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Natural Reclammation Of Gullies Using Sandbags

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ABSTRACT

The study was aimed at optimization of the use of sandbags for erosion control. Field studies were carried out in an experimental channel excavated on the slope of Otamiri River at Federal University of Technology Owerri and in a gully site at Ezinihitte-Mbaise, Imo state. Artificial runoff was simulated into the artificial channel by pumping water from Otamiri River. Sandbags of various patterns and heights were placed across the channel to reduce the erosive power of runoff and encourage siltation. The flow characteristics including sediment concentration and sediment accumulation rates upstream were recorded. Comparative analysis of the patterns of placement of sandbags based on hydraulic and structural considerations showed that transverse arrangement with stepped downstream face yielded better results compared to longitudinal pattern. A chart for determining the optimum location of sandbags in gullies was developed to aid design.

1.0 Introduction

According to Bettis (1983) [1], a gully is a relatively deep, vertical walled channel, recently formed within a valley where no well-defined channel previously existed. Gully erosion produces channels larger than rills. These channels carry water during and immediately after rains, and as clearly distinguished from rills, gullies cannot be obliterated by tillage. The amount of sediment from gully erosion is usually less than that from upland area, but the nuisance of having fields divided by large gullies has been the major problem. In tropical areas, gully growth following deforestation and cultivation has led to severe problems from soil loss and danger to buildings, roads and airports (Aneke, 1985) [10]. Some gullies are several kilometers long while other are as short as 30m and have nearly vertical walls. Gullies in large valleys contain streams which usually flow year round but streams in most gullies are dry during portions of the year.

Gullies develop because of decrease in the erosional resistance of the land surface or an increase in the erosional force acting on the land surface. What causes gullies to form, when and where they do is poorly understood. Field and laboratory studies indicate that certain reaches of a valley are more prone to gully development than other. However, the timing of the initial down cutting and which of the "most probable" reaches develops into a gully cannot be predicted with certainty. Once a gully has formed, the processes whereby it lengthens and widens are much better understood. The upper end of a gully is marked by a headwall, a vertical scalp separating the ungullied portion of the valley floor from the gully below. Water flows over the headwall during runoff and falls into a plunge pool at the base of the headwall. The water then erodes the base and sides of the pool, under cutting the headwall. When under cutting reaches an advanced stage, the headwall fails and topples into the gully, thereby lengthening the trench. This process is repeated many times as a gully advances up the drainage way. When first formed, most gullies are quite narrow and have vertical sidewalls. Increased pore pressure from groundwater moving toward the gully, coupled with some under cutting of the side walls causes deep enough water is flowing through the gully to carry away the slumped material, additional slumping can occur. This causes the gully to widen Widening also occurs when upper portions of gully walls separate and topple into the gully.

According Bradford and others (1973) [2], the rate of gully erosion depends primarily on the runoff-producing characteristics of the watershed; the drainage area, soil characteristics, the alignment, size and shape of the gully and the slope of the channel.
Evaluation and prediction of gully development are difficult because the factors are not well defined and field records of gullying are inadequate.. In Nigeria, especially in the South East region, erosion also poses a serious threat. The presences of gully sites in the area are some of the hazard features that characterize this zone as well as other zones that adjoin them (Ofomata, 1985) [3]. Asiabaka and Boers (1988) [4] had estimated that over 1970 gully sites exist in Imo and Abia states. Each year, the Nigerian Government spends billions of Naira on provision of structures for gully control, (Ijioma, 2009) [5].

Reclamation is a process of reinstating and improving the land that has been distorted by erosion back to its original condition and prevent further deterioration (www.answers.com, 2013)[6]. Reclammation is necessary to overcome the problem of soil erosion (Hussain, 2008) [7]. The practicability of shaping a gully depends on its size and the amount of fill needed to restore the gully to its desired shape (Carey, 2006) [8]. Steep gully sides can be reshaped. Topsoil should be stockpiled and respread over exposed areas to ensure the rapid establishment of vegetation. Annual crops such as millet (summer), oats or barley (winter) can be used to provide a quick cover. It may be possible to temporarily divert water from the battered gully while grass is generating.

Haagsma (1992) [9] observed that though current engineering approach favours filling of gullies, the results are not very encouraging. Technically, this method may be effective for smaller gullies, if proper compaction is done. For bigger gullies, this method is clearly inappropriate, as proper compaction cannot be achieved and ground water movements are likely to endanger the result, with more serious impact as ever before. Gullies in cultivation can be filled when constructing contour banks. The banks must have sufficient capacity where they cross old gully lines as this is a common site for contour bank failure.

