EVALUATION OF PLANT ROOTS PROLIFERATION AND VEGETATION CHARACTERISTICS ON THE GULLY HORIZON OF SOME SELECTED EROSION SITES IN IMO STATE, NIGERIA.

Abstract

The development of vegetative in the gully erosion sites has been proved to be dependent on the type of soil found in the erosion site. The growth of vegetation along the gully horizon is determined by the depth the roots of these plant species will grow down the horizon. This study aimed at determining the plant root proliferation along the gully horizon of three different locations of gully erosion sites, which include the urban, semi-urban and rural areas.

This study was carried out in three selected gully erosion sites in Imo State, South East, Nigeria from 15th January 2021 to 31st March 2021.

Random sampling technique was used in determining the vegetation characteristics of the gully profile with quadrat. Knife was also used in cutting and counting the roots, while tapes, pegs and compass were used in the location mapping.

The rural gully erosion location has more vegetation and roots proliferation on the gully profile (L1) than the semi-urban (L2) and urban locations (L3), respectively.

Urbanization and other destructive man activities reduce the species diversity of many plant communities. This is seen in the number of roots and vegetation seen growing on the gully horizon which is higher in the rural than the Urban areas of these locations. Therefore, some species seen thriving at these erosion sites, such as *Oxythenantera abyssinica* and other species from this study, should be used a means to control erosion and reclamation of soil in these areas.

Key word: Gully, Species, Horizon, Profile, location, Proliferation.

INTRODUCTION

Green plants are essential for the existence of all kinds of life (Dutta, 2009). They function both in purification of the atmosphere and manufacture of food. It is evident, therefore that animals including human beings are indebted to plants for their basic needs. These plants in turn need the soil for anchorage and nutrient intake (Gruyter, 2020).

The degree of variation of life forms within a given specie, ecosystem, biome or planet (biodiversity) has a strong link with the soil which is the medium for a large variety of organisms and interacts closely with the wider biosphere where the biological activities is based (Ross, 2013), soil provides a vital habitat-primarily for microbes including bacteria and fungi; also for micro fauna, mesofauna and macro fauna (Ross, 2018).

Human intervention such as deforestation and practices associated with over farming remove the components of the soil that help to bind soil together and the structures that protect it from the forces of the elements. When this happens, erosion and other factors of degradation can act to draw the nutrient-rich topsoil off the farmland, often depositing it in water courses. This destroys the productivity of the land and damages the rivers and lakes where the top soil ends up (Sakinatu, 2017). The countries of sub Saharan Africa are besieged by serious environmental degradation resulting in desert encroachment, draught and soil erosion due to either wind impact or very high intensive rainfall (Daniel, 2012). The ecological and social settings of this zone are often distorted sometimes leading to losses in human and materials capitals (Zommers, 2016).

The greatest threat to the environmental settings of Southern Nigeria is the gradual but constant dissection of the landscape by soil erosion by water (Daniel, 2012).

Food crops grow best in fertile soil, which is a serious is a mixture of sand, clay and rock particles. Most of the humus that sustains the activities of the micro-organisms and plants is found in the uppermost layer of the soil, called the top soil. Such soil produced by long term interaction between the soil and plants growing in it (Dora, 2019).

The role of vegetation in soil reclamation is an ameliorating one. The binding properties of their root systems and the formation of humus from leaf fall contribute to soil development. According to Numbere (2020), vegetation, especially the root system possessed by particular dominant species growing on a particular land area. Plays a major role in stabilization and rehabilitation of eroded lands.

Visual observation on some selected gully erosion sites shows that areas with less species of some particular plants show greater damages by gullies than areas with these plants.

In South Eastern Nigeria, there is rapid depletion of soil due to erosion and other forms of soil degradation. This can be attributed to the reckless exploitation of our land resource to satisfy man’s unending wants. This study aims at studying the root proliferation along the walls of gully horizon of some selected erosion sites which when understood well, will be of great help in identifying some plant species that thrives on erosion gully horizon. This in-turn can be of major help in controlling the menace of erosion in the world.

This study was carried out to study plants that are able to thrive in a low nutrient and acidic soils, thereby restoring the productivity of such soils. Plants are able to achieve this through their roots which bind soil particles together thereby increasing the soils ability to resist detachment and soil erosion.

There are some factors that cause some soil to be more susceptible to degradation, than others. The analysis of soils on erosion sites physically and chemically can give a reasonable answer to the causes of erosion on these sites. Also some dominant plant species seen at these erosion sites can be a solution to the type of plant needed to control erosion on any soil with the same characteristics in any part of Africa or the world at large. Hence, profile characteristics study of selected gully erosion sites (Vegetation growth and root proliferation on the gully horizon) in South-East Nigeria will be of great help in order to solve the erosion menace even in Africa as a whole.

