International Journal of Innovative Environmental Studies Research 5(2):46-55, April-June, 2017

 www.seahipaj.org ISSN: 2354-2918

Rainfall Erosivity Index in Response to Soil Loss Under Different Landuses in Obudu Local Government Area of Cross River State, Nigeria

[1]Abua, M. A., [2]Kofi, B ; [1]Edide, J. I. [1]Obiefuna, J. N. Ogar, B.I.

1Department of Geography and Environmental Science
University of Calabar, Calabar, Nigeria

2Department of Geography and Regional Planning
University of Cape Coast, Ghana

ABSTRACT
Intense rains are caused by big and more rain drops per unit area, per unit time, or both. The drop size distribution is an important factor affecting rainfall erosivity. The nature of surface materials influences the rate of infiltration, surface runoff and, the nature and rate of incision. The study is aimed at examining rainfall erosivity in response to sediment yield under different landuse types in Obudu Local Government of Cross River State, Nigeria. Thirty rainstorm events were observed over three different surface types. Rainfall properties of amount, duration and intensity were measured. Runoff amount and sediment yield were also measured after every rainstorm event. The kinetic energy was also determined as outlined by Hudson and only intensities greater than 25.4mm/hr were used in determining the K.E.>25.4. The pearson's product moment correlation and multiple regressions were employed in analyzing the data. The results revealed that of the three surfaces studied, the vegetated surface produces the least amount of runoff and sediment yield amount followed by the mulched surface while the bare surface produces the highest amount of runoff and sediment yield. Rainfall characteristics with runoff amount on vegetated, mulched and bare surfaces were highly correlated with r- values of (0.84>0.01, 0.87>0.01 and 0.97>0.01) respectively. The independent variables jointly explain 72.8%, 77.7% and 96.1% of runoff respectively on vegetated, mulched and bare surfaces. The predictive variables explain 50%, 60.8% and 62.7% of sediment yield respectively on, mulched and bare surfaces. The implication from the analysis is a pointer to the vegetated fact that the rainfall produces total K.E. of 14795.90Jm-2- which yielded 5324.53 gram of sediment on the three surfaces with the highest amount of sediment yield of 4994.49gm on the bare surface.
Keywords: Erosivity, Rainfall, Sediment yield, Landuse and Obudu

INTRODUCTION
The study of sediment loss, given an amount of runoff, being generated by an amount of rainfall is an important factor in soil erosion studies. Vegetation cover has influence on hydrological factors in soil erosion research as well as on hydroclimatological processes directly intercepting precipitation to the ground surface (Eze & Abua, 2002; Abua & Digha, 2015; Abua & Ajake, 2013; Abua, 2017).
The natural environment of Nigeria is seriously threatened by land degradation, mainly caused by agricultural practices, urbanization, deforestation, grazing, the processes that lead to its eventual formation are noteworthy. Surface runoff prediction is not only an important component of the hydrological cycle, it is also a very vital process that determine the magnitude of erosion. Soil erosion is a

complex phenomenon, involving the detachment and transport of soil particles, runoff of rainstorm and infiltration (Oyegun, 1995; Romkens, 2002; Abua & Ajake, 2015; Adekalu, 2006; Morgan, 1997).

Soil, the most basic of all resources, is non renewable. Once lost, it is difficult to replace within the foreseeable future. New soil formation, development of a biologically productive and economically fertile soil from parent rock, is a slow process measured only on a geological time scale. It takes hundreds of thousands of years to develop the equivalent of, say, a 5-cm layer of fertile soil. In contrast, soil erosion can be drastic and rapid. The equivalent of 1cm or more of topsoil may be lost in a single rainstorm or windstorm (Lal, 1990; 2013).

Erosivity refers to the climate's aggressivity. Climatic factors that affect erosivity are precipitation, wind velocity, water balance, mean annual and seasonal temperatures, etc. Temperature and water balance affect the rate at which rainfall is accepted with the onset of rains. Runoff and rainfall are important components of climatic erosivity.

Soil erosion is physical, fluvial, or geomorphic "work". Work is involved in detachment, transport and deposition of soil particles. Performing work involves expending of energy. Energy is supplied by the agents of erosion, e.g. rain drops, water and wind movement, gravity etc. Depending on the predominant agent of soil erosion, different types of energy are involved in performing the work, e.g. kinetic and potential energy. Kinetic energy is possessed by a moving body, e.g. falling rain drops, water moving on the soil surface and in the subsurface, flowing water in channels and streams, moving ice as a glacier, blowing wind etc.

