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Research article

ASSESSMENT OF THE EFFECTIVENESS OF USE OF CONCRETE STRUCTURES IN MANAGING GULLY EROSION IN ANAMBRA STATE, NIGERIA.

Onwuka, S. U. and Okoye, Chinedu.O.

Department of Environmental Management, Faculty of Environmental Sciences,

Nnamdi Azikiwe University, Awka, Anambra state, Nigeria.

+234 8036680344 ; +234 80181439134

E-mail: chinedubisi4@gmail.com

Abstract

Consequent upon the menace of gully erosion in Anambra State, several governments and agencies have attempted managing it using concrete structures. The study, therefore, assessed the effectiveness of the use of concrete structures in management of gully erosion in Anambra State using areal photographs, field measurement and observation methods in the ten selected towns. Data on the dimensions of the erosion sites before and after the construction of the concrete structures were obtained from LANDSAT 2001, 2004, 2006 and Google Map 2011. Again, data on the physical damage of the concrete structures was obtained through visual observations of the concrete structures. Students T- test and simple percentages, respectively, were used to test these two hypotheses: **(**1) Concrete structures do not control the expansion of the erosion sites, and (2). There is no significant physical damage of the concrete structures. The findings showed that: (1) the concrete structures do not control the expansion of the erosion sites; (2) there is a significant physical damage of the concrete structures; (3) 75% of the erosion sites increased in dimensions from one to three years after the construction of the concrete structures; and (4) 63.64% of the total concrete structures were physically damaged. The study concluded that the use of concrete structures in controlling gully erosion in Anambra State is not effective. Consequently, the study recommended among others, that in order to get maximum result in gully erosion management in the area, nature should be used to fight nature. Further researches should be on: 1.The place of soil characteristics in the soil erosion in the area, and 2. Suitable plant specie(s) for management of gully erosion in Anambra State.

Keywords: Anambra State, Gully erosion, concrete structures, soil texture and erosion control measures

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INTRODUCTION

Background of the Paper

Soil erosion remains one of the world's biggest environmental problems threatening sustainability of both plants and animals in the world. Over 65 percent of the soil on earth is said to have displayed degradation phenomenon as a result of soil erosion, salinity and desertification (Okin, 2002). Soil is one of the most vital of earth's natural resources. It hosts both plants and animals and carries over three quarters of the world's manmade developments. Most earth's natural resources are directly linked to or found in the soil.

Threat to soil is, therefore, threat to life. At all times soil erosion threatens land and indeed human life sustaining environmental support systems. It is not surprising that United Nations (UN) Convention to combat land degradation opines that soil erosion automatically results in reduction or loss of the biological and economic productivity, and complexity of terrestrial ecosystems, including soil nutrients, vegetation, other biota and the ecological processes that operate therein (Classen, 2004).

Hudec et al (2005) argued that poor design and construction of roadside drainage is a major cause of gully erosion. Improper termination of drains and blockage of drains by silt and debris cause the water to overflow. This erodes the sides and ends of drains, undercuts them, and causes their collapse. The resulting, unregulated flow causes the rapid development and advance of gullies. Similarly, Igbokwe et al (2007) and Onwka and Okoye(2009) also noted that wrong human practices in the area trigger and aggravate soil erosion problem in the area.

According to Ofomata (1987), one of the reasons usually given for the failure of soil conservation measures in the country is that the farmers do not co-operate in the attempts, but are rather passive and apathetic to any plans aimed at combating soil erosion. They are accused of unwillingness "to adapt the procedures deemed necessary to heal the land". In fact, the ills of soil erosion are easily blamed on the so called "bad farming techniques" of the affected communities. He attributed the missing links in our soil conservation measures to: lack of communication between the Government and the people; inadequate knowledge of the environment, and exploitative excesses of the people. Miller (2004) quoting Pimentel (2000) said that one reason why soil erosion is not a high priority for many governments and farmers is that it usually occurs so slowly that its cumulative effects may take decades to become apparent.

