EFFECT OF RAINFALL INTENSITY AND ENERGY ON GULLY DEVELOPMENT IN NORTHEASTERN ENUGU STATE, NIGERIA

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ABSTRACT

An in-depth study of rainfall parameters and gully developments in four experimental sites in northeastern, Enugu state of Nigeria has been carried out. The study involved an environmental report of the study area, use of four experimental sites where data on rainfall parameters were obtained. Thereafter the data were analysed. Weekly computed values of rainfall intensities and kinetic energy were used to assess the weekly corresponding incremental rates of gully developments in the sites. Also the galling impact of soil erosion on the study locations which were observed to have biophysical and socio-economic ramifications were looked at. Farming is the dominant land use of the area intensifies in two orders of magnitude annually. Also, the high rainfall belts of the study area, frail soil type, undulating topography among others factors make it susceptible to soil erosion. The findings show a high correlation between rainfall intensities against gully growth as well as between rainfall kinetic energy and gully developments. Gully erosion management measures such as the planting of suckers, wattles, live stick fencing, post management of stabilized gullies and soil erosion awareness were proffered to stem the hazard.

KEYWORDS: ***Gully Erosion, Rainfall, Rainfall Kinetic Energy.***

INTRODUCTION

Man's inordinate quest for development results in the high demands placed on natural resources. Soil, water, air, wildlife among other resources are more often, unsustainably harnessed for development purposes. Land and the entire environment obviously get degraded or eroded from over utilization or by other natural forces.

Soil erosion can be defined as the gradual removal of the land surface by water, wind, glacier, processes of gravitational creep as well as other natural agents [1, 2, 3]. Soil erosion in a grave and multi-facetted hazard that has an array of galling consequences on the bio-physical and socio-economic components of the environment. Rainfall, soil properties, hydraulic disposition of the terrain, extent of vegetal cover and land-uses determine the facet and magnitude of the hazard in any location.

The general environmental setting of the study area some decades ago, showed a serene vast land that experienced very minimal land pressure problems. However, the present geometric rate and scale of cultivation; growth of human settlements and transversing road networks have induced very high land use pressure problems. These obviously imply serious destruction of vegetation and soil structure. Hence, these complement rainfall and other soil erosion factors mentioned earlier and the hazard took to, serious pervasion mainly in form of gulling in the study area. A number of traditional measures by the indigenes as well as studies undertaken by Niger Tech. Ltd [4], Igwe [5], ASTFSEC[6] and Eze [7,8] were attempts on how to stem the hazard in the area.

The biophysical impacts of soil erosion in the study area include terrain distortion and disorientation by rills, awesome gullies, biodiversity loss, siltation and pollution of surface water bodies, while the socio-economic impacts are traceable to low crop yields, diminution of land from the spreading gullies, destruction of social services and soil erosion control expenses.

In light of these, this study seeks to investigate the relationship between rainfall parameters and the development rates of gullies in the study locations as well as to proffer control measures.

The Study Area:

The Northeastern Enugu state which is the Upper Ebonyi River Basin is the study area. It lies between longitude 7° 50′ and 7° 57′ east and latitude 7° 36′ and 7° 41′ north (fig. 1). It occupies a landmass of 1346km^2 which comprises of Udenu, Isi-Uzo as well as some parts of Nsukka and Igbo-Etiti Local Government Areas (L.G.A.s). With a population of 27715 (1991 census), the population density 206 persons/km^2.

The climate type as per Koppen's Climate Classification shows that if falls within the (AW type) tropical wet and dry climatic zone. It has a maximum temperature of 28.5°C in March and a minimum of 24°C in July and August. A total rainfall of 1580.66mm with intensity of 50mm/hr which seldomly gets up to 100mm/hr was recorded in 1999. Ofomata [9] remarked that the underlying geology is very weak based on their predominance of sandstones and manifest high degree of susceptibility to gully erosion.

The drainage system which is super-imposed is occasioned by the incessant sculpturing of the substructural geology by denudation and fluvial processes. The high rainfall of the area sustains and accentuates these process [10].

The Ebonyi River is the dominant hydrological feature of the area. It has a network of tributaries and distributaries. Numerous irregular branches of gully formations respond to local runoff flows into streams and rivulets from where they converge into the Ebonyi River.

