the erodibility indices of the soils, hence identify the areas that are prone to erosion.

Objectives
General Objective
The general objective of the study is to determine the erodibility indices of soils in Michael Okpara University of Agriculture, Umudike.
Specific Objectives

The specific objectives of the study are:
[1] To determine the erodibility indices of soils at various locations at MOUAU.
[2] To compare the erodibility indices of the various soils in MOUAU with a view of knowing the areas that are more prone to erosion.
[3] 3 To predict soil losses from these areas.
[4] Justification

Soils play an important and integral role in our everyday life. They supply our foods support our houses and high ways and acts as building materials. It is therefore necessary to predict and conserve this valuable natural resource. Erosion menace is common in rain forest regions of the world and Michael Okpara University of Agriculture belongs to this climatic zone. There is therefore the need to provide the erodibility data which will enable engineers know the areas that are prone to erosion and hence provide control measures that will help to check the menace in future. Therefore this work is justified.

II. METHODOLOGY

Description of the study area

The study site which is Michael Okpara University of Agriculture, Umudike lies on latitude 05^o 29^1 N and longitude 07^o 33^1 E in the rainforest area of South – East agricultural zone of Nigeria (Agroclimatic data 2007). The area covers about 100,000m^2 and lies at about 8 to 10 kilometers east of Umuahia, the Abia State capital. It has a humid tropical climate with marked wet and dry seasons. The rainy season spans for eight months (from March to October) and the dry season starts from November to February. The average annual rainfall for Umudike ranges from 1568.4mm to 2601.3mm within ten (10) years period(Agroclimatic data, 2007). The rainy season has its peaks occurring irregularly between june and October. Sometimes a little break is experienced in the month of August in this area. The average annual temperature of Umudike is 26.7^{o}C. The mean average annual evaporation (pitche) from the ten years data is 3.1mm, and the mean annual sunshine in hours is 4.4 hours, while that of radiation is 3.9m.The geology of the study area is sedimentary to the formation of coastal plain sand. The agricultural land use is arable crop production.

Collection of soil samples : The soil samples for analysis were collected from five randomly selected locations in this area. The locations are as shown in table 1 below.

Table 1: Sample Depths and Locations

PLOT	SAMPLE DEPTH (CM)			LOCATION
	0- 30	31-60	61-90	
A	1	2	3	NDDC Assisted Hostel Project Site
B	4	5	6	Block D Site CASAH Building
C	7	8	9	Behind the University Administrative block
D	10	11	12	Behind Block E (CNREM)
E	13	14	15	Behind the University Poultry Farm

From each sampling plot, three soil samples were collected at different depths as shown in table 1.
All the laboratory analysis involved in this work were carried out at the soil science department of the University in the study area.

Soil Erodibility Determination : For this work, soil erodibility was determined based on Wischmeier and Smith (1963) formula for the determination of erodibility index. This formula made use of some soil characteristics namely; Structural Class Index, Permeability Class Index, Organic Matter Content and % Silt + Very fine sand and % sand (i.e. 100- % clay) .This method was used because of its simplicity.

(a) Soil Structural Class Index

The structural class index of the soil samples were determined based on Wischmeier and Smith (1963) method of erodibilty determination. It was determined by taking soil clods from each plot and at each depth, and dropping them from known height of about 1.2m, watching how the clods were broken for classification as shown in table 2 below.

Table 2 : Structural Class Indices of Soils

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

Source: A Soil Erodibility Monograph for Farm Land Construction Site by Wischmeier and Smith (1963).
These numbers above are the structural class indices of different soil samples . Three different depths of each plot were worked on and the average obtained.

(b) Soil Permeability Class Index

The permeability class index of the soil samples were determined based on Wischmeier and Smith (1963) method. This is done by using a cylinder infiltrometer test . In this method, each point location was tested by measuring a known quantity of water (300ml) and watching how long it takes (in minutes) to infiltrate into the soil at each depth. Also a constant head permeameter can be used. The time taken was then classified using table 3.Three samples of soil were worked on at each plot and the average taken.