Ofomata (2007), noted the usually haphazard and adhoc construction of concrete structures and improperly located drainage channels as means to control gullying, but which end up creating more problems than they were intended to solve. Gullies usually intensify their activities in the wake of the building of such structures, contrary to expectation. But this will not surprise any one familiar with the dynamics of gullying.

It is on this background that this study seeks to assess the effectiveness of the use of concrete structures in management of gully erosion in Anambra State.

Statement of the Problem

Throughout Anambra State, especially areas with deep sand plains, high stream banks or sloping valleys, extensive soil erosion problems occur. Large quantities of valuable agricultural soils are lost each year to soil erosion, especially gullies. Consequently, this menace in Anambra State has attracted the attention of both the state, federal and international agencies. This is in a bid to proffering meaningful solutions to the problem.

Efforts made by the State Government to cope with the menace include measures like hydraulic regulatory works that integrate a drainage network with storage ponds to cut off flood crests; lower hydraulic loads of interceptor canals; stabilization work such as check dams on the main channels of gullies; and wicker-work fences and hedges at the inner gully slopes.

There is speculation that surface regulation of surface waters through engineering measures is effective in controlling only shallow (≤15m deep) gullies that have not cut through a saturated zone. These measures tend to fail when used for deep gullies that are greatly affected by ground water especially when such gully floors are located in non-cohesive and very permeable sands (Hudec et al, 2005).

Numerous gully sites which have been controlled by both the State and Federal Government with the use of concrete structures include, among others, Awka, Mbaukwu, Agulu, Nanka, Ekwulobia, Nnewi, Nnewichi, AdaziNnukwu and Nsugbe Erosion Sites. A close observation reveals that majority of the concrete structures have collapsed thereby increasing their dimensions and leading to continuous widening of the sites said to have been controlled. Examples of such sites with failed structures include St. Theresa's Catholic Church Gully

Erosion Control Project at Agulu, Umuchu Gully Erosion Control Project, Nnewichi Gully Erosion Control Projects, to mention but a few.

Huge amounts of money running into hundreds of millions of naira are continuously spent by the State and Federal Governments on the construction of concrete structures in Anambra State. For instance, the State Commissioner for Finance and Budget, Mr. EzeEchesi acknowledged that the State received the sum of eight hundred million naira (N800m) from the Federal Government, but has committed about nine hundred million naira (N900m) on erosion control between 2007 to 2008 (Fortune News, May 20, 2009). But, so far, there is no clear indication of success from these efforts. Instead, the attempts seem to have failed, at least in a large measure (Ofomata, 2007).

The question that comes to the mind of every observer is: Has the use of concrete structures achieved the aim for which they were constructed?

It is to this effect that this paper assessed the effectiveness of the use of concrete structures in management of gully erosion in Anambra State.

Aim and Objectives

The aim of this paper is to assess the effectiveness of the use of concrete structures in managing gully erosion problem in Anambra State.

To achieve the above aim, the following objectives were pursued:

1. to ascertain the erosion sites where concrete structures were used as control measures;
2. to ascertain the dimensions of the erosion sites before and after the construction of the concrete structures;
3. to conduct visual inspection of the physical damage of the concrete structures in the controlled erosion sites; and
4. to ascertain the extent to which the concrete structures have gone in managing the gully erosion problems in the area.

Hypotheses

The following hypotheses were tested in the paper.

H_O: Concrete structures do not control the expansion of the erosion sites.

H_O: There is no significant physical damage of the concrete structures.

Area of Study

This study is carried out in Anambra State. The state is located between latitudes 05^0 40’N and 07^0 10N’ and longitudes 06^0 35’E and 07^0 20’E (Figure 1). Anambra State is made up of 21 local government areas. The state is located in South-Eastern Nigeria.