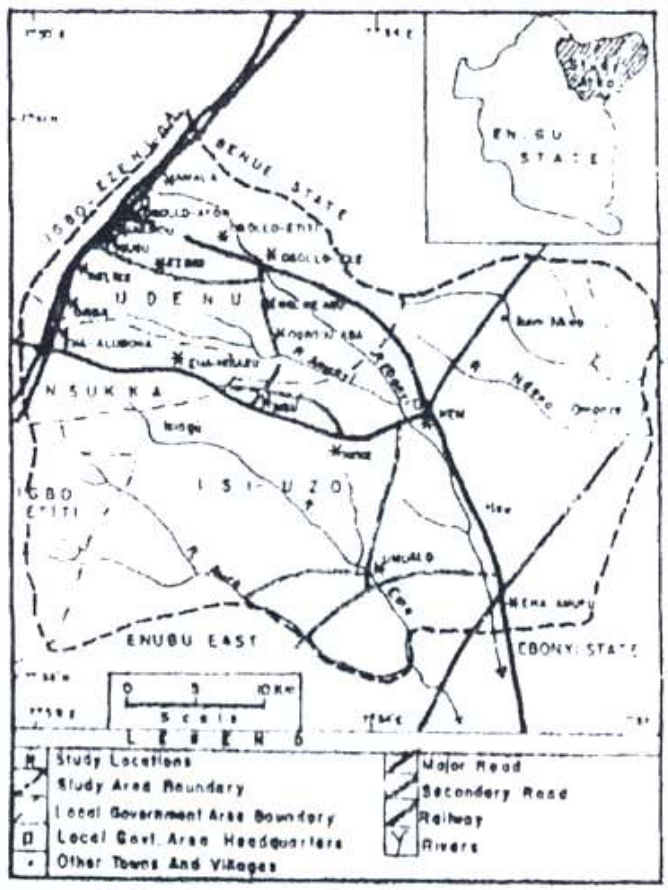


Fig. 1 MAP OF THE STUDY AREA

The topography is aptly defined by the Nsukka-Okigwe cuesta which stretches from Eha-Alumona to Obollo Afor as its higher limit and Eha-Amufu as the lower limit. The gradient of 15 – 22% which was recorded from field work is a soil erosion factor. A loose sandy ferrallitic soil type occupies two thirds of the area with a loamy clay type in the remaining area. The vegetation type is the derived guinea woodland savannah with grass tufts which are deficient as soil cover. The major land use- in the area is agronomy. Kowal and Kassam [11] remarked that subsistence agriculture is the predominant occupation in this vegetation zone. Buildings and road construction are other land-use.

2.0 METHODOLOGY

Four experiments sites in the study area were chosen for the study. They were Imilike-Uno, Obollo Etiti, Ikem and Eha-Amufu. For the rainfall parameters, the Kowal and Kassam [12] methods of measurement of rainfall amounts and computations which entailed the use of two rain gauges with lids and a stopwatch was adopted. The first rain gauge was open so that rainfall was collected for 15 minutes and then quickly covered. Immediately, the second rain gauge was uncovered for the next 15 minutes collection. These rain water were later measured with the measuring cylinder and used for the computation of rainfall parameters such as rainfall intensities I_{30} and Kinetic energy K.E.

The rainfall intensities of 30 minutes duration collected at two intervals of 15 minutes were calculated as follows [12]:

$$\text{Max 30mins Intensity } I_{30} = 2(a_1 \ a_2) \quad \ldots(1)$$

Where: I_{30} is the rainfall intensity for 30mins, a_1 and a_2 in cm are 2 rainfall amounts for the first and second 15 minutes.

The Kinetic Energy (KE) of rainfall (x103 erg/cm2) was calculated applying this expression:

$$\text{K.E.} = (41.3P - 120)\ (\text{x103 erg/cm2}) \quad \ldots(2)$$

Where P is the precipitation or rainfall amount.

The rainfall parameters were measured weekly during the period of experiment and applied in the assessment of gully growth rate in the erosion experiment sites. The relationship between rainfall intensity and energy were determined using regression analysis.

3.0 RESULTS AND DISCUSSIONS.

The measured rainfall intensities (x_1), gully areal growth (x_2) and gully depth increase (x_3) are shown in Table 1 for the two sites.