Agents of erosion are the forces involved in the erosion process. The term force denotes an operating agent. It may also be defined as the capacity to persuade. In the context of rainfall - soil erosion, it is the force of rain drops, wind and water flow, or gravity that causes or persuades soil movement. While causing the soil to move, the agents of erosion perform work.

In relationship to soil erosion, the two most important climatic factors having direct effects on erosion are precipitation and wind velocity. Other climatic factors have an indirect effect on soil erosion, such as water balance, evapotranspiration, temperature, and relative humidity. Indirect factors affect the erosivity of rainfall that may become overland flow.

Soil erosion is affected by the character of rainfall, including the amount, distribution, energy load, seasonally and variability. In general, erosion per unit amount of rain decreases with increasing rainfall. The amount of rainfall governs the overall water balance and the relative proportion that becomes runoff. In addition to the rainfall amount, intensity and distribution of intensity during storm affects erosion by altering the amount and rate of overland flow. The time of the peak intensity period in a rainstorm influences the amount and rate of runoff.

The effects of rainfall characteristics on erosion are not constant but vary with soil type, relief, and predominantly vegetation. Over and above the amount of rainfall, it is effective rainfall that influences the amount and rate of runoff. In terms of soil erosion both the amount and the rate of rainfall, or its intensity, affect soil erosion. The same amount of rain falling over a short time causes more erosion than when it is distributed over a relatively longtime and falls as a gentle rain of low intensity (Lal, 1990; 2013; Oyegun, 1998; Ofomata, 1995).

Intense rains are caused by big drops, more drops per unit area, per unit time, or both. The drop size distribution is an important factor affecting rainfall erosivity. The nature of surface materials influences the rate of infiltration and, thereby, of slumping and/or sliding. It also affects the nature and rate of surface runoff and, thereby the nature and rate of incision.

Runoff behavior on different surface covers and different landuse types have been discussed by Scholars (Arnaez, 2007; Descroix, 2011; Abua & Ajake, 2013; Abua & Digha, 2015). There are dearth of literatures on the relationship among rainfall, runoff and sediment loss (yield) in the study area as field evaluation has however, shown that researches that involve rainfall worked well under natural condition. It is against this background upon which this study is contemplated with the aim of examining the level of rainfall erosivity in response to soil loss under different landuse types in Obudu Local Government Area of Cross River State, Nigeria.

MATERIALS AND METHOD

Study Area

Obudu Local Government Area is located in the northern part of Cross River State, Nigeria. It lies between longitude 8055I and 9150E and latitude 60221 and 6040IN, bounded by Benue State in the north, in the south by Boki Local Government Area, in the east and west by Obanliku and Bekwara Local Government Areas respectively. It is a mountainous area north of the Cross River National Park with an altitude of about 5,000ft. The climate of Obudu falls into the tropical Monsoon category which is winter-summer reversal of air flow in the tropics. Temperature remains fairly high throughout the year, and there is pronounced seasonality (Abua & Ajake, 2015) (Fig.1).

The Runoff Plots

The instruments that were used on the field were the funnel type rain guage and the sediment sieves. Three experimental runoff plots were utilized. Each plot measured 20 meters long and 5 meters (i.e. 100m2 or 0.01ha). The three runoff plots A, B and C which represented the Natural vegetated surface, the Mulched surface and the open (bare) surface respectively. Each runoff plot was demarcated with bricks that were six (6) inches high. The runoff plots slope at a mean angle of 60. Each runoff plot had a 500 liter capacity tank attached to its end where the surface water is expected to be emptied into.

The overland flow was carefully channeled into the tanks with the aid of well carved metal plates. The tanks were covered to prevent direct rainfall from entering into the tank. Locally made funnel-type rain gauges were designed in the absence of the standard rain guage. Thirty (30) funnel-type gauges were used in all, with each plot having 10 rain gauges installed across at regular intervals. The bottles buried 7cm into the ground for stability.