Two climatic seasons exist in the study area, namely rainy season (March- October) and dry season (November-March). The dry season is characterized by heavy down pours accompanied by thunder storms, heavy flooding, soil leaching, extensive sheet outwash, ground water infiltration and percolation (Egboka 1993). The annual rainfall of the area is about 2000mm.The study area lies within the rain-forest belt of Nigeria. In the south, the area is bounded by mangrove swamp forest, and in the north, by savannah grassland.

Theoretical Framework

The paper is based on the popular failure theories. This is because sound understanding of these theories will be an edge in understanding pavement failures. Failure theory is the science of predicting the conditions under which solid materials fail under the action of eternal loads. The failure of a material is usually classified into brittle failure (fracture) or ductile failure (yield). Depending on the conditions (such as temperature, state of stress, loading rate), most materials can fail in a brittle or ductile manner or both. However, for most practical situations, a material may be classified as either brittle or ductile. In mathematical terms, failure theory is expressed in the form of various failure criteria which are valid for specific materials. Failure criteria are functions in stress or strain space which separate “failed” states from “un-failed” states. A precise physical definition of a "failed" state is not easily quantified and several working definitions are in use in the engineering community. Quite often, phenomenological failure criteria of the same form are used to predict brittle failure and ductile yield (Besson and Steglich, 2003).

The failure theories are indispensable in understanding the processes of pavement failures for both ductile and brittle sub grades and sub-base courses (the layers under the pavement surface). For the purpose of this study, we will lay hands on four important failure theories, namely:

(1) Maximum Shear Stress Theory,

(2) Maximum Normal Stress Theory,

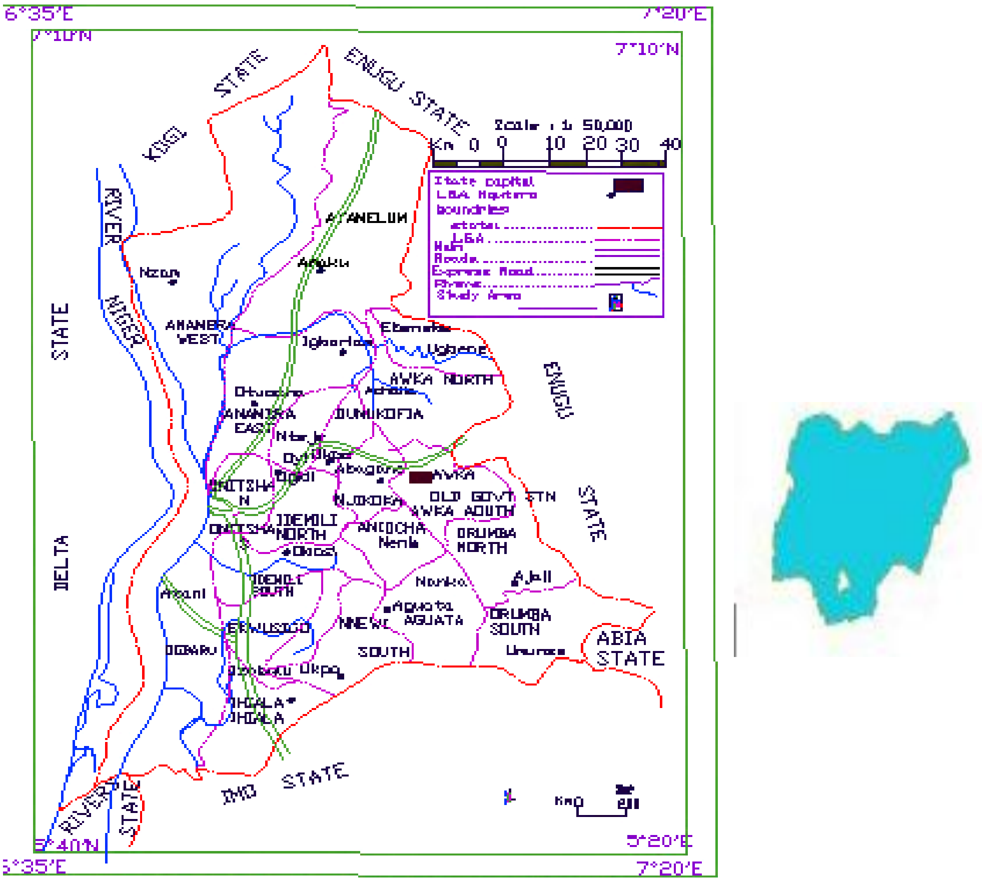

Fig. 1: Map of Area of Study (Anambra State)