Some non conventional and traditional methods control development of gullies at the early stage (Osuagwu, 2012) [11] Among these methods include the use of sand bags, which are basically units of bags filled with sand and placed across flow directions in natural channels to reduce runoff velocity and encourage siltation upstream. This is natural way of reclaiming gullies. Sand bags are randomly adopted by rural inhabitants in Nigeria to reduce the erosive power of runoff. They are cheap and easy to apply..There is however absence of standards and specifications for its optimal application. The study is therefore aimed at formulating analytical standards and specifications for optimum utilization of sandbags for erosion control.

2.0. Methodology

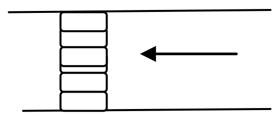
Data for analysis were collected through field and laboratory investigations. These include hydraulic, hydrological, topographical, and geotechnical parameters. Specifically, the following data were collected; depth of flow (m), and duration (hrs) flow rate of runoff (m^3/s) Velocity of flow (m/s),rate of accumulation of sediments (m^2/s) and sediment concentration. Pilot studies were carried out at two different sites. Site 'A' was a natural gully developing at a location in Okpofe Ezinihitte – Mbaise, Imo state. The gully was at an early stage of development.
On the other hand, Site 'B' was an experimental channel formed on the slope of Otamiri River at Federal University of Technology, Owerri. The channel has a cross section of 1.2×0.6m measuring a length of 15m. Artificial runoff simulated by pumping water from Otamiri river was directed into the channel.
Polypropylene bags of 0.9m length and 0.45m width were filled with sand to an average thickness of 0.25m and placed across the gullies. The heights and patterns of placement (transverse and longitudinal) were varied for different flow conditions. Figs. 1a and 1b shows the patterns of placement.

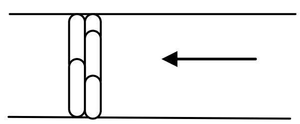
In order to determine sediment concentration, volumes of collected runoff samples were determined in a measuring cylinder. The weights were also recorded. Thereafter the water was evaporated by drying in an oven leaving the sediments. The remaining sediments were scooped and weighed in a weighing balance.

$$Concentration = \frac{m_s}{m_r} \qquad 2.1$$

$$m_s = weight\ of\ sediments,$$

$$m_r = weight\ of\ runoff$$

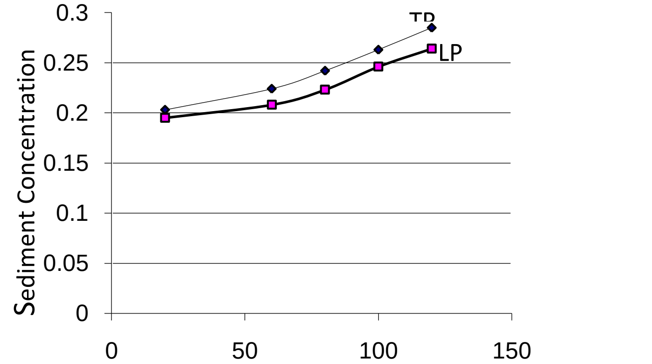




3.0. Results and Discussions.

3.1. Variation of Sediment Concentration for different Placement Patterns.

Variations of sediment concentration with time for transverse (Tp) and longitudinal placement of sandbags (Lp) is presented in Fig. 2.. The result showed that sediment concentration at a given time is higher for transverse arrangement than for longitudinal placement. This implies that transverse arrangement is more efficient.



3.2. Profile of Sediment Deposits.

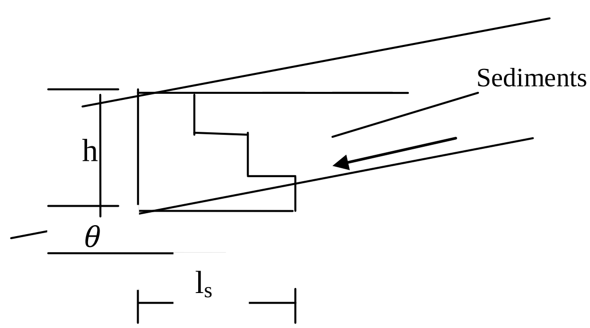
Studies of the profile of the sediments deposited upstream indicated that the sediments tended to form a horizontal surface at any height as shown in Fig. 3 The sediment storage continued until the deposited materials flushed with the top level of the bags and no other deposits were made. This is consistent with findings of Agostini (1985) [11] on the application of Gabions in River training.