MATERIALS AND METHODS

LOCATIONS AND DESCRIPTIONS OF SITE

Imo state is a state found in the Eastern part of Nigeria which is characterized as rainforest zone. Imo State is located at longitude 5.5720^{0}N and latitude 7.0588^{0}E. Owing to mass deforestation they are now in the derived savannah ecological zone that receives between 1500mm-2000mm rainfall annually (Derek, 2019). The rainfall of these areas is always at the peak in the month of July and September.

Within the vicinity of these three erosion sites are shrubs, especially *Oxytenanthera abyssinica* (bamboo) are seen majorly at the erosion sites in abundance. Within the erosion sites in Owerri are found fruit plants like Musa species (*Musa paradisiaca* and *Musa sapietum*) banana and plantain respectively.

These areas are located within the highly weathered soil (utisols) of Eastern Nigeria (Imo state). The areas have been subjected to intensive flood coming from rainfall. The soils of these areas due to this intensive flood were carried away by erosion. These areas are in the devastating conditions, in that gully erosion, has set in from the study, the soil in these sites had low nutrient reserve and high acidity (Igwe, 2012).

The location of the gully sites studied is in Owerri Municipal, the capital territory of Imo state; also in a semi urban area of Awo-Omamma in Oru East and in a rural Area of Orlu all in Imo State.