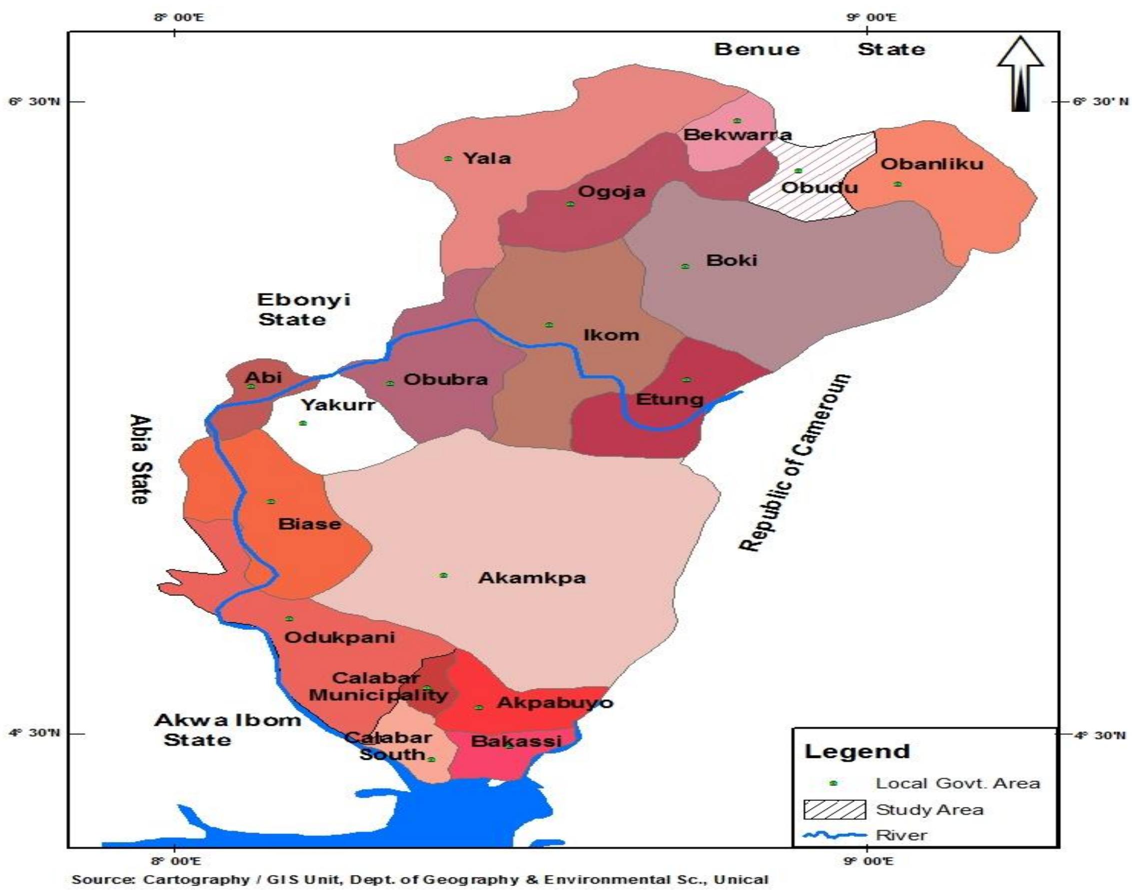

Fig. 1: Map of Cross River State showing the study area.

Each runoff plot had sieves that were $1cm^2$ wide at its month. The sieves were installed at about 40cm away from the tank's mouth meant to stop coarse sediments that were greater than 1cm in diameter. The sediments after every rainstorm, as expected, accumulated before the sieve on a cemented surface.

Wire mesh were also attached to the mouths of each plot, were it meets with the tank (after the $1cm^2$ sieve). These were installed to trap fines sediments.

Thirty (30) rainstorms were observed, measured and analyzed in the study. The analyzed rainstorms all fell between April and August. Not all rainstorms that fell within this time frame were used. Some were disregarded as such events were traces of rainfall that might spread on indefinite time frames.

This study used 30 storms because those were the definite ones that could be observed within the time frame. It must be noted that rainfall is unpredictable in nature, and it was not possible to determine the probable number of rainstorms that would occur between April and August. The data that were sourced for are rainfall data, runoff data and sediment yield data. Data on rainfall amount, rainfall duration and rainfall intensity were from the Obudu Dam Met. Station.

The only data that were obtained on runoff were on the total amount of runoff produced on a given surface cover, given an amount of rainfall. Total amount and weight of sediment transported were determined to obtain insight into the extent of materials eroded.

Rainfall Measurement

Rainfall data were collected from both the funnel-type rain guages that were installed on the experimental site and daily rainfall data from the Meteorological Station at Obudu dam. The first ten (10) rain storm events at both the experimental site and at the weather station were correlated.

