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Examining the Influence of Gully Erosion on Land Use Development in South Eastern Nigeria

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ABSTRACT

The consistent physical development in housing and reshaping of the natural environment by man constitutes a major factor in the weathering effect on the overall set up of the natural Anambra and Abia State environments. The purpose of this study is to examine the impact of soil erosion on the built environment of Anambra and Abia States gully sites. The study, therefore, explains the causal factors and consequences of soil erosion ravages in the area. The systematic random sampling technique and laboratory analysis were employed in analysing data. The study relied both on primary and second-handed information. However, credence is given to primary source of data acquisition, through questionnaire, field surveys, spot measurements, and interviews and direct observations. Having being constituted of primary data, it is, therefore, evident that the study is a quantitative in nature, and as to that, laboratory testing is required in order to substantiate the facts. This is performed by testing and analysing soil samples from the selected sites. The analysed data were presented using Tables and Charts. The result of the study reveals that the influence of soil structure and slope gradient are dominant factors in the existence of soil erosion in the area. The soil in Agulu-Nanka is mainly composed of weak and porous materials that do not resist the force of water runoffs. The soil structure of Ndiegoro is predominantly sandy clay, this show that the soil formation is permeable, and does not retain much water, hence resisting the strength of water runoffs, especially where the slope is very steeply. Onu Ibina soil formation is porous and does not retain much water, hence having exacerbated impacts on the immediate land, and properties locate within steep and gentle slope gradients. Therefore, there is the need to check the velocity of water runoffs in addition to levelling and greening the gully erosion sites.

Keywords: Accelerated erosion, deforestation, greening, soil structure, water concentration.

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INTRODUCTION

Erosion is the ability of the denudation agents to dislodge, transport, and deposit particulate soil materials from one location to another (Egboka, 2004). Soil erosion, simply put, is the detachment and transportation of soil particles from one place to another through running water, wind and human activities.

The origin of soil erosion can be traced back to when the green vegetation that covers the earth surface begins to loose its natural support and coverage over the earth surface (Adegun, 2016). This inadvertently results to sterility and subsequent collapse in the support of biological adjourning properties of the soil (Arunsi and

Umunnakwe, 2003). Within the last two decades, the south-eastern states, particularly Abia State has been experiencing serious erosion problems – both gradual and accelerated. In the south-eastern Nigeria in particular, flood water is a major agent of soil erosion (Igbokwe, 2001).

In Agulu-Nanka, Ndiegoro, Onu-Ibina and environs, gully erosion has become an annual phenomenon, broadening in proportion with every passing year (Onwuchekwa, 2013). Hence, there is therefore, the need to understand the extent of the damage in the study area, as well as the local process of soil erosion.

Over the years, as a result of development and economic growth, there has been a great demand for expansion of roads, housing rail-line and other infrastructure (Albert et al., 2014). These factors resulted into massive construction and expansion of transportation routes, and the concomitant land exposure and eventual erosion menace problems associated with this include a gradual disturbance of the protective soil cover of the earth's crust resulting in soil erosion, sedimentation, pollution of rivers and streams in the environment (Kalu, 2007).

According to Anarda and Herath (2015), virtually in every part of south-eastern Nigeria, the earth presents gaping chasm ready to allow whatever that readily comes to sight. Soil erosion, traditionally, has been responsible for the formation of big gullies in various parts of Agulu-Nanka, Ndiegoro and Onu-Ibinasub-region (Emeribe, 2017). These gullies have placed serious limitations to the general development of the sub-region and at the same time have damaged infrastructural provisions in the area. Following this trend, therefore, if the trait is not properly checked, the available scarce land resources may look so lean, if not completely impoverished.

The expected loss will have its consequences on the life of the people and on the natural ecosystem of the host communities in Abia state. Meanwhile, it is obvious that Agulu-Nanka, Ndiegoro and Onu-Ibina and its environs currently faces a very active accelerated soil erosion, which leads to various forms of environmental problems, even as people are displaced from their native homes, with properties worth millions of naira lost annually to soil erosion menace and has implicitly affected both the socio-economic and environmental out-look of the sub-region (Kalu, 2017).

According to Bekko (1991) and Strahler (2008), soil erosion removes soil at roughly the same rate at which the soil is formed; this is a very frustrating situation which demands both local and international sympathy. During active rainfall/windstorm, soil is often detached, transported (in most cases over a very long distance and deposited from one location to another, thereby subtracting from and/or adding to the quantity of soils in existence at a particular location.