The length of the sediments deposited would depend on the bed slope, θ of the gully:

$$\frac{h}{l_s} = tan\theta \qquad 4.27$$

Where, h = maximum depth of sediments

θ= bed slope



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3.3 Spacing of Sandbag Locations:

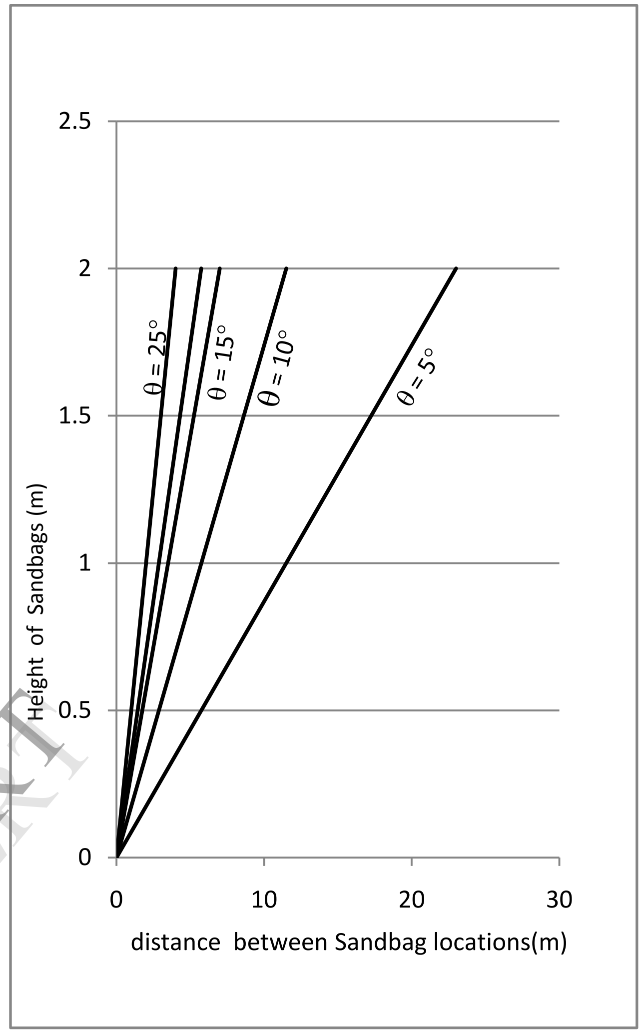
Studies of the profile of the sediments deposited behind the sandbags indicated that the sediments tended to form a horizontal surface at any height. The sediment storage continued until the deposited materials flushed with the top level of the bags and no other deposits are made. Thus the length of the sediments deposited would depend on the bed slope, θ of the gully

$$\frac{h}{l_s} = tan\theta \qquad 3.1$$

Where, h = maximum depth of sediments
θ= bed slope

The horizontal distance between the locations of the bags thus depends on the height of sandbags and the bed slope. The optimum distance between sandbags corresponds with the intersection of a horizontal line from the top of the sandbags with slope.

Fig 4 shows the relationship between height of sandbags and the horizontal spacing of the bags for different bed slopes. The plots indicate that the intervals for placement increases as the bed slope decreases. The chart could be applied in design of sandbags for erosion control works. The optimum horizontal spacing could easily be determined for any chosen height of sandbags once the bed slope is known.



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3.3 Limitations of Sandbag Checkdam

Based on our field observations, the following limitations were noted on the use of sandbags:

(i) Water going around the bags and eroding the sides.
(ii) Limited durability: Degraded sandbags may rupture, spilling the sand .

To reduce the problem of water going around the sides, it is necessary to turn the ends of bags at the gully walls. That is, placing the sandbags perpendicular as illustrated in Fig 5

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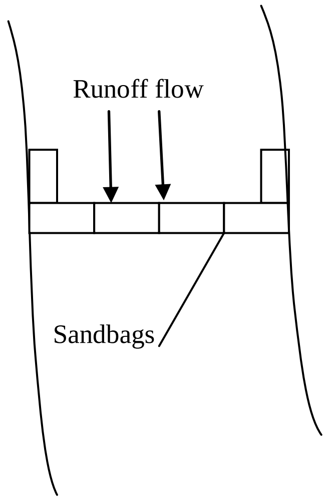

4.0. Conclusions and Recommendations.

Though reclamation is an expensive venture, the use of sandbags guarantees a natural and cost effective approach that requires little technical skill. The pattern of placement of sandbags affects the efficiency of the sandbags in trapping sediments inside gullies. A transverse interlocking arrangement with stepped downstream face is recommended. With proper placement pattern, problems of stability are unlikely to arise.

It is recommended that engineers involved in erosion control works should consider the use of sandbags especially for gullies at early stages of development. The design chart for optimum location will be of immense use

Finally, though propylene bags were used for studies, environmentally friendly bio-degradable bags are recommended for large scale application.

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