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EXTENT AND REMEDY ON GULLY EROSION IN BANGSHIKA AREA ADAMAWA STATE, NIGERIA

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ABSTRACT

A study was carried out in order to obtain sufficient information regarding the severity of soil erosion in Bangshika area. The soil losses in each gully site were evaluated. Representative soil samples in their disturbed forms were collected from each location visited. Soil sample weighing 20 kg each in polythene bags were taken to the laboratory for analysis. Parameters related to soil erodibility were determined, these includes erodibility index, mechanical analysis, organic matter contents, permeability of the soils, soil structure, and aggregate stability. The results show that the area is prone to erosion. The bulk density, particle density and percentage pore space were found to be 332.4 kg/m^3, 418.6 kg/m^3 and 20.60 % respectively. The volumes of soil loss in the gullies range from 697 to 3362 m^3 in Dilguda and Gulang Nduson. The slope 5 – 10 % in study area is generally undulating. Soil aggregate stability is from 6.4 to 23 MJ in Dilguda and Mugadiji.

Keywords: Aggregate stability, Bulk density, Bangshika, Gully Erosion and Soil

INTRODUCTION

Soil erosion can be defined as a systematic removal of soil from the land surface by various agents of denudation under different geologic, climatic and soil conditions. It is a complex interaction with of many factors, the most basic being edaphic and rainfall. These factors vary from one region to another and the type of erosion they influence. Soil erosion can be categorized into two major types that is geologic and accelerated erosion. Geologic are caused by the forces of nature while the accelerated are caused by man's activities on the environment and the two main agents of soil erosion are water and wind. Water erosion is divided into splash, rill, sheet and gully erosion.

Raindrop erosion is soil detachment and transport resulting from the impact of water drops directly on soil particles or on thin water surfaces. Although the impact of raindrops on shallow streams may not splash soil, it does increase turbulence, providing a greater sediment carrying capacity (Glenn *et al.,* 1993). The idealized concept of sheet erosion was the uniform removal of soil in thin layers from sloping land, resulting from sheet or overland flow (Glenn *et al.,* 1993). Rill erosion produces channels just like gully erosion but the channels are much smaller than those of gully erosion. Rill erosion can easily be destroyed by simple tillage. The channels carry water during and immediately after rains and are being further eroded in the process, thereby developing into gully with time. Bradford *et al.,* (1973) stated that, the rate of gully erosion depends primarily on the runoff producing characteristics of the watershed, the drainage area, soil characteristics and the slope in the channel. Gully erosion produces channels larger than rills. Erosion by water is a serious problem in the tropics, especially in West Africa with its prevailing weather conditions of alternation of severe desiccation

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and high intensity rainfall (Aneke, 1986). This coupled with erodible soils, which are often predominantly sandy in the surface layers. In the northeastern sub region of Nigeria; Splash, Sheet, Rill and Gully erosion may account for as much as 21tons of top soil loss per hectare per year (Adeniji, 2003). Though the region receives relatively low amounts of rainfall, serious erosion occurs since the rains normally have large drop sizes and are of high intensities (Ekwue & Tashiwa, 1992). Erosion obstructs development and is a serious land management problem throughout the world. Roads, houses, bridges, even human lives have been lost. At Uyo gullies completely consumed the township stadium, numerous houses and bridges. This phenomenon is the same in most gully affected areas of Nigeria (Aneke, 1986). Soil erosion has continuously depleted agricultural lands reducing soil quality and productivity; this has resulted in increase in the use of fertilizer and increase in energy requirement for crop production (Glenn *et al.,* 1993). The climate of the study area is divided into wet and dry seasons of the tropical type. The rainy season begins in Bangshika from April with rain increasing progressively, reaching its peak in August, subsiding in October. The dry season starts from November to March. The average annual rainfall ranges from 875 to 1000 mm (Udo, 1980), but at certain times may increase to over 1,125 mm in some places.

