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ASSESSMENT OF THE EROSION SITE AT ORONI, ABIRIBA, OHAFIA LOCAL GOVERNMENT AREA, ABIA STATE

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ABSTRACT

This project work identifies Oroni in Abiriba, Ohafia Local Government Area of Abia State as an area that is badly affected by gully erosion, the work also identifies the cause of the gully erosion at Oroni as poor channel construction at the site which makes the discharge from upstream to flow in another direction thereby creating a parallel channel instead of the installed channels. A new design of soil erosion control system for Oroni, Abiriba, Ohafia Local Government Area was proposed and various field and laboratory tests were carried out which include particle size analysis, atterberg limits, specific gravity and moisture content. The proposed trapezoidal channel to be designed must carry discharge of $2.5\text{m}^3/\text{s}$ with bottom width of 0.8m and depth of 0.4m, respectively to convey the run off safely to the outlet (nearest river). When these measures are properly implemented, the erosion occurring at the study site should have been effectively controlled.

KEYWORDS: Assessment, Erosion, Site, Oroni, Obiriba, Ohafia

1.0 INTRODUCTION

Erosion is the actual removal of the surface soil, which contains vital plant nutrients by wind, water and other associated agents. The devastating effects of erosion have resulted in the loss of human lives and properties. There has also been increasing loss of the fertilized topsoil through erosion resulting in huge economic loss to individuals, farmers and the nation. For this cause, the attention of the local communities, states and the federal government have been attracted towards finding solutions to this pressing problem. In Abia State alone, good percentages of useful agricultural lands have been rendered

unproductive by progressive soil erosion. Initially, soil erosion was seen as mainly causing agricultural hazards, hence studies of soil erosion process were done by agriculturist, geographers, and agricultural engineers, whose research have placed much emphasis on sheet erosion which is mainly a surface phenomenon (Bornelli, 2014).

However, soil erosion involved more than wearing away of the soil surface, it includes gullies of different depths, therefore any meaningful erosion control recommended must be based on critical examination of soil characteristics of the area affected. A good knowledge of the soil test, topography, climatology, vegetation, and location would guide the agricultural engineer in the design and construction of effective soil erosion control measures. Always remembering that soil characteristics vary from place to place, hence, the rate of erosion and level of soil degradation varies from one place to another (Uzoamaka, 2001).

According to Wischmeier and Smith (1999). Erosion is a three - step process involving the detachment, transportation and deposition of soil particles. All these three take place through a medium, which may be water, wind, snow melt etc. Soil erosion is driven by rainfall erosivity, which is the potential of rainfall to cause erosion. Detachment of individual soil particles may occur when raindrops strike the particles together which is referred as rain splash and it involves dislodgement of soil particles from surface. When rainfall rate and or amount exceed the combined interception by vegetation cover and the infiltration capacity of the soils, water begins to accumulate on the soil in micro depression. If it continues to rain, the water eventually flows on the surface as runoff or overland flow. Runoff on slopes acts as a transporting agent, carrying away the dislodged soil particles. However, runoff can also act as an eroding agent by detaching soil particles when flowing over the surface (Paul, 2012).

Erosion does not only deteriorate the soil but also its nutrients. The Federal, State and Local Governments have been spending huge sums of money in controlling erosion menace especially in Abiriba, Ohafia Local Government Area, Abia State, which has become a very big problem to farmers and the entire populace in the area.

According to Schwebs *et al.*, (2006). Gully erosion is caused by raindrop action on the soil. Raindrop strike on bare soil, detach and split the soil into fine particles, these particles are then carried in suspension by running water as sheet erosion down the slope. If the running water is concentrated into channel down the slope, it leads to gully. Okolo (1999), reported that erosion could be due to man-made factors, such as deforestation, forest fires or bush burning construction and urbanization. He also enumerated the causes of gully erosion by water as removal of vegetation cover and or deforestation, diversion of runoff into earth drainage channel, abrupt termination of concrete drainage channel,

defective design/construction of channels, delinquent blockage development, road narrow pits, misguided erosion control works, quarrying buildings sands/stones and unsuitable farming practices.