The contents of the funnel-type rain guage bottle were poured out into a measuring cylinder to determine the amount of rainfall after each storm. The difference in the value of the amount and intensity of rainstorms at the two stations were found negligible. Consequent upon this, the rainfall data from the Meteorological Station was adopted for the study.

The duration of every rainstorm were recorded and the intensity calculated by dividing the amount of rainfall by the duration.

$$TRI = \frac{RA}{RD}$$

Where: TRI is Total Rainfall Intensity

RA is Total Rainfall Amount

RD is Rainfall Duration

The definition of a 'rainstorm' in this study was any rainstorm that could cause runoff on the open bare surface. The least amount of rainfall that generated runoff was 6.2mm which fell on 06/04/12. Hence, 6.2mm was adopted as the threshold rainfall amount for the study.

Rainfall Measurement

This was done on the field after every rainstorm event. The amount of runoff was measured in liters by emptying the runoff in the collecting tanks at each plot into measuring buckets after every rainstorm event. Sediments were separated from generated runoff. Though there was instance when surface runoff was not produced in some of the plots.

Soil Loss Measurement

Soil loss measurement was done in all the three runoff plots. Coarse sediments that accumulated at the 1cm2 sieve were packed after every rainstorm event. Also were those that were trapped by the wire mesh attached to the top of the collecting tanks. Sediments in solution were obtained by adding alum to emptied runoff waters. The runoff waters were left undisturbed for 30 minutes so that the sediments could settle at the base. The water was thereafter, sieved so as to separate the sediments from the water. Soil samples were oven-dried and weighted in the laboratory.

Analytical Tool

The Pearson's Product Moment Correlation and the multiple regressions were the statistical analysis adopted in analyzing the data for the study. In addition, the kinetic energy of the storm was computed with the equation given below as outlined by Hudson (1965):

$$K.E. = 29.8 - \frac{127.5}{I}$$

Where K. E. is the kinetic energy in Jm-2-mm-2 and I is the rainfall intensity.

The kinetic energy of each rainstorm was determined as in table 6. Only intensities greater than 25.4mm/hr were used to determining the K.E >25.4 (Morgan, 1979).

RESULTS AND DISCUSSION

The range, minimum, sum and mean values for rainfall amount, rainfall intensity and rainfall duration for the thirty rainstorm events are presented in Table 1 and 2. The month of July recorded the highest of rainfall amount of 79.50mm with a lowest value of 2.2mmin August.

Table 1: Data on rainfall, runoff and soil loss parameters

S/N	Date	Rainfall Amount (mm)	Rainfall Intensity mm/hr	Rainfall Duration (min)	Runoff vegetated (lit)	Runoff Mulched (Lit)	Runoff Open-bare (Lit)	Soil loss (Vegetated)	Soil loss Mulched	Soil loss Open-bare
1	April 3	14.2	85.2	10	2.1	21.5	73.5	3.25	10.8	141.8
2	" 6	6.2	74.4	5	0.0	0.0	0.2	0.0	0.0	0.18
3	" 20	1.8	27	4	0.0	0.0	0.0	0.0	0.0	0.0
4	" 21	33.2	79.68	25	2.9	42	140	8.26	36.8	202.05
5	" 24	28.1	76.6	22	2.5	37	129	7.1	33.4	186.3
6	" 25	50.3	100.6	30	17.0	111	215	23.5	47.3	916.3
7	May 6	2.6	39	4	0.0	0.0	0.0	0.0	0.0	0.0
8	" 7	29.2	70.1	25	1.8	3.4	126	17.9	30.1	189.5
9	" 8	1.2	24	3	0.0	0.0	0.0	0.0	0.0	0.0
10	" 9	3.5	70	3	0.0	0.0	0.0	0.0	0.0	0.0
11	" 10	20.3	81.2	15	1.1	29.1	82	2.9	9.4	131.8
12	" 15	37.7	107.7	21	1.2	30.1	146	3.1	29.6	236.7
13	" 22	13.2	56.6	14	0.9	20.6	71.3	0.7	5.6	86.9
14	June 2	60.3	92.8	39	10.5	28	280	9.6	13.6	1247.78
15	" 10	1.2	12	6	0.0	0.0	0.0	0.0	0.0	0.0
16	" 11	70.3	86.1	49	17.9	150	310	9.35	14.9	1125.9
17	" 16	13.6	40.8	20	1.3	21.1	74	0.4	4.76	81.5
18	" 25	12.6	26.1	29	0.0	17.4	69	0.0	2.9	57.9
19	" 27	7.1	20.3	21	0.0	0.6	30	0.0	1.28	49.0
20	July 2	7.3	16.8	26	0.0	0.5	29.6	0.0	0.69	43.5
21	" 6	30.4	30.4	60	1.0	40.6	120.1	0.25	6.13	148.3
22	" 14	31.3	38.3	49	0.4	43	147	0.03	6.3	97.56
23	" 16	77.5	35.5	131	9.8	96	247	2.63	9.5	124.0
24	" 25	17.2	16.4	63	1.5	21	30	0.02	2.91	113.9
25	" 27	12.8	8.5	90	0.0	17	26	0.0	1.34	37.53
26	Aug 3	9.4	6.8	83	0.0	1.6	12	0.0	0.09	16.67
27	" 11	12.9	9.8	79	0.0	2.1	26	0.0	0.12	29.9
28	" 14	12.0	8.7	83	0.0	1.6	25	0.08	27.3	83
29	" 20	11.2	3.7	182	0.0	0.0	24.6	0.0	33.4	182
30	" 29	16.8	4.8	210	0.0	0.0	40.6	0.0	46.2	210