The soils in this area fall into the category of lithosols (Agboola, 1989). The general physical feature is the Adamawa Mountain. The mountain is a mix assemblage of granite out crop, consisting of dissected surfaces, steep slope and plain. The vegetation is mainly the Sudan Savanna type, distinction which implies a grassland vegetation interspersed by short trees. This is characterized by the presence of eucalyptus and accasia albida. Other trees include the shear - butter and African locust bean trees (Udo, 1980). In order to tackle soil erosion menace, there is need to carry out a study of the affected areas to determine the extent of erosion and their causes. In this study a survey on soil erosion features in Bangshika area of Hong Local government, Adamawa state.

MATERIALS AND METHODS

The study area is an Agricultural Settlement Called "Bangshika" in Hong Local Government Area of Adamawa State Nigeria. It is located on Longitude 11°1' - 14°12' E, Latitude 7°22' - 11°16' N. It is about ten kilometers South-East of Hong township. A survey was carried out in order to obtain sufficient information regarding the severity of soil erosion in the study area. The soil loss in each gully was estimated by measuring the length, width and depth of the gullies at 30 m intervals, which was used to calculate the volume of the gullies. Other observations made include land use, description of the general topography, vegetation and measurement of the slope angle. Photographs were taken to show some of the gully erosion affected areas. Representative soil samples in their disturbed forms were collected from each location visited. The collected samples (20kg each) in polythene bags were taken to the laboratory for analysis of parameters related to soil erodibility, which include erodibility index, mechanical analysis, organic matter contents, assessment of permeability of the soils, assessment of soil structure, and determination of soil aggregate stability.

Prediction of Erodibility Index

The soil erodibility equation described by Wischmeier and Smith (1978) was used in the present study. The equation as described by United States Department of Agriculture handbook No. 537 of 1978 is given as:

$$K' = [2.1 \times 10^{-4} (12 - \% OM) \times M^{1.14}]\ 1/100$$

and

$$K = K' + [3.25 \times (S - 2) + 2.5(P - 3)]\ 1/100$$

Where:

K' - the first approximation of soil erodibility

K - final soil erodibility factor

S - structure code

P - permeability code

M -particle size parameter = (SI + VFS + SA) (SI + VFS)

in which, SI = % silt, VFS = % very fine sand, SA = % sand

and OM = % organic matter content.

Mechanical Analysis and Soil properties

Both the Sieve and the standard hydrometer method described by Lal (1984) were used for the coarse and finer particles respectively. After sieve analysis, soils in their ground form were screened to pass through a 2.0mm sieve and the finer materials used in the hydrometer analysis. The result was used to obtain the textural classes of the soil samples.

Standard Walkley-Black method was used as described in the International Institute of Tropical Agriculture (IITA), manual series No.1. Assessment of permeability using the Wischmeier's coded permeability index was used to facilitate the assessment in this research. This was done by classifying soils into relative permeability classes by assessing their inherent properties like structure, (Table 1) texture, organic matter content, porosity and cracking.

Table 1. Permeability and soil structural codes

Permeability class	Code	Structural category	Code
Rapid	1	Very fine granular	1
Moderate to rapid	2	Fine granular	2
Moderate	3	Medium or coarse granular	3
Slow to moderate	4	Blocky, massive or platy	4
Slow	5		
Very slow	6		

Source: Wischmeier and Smith (1978)

The drop testing method was used to evaluate the aggregate stability of the study soils following the examples of Luk (1979). The number of water drops of 6mm diameter required to fall a distance one meter to break down soil aggregate, 4 – 8mm diameter in order to pass through a 4mm sieve was used as an index of soil aggregate stability. The Structure of soils used in this study. Structure types and classes both in the field during sample collection and in the laboratory were made. The assessment was based on the categories shown in Table1.

RESULTS AND DISCUSSION

Table 2 - 6 shows the details of soil erosion survey and results of the Wischmeier's erodibility index, aggregate stability and drop tests.