Table 3: Permeability Class Indces of Soils

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

Source: A Soil Erodibility Monograph for Farm Land and Construction Site by Wischmeier and Smith (1963)

(c) Percent Silt + Very Fine Sand and Percent Sand

In determining the percent silt+ very fine sand and percent sand of soil samples, the combined analysis of both sieve and hydrometer test methods were employed for soil samples collected at different depths and locations .The average values were then taken.

(d) Organic Matter Content

The organic matter content of the soil samples was determined at each location and at different depths using the Wackley – Blank method. This method is by titrating a known volume of dichromate solution against a solution of known weight of soil. The formula given by Wackley- Blank was used in computing the percentage organic carbon as shown below:

$$\text{Percentage organic carbon (\% OC)} = \frac{V_1 - V_2 \times 0.003 \times 100 \times f}{W} \quad \ldots\ldots 1.1$$

Where,

V_1 = Volume of dichromate

V_2 = volume of titrant (Ferrous ammonium sulphate)

W = weight of air-dried soil

f= correction factor (usually 1.33)

$$\text{Percentage organic matter (\% OM)} = \%OC \times 1.724 \quad \ldots\ldots 1.2$$

(e) Calculation of soil erodibility index

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

$$K = 2.1\times10^{-6} M^{1.14} (12 - OM) + 0.0325 (S-2) + 0.025 (P -3) \quad \ldots\ldots 1.3$$

Where,

K= erodibility index of soil

OM =organic matter content

M =% silt + % very fine sand and % sand (i.e. 100 - % clay)

P = permeability class index

S = structural class index

(f) erosion prediction

The revised USLE, A = 2.24RK by Schwab et al (1993) was used in calculating the soil losses for the various sampling locations.

Where,

A = Soil loss in tons/ha/yr

R = mean annual rainfall factor

K = erodibility index

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

Thus,

$$R = 0.5 H \quad \ldots\ldots 1.4$$

Where H is the mean annual rainfall in mm. The mean annual rainfall from 1997 to 2006 (10years) for Umudike is 2106.42mm, which is H in equation 1.4

III. RESULTS AND DISCUSSION

Results : The structural class indices, permeability class indices, % organic matter content, % silt and % very fine sand and % sand of the soils from the five randomly selected locations- the NDDC assisted hostel project site taken as location A; the block D- college of animal science and animal health (CASAH) building site taken as location B; behind MOUAU administrative Block taken as location C; Behind Block E-College of natural Resources and Environmental Management (CNREM) building site taken as location D; and behind MOUAU poultry farm site taken as location E; in Michael Okpara University of Agriculture, Umudike are presented in appendices B, C, D and E accordingly in their order of arrangement.Location B has the highest average structural index of. Location E has the lowest structural index of 2.67. Locations A, C and D have the same average structural index of 3.33. The permeability class indices of all the soils worked on fall within the same range of time (21-30 minutes), thus have the same average permeability class index of 3 at every location. Location C has the highest average % organic matter content of 3.83% followed by location D with % OM of 3.78%. Location A has the lowest average % OM of 2.55%, location B 3.20%, and location E, 3.23%. The average % silt + % very fine sand + % sand was highest for location B with the value of 86.23%, location C, 82.23% and location D, 82.56%. The results of the erodibility indices of soils are presented in Appendix F. the Results show that location B has the highest K value of 0.07. Locations A, C and D have Equal K value of 0.05, while location E has the lowest K value of 0.03. The mean K value was therefore calculated to be 0.05 which is is the erodibility index of MOUAU soil. The results of the average annual soil loss at the locations are presented in Appendix G. The results show corresponding values of soil loss with the erodibility indices for the locations. Locations B has the highest average annual soil loss of 165.14 tons /ha/yr, while location E has the lowest soil loss of 70.78 tons /ha/yr. Locations A, C and D have equal average annual soil loss of 117.96 tons/ha/yr. the mean average annual soil loss was calculated to be 117.96 tons/ha/yr.