Source: Fieldwork, 2012

The month of May recorded the most-intense rainfall of 110mm/hr and least intense in August 5, 28mm/hr while duration increases as the year ran out. The largest period of rainstorm was experienced in a rainstorm event in August that lasted for 225 minutes while the least was recorded in the month of May that lasted about 5 minutes.

Table 2: Values for the 30 rainstorm events (Aggregate)

Rainfall Parameters	Range	Minimum	Maximum	Sum	Mean
Rainfall Amount (mm)	77.3	2.2	77.5	643.9	21.4
Rainfall Intensity (mm/hr) Rain Duration (mins)	104.7	5.28	110.2	134.05	44.68

It is evident that the least average amount of runoff observed was 3.6 liters although there were cases of little or non- generation of runoff as 0.3 liters was the least amount of runoff that was produced on the vegetated surface while 19.6 liters was the maximum amount of runoff generated. The mean values of runoff observed on both the mulched and bare surfaces were 26.7 liters and 83.6 liters respectively (Table 3). The study further revealed that of the three surfaces studied, the vegetated surface produced the least amount of runoff followed by the mulched surface while the bared surface produces the highest amount of runoff.

Table 3: Runoff on the different surfaces studied

Surfaces	Range	Minimum	Maximum	Sum	Mean
Vegetated	19.6	0.0	19.6	72	3.6
Mulched	17.0	0.0	170	765.80	26.7
Bared	33.0	0.0	330	2473.9	83.6

***** Values in liters

Like surface runoff, there were some cases were rainstorm event could not generate or produce sediments on the vegetated surface which explain the zero value of soil loss. However, the maximum amount of sediment yield (loss) was 19.6gm which was recorded in the month of July which was the day the maximum rainfall of 77.5mm was recorded. On the mulched surface, 264gm of sediment was the figure recorded and this was the amount distributed over the 30 rainstorm event studied. The highest amount of sediment that was lost on this surface was 43.5gm with a mean value of 9.9gm of sediment lost while the bared surface recorded maximum value of soil lost of 1248.4gm with a mean value of 180.6gm of sediment lost (Table 4).

Table 4: Sediment yield on different surfaces studied

Surfaces	Range	Minimum	Maximum	Sum	Mean
Vegetated	19.1	0.0	19.1	73.2	3.6
Mulched	43.5	0.0	43.5	264.0	9.9
Bared	1248.4	0.0	1248.4	5384.0	180.6

***** Values in grammes (gm)

Relationship among Rainfall, Runoff, Vegetal Cover and soil loss

The level of relationship was sought among the nine variables. Below is a nine by nine (9 x 9) correlation matrix showing the strength, direction and the level of significance of correlation among the variables.