1.1 EROSION CONTROL ALTERNATIVES/TECHNIQUES

According to Stafford (2014) erosion control alternatives is said to be the many ways in which technologies and techniques have advanced in finding ways to secure our land from the constant ravages of erosion.

1.1.1 Biological erosion control: Blanco *et al.*, (2010), reported that a number of biological and agronomic management practices are available for controlling soil erosion. Important among these are no-till, reduced tillage, crop rotations, cover crops, residual and canopy cover management, vegetative filter strips, riparian buffers, agroforestry and soil synthetic conditioners.

1.1.2 Mechanical erosion control: According to Gundu (1999). Several mechanical methods are used to control and prevent erosion which includes:

Flumes: Flumes are artificial channels that control the flow of water down a slope and release it into an area where its impact is reduced. They are often placed at head of gullies to prevent the backward erosion of the head wall by water flowing over the top.

Dams: There are debris dams, those which are sited in the floor of gullies, built of wood planks or types; they trap material moving down the gully's floor. And deterioration dams are small dams on farms or sites such as ephemeral waterway which under heavy rainfall can create erosion within the water way.

Bulldozing: Where an earth flow has occurred, land smoothing is used to stabilize the soil. Bulldozers smooth the surface of the earth flow so water will run off rather than pond and saturate the unstable soil. This technique is expensive.

Furrows: Pasture furrows were introduced in the 1950's, notably in canterbury's cultivated downlands, to control run-off and prevent sheet and rill erosion.

Cultivation techniques: Conservation tillage is where crop-growing and left, after harvest, covered in crop residues. This acts as mulch, protecting the soil from wind, erosion and raindrop impact.

1.2 STRUCTURAL MEASURES FOR EROSION CONTROL

Donald *et al.*, (2005), reported that structural erosion and sediment control practices have been classified as either temporary or permanent, according to how they are used; Temporary structural practices are used

during construction to prevent off site sedimentation. The length of time that temporary practices are functional varies from project to project, since the sediment control strategy may change as construction activity progresses. Permanent structural practices will remain in place and continue to function after the completion of construction. The following are some common sediment control measures; Earth dike, Drainage swale, Gravel, Sediment control fences, Straw bale filter barriers, Check dams and Stone check dams

The main purpose of the research reported in this paper is to study erosion situation in Oroni, Abiriba, Ohafia, Local Government Area, Abia State, and thus propose solution (erosion control measures to stem the tide). Secondly, to determine the areas (coverage) and extent (intensity) of erosion menace in Oroni, Abiriba, Ohafia, Local Government Area, Abia State as well as to determine the causes of gully erosion at Oroni, Abiriba, Ohafia Local Government Area, Abia State. Thirdly, to propose effective soil erosion control measures for the affected site and gather necessary data for the design and construction of proposed erosion control structures/measures.

2.0 MATERIALS AND METHOD

2.1 NATURE OF THE EROSION IN ORONI

The nature of the erosion at the project site is predominantly gully erosion with U-shape. The people living around the community are predominantly farmers and civil servants and the vegetation is sparse due to annual deforestation in action. The soil is mainly sandy loam soil.

According to Inyang (2009), the causes of this gully erosion in Oroni can be traced to the following factors:

Land slope: Most of the areas affected have undulating or slope terrain that encourage fast movement of runoff water on the surface soil as well as detachment and transportation of framework materials. On the other hand, steep slopes had high velocity, which causes serious erosion and soil sediment.

Deforestation: Most areas lack canopies, which would have intercepted the rainfall and thus reduce runoff.

Soil type: The areas are predominantly sandy loam soil, less cohesive due to low level content of clay and are easily erodable.