IV. DISCUSSION

From the results, it is observed that location B which has the highest K value has the lowest clay content, and location E with the lowest K value has the highest clay content. Soils with higher K values should have lower clay content and are more prone to erosion. Low clay % content results in lower binding forces and poor cohesion. Therefore the interlocking forces between the grains will be reduced and hence the resistance to the detachment by any for by any force whatsoever will be reduced. But soils with lower K values are less erodible. These values of low K index ensure a high cohesion and a good interlocking force which could resist the forces due to detachment and transportation by water. Also comparing the erodibility indices of MOUAU soils with the standard erodibility indices by Olson (1984) presented in Appendix A, the soil in MOUAU lies between 0-0.1 range, which is classified as erodible and such soil is designated a permeable well drained soil having slowly permeable substrata.Furthermore, from the calculated erosion losses, location B has the highest K value also has the highest soil loss and location E with the lowest K value has the lowest soil loss under constant mean, annual rainfall factor R. this implies that the erodibility index, K, of soil in an area is directly proportional to erosion in that area.All the soils worked on have greater percentage of their particles as sand and are rich in organic matter content.

V. CONCLUSION AND RECOMMENDATION

Conclusion : The erodibility indices of soils in Michael Okpara University of Agriculture, Umudike were investigated at five randomly selected locations labeled A, B, C, D and E. The results obtained show that location B (Block D-CASAH building site) has the highest erodibility index of 0.07. Location A (NDDC assisted Hostel Project site), location C (Behind MOUAU Administrative Block), and location D(Behind Block E – CNREM building) have equal erodibility index of 0.05. Location E (Behind MOUAU Poultry farm site) has the lowest K value of 0.03. The mean K value was hence, calculated to be 0.05 which stands as the K value for MOUAU soil. The erodibility indices of soils at the various locations therefore range from 0.03 to 0.07. Comparing this result with the standard erodibility indices provided by Olson (1984), as represented in Appendix A, the soil in MOUAU lies between 0 – 0.1 range, which is classified as erodible and designated as permeable well drained soil having slowly permeable substrater.

From the results, the soils in MOUAU are predominantly sandy soils and have low binding forces. Hence, the soils will not offer much resistance to the detachment and transportation by rain drops and runoff. These soils are therefore prone to erosion unless adequate conservation practices are undertaken.

The calculated average annual erosion losses was highest for location B with the value of 165.14 tons/ha/yr. Location E has the lowest soil loss of 70.78 tons/ha/yr. Locations A, C and D have equal average soil loss of 117.96 tons/ha/yr and the mean average annual soil loss is therefore 117.96 tons/ha/yr.

VI. RECOMMENDATION

The effect of erosion to agriculture and infrastructural development in any place cannot be overemphasized. Therefore the soil depths which covered the first 60cm should be protected by the use of adequate conservation structures, drainage facilities such as culverts and bridges, and wind breakers or shelter belts to help prevent water and wind erosion. This will help to reduce occurrence of erosion hazards.

REFERENCES

[1] Agroclimatic data (2007): Daily climatic data from National Root Crop Research Institute (N.R.C.R.I), UmudikeS. Agro metrological Department
[2] Berneth, H.E. (1926): Soil Conservation. 2nd Edition. Mc Graw – Hill, London. PP105 – 128.
[3] Olson, W.G. (1984): Standard Erodibility Indices. Dowden and Culver Inc.
[4] Roose, E.J. (1977): Dix Annese De Mesurde L'Erosion D'Arret Pourla Conservation De L'EAU Et Des Soils Cyclo. Orston, Adiopodoume Ivory Coast.
[5] Schwab, G.O., D. D. Fangmeier, W.J. Elliot and R.K.Frevert (1993): Soil and Water Conservation Engineering. 4th ed. John Wiley & Sons Inc., Canada.
[6] Wischmeier, W.H. and D.D. Smith (1963): A Soil Erodibility Monograph for Farm Land and Construction Sites. Soil and Water Conservation No 26, PP 189-193
[7] Wischmeier W.H. and D.D. Smith (1969): Predicting Rainfall Erosion Losses from crop and land. East of the Rockey Mountains. Agric Handbook No 477, PP275-298.United States Dept. of Agriculture.
[8] Wischmeier, W.H. and D.D.Smith (1978): Predicting rainfall Erosion Losses- A Guide to Conservation Planning. Agriculture Handbook No 537. U.S. Department of Agriculture, Washington D.C. PP 58.