Table 5: Zero order correlation matrix of rainfall, runoff and sediment yield

Rainfall Amount	1.0							
Rainfall Intensity	0.519	1.0						
Rainfall Duration	0.197	-0.487	1.0					
Runoff Vegetated	0.840	0.544	0.23	1.0				
Runoff Mulched	0.869	0.525	0.031	0.898	1.0			
Runoff Open bare	0.968	0.624	0.050	0.851	0.867	1.0		
Sediment Loss Vegetated	0.583	0.652	-0.151	0.714	0.635	0.645	1.0	
Sedi Loss Mulched	0.571	0.747	-2.207	0.529	0.581	0.631	0.841	1.0
Sedi Loss bared-area	0.950	0.603	-0.958	0.886	0.701	0.828	0.687	0.501

Rainfall and Runoff Relationship

The relationship of rainfall variables (Rainfall Amount; Rainfall Intensity and Rainfall Duration) with runoff amount on three different plots was investigated.

Rainfall amount and runoff on vegetated surface were found to be highly correlated, however, with 't' value of 0.84 at 0.01 level of significance. There were also significant correlations between rainfall amount and the other surface types (the mulched and the bared surface) with 'r' values of 0.87 and 0.97 respectively. They were both significant at 0.01. This, by implication shows that runoff amount increases as rainfall amount increases, on an open-bare surface, on a mulched and even on a vegetated surface.

Rainfall intensity correlates fairly with runoff amount on the vegetated, mulched and open-bare surfaces with 'r' values of 0.54, 0.53 and 0.62 respectively. These values are all significant at 0.01 levels. Thus, how intense a rainstorm is, is relevant in predicting the amount of runoff that will be generated on a given surface. This is in agreement with theoretical postulation that there is a direct relationship between rainfall and runoff. That is to say as rainfall increases there is a corresponding increase in surface runoff.

The level of significance between rainfall amount and soil loss on the vegetated surface was sought. The 't' value of 0.58 shows that rainfall amount does not strongly correlate with soil loss on this surface. Consequently, the mulched surface proves to be the most protective of the three surfaces in terms of incidence of soil erosion as determined by rainfall amount. This is closely followed by the vegetated surface as the study revealed that though the mulched surface produces more runoff, the amount of soil that was generated was relatively lower than on the vegetated surface.

The investigated relationship between rainfall intensity and soil shows that rainfall intensity strongly correlate with sediment loss on all the surfaces. The strongest correlation is shown with the mulched surface, with an 'r' value of 0.75. It is significant at 0.01 level of correlation values of 0.65 and 0.60 are against the vegetated and the open bare surfaces respectively. Hence, rainfall intensity is most important in soil loss on mulched surfaces. In other words the higher the intensity the higher the erosion rate.

The weak negative correlations between rainfall duration and sediment yield suggests that there is an inverse relationship between rainfall duration and sediment yield, thus, as sediment yield decreases, rainfall duration increases on all considered surfaces. The 'r' values of -0.15, -0.21 and -0.06 on the vegetated, the mulched and the bared surfaces were found insignificant.

On the vegetated surface, there is a significant correlation between runoff amount and sediment loss. An 'r' value of 0.71 at 0.01 level of significant suggests that an increase in runoff brings about a corresponding increase in soil loss. This also implies that runoff explain 51% of sediment yield on a vegetated surface.

A fairly strong correlation exists between runoff and sediment loss on mulched surfaces. Its coefficient of 0.58 is significant at 0.01 levels. Here, 3.3% of sediment yield can be explained by runoff. The strongest correlation is shown between runoff and sediment yield on the open-bare surface. An 'r' value of 0.87, significant at 0.01 level shows that runoff explain 68.5% of sediment loss on open-bare surfaces. These results show that runoff is very important in predicting sediment loss on an open-bare surface and has ability to predict soil loss on a mulched surface. This can be attributed to the presence of other determinants of soil loss amount on mulched surfaced for instance rainfall intensity.

The consequence of changes in the density of vegetal covers with time on runoff and sediment loss was considered. For runoff and vegetal cover change, the following model was derived:

R = 4.154 – 0.605 VCA

Where R.O = Total runoff

V.C.A = Vegetal Cover Change

The relationship between changes in vegetal cover and runoff shows that only 3.1% of changes in runoff can be explained by changes in vegetal cover. This is not significant. On the other hand, vegetated cover change can explain about 17.6% of sediment loss. It is significant at 0.05 levels. The relationship takes this form:

SL = 7.929 – 1.711 VCA

Where

SL = Sediment loss

VCA = Vegetal cover change

Vegetal cover change was however found to be more significantly correlated with sediment loss than with runoff. The negative significance of the coefficient shows that as canopy coverage increases, sediment yield and runoff decreases. The collective effectiveness of the amount of rainfall, intensity of rainfall and the duration of rainfall in predicting runoff and sediment yield was investigated on the three different surface types.