Separately, Anozie (2006) and Tricart, (2009) revealed that rill erosion starts due to irregularities of the soil surface, the water is often forced to concentrate in small and shallow canals. The flowing water loosens the soil particles, lifts and transports them away. The more water is concentrated in these rills, the stronger the strength of the soil erosion. In a follow-up to Anozie (2006), Udeh (2001) submitted that soil erosion is a function of the hydraulic shear of the water flowing in rills, therefore the erodibility (Kr) and the critical shear (Rc); the shear below which soil detachment is negligible. Detachment rate (Dr) is the erosion rate occurring beneath the submerged area of the erosion. The relationship among the variable is stated as:

$$D(r) = Kr\,(R - Rc)\,(1 - Os/Tc) \text{ ----------(2.1)}$$

Where: D(r) = soil detachment rate in Kg/m^2 -5; Kr = erodibility resulting from shear in s/m; Rc = critical shear below which no erosion occurs; Qs = rate of sediment flow in the erosion in Kg/ms; and R = hydraulic shear of flowing water in Pg = Pg/rs.

According to Anozie, (2006) and Ruxton, (2007), gully erosion is similar to rill erosion but can be considered as an advanced state of rill erosion. Traditionally, gullies are formed when many rills join to increase the volume and bargaining power of the erosion to cave a little deeper into the earth sub-soils. It can be stated here that gully erosion, unlike the rill or any other form of soil erosion, cannot be levelled by mere ploughing because of its depth which cuts across several distances into the earth crust.

Thus, this study strives to identify the major gully sites in the study area and also studied very closely the impacts of soil erosion (accelerated) on the built environment. Following this, the study attempted an explanation to the effects of the major factors that influences soil erosion in the areas; as well as identifies the consequences and effects of soil erosion on the built environment, thereby seeking possible precautionary/corrective measures to check the soil erosion excess and maximize the use of this knowledge in the prevention of soil menace.

MATERIALS AND METHODS

Agulu-Nanka, Ndiegoro and Onu-Ibina are located in the rural areas of Aguata, Aba-South and Igbere Local Government Areas respectively. It is dispersed with a few infrastructural facilities like electricity, water, and educational services. Most of these facilities came as a result of the establishing Onu Ibina in its domain. Nanka, Ndiegoro and Onu-Ibina have a moderate population in terms of its rural and urban setting. Its economy is an agrarian one. The longitudes of the study areas lie between 5^o 22'E and 7^o42'E and latitudes between 3^o 15'N and 5^o 45'N (Ibitioye, 2015). Collectively they span across a total land area of 98,997 hectares. The study areas population ranges from168, 507 to 334, 088 with

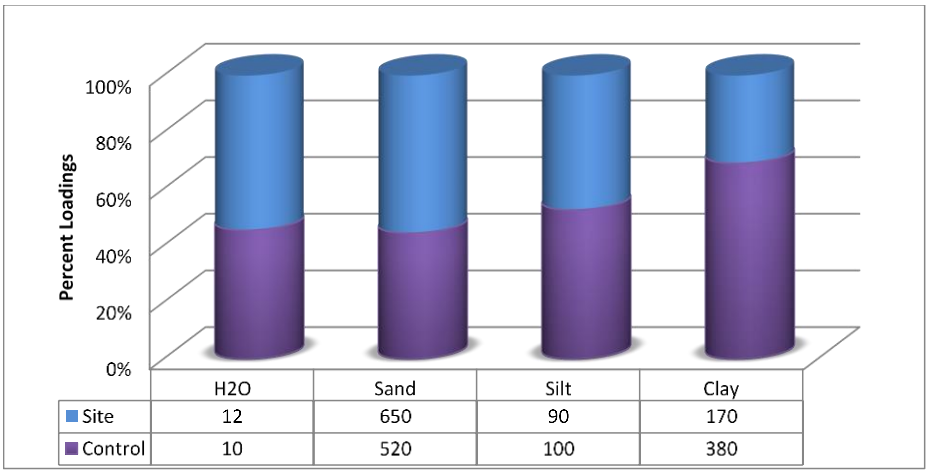


Figure 1. Comparative analysis of gully erosion sites between Agulu-Nanka gully erosion and the control sites.

autonomous communities (Bassey, 2005). The climate is of tropical Monsoon type (Okin, 2017). According to Onwuchekwa (2013), the rainfall starts early March and ends late October annually with a total annual rainfall of 2250mm.