Maximum Shear Stress Theory: This theory was postulated by H. Tresca in 1864. It states that failure will occur in the part of any material if the magnitude of the maximum shear stress in the part exceeds the shear strength of the material determined from uniaxial testing.

Maximum Normal Stress Theory: This theory was postulated by W. Rankine in 1857. It states that failure will occur in the part of any material if the maximum normal stress in the part exceeds the normal strength of the material as determined from uniaxial testing. This theory caters to brittle materials and we have learnt that brittle materials behave differently in compression and tension tests. In compression test it fails when the comprehensive stress reaches suc, the ultimate compressive strength of the material and in tensile test it fails when the tensile stress reaches the ultimate tensile strength of the material. Also generally, the magnitude of suc is larger than for brittle materials.

Study Methodology

A total of eleven (11) sites were selected from ten (10) towns for the study. The sites were selected due to: their popularity, havocs done by them, the attention given to them by various governments and the use of concrete structures in controlling them.

The data used for the study were of two types: primary and secondary data.

The primary data includes interviews and all the data collected by the researchers through field observations and measurements.

The secondary data include data on population of the area, sourced from the National Population Commission of Anambra State; and data on the dimensions of the erosion sites before and after the construction of the concrete structures, obtained from satellite imagery ofLandSat 2001; 2004; 2006; and Google Map 2011. In testing the hypotheses, hypothesis 1 was tested using students T-test. Hypothesis two was tested using simple percentages. In testing the second hypothesis, students T-test statistics for test concerning two dependent samples was employed.

Data Presentation, Analysis and Discussion of Findings

This section presents and discusses the dimensions and areas of the erosion sites before and after the construction of the concrete structures, and Table 1 below was used.

Table 1 shows that the area of Adazi-Nnukwu (36,382 meter square) Gully Erosion Site remained the same after being controlled with concrete structures. This implies that this erosion site did not expand after being controlled. On the other hand, the areas of the gully sites of Agulu (29,456m2), Ekwulobia (831,500m2), Umuchu (67,192m2), Nnewichi (271,820m2), Nkpor (134,200m2) and Nanka (1,892,600m2) increased between 1 and 3 years after being controlled with concrete structures, showing that the gullies caused more problems in the area. Nsugbe Gully Erosion Site was controlled, additionally with land reclamation, that is, the gully site was filled up with laterite and flood drainage was created to divert and channel flood to Oji River in Nsugbe.

Again, this section presents, analyzes and discusses data on visual inspection of the physical damage of the concrete structures in the controlled erosion sites in Anambra State. The data is presented using cross-tabulation (Table 2), and simple percentages, and bar chart.

Table 2 below shows that 36.36 % of the concrete structures were as when built. They include erosion control works at St. Patrick's Catholic Church, Awka; Mbaukwu; Adazi-Nnukwu, and Amumu, Nsugbe. 45.45% of the concrete were slightly damaged including the ones at St. Anthony's Catholic Church, Agulu; Umuchu; Mbanakwu-Umuogbo, Nnewichi; and New Tarzan, Nkpor. 9.09% of the concrete structures was fairly damaged, including the control works at Umuchiana-Ekwulobia. 9.09% of the concrete structure was badly damaged; this includes erosion control works at Nanka.