Table 1: Average Weekly Rainfall Intensities (X1), Gully Areal Growth (X2) and Gully Depth Increase (X3) at the Imilike-Uno and Obollo Etiti Experimental Sites (1/7/99 – 6/10/99)

	IMILIKE-UNO			OBOLO ETITI		
Period of measurement	X_1	X_2	X_3	X_1	X_2	X_3
1-7/7/99	45.1	0.52	0.24	106.3	0.23	0.11
8-14/7/99	100.2	2.03	0.19	33.7	0.37	0.13
15-21/7/99	31.4	0.40	0.11	65.1	0.93	0.14
22-28/7/99	99.3	1.56	0.28	49.0	0.48	0.19
29/7-4/8/99	11.6	0.33	0.15	33.9	0.47	0.12
5-11/8/99	59.0	0.98	0.17	85.7	1.96	0.16
12-19/8/99	141.5	0.70	0.13	21.4	0.30	0.12
19-25/8/99	58.1	0.26	0.09	18.2	0.36	0.09
26/8-1/9/99	167.4	2.61	0.38	54.4	0.22	0.07
2-8/9/99	88.4	0.29	0.13	29.0	0.38	0.08
9-15/9/99	13.5	0.38	0.10	99.1	0.37	0.25
16-22/9/99	31.6	0.51	0.14	127.1	0.63	0.10
23-29/9/99	24.7	0.43	0.15	12.4	0.35	0.08
30/9-6/10/99	23.4	0.40	0.11	168.6	2.56	0.34
	Σ 812.95	11.4	2.37	Σ 908.9	10.01	1.98

The computation gave: r_{12}=0.829, r_{13}=0.822, r_{23}=0.828 and r_{123} which is the multiple correlation coefficient became 0.863. On testing for significances t-cal of 6.303 was obtained. At 95% confidence level and a degree of freedom of 12 in the student's 't' test, the $t_{\forall}$ on the distribution table was 2.176. Since $t_{cal} > t_{\alpha}$, there is a significant relationship between rainfall intensity and gully development in the location.

The values of r_{12}, r_{13}, r_{23} and the multiple correlation coefficient r_{123} obtained were 0.76, 0.89, 0.91 and 0.672 respectively. The test for significance gave a t_{cal} of 3.19. At 99% confidence level and a degree of freedom of 12, the $t_{\forall}$ arrived at was 3.055. Because t_{cal} 3.19 > $t_{\forall}$ 3.055, the alternate hypothesis which holds that there is a significant relationship between rainfall intensity and gully development at the Obollo-Etiti experimental site was upheld.

Table 2: Rainfall Kinetic Energy on Gully Development at the Ikem and Eha-Amufu Experimental Site (1/7/99 – 6/10/99).

	Ikem		**Eha-Amufu**	
Period of measurement	Rainfall Kinetic Energy "X" (x10 $ergcm^2$)	Gully Vol. Growth (m^3) "Y"	Rainfall Kinetic Energy "X" (x10 $ergcm^2$)	Gully Vol. Growth (m^3) "Y"
1-7/7/99	412.0	0.125	830.13	0.025
8-14/7/99	895.3	0.386	93.21	0.051
15-21/7/99	142.9	0.044	536.19	0.130
22-28/7/99	1022.6	0.437	430.62	0.091
29/7-4/8/99	-22.7	0.050	189.40	0.056
5-11/8/99	522.7	0.167	917.07	0.314
12-19/8/99	1287.6	0.91	-15.47	0.036
19-25/8/99	503.1	0.023	12.48	0.032
26/8-1/9/99	1654.0	0.992	519.6	0.015
2-8/9/99	817.7	0.038	162.56	0.030
9-15/9/99	845.7	0.038	1041.27	0.343
16-22/9/99	175.0	0.071	1229.64	0.063
23-29/9/99	78.7	0.065	-16.5	0.028
30/9-6/10/99	7.3	0.044	1680.9	0.87
	Σ 8341.9	3.39	Σ 7611.1	2.084