Table 2. Some physical parameters on Gully Eroded sites

Location	Average Gully slope (degrees)	Present land use	Vegetation
Gadagimi	5	Human settlement	Few grasses and trees
Lum	7	Arable	Trees, shrubs and grasses
Dilguda	4	Human settlement	Few grasses and trees
Mugadiji	6	Arable	Trees, shrubs and grasses
Gulang Ndusom	8	Arable	Trees, shrubs and grasses
Dakdaba	10	Human settlement	Few grasses and trees

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Table 3. Detailed Results of computation of Gully Volumes

Location	Length of the gully (m)	Average width of gully (m)	Average depth of gully (m)	Total volume (m^3)
Gadagimi	110	7.83	1.12	965
Lum	180	6.98	1.13	1445
Dilguda	100	6.45	1.08	697
Mugadiji	210	5.77	1.03	1248
Gulang Ndusom	240	11.87	1.18	3362
Dakdaba	150	4.70	1.13	797

Table 4. Computation of Wischmeier's Soil Erodibility Index

Location	Soil Erodibility classification	First approximation of Erodibility (K')	Final Erodibility (K)
Gadagimi	Moderate	0.17	0.26
Lum	Moderate	0.19	0.22
Dilguda	Moderate	0.29	0.26
Mugadiji	Low	0.14	0.13
Gulang Ndusom	High	0.38	0.40
Dakdaba	Moderate	0.27	0.30

Table 5: Result of aggregate stability and splash Detachment

Sample location	Average number of drops	Aggregate energy (MJ)
Gadagimi	41	20.1
Lum	24	11.8
Dilguda	13	6.4
Mugadiji	47	23
Gulang Ndusom	18	8.8
Dakdaba	23	11.3

Table 6: Prediction of Causes of Erosion in the Survey Area

Location	Vegetation	Slope of land around erosion area (degree)	Aggregate Energy (MJ)	Volume of soil loss (m^3)	Probable causes of erosion
Gadagimi	Few grasses and trees	5 – 7	20.1	965	The soil has no sufficient cover
Lum	Trees, shrubs and grasses	7 – 10	11.8	1445	Human activity and steep slope
Dilguda	Few grasses and trees	4 – 7	6.4	697	Human activity with little or no soil cover
Mugadiji	Trees, shrubs and grasses	6 – 8	23	1248	Human activity and steep slope
Gulang Ndusom	Trees, shrubs and grasses	8 – 12	8.8	3362	Human activity and steep slope
Dakdaba	Few grasses and trees	10 – 12	11.3	797	Human activity, steep slope with little or no soil cover

DISCUSSION

The extent of gully erosion in the study area may be related to land use, topography, vegetation and soil characteristics. The main causes of erosion in Bangshika can be traced to the following;

Table 2 shows the survey of land use, vegetation and slopes around gully areas. The slopes of the surrounding gully areas range from 5 to 10%.The slopes in study area are generally undulating and hence susceptible to erosion. The presence of mountains around Bangshika and its undulating topography contributes to high run off. Also the presence of Dilguda Dakadaba streams generates lot of gullies. These streams (especially Dilguda) over flood their banks almost every year destroying lives and properties. As the streams flows through Bangshika and its adjoining farmlands, the gullies they generates also increase in number and sizes. Uneven distribution of otherwise sparsely distributed trees, shrubs and grasses also lend the soil to erosion agents.

