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Research article

Understanding Effective Gully Control Measures in Imo State, Nigeria

Gordon Tami Amangabara

Dept. of Environmental Technology
Flood and Erosion Control Unit
School of Environmental Technology
Federal University of Technology, Owerri.

E-mail: amangabara@yahoo.com
+234 803 3094635

Abstract

Gully erosion constitutes the major ecological problem in southeastern Nigeria and requires adequate scientific and proper technical competence in the prevention and control of this menace. An effective control of any phenomena is not possible unless and until the principles and mechanics underlying its behaviour and distribution over time and space are fully understood. The objective of this paper is to present some examples of gully erosion control works that failed Imo State, Nigeria. Generally, the initiation and development of gully erosion is facilitated by natural processes (such as rainfall, topography, engineering-geological properties of soils, especially texture & structure, etc) and the activities of man, especially road construction. Incorrect information, incomplete data or wrong concepts in the application of either methods of erosion control have aggravated gully erosion problems. Many of the erosion control measures put in place in Imo State show that hydrological variables (e.g. runoff) which constitute major factors in soil erosion, were not considered in the design and has resulted in deep gullies, instead of checking erosion.

Keywords: Gully, Environmental, Soil Erosion, Hydrology, Watershed

1. Introduction

Globally, environmental issues have become major concerns to governments and citizens of various nations, including Nigeria. The environment, which is at the heart of economic, social, cultural and human activities, has been disrupted by man's neglect and abuse. Pollution, deforestation, erosion, flooding, landslides, global

warming etc are the aftermaths of this abuse in and on the ecosystem. By virtue of Nigeria's spatial extent and its location in the tropical latitudes, the country encompasses various climatic regimes and physiographical units, which have severely exposed the country to the destructive influences of climatically induced hazards including flooding, erosion, drought and desertification (FMEnv, 2005). One serious geo-environmental hazard is soil erosion – defined simply as, a systematic removal of soil, including plant nutrients from the land surface by the various agents of denudation (Ofomata, 1987).

Soil erosion is a widespread environmental problem in Nigeria occurring in many parts of the country under different geologic, climatic and soil conditions. The degree of occurrence varies considerably from one part of the country to another; as well as the types and factors responsible for their initiation and development (Onwueme and Asiabaka, 1992; Idah *et al.*, 2008; Onu, 2011). The consequences of the occurrence of erosion are usually several and frequently hazardous to humans and their environment which are usually classified as on-site and offsite impacts.

2. Gully Erosion Development Process

Erosion by the action of water has produced some of the most spectacular landscapes we know. Natural erosion occurs primarily on a geologic time scale, but when man's activities alter the landscape, the erosion process can be greatly accelerated. The type of erosion that inspires fear in the lives of people in the southeastern part of Nigeria is gully erosion. Gully erosion can simply be defined as the erosion process whereby runoff water accumulates in narrow channels and removes considerable amount of soil from this narrow channel over a short time period. According to Sidorchuk (2001), gully erosion is a linear deep erosion feature with active head cut, unstable side walls, subject to mass movement, and non-graded longitudinal profile, with temporal water flow, while Poesen *et al.*, (2003), defined gully as a steep-sided channel, often with steeply sloping and actively eroding head scarp, caused by erosion due to the intermittent flow of water, usually during and immediately following heavy rains.

Gully erosion is the terminal phase of a four-stage erosion process involving splash, sheet, rill, and gully (Figure 1). The process begins by water falling as raindrops and flowing on the soil surface. Splash erosion results when the force of raindrops falling on bare or sparsely vegetated soil detaches soil particles. Sheet erosion occurs when these soil particles are easily transported in a thin layer, or sheet, by flowing water. If this sheet runoff is allowed to concentrate and gain velocity, it cuts rills and gullies as it detaches more soil particles. As the erosive force of flowing water increases with slope length and gradient, gullies become deep channels and gorges. The greater the distance and slope, the more difficult it is to control the increasing volume and velocity of runoff and the greater the resultant damage.

While gully erosion is not a new phenomenon by any means, its importance has however, gained more attention lately. Recent studies indicate that gully erosion represents an important sediment source in a range of environments and are effective links for transferring runoff and sediments from upland to valley bottoms and

permanent channel where they aggravate off-site effects of water erosion (Poesen *et al.*, 2003; Brooks *et al.*, 2009).