For runoff on the vegetated, mulched and bare surfaces, these different models were derived respectively:

Vegetated

R.O = 1.726 + 0.199 RA + 8.042 RI – 1.074RD

Mulched

R.O = 8.653 + 4.045RA + 0.253RI – 0.150RD

Where:

R.O = Runoff

RA = Rainfall Amount

RI = Rainfall Intensity

RD = Rainfall Duration

The independent variables can jointly explain 72.8%, 77.7% and 96.1% of runoff on the vegetated, mulched and open-bare surfaces respectively. Also, of all dependent variables, Rainfall Amount is significant at 0.01 level of significant on all the surfaces.

By implication, rainfall intensity, duration and amount (most importantly) are effectively in predicting runoff on vegetated and mulched surfaces though not as highly effective as on open-bare surface that has an R2 value of 96.1%.

For sediment loss as predicted by rainfall amount, rainfall intensity and rainfall duration on the three surfaces, the following models were derived.

Vegetated

SI = 3.028 + 8.865RA + 8.775RI + 3.640RD

Mulched

SL = -6.702 + 0.122RA + 0.265RI + 2.196RD

Bared

SL = 121.601 + 10.177RA + 2.305RI + 0.437RD
Where;
SL = Sediment Loss
RA = Rainfall Amount
RI = Rainfall Intensity
RD = Rainfall Duration
The predictive variables explain 50.8%, 60.8% and 62.7% of sediment loss on the vegetated, the mulched and the bare surfaces respectively. In other words, rainfall amount, rainfall intensity and rainfall duration are more effective in predicting sediment loss on vegetated surfaces and mulched surfaces than on open-bared surfaces of all, only rainfall intensity on mulched surface and rainfall amount on open bare surface are significant at 0.01 significant levels.

Table 6: Calculation of Hudson, K. E. >25 Index

S/N	Rainfall Amount (mm)	Rainfall Intensity mm/hr	Rainfall Duration (min)	Kinetic energy (KE) jm^{-}	Total K.E. jm^{-2}
1	14.2	85.2	10	28.3	401.86
2	6.2	74.4	5	28.1	174.22
3	1.8	27	4	25.1	45.18
4	33.2	79.68	25	28.2	936.24
5	28.1	76.6	22	28.1	789.61
6	50.3	100.6	30	28.5	1433.55
7	2.6	39	4	26.5	68.9
8	29.2	70.1	25	28.0	817.6
9	3.5	70	3	28.0	98
10	20.3	81.2	15	28.2	572.46
11	37.7	107.7	21	28.6	1078.22
12	13.2	56.6	14	27.5	363
13	60.3	92.8	39	28.4	1712.52
14	70.3	86.1	49	28.3	1989.49
15	13.6	40.8	20	26.7	363.12
16	12.6	26.1	29	24.9	313.74
17	30.4	30.4	60	25.6	778.24
18	31.3	38.3	49	26.5	829.45
19	77.5	35.5	131	26.2	2030.5

Source: Fieldwork, 2012

Rainfall Erosivity

The analysis revealed that the lowest rainfall amount of 1.8mm with an intensity of 27mm/hr yielded total kinetic energy (K.E.) of 45.18Jm-2 with no runoff and sediment loss (yield) on any of the three surfaces (vegetated, mulched, bare) as this was accounted for the short rainfall duration of four minutes (table 6). Conversely, the highest rainfall amount of 77.5mm recorded on the 16th of July had an intensity of 35.5mm/hr and duration of 131 minutes which produced a total K.E. of 2030.5Jm-2. This K.E. value of 2030.5Jm-2 produces runoff of 9.8, 96 and 247 liters on vegetated, mulched and open bare surfaces respectively. The second highest rainfall amount was recorded on the 11th of July with an intensity and duration of 86mm/hr and 49 minutes respectively which produces runoff of 17.9, 150 and 310 liters on vegetated, mulched and bare surfaces respectively. This is not surprising as the rainfall generated a total K.E. of 1989.49Jm-2. Only intensities greater than 25.4mm/hr were used in determining the K.E.>25.4 (Morgan, 1979). This study has established a close interrelationship among rainfall characteristics (amount, duration, and intensity), sediment yield and the K.E. generated to detach the surface materials. The implication of the analysis is that the higher the rainfall characteristics, the higher the surface runoff consequently the sediment yields (Table 6). The study has further x-rayed the fact that within the period under review the total amount of rainfall of 536.30mm of 555.00minutes duration with intensity of