APPENDIX A: STANDARD ERODIBILITY INDICES

GROUP	K------------- FACTOR	NATURE OF SOIL
1	0 — 0.1	Permeable glacial out wash well drained soil Slowing permeable substrater.
11	0.11 — 0.17	Well grained soils in sandy gravel free material
111	0.18 — 0.28	Graded loams and silt loams
1V	0.29 — 0.48	Poorly graded moderately fine and fine textured Soils
V	0.49 — 0.64	Poorly graded silt or very fine sandy soil .Well and moderately grained soils.

Source: Standard Erodibility Indices by Olson W. Gerald (1984). Dowden and Culver Inc.

APPENDIX B: SOIL STRUCTURAL CLASS INDEX (SSI)
LOCATION A: NNDC Assisted Hostel Site

Depth (cm)	Structure	Class Index
0 – 30	Massive	4
31- 60	Coarse granular	3
61 - 90	Coarse granular	3
Average	-	3.33

Location B: Block D (CASAH Building Site)

Depth (cm)	Structure	Class Index
0 – 30	Massive	4
31- 60	Massive	4
61 - 90	Massive	4
Average	-	4

Location C: Behind Administrative Block

Depth (cm)	Structure	Class Index
0 – 30	Massive	4
31- 60	Fine granular	2
61 - 90	Massive	4
Average	-	3.33

L OCATION D: Behind Block E (CNREM Building) Site

Depth (cm)	Structure	Class Index
0 – 30	Massive	4
31- 60	Fine granular	2
61 - 90	Massive	4
Average	-	3.33

L OCATION D: Behind Poultry Farm Site

Depth (cm)	Structure	Class Index
0 – 30	Massive	4
31- 60	Fine granular	2
61 - 90	Fine granular	2
Average	-	2.67

APPENDIX C: PERMEABILITY CLASS INDEX (P)
Location A: NNDC Assisted Hostel Site

Depth (cm)	Time (Mins)	Soil Class
0 – 30	22	3
31- 60	24	3
61 - 90	24	3
Average	23.33	3

Location B: Block D (CASAH Building Site)

Depth (cm)	Time (Mins)	Soil Class
0 – 30	21	3
31- 60	24	3
61 - 90	24	3
Average	23	3

Location C: Behind Administrative Block

Depth (cm)	Time (Mins)	Soil Class
0 – 30	22	3
31- 60	25	3
61 - 90	25	3
Average	24	3

Location D: Behind Block E (CNREM Building)

Depth (cm)	Time (Mins)	Soil Class
0 – 30	22	3
31- 60	25	3
61 - 90	24	3
Average	23.67	3

Location E: Behind Poultry Farm Site

Depth (cm)	Time (Mins)	Soil Class
0 – 30	23	3
31- 60	26	3
61 - 90	27	3
Average	25.33	3

APPENDIX D : % ORGANIC MATTER CONTENT (% OM)

Location A: NDDC Assisted Hostel Site

Depth (cm)	% Organic Carbon	% Organic Matter
0 – 30	1.90	3.28
31- 60	1.62	2.79
61 - 90	0.91	1.57
Average	1.48	2.55

Location B: Block D (CASAH Building Site)

Depth (cm)	% Organic Carbon	% Organic Matter
0 – 30	2.38	4.10
31- 60	1.38	2.38
61 - 90	1.81	3.12
Average	1.86	3.20

Location C: Behind Administrative Block

Depth (cm)	% Organic Carbon	% Organic Matter
0 – 30	2.52	4.34
31- 60	2.19	3.78
61 - 90	1.95	3.36
Average	2.22	3.83

Location D: Behind Block E (CNREM Building)

Depth (cm)	% Organic Carbon	% Organic Matter
0 – 30	2.14	3.69
31- 60	2.29	3.95
61 - 90	2.14	3.69
Average	2.19	3.78

Location E: Behind Poultry Farm Site

Depth (cm)	% Organic Carbon	% Organic Matter
0 – 30	2.10	3.62
31- 60	1.71	2.95
61 - 90	1.81	3.12
Average	1.87	3.23