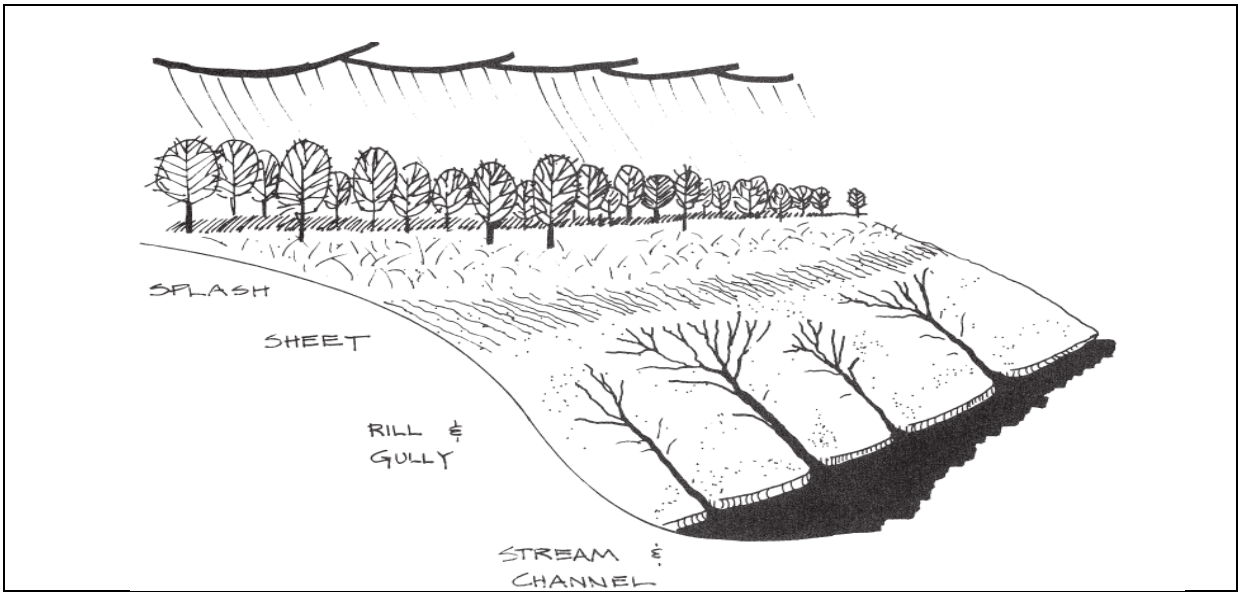

Figure 1: Four-stage Erosion Process

Unfortunately, the impacts of gully erosion are often far more severe in developing countries than in industrialized countries, often as a result of the lack of financial, technical, and institutional capacity (Tamene and Vlek, 2008). For example in the southeast of Nigeria, gully erosion is responsible for the destruction of transportation and communication systems, degradation of arable land, contamination of water supply, isolation of settlements and migration of communities (Grove, 1959; Nwajide and Hoque, 1979; Egboka and Okpoko, 1984; Onu, 2011).

Over the years substantial progress has been made with respect to modelling water erosion processes. However, many issues still remain unresolved. Of these unresolved issues are the process, formation and growth of gullies (Boardman, 1998; Poesen, 1998). While mechanisms for upland erosion are relatively well understood and acceptable soil loss rates have been established (Haile *et al*., 2006), the processes controlling gully erosion in the humid tropics are poorly understood (Hudec *et al*., 2006; Nyssen *et al.*, 2006). Control measures based on incorrect information, incomplete data or wrong concepts have failed. Except by chance, an effective control of any phenomena is not possible unless and until the principles and mechanics underlying its behaviour and distribution over time and space are fully understood.

3.1 Gully Erosion Control Measures

Gully erosion control measures are usually grouped into two categories: agronomic and engineering. Agronomical control method provides the soil with physical protection against scour and in slowing down the velocity of flow by increasing the hydraulic resistance of the channel (Lal, 1988). The cover crops help in

shading the land and reducing the impact of rain drop, the roots help to hold the soil together. The upper parts of trees intercept precipitation and thereby reduce the kinetic energy of the raindrops. When the velocity of flow is sufficiently reduced, some of the sediment load will be deposited and this can lead to the desirable rigorous vegetation, siltation of the gully and densification of the soil until the gully is refilled with soil, (Hudson, 1971). Engineering measures is essentially the construction of engineering structures such, as catch pits and soak-away pit, interceptor open drains, canals and underground pipes, with the objectives of preventing runoff from reaching the gullies and enhancing slope stability.

The application of any of the two mentioned methods requires a good knowledge of hydro-meteorology and surface hydrology. The amount, intensity, duration and frequency of rainfall and its capacity to generate surface runoff should be well considered from the onset in the design of erosion control works. This is because almost all gully erosion in southeastern Nigeria are located on moderate to very gently dipping, poorly consolidated sandstones, usually associated with local or regional highlands, amongst which, the Udi-Orlu and Okigwe-Ohafia- Aruchukwu highlands are the most prominent (Akpokodje *et al*, 2010). The major highlands, plateau and their precipitous escarpment are formed by sandstone bedrocks (Ajali sandstones and Nanka sands) while the lower slopes and plains are underlain by mainly shaly units (Imo, Mamu, Nsukka and Bende Ameki Formations). The gentle slopes of undulating plains are covered by thick and highly sandy overburden. The highest point in the region (about 343m) occurs around Okigwe while the southern plains of the region stand at about 81m above sea level (Akpokodje *et al.,* 2010). With this physiographic nature, surface runoff from any rainfall can easily be generated.