From the fore- going, it is clear that greater percentage (63.64) % of the total concrete structures used in controlling gully erosion sites in Anambra State were damaged leading to their partial or complete collapse, and increase in surface run off and sediments load. This results in further widening of the gully sites, leading to loss of farm lands, economic trees and farm products. Also, houses and other public facilities were destroyed. The resultant effects are the low productivity of vegetation in the area, including agricultural products, and subsequent migration of the people.

Table 1: Cross-Tabulation on Dimensions and Areas of the Erosion Sites before and after the Construction of the Concrete Structures. (Source: LANDSAT: 2001, 2004, 2006 and Google Maps 2011)

Erosion Sites	**Completion of concrete structure**	**Before Construction**		**After Construction**	
		Dimension (m)	Area (m^2)	Dimension (m)	Area (m^2)
St. Patrick's	2010	Data not available	Data not	St. Patrick's	2010

Catholic Church Awka			available	Catholic church Awka	
St. Anthony's Catholic church Awka	2010	Data not available	Data not available	St. Anthony's Catholic church Awka	2010
Mbaukwu	2010	L= 0.288	Data not available	Mbaukwu	2010
		b-?			
		d-?			
Agulu	2009	L-560	29,456	Agulu	2009
		b-14			
		d-12			
Adazi Nnukwu	2010	L-423	36,382	AdaziNnukwu	2010
		b-25			
		d-17			
Ekwulobia	2009	L-6380	831,500	Ekwulobia	2009
		b-30			
		d-35			
Nsugbe	2011	L-300	12,192	Nsugbe	2011
		b-8			
		d-12			
Umuchu	2009	L-875	67,192	Umuchu	2009
		b-23			
		d-15			
Nnewichi	2011	L-2,290	271,820	Nnewichi	2011
		b-35			
		d-24			
Nkpor	2010	L-1,480	134,200	Nkpor	2010
		b-25			
		d-20			
Nanka	-	L-1,270	1,892,600	Nanka	-
		b-558			
		d-130			

Table 2: Cross-Tabulation on Visual Inspection of the Physical Damage of the Concrete Structures. (Source: Researchers' fieldwork, 2012)

Visual Inspection of the Physical Damage of the Concrete Structures	Number of Sites	Percentage
Concrete structures that are as when built (AB)	4	36.36
Concrete structures that are slightly damaged (SD)	5	45.45
Concrete structures that are fairly damaged (FD)	1	9.09
Concrete structures that are badly damaged (BD)	1	9.09
Total	11	100

It is important to note that the remaining 36.36% of the concrete said to have not damaged were either the ones recently built or those that had additional measures like land reclamation, like that of Nsugbe Gully Erosion Site. The implication is that, considering the amount of money invested in those projects, and what happens after a little time, the whole exercise can be summarized as efforts in futility.
In order not to base the conclusions on mere observations, the sourced were subjected to statistical analyses as shown below:

Test of Hypothesis 1

H_o: The concrete structures do not control the expansion of the erosion sites.

In testing this hypothesis, Table 3 below, which shows the modified areas of the gully sites (before and after the construction of the concrete structures), was used.

The decision rule is that at 5% significant level, if the computed t value is greater than the critical t value, we reject the H_O and accept the H_1, otherwise H_O stands.

Table 3: Modified Areas of the Gully Sites before and after the construction of the concrete structures. (Source: LANDSAT 2001, 2004, 2006, Google Map 2011.

S/No	Erosion Sites	Area Before (in m2) x_{i1}	Area After (in m2) x_{i2}	Difference $d_i = x_{i1} - x_{i2}$
1	Agulu	29,456	34,432	-4,976
2	Adazi-Nnukwu	36,382	36,382	0
3	Ekwulobia	831,500	966,700	-135,200
4	Nsugbe	12,192	0	12,192
5	Umuchu	67,190	78,510	-11,320
6	Nnewichi	271,820	308,924	-37,104
7	Nkpor	134,200	159,400	-25,200