The study relied both on primary and second-handed information. However, credence is given to primary source of data acquisition, through questionnaire, field surveys, spot measurements, and interviews and direct observations. Having being constituted of primary data, it is, therefore, evident that the study is a quantitative in nature, and as to that, laboratory testing is required in order to substantiate the facts. This is performed by testing and analysing soil samples from the selected sites.

The study involves comparative analyses of three gully erosion sites in south eastern part of Nigeria. Data analysed here is mainly derived from data (soil sample) from the various gully sites of: Agulu-Nanka gully erosion site, Ndiegoro in Aba gully erosion site, often called Aba-South gully site and Onu-Ibina gully site in Igbere. Samples were obtained from the three sites, analysed and presented using statistical tables and illustrated using charts to illustrate vital issues. It is necessary to explain that the “control site” as used in this analysis refers to a non-erosion ravaged site, which is the base of assessing data from the three gully erosion sites from the case study areas. The following codes are applicable: Site 1: Agulu-Nanka gully erosion site; Site 2: Ndiegoro in Aba gully erosion site; and Site 3: Onu-Ibina gully erosion site. From the three sites, the assessment components are water, sand, silt and clay.

RESULTS AND DISCUSSION

Analysis of soil samples from Agulu - Nanka gully erosion site

Figure 1 shows the condition of the Agulu - Nanka gully erosion site and it illustrates that Agulu-Nanka’s soil is predominantly clay, with traces of silt and water; however, comparing the soil texture of the Agulu–Nanka gully erosion site with the control site, it is obvious that there are variations in proportion of water, clay and silt content of the soil composition.

These problems are directly or indirectly related to the following factors: percentage aggregate formation of the soil catena; variable proportion indices; and nearness to the existing water source closest to the sites. These problems together with their causal factors are responsible for the advanced state of the gully. Since the predominant sandy soil structure is highly associated with leaching and washing away of soil constituents (as substantiated by the whitish form of the exposed soil) that assist the soil mass in resisting possible erosion threats. It therefore, suffice it to suggests that the soil is composed of weak and porous materials that does not resist the force of water runoffs in the area, thereby exacerbating gully erosion ravages (Onwuchekwa, 2013; Adegun, 2016; Kalu, 2017).

Analysis of soil samples from Ndiegoro-Aba gully erosion site

The data obtained from the soil constituents of Ndiegoro gully erosion sites are presented in Figure 2. From the analysis, the textural composition of the soil is predominantly sandy, followed by clay and subsequently silt. Therefore, the soil texture of Ndiegoro-Aba gully erosion site is sandy clay. However, comparing the soil texture of the Aba-South gully erosion site with the control (ideal) site, it is noticeable that although sandy soil is predominant, clay soil has a greater impact on the gully, since clay has a shear percentage of the textural analysis, after that silt. This could also be adduced as being the reason behind the advanced nature of the gully. Secondly,

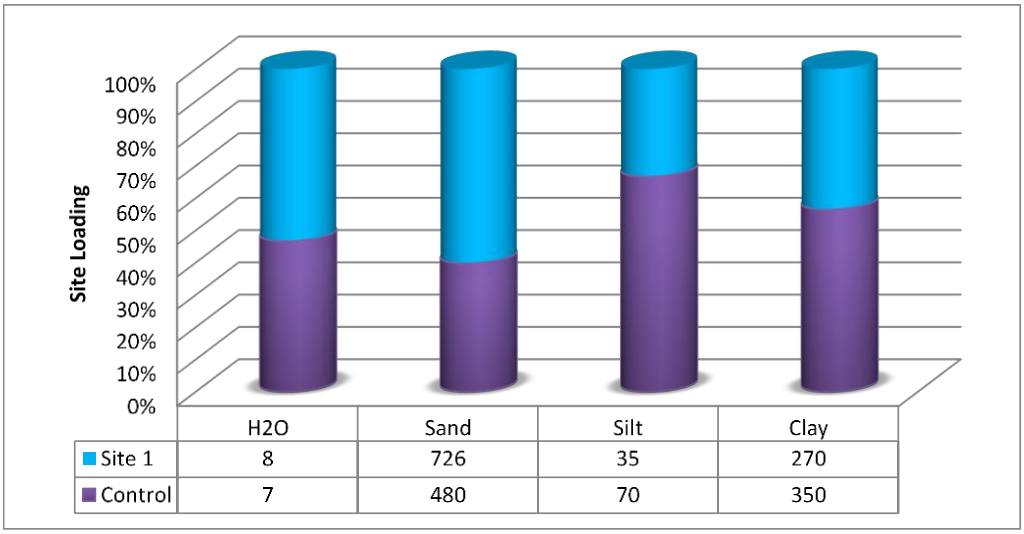


Figure 2. Comparative analysis of gully erosion sites between Ndiegoro Aba gully erosion and the control site.