Rainfall data, collected for some Nigerian roads and observations on the performance of road culverts and roadside gutters during periods of heavy rainfall revealed major flaws in the design of highway drainage throughout Imo, Abia, Anambra and Enugu States (Morgan, 1986). Gullies tend to form, where the concrete-lined drains and culverts are too small to accommodate peak surface runoff. Culverts are not terminated at base of- slope locations and are allowed to decay and become clogged with debris. The overflowing water erodes beneath the roadside gutter or culvert, which eventually falls away to provide a site of localized erosion. By the accumulation of larger quantities of water or by the gradual deepening, rills and erosion gullies of various sizes and forms come into being. Examples of such gully created by failed culvert and drains in Imo State include Umuaka – Njaba Gully; Umuoka Ubiri-Elem Gully in Orsu LGA, Omuomi Uzoagba Gully in Ikeduru and Ogberuru- Acharaba Gully in Orlu.

3.2 Case Studies

3.2.1 Njaba River Catchment

In this catchment, there are a network of gullies with average depth of 50 m, width of 80 m and length of 2000 m respectively. The gullies mainly originated from poorly constructed side drains and termination of culvert at unsafe points at the Njaba River valley along the Owerri – Orlu road (Figure 2). The gullies originate as narrow rills with a down-slope orientation, which undergo progressive widening and deepening, with successive rainfall

events. The poorly terminated drain generated a waterfall effect on the poorly consolidated sandstones and cohensionless soil which resulted in the gully erosion. A good knowledge of surface hydrology would have prevented this scenario by determining the effective runoff and properly designing an effective drain that can accommodate the volume and velocity of runoff generated in the Njaba watershed.

The small drain in the background initiated the massive roadside gully at Umuaka

Umuaka gully by KM22 +350 Owerri-Orlu Road, Umuaka, Njaba. Imo State

Figure 2: Umuaka Gully

3.2.2 Umuoka Ubiri-Elem Gully, Orsu LGA.

The control method adopted was simply flattening the gully by bulldozers down to the receiving water body (Azezie Asa River) a tributary of Orashi. The gully soil were poorly compacted, the concrete channel was also defective in design (e.g. the channel drainage length - 900m, depth - 1m, width-1m, thickness of concrete - 0.15m, no rip-rap, no groin, no armoury, no detention). This poor control measure has resulted in the formation of rills which have begun to develop measuring up to700 m in length and 1.4 m in depth. Community efforts include the use of sandbags (Figure 3). The power of surface runoff was completely disregarded in this site. The situation is made worse by in-streaming activities downstream of the gully.

3.2.3 Omuomi Uzoagba Gully, Ikeduru

This gully developed from failed culvert. The length of the slope, and perhaps long duration and intensive rainfall initiated sheet erosion as a result of the loose soil in the area. As the sheet erosion occurs, the walls of the gutter (concrete drains) besides the earth became exposed and gradually collapsed, forming rill which later develop on weak zones to form three major gullies dissecting the entire slope into series of small rills forming a badland topography (Figure 4). Site investigation showed that at the design stage, the effective runoff for this watershed vis-à-vis the slope was not considered.

A) The contract signboard

B) Rills developing by the gutter

C) Advanced rills on the road

D) Sandbags used to check the erosion

Figure 3: Umuoka Ubiri Elem erosion site

a) Gully formed beside the concrete drains. Black arrow indicates direction of road. Red arrow show new incision (weak zone) on the road

b) Inside view of gully figure 4a

Figure 4: Ikeduru gully

3.2.4 The Ogberuru- Acharaba Gully.

This gully started sometime in the 1990s at the outlet of the earth road from the Ogberuru main town to the maternity, and continued to a nearby village called Uhuala. The earth road from Ogberuru town to the Acharaba maternity was badly constructed with poor side drains that increased the erosivity of the water flowing through it. The culvert outlet was not armored, the erosion at the invert of the culvert created a waterfall efect that increased the energy potential of the channel concentrated flow.

Culvert outlet (not armored,) created a waterfall that increased the energy potential of the channel concentrated flow.

Inside the gully

Figure 5: Ogberuru gully formed by drainage

4 Summary and Conclusion

The seriousness of deep gully erosions advancing at alarming rates and swallowing communities, villages and farmlands in the southeastern States of Nigeria, cannot be over-emphasized. Solving the problem requires adequate technical and institutional competence as well as well articulated sustainable policies. The development of an effective gully erosion control/prevention management programme must be based on accurate scientific and engineering data on the size of the gullies, the engineering geological properties of the soils, the watershed characteristics (volume/velocity) of the surface run-off and the associated human activities. If the present practice, where hydrological knowledge is continually relegated to the background in the design of gully erosion control work continues, the problem of gully erosion and its negative impacts will continue.

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