Table 4: T-test Table

S/No	Difference $d_i = x_{i1} - x_{i2}$	$d_i - \bar{d}$	$(d_i - \bar{d})^2$
1	-4,976	87, 355	7,630,896,025
2	0	92,331	8,525,013,561
3	-135,200	-42,869	1,837,751,161
4	12,192	104,523	10,925,057,529
5	-11,320	81,011	6,562,782,121
6	-37,104	55,227	3,050,021,529
7	-25,200	67,131	4,506,571,161

$$SD = \sqrt{\frac{\sum(d_i - \bar{d})^2}{n!}}$$

$$= \sqrt{\frac{240,804,187,765}{7}}$$

$$= \sqrt{34,400,598,525.5}$$

$$= 185473.98$$

$$\Rightarrow t = \frac{\bar{d} - d_o}{s/\sqrt{n}}$$

$$= \frac{-92,331}{\frac{185,473.98}{\sqrt{n}}}$$

$$= \frac{-92,331}{65,538.1}$$

=/-1.41/

$$t = 1.41$$

$$t_1 - x; n - 1 = t_{0.95}; 7 = 1.895$$

Conclusion: Since the computed t-value (1.41) is less than the critical t-value (1.895), we accept the null hypothesis and conclude that the concrete structures do not control the expansion of the erosion sites.

Test of Hypothesis 2

Ho: There is no significant physical damage of the concrete structures.
In Table 5, the researcher tested whether there is a significant physical damage or no significant physical damage of the concrete structures.

Table 5: Caption (Source: Researchers' Fieldwork, 2012)

Visual inspection of the physical damage of the concrete structures	Number of sites	Percentage
Concrete structures that are as when built (AB)	4	36.36
Concrete structures that are slightly damaged (SD)	5	45.45
Concrete structures that are slightly damaged (SD)	1	9.09
Concrete structures that are fairl1y damaged (FD)	1	9.09
Concrete structures that are badly damaged (BD)	11	100

In testing the hypothesis above, simple percentages was employed thus:

K = a x 100
n 1

Where

k = constant

a = number of erosion sites

n = total number of erosion sites

The physical damage is further grouped into two in Table 6 below.

Table 6: Caption (Source: Researchers' Fieldwork, 2012)

Issue	Number of sites	Percentage
Concrete structures that are as when built	4	36.36
Concrete structures that are damaged	7	63.64
Total	11	100

Conclusion: since majority of the total structures (63.64%) are physically damaged, we reject the H_o and accept the H_i; and conclude that there is a significant physical damage of the concrete structures.

Summary, Conclusions and Recommendations

Summary of the Study

This study assessed the effectiveness of the use of concrete structures in management of gully erosion in Anambra State. The study looked at the dimensions and areas of the erosion sites before and after the construction of the concrete structures with the aid of LANDSAT: 2001, 2004, 2006 and Google Map 2011. It showed that out of the ten (10) erosion sites studied, 63.64% increase in their areas. The study also looked at the physical damage of the concrete structures through field measurement and observation. Furthermore, the concrete structures do not control the expansion of the erosion sites in the area. In addition, the study also shows that there is a significant physical damage of the concrete structures.

Conclusions and Recommendations

- Based on the findings, the paper concludes that sincethe concrete structures do not stop the expansion of the erosion sites, and also added to the fact that there is a significant physical damage of the concrete structures within a short period of time, the use of concrete structures in controlling gully erosion problems in Anambra State is not effective and should be discontinued.
- There should be attitudinal change in the use of environment in the area as advocated by Onwuka and Okoye (2009)
- This paper recommends the following:
  1. Nature should be used to fight nature in the area. This involves incorporating planned woody vegetation elements in engineering designs. This is also known as bio-structural approach to erosion and slope stability problems.
  2. Research should be carried out to find out proper vegetation species capable of adequately handling erosion problem in the area.

The physico-chemical characteristics of the soil area should be researched upon so as to know why the concrete structures are failing viz-a-viz to know whether they could be improved upon during construction, if the use of concrete structures must be used.

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