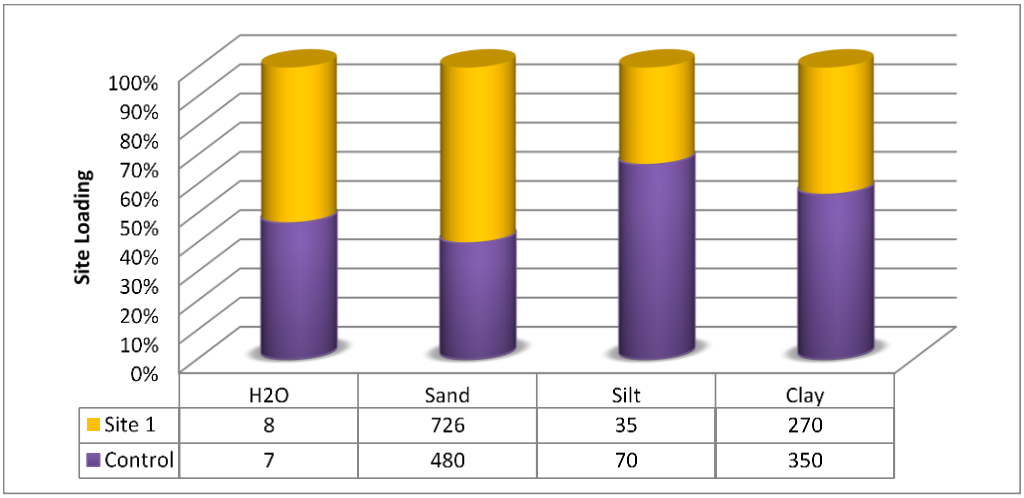
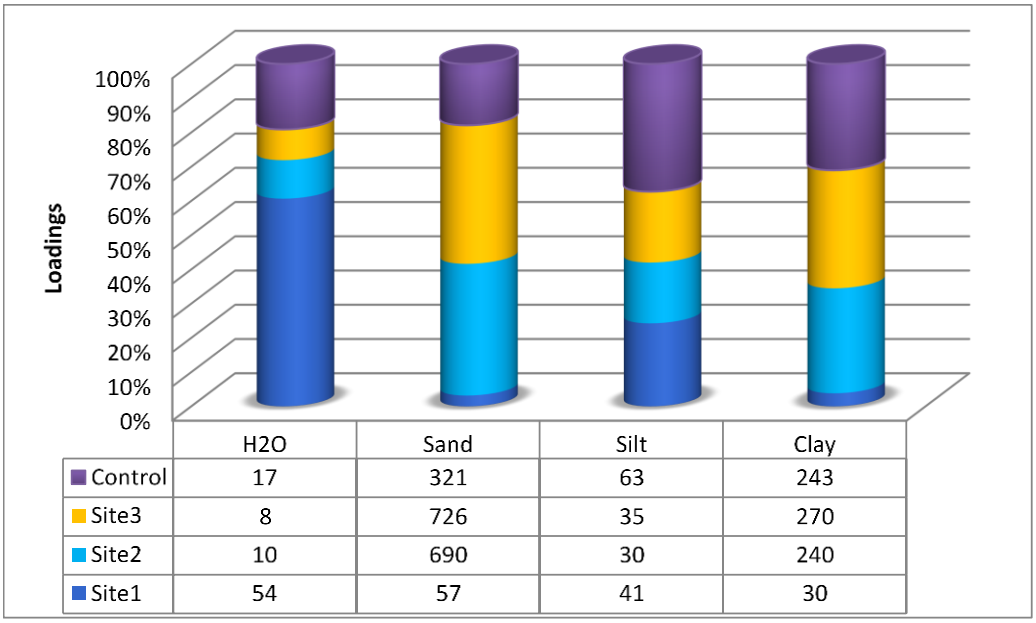


Figure 3. Comparative analysis of gully erosion sites between Onu-Ibina Igbere gully erosion and the control site.

since sand is predominant in the soil structure, it then suggests that the soil formation is permeable, hence, does not retain much water, for this reason, resists the strength of water runoffs, especially where the slope is very steep (Bassey, 2005; Albert, Abegunle and Samson, 2014; Emeribe, 2017).