Land management: These areas are heavily prone to erosion due to poor agricultural practices, complete removal of vegetation, which encourages the impact of raindrop on the soils and the transportation of

eroded materials. This also is encouraged by high population density, which added pressure to land that the soils have no time to regain its fertility and stabilization.

Faulty construction work: Wrong placement of channel constructed to carry the runoff, the channels were not positioned at the appropriate place, and also the area was not considered therefore, this makes a large concentration of runoff to flow on land surface instead of the designed channel.

Poor road maintenance: This is responsible for 90% erosion activities observed in the community. Most of the roads are not maintained, side drains are blocked, concentrated and sufficient runoff criss-cross road without control.

Poor drainage: Due to the nature of the soil, most of the areas are water logged and they lack appropriate drainage technology.

Culverts and drains: Improper terminations of culverts and drains or poorly maintained ones were identified to cause 8% of gully in this project site. This is attributed to poor engineering design, construction, and maintenance. The concentrated/surficial runoff capitalizes on this weakness to undermine and erode the structures. Subsequently, the failure encourages further deepening and widely of the gully, 2% of surveyed opening identified wrong terminations of drains and culverts as the main cause of erosion.

Intensive rainfall and concentrated runoff: This is the major cause of gully erosion at Oroni. 3.2

2.2 TOPOGRAPHICAL SURVEY OF THE AREA

Since the topographical survey was not self-carried out, the map was obtained from the local government area. From the available map, the following were obtained. Mean slope of the area, $S = 3.16\% = 0.0316$. Length of flow, $L = 912\text{m}$. Area of water shed contributing run off, $A = 20\text{ha}$.

2.3 HYDROLOGICAL ANALYSIS.

The hydrological characteristics of the site considered were; the rainfall intensity and the time of concentration of flow.

2.3.1 Intensity duration frequency curve

The intensity duration frequency curve for ten (10) years return period is a normal return period for any design work (Duru, 2007). Therefore an intensity duration frequency curve for ten years period was obtained from the meteorological center, Owerri. This data was transposed to the project area to be used

in obtaining the rainfall intensity. This data was obtained on assumption that Owerri and Oroni (Abiriba) are in the same climatic/rainforest zone.

2.3.2 Time of concentration, T_c

The rainfall intensity was determined by the time of concentration as determined by Kirpch (1940).

$$T_c = 0.019SL^{0.77} \times S^{0.335} \tag{1}$$

Where T_c = Time of concentration in minutes

L= Length of flow in meter

S = Slope of the area in percentage.

For this research, the length of flow is determined as 912m for both sides of the road and using a slope of 3.16%, then from equation (1)

$$T_c = 0.0195 \times 912^{0.77} \times 0.0316^{-0.385} \tag{2}$$

$$T_c = 14.02674715 \text{min}$$

$$T_c = 14 \text{min.}$$

3.0 DETERMINATION OF SOIL PROPERTIES

3.1 ATTERBERG LIMIT TEST

This consists of the liquid limit and the plastic limit test.

3.1.1 Liquid limit determination

The liquid limit was determined using casagrade apparatus.

3.1.2 Plastic limit determination

The plastic limit was determined by the general method of lowest moisture content at which the soil is plastic. The plasticity index is the difference between the liquid limit and the plastic limit.

$$PI = L_L - P_L \tag{3}$$

Where PI = Plasticity Index

L_L = Liquid Limit

P_L = Plastic Limit.

3.2 BULK DENSITY AND DRY DENSITY DETERMINATION

This was determined in the lab using core cutter method. It was calculated using the formula;

$$D_b = \frac{\text{mass}}{\text{volume}} \text{g/cm}^3 \text{ (m/g)} \quad (4)$$

$$\text{Mass} = M_2 - M_1$$

Where D_b = Bulk Density in g/cm^3

V = Volume of soil in cm^3

M = Mass of the soil

M_1 = Mass of core cutter (g)

M_2 = Mass of core cutter + air dried soil (g).