APPENDIX E: % SILT ɫ % VERY FINE SAND ɫ % SAND (100 — % CLAY) (M)

Location A: NNDC Assisted Hostel Project Site

Depth (cm)	% very fine sand 0.02 -0.1mm)	% sand 0.1 – 2.0mm)	% silt	% clay	% silt ɫ % very fine sand ɫ % sand (100 —% clay) (M)
0—30	3.79	80.03	7.74	8.44	91.56
31—60	3.61	76.25	4.70	15.44	84.56
61—90	3.43	72.43	3.70	20.44	79.56
Average	3.61	76.24	5.38	14.77	85.23

Location B: Block D (CASAH Building)

Depth (cm)	% very fine sand 0.02 -0.1mm)	% sand 0.1 – 2.0mm)	% silt	% clay	% silt ɫ % very fine sand ɫ % sand (100 —% clay) (M)
0—30	4.29	90.57	0.64	4.50	95.50
31—60	3.70	78.16	1.70	16.44	83.56
61—90	3.43	72.43	4.70	19.44	80.56
Average	3.81	80.39	2.35	13.46	86.54

Location C: Behind Administrative Block

Depth (cm)	% very fine sand 0.02 -0.1mm)	% sand 0.1 – 2.0mm)	% silt	% clay	% silt ɨ % very fine sand ɨ % sand (100 —% clay) (M)
0—30	3.39	71.47	14.70	10.44	89.56
31—60	3.40	71.86	3.30	21.44	78.56
61—90	3.39	71.47	3.70	21.44	78.56
Average	3.39	71.60	7.23	17.77	82.23

Location D: Behind Block E (CNREM Building) site

Depth (cm)	% very fine sand 0.02 -0.1mm)	% sand 0.1 – 2.0mm)	% silt	% clay	% silt ɨ % very fine sand ɨ % sand (100 —% clay) (M)
0—30	3.84	81.02	6.70	8.44	91.56
31—60	3.34	70.52	2.70	23.44	76.56
61—90	3.48	73.38	2.70	20.44	79.56
Average	3.55	74.97	4.03	17.44	82.56

Location E: Behind Poultry Farm site

Depth (cm)	% very fine sand 0.02 -0.1mm)	% sand 0.1 – 2.0mm)	% silt	% clay	% silt ɨ % very fine sand ɨ % sand (100 —% clay) (M)
0—30	3.61	76.25	7.70	12.44	87.56
31—60	3.11	65.75	2.70	28.44	71.56
61—90	2.89	60.97	4.70	31.44	68.56
Average	3.20	67.66	5.03	24.44	75.89

APPENDIX F: ERODIBILITY INDICES FOR THE SOIL SAMPLES

Location A: NDDC Assisted Hostel Project site

Depth (cm)	Erodibility Index (k)
0—30	0.07
31—60	0.04
61—90	0.04
Average	0.05

Location B: Block D (CASAH Block)

Depth (cm)	Erodibility Index (k)
0—30	0.07
31—60	0.07
61—90	0.07
Average	0.07

Location C: Behind Administrative Block)

Depth (cm)	Erodibility Index (k)
0—30	0.07
31—60	0.002
61—90	0.07
Average	0.05

Location D: Behind Block E (CNREM Building)

Depth (cm)	Erodibility Index (k)
0—30	0.07
31—60	0.002
61—90	0.07
Average	0.05

Location E: Behind Poultry Farm Site

Depth (cm)	Erodibility Index (k)
0—30	0.07
31—60	0.002
61—90	0.002
Average	0.03

Mean Erodibility Index	0.05

APPENDIX G: CALCULATED SOIL LOSSES AT VARIOUS LOCATIONS IN MOUAU

Location	R = 0.05H	K	Erosion Loss A =2.24RK (tons/ha/yr)
A	1053.21	0.05	117.96
B	1053.21	0.07	165.14
C	1053.21	0.05	117.96
D	1053.21	0.05	117.96
E	1053.21	0.03	70.78
Mean value	1053.21	0.05	117.96