Analysis of soil samples from Onu-Ibina gully erosion site

Analysing the soil sample data generated from Onu Ibina gully erosion sites, Figure 3 shows the condition of the Onu Ibina gully erosion site. From the results, it is apparent that the textural composition of the soil is mainly sandy, with little quantities of silt and clay. Therefore, the soil texture of Onu-Ibina gully erosion site is sandy clay. However, comparing the soil texture of the Onu Ibina gully erosion site with the control (ideal) site, it is noticeable that although sandy soil is predominant, the presence of little quantities of silt and clay soils suggests that the soil does not retain water in the required proportion. This could also be the reason behind the accelerated gully erosion. Following the analysis, it is evident that there is a significant difference between the control site and the Onu-Ibina gully erosion site; this could also be the reason for the existence of the gully. In addition, since sand is



	H2O	Sand	Silt	Clay
Control	17	321	63	243
Site3	8	726	35	270
Site2	10	690	30	240
Site1	54	57	41	30

Figure 4. Summary of the comparative analysis of sampled gully erosion sites.

predominant in the soil structure, it then suggests that the soil formation is porous and does not retain much water, hence having exacerbated impact on the immediate land, particularly, properties having steep and gentle slopes gradients.

Summary of the analyses of the sampled gully erosion sites in Aba-South and Aguata Local Government Areas

Sequel to the analysis of the three gully erosion sites, Figure 4 indicates that the general difference in the soil samples is pronounce in the level of soil formation and permeability, which is a common phenomenon with soils from Aba-South and Aguata regions. The three sampled gully erosion sites have sandy soil as its major soil composition. This is followed by clay and silt. The presence of clay and silt in little quantities especially in sample 3 shows the level of soil weakness and water permeability. Therefore, the three erosion sites sampled are greatly influenced by natural and anthropogenic factors. Most of these sites, like Agulu-Nanka gully erosion site, Ndiegoro in Aba South gully erosion site, and Onu-Ibina Igbere gully erosion site, have been there for over 48 years. The reason for the advanced state of the gullies is highly suspected to be the combination of slope gradient and slope types which are mainly natural (Figure 4).

Conclusion

This study identified the major gully sites in the study area and studied very closely the impacts of accelerated soil erosion on the built environment. As a result of this, the study attempted an explanation to the effects of the major factors that influence soil erosion in these areas; as well as identifies the consequences and effects of soil erosion on the built environment, thereby seeking possible precautionary/corrective measures to check soil erosion excess and maximize the use of this knowledge in the prevention of soil menace.

The study further revealed that gully erosion is at advance state, intensifying in all the case study areas. The soil in Agulu-Nanka area is mainly composed of weak and porous materials that do not resist the force of water runoffs in the area, thereby exacerbating gully erosion ravages. In Ndiegoro-Aba area, the soil structure is predominantly sandy clay; this shows that the soil formation is permeable, and does not retain much water, hence resisting the strength of water runoffs, especially where the slope is very steep. Onu Ibina soil formation is porous and does not retain much water, hence having exacerbated impacts on the immediate land, and properties located within steep and gentle slope gradients. The three gully erosion sites studied have been there for decades. The old gully sites are fast being amazingly recovered naturally, while new sites are deepening and widening daily. The consequences are enormous with the reoccurring one being socio-economic. The socio-economic consequence also results in a continuous loss in soil fertility, thus leading to low yields from farming, which is the main occupation of the vast majority of the sampled pollution; a phenomenon that might lead to

increase diminution of cultivable lands – the main resource of the people.

The control and management of soil erosion require prompt attention and well-tailored decisions, because of the dynamism of its immediate and future consequences. The dynamic nature of the problems, therefore, demands peremptory consideration, as wrong actions quite often produces incorrect results, hence potential large gully erosions sites can be regained through concerted efforts by the stakeholders, and this most begin early if we all must stop the much-maligned and hydra-headed soil erosion ravaging Nigerian towns and rural areas.

Consequently, there is the need for a legislation aimed at reducing, if not abating the practice of deforestation;the act of land fragmentation mainly for agricultural purpose should be checked, on the contrary, mixed cropping should be encouraged; there is the need to ensure that part of the recovering measure to gully erosion site should include re-grassing of the gully belts and forestation of its banks. This will yield an amazing result; unchecked water runoffs should be avoided or properly coursed to reduce further damage on gully sites, and government and private organizations should unit to reduce the wild spread of gully erosion in the case study areas.

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