While the volume of the soil is determined using:

$$\text{Vol.} = \pi r^2 h \quad (5)$$

Where

r = radius of the cylinder

h = height of the cylinder.

3.3 MOISTURE CONTENT DETERMINATION: Moisture content was determined in the soil and water laboratory using gravitational method that is oven dry method with the formula.

$$M = \frac{w_2 - w_3}{w_3 - w_1} \times 100\% \quad (6)$$

Where;

W_1 = Weight of can (g)

W_2 = Weight of can + moist soil (g)

W_3 = Weight of can + dried soil (g)

M = Moisture content in %

3.4 SPECIFIC GRAVITY TEST (DENSITY BOTTLE METHOD)

This was determined using specific gravity bottle (density bottle). Then, it was calculated using the formula.

$$D_p = \frac{D_w - (w_s - w_a)}{(W_s - W_a) - (W_{sw} - W_w)} \quad (7)$$

Where:

D_p = Particle Density g/cm^3

w_a = weight of empty bottle

w_s = weight of empty bottle + soil

w_{sw} = weight of empty bottle + soil + water

w_w = weight of empty bottle and water alone.

3.5 MECHANICAL SIEVE ANALYSIS

This was carried out to determine the given grain sizes of the soil particles in order to know the soil type. The weight of the cans and sieves were determined and the sieves arranged in the order of their sizes. Therefore, 300 grams of the soil sample was put at the topmost sieve and then the sieves containing the soils were shaken for about 10 minutes. After that, the weight of the individual sieves with the soil contained in this was recorded and the quantity passing and its percentage are determined. Finally, about 50 grams of the soil sample collected from sieve No. 200 was used for hydrometer test.

3.6 HYDROMETER TEST

A hydrometer analysis is used to determine the grain size percentage of sand, silt and clay using soil sizes smaller than the No. 200 sieve. About 50 grains of the samples that passed No. 200 sieve were placed in a 500 ml dispersing cup 20ml of the dispersing solution (Naocl or bleach) was added into the dispersing cup and the soil was allowed to soak for 25 minutes. The baffle was inserted into the cup and the suspension and the content of the mixture were stirred for 10 minutes. The suspension in the cylinder was made up to 125ml mark with distilled water. The cylinder was covered with the palm and inverted in an upside-down process for several times and then placed on a flat surface. The time when the cylinder was

placed on the table was recorded and also with the temperature T (where T is usually taken as 20°C). After about 40 seconds, the hydrometer was slowly and carefully inserted into the suspension (to measure the soil density) hence the hydrometer reading was taken as H₁. This was followed by removing the hydrometer and rising off the soil particles on the bulb and then inserting the thermometer in and out of the solution to record the temperature of the solution T₁. Finally, after about 18 hours, the hydrometer was placed into the suspension again and the reading of soil density taken as H₂ and the thermometer inserted again for temperature reading as T₂.

4.0 RESULTS OF THE SOIL PARAMETERS

From the laboratory test conducted, the soil has the following physical parameters.

4.45% silt content

25.8375% clay content

69.6625% sand content

31% liquid limit

0 plastic limit

Specific gravity, SG = 2.53

Effective Size = D₁₀ (mm), = 0.149

Uniformity coefficient, Cu

$$Cu = \frac{D_{60}}{D_{10}} = \frac{0.52}{0.149} \tag{8}$$

$$D_{10} = 0.149$$

$$= 3.4899$$

Coefficient of curvature

$$Cc = \frac{D_{30}^2}{D_{60} \times D_{10}} = \frac{0.32^2}{0.52 \times 0.149} \tag{9}$$

$$= 1.1616$$

Bulk Density = 1.35 g/cm³

Moisture content = 7.4%

4.1 THE RESULTS FROM THE TOPOGRAPHICAL MAP

The topographical map of the study area and the watershed was accessed from ministry of lands and presented in the appendices. The parameter calculated from the survey map includes;

- i. Mean slope of the area $S = 0.0316 = 3.16\%$
- ii. The area of the watershed, $A = 20\text{ha}$
- iii. Maximum length of flow, $L = 912\text{m}$

4.2 HYDROLOGICAL ANALYSIS RESULTS

The hydrological results of the study area were gotten based on the data obtained from the survey. These include;

- i. Time of concentration, $T_c = 14\text{min}$
- ii. Peak flow in the area, $Q = 2.5\text{m}^3/\text{s}$
- iii. The rainfall intensity from intensity duration frequency curve, $I = 99\text{mm/hr}$.