1218.08mm/hr produces total kinetic energy (K.E.) of 14795.90Jm. Detaching and eroding surface materials on the three surfaces (vegetated 86.97gm, mulched 261.09gm and bare 4974.49 grammes. The implication from the analysis is a pointer to the fact that the rainfall produces total K.E. of 14795.90Jm-2-Which yielded 5324.53 grammes of sediment on the three surfaces with the highest amount of sediment yield of 4994.49gm on the bare surface. This is a clear indication that erosion is more aggressive on the bare surface than on other surfaces.

CONCLUSION

Soil erosion as a process of landform development is no doubt a complex process. Hence, its understanding in real world situation is difficult. This study has been able to establish the fact from the analysis that there is a direct relationship between rainfall amount, intensity and runoff, irrespective of the nature of the surface cover. It was also evident that runoff amount and sediment yield (soil loss) amount have a significant relationship. Thus, high rainfall brings about a high runoff and consequently, a high erosion rate though the magnitude of the generated runoff and soil loss varies greatly, in relation to the surface cover type. The study made it clear that there is an inverse relationship between the amount of vegetal cover and soil loss as soil erosion does not pose any threat to surfaces that are mulched with plant liters. However, for erosion to take place on a mulched surface, the intensity of rainfall should be high. The study concludes that rainfall amount, intensity and duration are important predictors of soil loss and runoff.

REFERENCES

Abua, M. A. and Ajake, A. O. (2015). Soil – Vegetation Variability on a toposequence in Obudu Local Government Area of Cross River State of Nigeria. Journal of Biodiversity and Forestry. Vol. 4,No. 3, pp. 1 – 7.

Abua, M.A. and Digha, O. N. (2015).Asessment of rainfall-runoff relationship on soil loss using runoff plots in Obudu, Nigeria. International Journal of Contemporary Applied sciences. Vol.2, No.5, pp. 108-120.

Abua, M. A. and Ajake, A. O. (2013). Assessment of soil quality under different land use in Akpabuyo Local Government Area of Cross River State – Nigeria. International Journal of Agriculture Innovation and Research, Vol. 2, No. 1, pp. 137-140.

Abua,M. A. (2017). The Influence of Slope on Infiltration Capacity in Obudu Local Government Area of Cross River State, Nigeria. International Journal of Innovative Environmental Studies Research 5(1); 13 – 27.

Brown, L. R. (1981). The global loss of top soil. J. Soil Water Conservation. 39:162-165.

Dent, F. J. (1984) Land degradation: Present status, training and education needs in Asia and the Pacific. In: UNEP Investigations on Environmental Education and Training in Asia and the Pacific, pp. 1-20, FAO Regional Office, Bangkok, Thailand.

Dregne, H. E. (1982) Historical perspective of accelerated erosion and effect on world civilization. In: Determinants of Soil Loss Tolerance, pp. 1-14, ASA Spec. Publication 45, Madison, wis.

Eze, B. E. and Abua, M.A. (2002). Environmental Hydrology. Ushie Printer and Publisher, Calabar.

Lal, R. (1987) Tropical Ecology and Physical Edephology, Wiley, New York.

Lal, R. (2013). Soils and ecosystem services in Lat et al eds. Ecosystem services and carbon sequestration in the Biosphere. Springer, London, pp. 11-28.

Larson, W. E. (1981) Protecting and soil resource base. J. Soil Water Conserv. 36:13-16.

Lee, H. T., (1984) Soil conservation in China's loess Plateau. J. Soil Water Conserv. 39:306-307.

Mitchell, J. K., and Bubenzer, G. D. (1980) Soil loss estimation. In: Soil Erosion (M. J. Kirby and R. P. C. Morgan, eds), pp. 17-62, Wiley, Chichester, England.

Mou, J., and Meng, Q. (1981) Sediment delivery ratio as used in the computation of watersheds sediment yield. J. Hydrol. 20:27-38.

Pickup, G., Higgins, R. J., and Warner, R. F. (1981) Erosion and sediment yield in Fly River drainage basins. IAHS Publication. 132:438-456.

Williams, L. S. (1987) Inca terraces and controlled erosion. Proc. Conf. of Latin