The volumes of soil loss in the gullies range from 697m^3 in Dilguda to 3362m^3 in Gulang Nduson (Table 3). The Bangshika soil is texturally classified as fine to medium loose sandy soil (0.06-0.6mm). Therefore, the soil particles lack sufficient physico-chemical interactions (cohesion) and are free to move hence their high detachability. Once detached they can easily be transported and the process of erosion is then initiated. Bangshika soil with a very low bulk density of about 33.245kg/m^3 is highly detachable, hence highly erodible. The more compacted individual soil particles are, the lesser the tendency for them to be transported and vice versa. Therefore Bangshika soil with a very low particle density of 418.68kg/m^3 has high tendency to be transported hence can be easily eroded. Table 4: Shows the values of Wischmier erodibility indices. They include firs approximation of soil erodibility (K') and erodibility factor (K). Values of K ranges from 0.14 to 0.40 with erodibility classes of either low or moderate using bradny (1984) only the soil from Mugadiji shows high erodibility. The higher the percentage pore space of soil, the higher will be the infiltration rate and the higher the infiltration rate the lower will be the run off generation and the lower the run off the lower the tendency of the soil to be eroded. Bangshika soil with percentage pore space as low as 20.60% generates enough run off for considerable water erosion. Table 5: Summarizes the result of aggregate stability and splash detarchment. The average number of drops to achieve splash range from 13 in Dilguda to 47 in Gulan Nduson . The aggregate stability range from 6.4 MJ in Dilguda to 23MJ in Mugadiji. Both the splash and aggregate stability are related to soil texture, soils with high clay content had low splash detachment and high aggregate stability while soils with high sand content had high splash values with low aggregate stability. The splash detachment values also reduce with increase in organic matter content. Human Activities: The exploitation of natural resources is a major contributor to erosion in Bangshika area. Beside land use for agricultural purposes, sand collection is a major factor contributing to soil erosion in the study area (Plate 1).

Plate 1. Sand mining accelerates Gully erosion in the area

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DAMAGE ASSESSMENT

Gully erosion has caused considerable damage to infrastructure, like roads, residential buildings, schools and farmlands in Bangshika and still posing a serious challenge to other arable lands (Plates 2 and 3). Though, the damages caused by this singular phenomenon cannot be easily quantified, but properties worth hundreds of thousands of naira have been destroyed, animals and human lives has been lost to gully erosion in the study area.

However, from the result of study conducted it showed that 40% of inhabitants of the area have their houses under threat by erosion, while 73% of farmlands in the area are affected by erosion at different stages of development (Plates 3).

An estimated average decline of 22% in farm productivity was observed right from the time the land was put under cultivation to date, due to decline in soil fertility.

Plate 2: Showing Gully erosion cutting across a road in Lum

Plate 3: Gully erosion at farm level

CONCLUSION AND RECOMMENDATION

This study reveals that Bangshika soil is very susceptible to erosion due to its textural nature, low bulk density, particle density and low percentage pore space. The presence of two major streams, Dilguda and Dakdaba escalates rate of erosion and results to flood. Human activities such as inappropriate cultivation methods and sand collection in the study area accelerate the erosion process.

Farmlands and potential arable lands devastated by gully erosion can be improved by filling the gullies with compacted soil mixed with crop residues, sand bags, and gabions. Planting of grasses along natural drainage channels can also help. Good cultural practices that support erosion control like terraces, strip cropping and contouring should be encouraged.

Very steeply sloped areas such as those closer to the mountains should be used for cultivation of forages. Forages can be grown on poor soils or steep slopes not suitable for other crops, or used in rotation to build organic matter, its fibrous roots holds the soil in place hence preventing erosion.Tillage should also be reduced to minimum by use of herbicides.

Sections of the residential areas adversely affected by gully erosion should be loaded with revetment to armour the banks against scour and erosion. This would also offer some resistance against mass soil movement, but primarily would prevent loss of bank material as a result of channel current action. The extension of this protective measure below the level of bed will provide an effective solution to the problem of erosion (Youdewei, 2003). The use of concrete is also a good alternative in this direction.

Open drains are required along (on both sides) the road leading to Bangshika from 'Fadamarake'. It should continue along the 'Gashaka' road and discharge to 'River yau'

Surface drains are also required along major natural drainage paths in residential areas to drain in the same 'river Yau' via the roadside ditches. Storm water drainages should also be constructed to discharge into 'river Yau'.

There is need for construction of a dam across Dilguda stream and flood diversion structures around Dakdaba stream. There should be control of sand collection activities in the study area, selection of appropriate land use and filling of gullies.

Soil and water resources conservation unit should be established as a matter of urgency to obtain and keep up to date records of rainfall, stream flow, run off rate etc. in order to have enough data for details design of some of the recommended control measures.

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