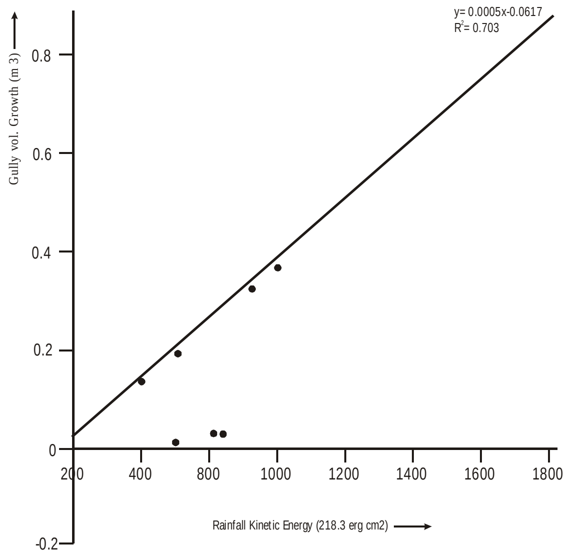
The linear correlation coefficient computed was 0.856 and was found to be significant at 5% level of significance.

The linear relationship between rainfall kinetic energy and volume of gully growth described in fig. 2 is expressed by the equation.

$$Y = 0.00054x - 0.076 \quad \text{....(3)}$$

Similarly, the average weekly rainfall kinetic energy and gully volume increase was assessed at the Eha-Amufu erosion experimental site. The generated data were also subjected to the linear correlation analysis to determine their relationship (Table 2). The linear correlation coefficient, *r* gave 0.883 which is significant at 1% level of significance. The linear relationship between rainfall kinetic energy and gully volume growth. (Fig. 3) is expressed by:

$$Y = 0.005x - 0.098 \quad \text{....(4)}$$



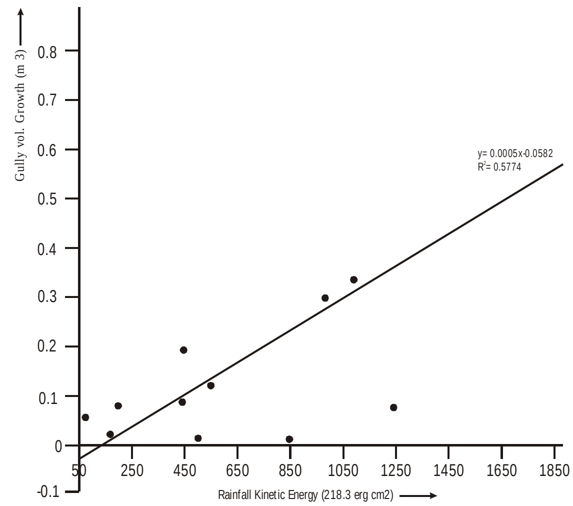


Fig. 2: Rainfall Kinetic Energy on Gully volume Growth Regression Line(Ikem)

RECOMMENDATIONS AND CONCLUSIONS

An articulated synergy of biological and engineering erosion control measures are proffered constraints.

Gully Walls and Slopes: Trenching are been carried out across erosion prone slopes and gully walls. Wattles, easy rooting suckers and rhizomes should be buried with the excavated material. The trenches delay runoff flows, hence reduces erosion and moistens the wattles and suckers. Both the wattles and trenches make complementary efforts to stop erosion.

Gully Flours: Livesticks such as Indian Bamboos *Bambasa Vulgaris* and *Acio bateri* should be planted across gully floors with palm fronds tied across their lowest portions. Then broad based earth or stone rip raps are built at downslope side of the live stick barriers. This checks further earth loss on the gully floors. Stabilized gullies should be postmanaged by the planting of edible and exotic tree species as well as grass and legumes to forestall future gulling and rilling.

Awareness of Soil Erosion: Humans who are at the centre focus of soil erosion causes and impact are to be fully involved in all local participations of soil erosion prevention and control. This awareness programme involves correct farming techniques, strict adherence to soil erosion prevention bye-laws and sustainable use of soil.

CONCLUSION

The results show that there are strong relationship between rainfall parameters and gully development in the study locations. The environmental impact of soil erosion is serious in the area. Since soil erosion puts the survival of the people on the edge, the strict application of the articulated synergy of biological and engineering control measures, erosion bye-laws and sustainability of land resources will put soil erosion to a check.

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