4.3 DISCUSSION

4.3.1 Discussion of the results based on soil parameters

The results from both the mechanical and hydrometer tests show that the soil in this area is predominantly sandy soil with low percentage of silts and clays. A low percentage of clay in the soil profile shows that the soil is cohesionless and the inter-particle bonding is low. This condition makes the soil vulnerable to erosion, which caused various sizes of gully in Oroni, Abiriba.

4.3.2 Discussion of the topographic and hydrological results

The gradient from the upstream and to the downstream end is high. This encourages high velocity of the runoff which is usually associated with the wearing away of soil particles, transportation as well as deposition at the outlet. At the Oroni site, the average gully depth is 37m and average gully width is 17m. The total length of gully is 456m. The gullies have 4 cross-sections which exist at both flange of road. The design and installation of concrete drain at both sides of the road will help the channel to discharge into the Oroni river without much havoc to the road.

4.3.3 Discussion based on the proposed channel design

The erosion control structures must be designed and installed in such a way as to help empty the total runoff generated from the catchment area which is assumed to be the cause of the problem at the erosion site and in most of the affected area. The design and installation of a trapezoidal channel at the appropriate places will help to direct the runoff into the nearby outlet after which the existing gullies should be filled with laterite soil or red soil, compacted and grassed. A trapezoidal channel must be designed to carry discharge of $2.5\text{m}^3/\text{s}$ with bottom width of 0.8m and depth of 0.4m, respectively to convey the run off safely to the outlet (nearest river).

The structures should be installed to divert the runoff from entering the gully hence the gully depths are then filled up with the same type of laterite associated with the site and then compacted before sodding, hence, the anticipated discharge is then directed into a safest outlet.

Runoff may be conveyed in open drains (canals) or closed drains. Open drains are easily inspected and maintained. On the other hand, they interfere with vehicle and pedestrian traffic, which necessitate the use of culverts and bridges, create safety hazards, occupy considerable areas of land, and may cause an environmental nuisance if used for garbage disposal. Close drains do not interfere with traffic, pose no safety hazards, and take up no land but they are hard to clean and maintain, require manholes for inspection and maintenance. In most of the erosion projects, concrete or lined channel are used.

5.0 CONCLUSION

The development of the gully erosion at Oroni, Abiriba is as a result of wrong installation of drains at both flange of the road whereby the discharge generated at the area do not pass through the channels rather create parallel pathways resulting to gully formations. However, the design and installation of a trapezoidal channel at the appropriate places will help to direct the runoff into the nearby outlet after which the existing gullies should be filled with laterite soil or red soil, compacted and grassed. The trapezoidal channel to be designed must carry discharge of $2.5\text{m}^3/\text{s}$ with bottom width of 0.8m and depth of 0.4m, respectively to convey the run off safely to the outlet (nearest river).

When these measures are properly implemented, the erosion occurring at the study site should have been effectively controlled.

5.1 RECOMMENDATIONS

- I. A suitable trapezoidal channel capable of carrying the anticipated discharge should be installed at both flange of the road.

- II. The gullies should be filled up, compacted, and grassed.
- III. The dumping of refuse and waste materials around these areas should be discouraged to prevent creating another part for the discharge which can cause gullies or result into gully formation.
- IV. Excavation of sand for any purpose near the gully lands should be stopped.
- V. The existing culverts should be re-aligned to empty its discharge into the new designed channels.

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