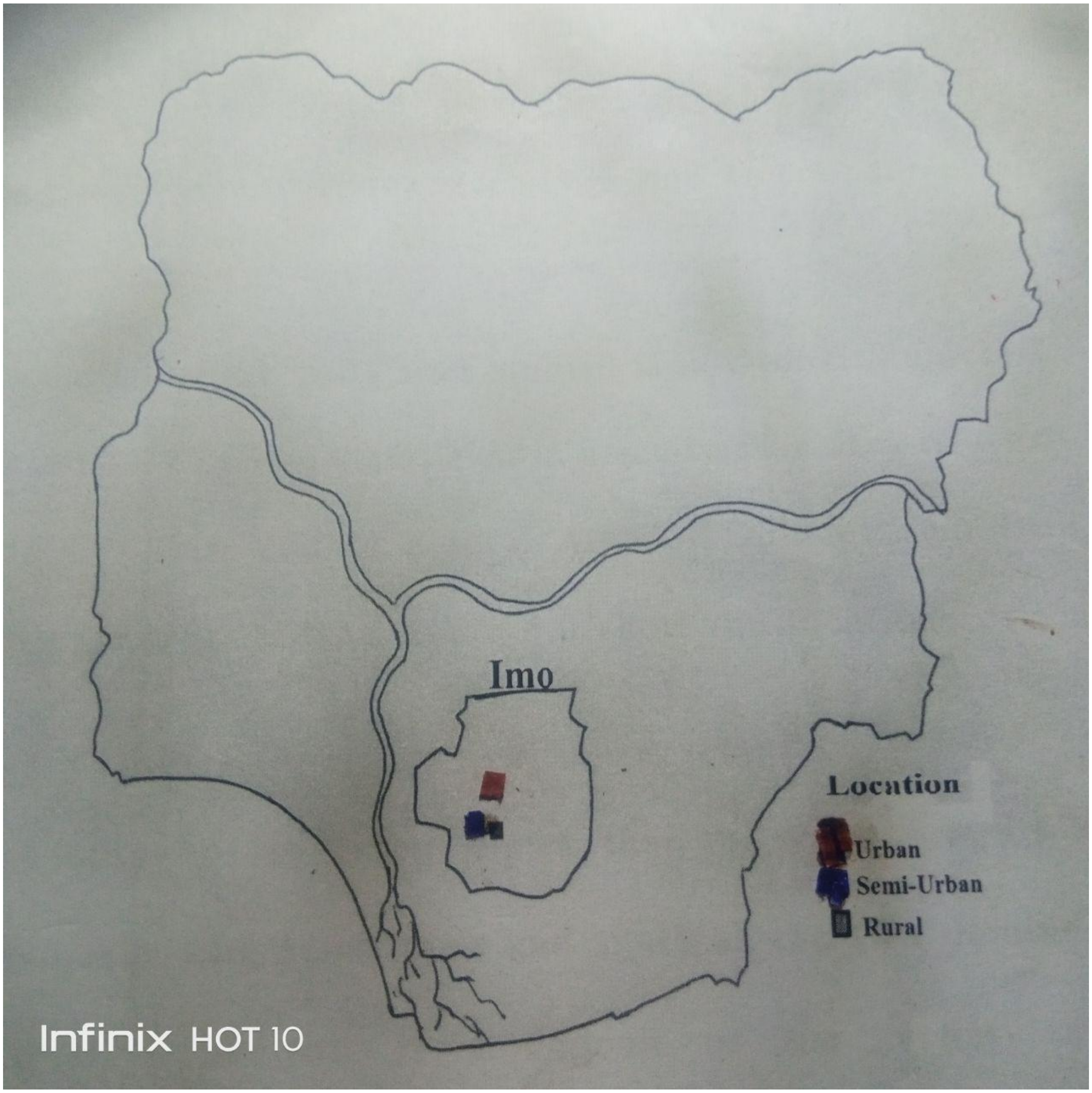

Figure 1: Map of Nigeria Showing Locations of the gully sites in Imo State.

The pedology of the area shows that the soils are all of sedimentary origin with sandstones and shale as the two dominant parent materials. The soil is a deposit of the territory age characterised by red and brown soils rich in iron. It belongs to the utilised order (Alka, et al., 2017).

The climate of the area is dominantly the tropical types and has a uniformly high temperature with mean monthly minimum of 26^{o}c. The rainfall is intensive with an annual range of 1200mm-1500mm, and occurs in a single season from March to November.

MATERIALS USED

The materials used include measuring tape, spade, polythene bags, white cello tape for labelling, knife, which were collected from the Botany laboratory, Nnamdi Azikiwe University, Awka. Nigeria

EXPERIMENTAL DESIGN AND LAYOUT:

The experiment was performed/carried out in three different locations. Before samples were collected, a preliminary survey of the gully site area was carried out to ensure proper sectioning of the sites to be located in an urban, semi urban, and rural areas. This was aimed at establishing the gully effects of water runoff in three locations in order to arrive at a reasonable conclusion in solving the related problems in this type of areas in other parts of the country and West Africa under the same type of geographical climate taking into consideration the effects of (some plants that thrives in this areas prone to erosion. *Oxytenanthera Abyssinica* which is one of the plants seen around the gully sites will be studied). The root proliferation along the gully horizon

(if any) of the *Oxytenanthera abyssinica* (bamboo) in reclamation of these areas will also be studied considering the depth of the gully.

These sites having been ascertaining to be prone to erosion were marked out with pegs and tapes, and the depth of the gullies from the top soil to the floor were measured.

Furthermore, 9 metres was map out horizontally along the left and right side of the gully horizon. The lengths taken, were further divided horizontally into three parts to make up 3 metres each. These areas were mapped out, considering the terrain of the gully, which cannot be covered. The measurement of 5 metres from the topsoil were also taken vertically as depth 1, another 5 metre depth were marked out and recorded as depth 2 and the last 5 metre as depth 3.

Using the same 5 metre vertically and 3 metre horizontally, the first 5 metre depth were taken as depth 1, second metre as depth 2 and the third, depth 3 respectively, while the 9 metres divided into three parts were taken as row 1, 2 and 3 respectively.

Using a compass as a determinant, the left side of the gully sites were taken as the East side while the other right side were taken as the West side of the gully sites.

ROOTS SAMPLE COLLECTION

The first locations of the gully sites in the urban area was given location A, semi urban area was given location B, while that of the rural area was given location C.

The roots seen on the surface of these gully erosion horizon sites were cut through the depth and the horizontal parts and the root numbers counted depth by depth and the total number recorded for root proliferation calculation.

PLANTS SPECIES ROOT PROLIFERATION COUNT.

Procedures: Physical methods of collecting of plants root seen on the surface of the two sides of the gully were used. A sharp knife is used to cut the root seen on the surface of the rows of the three depth mapped out. The roots collected were counted and recorded for each row of the depth and the proliferation on each depth determined in the relation to the depth of the gullies.

PLANTS SPECIES IDENTIFICATIONS AND POPULATIONS COUNTS.

A 60cm x 60cm quadrat was placed at random between a distance of 30 metres each from the two sides of the gullies to determine the lower plants species growing on the walls of the erosion site. The plants species were counted and specimen collected for identification. The method used in the plant species sampling is the random sampling to ensure that every part of the sampling area has an equal chance of being sampled. Two straight lines at right angles to each other from the margin of the 30m × 30m area mapped out and around its gully sites will be established. This area mapped out was sampled ten times with a 1m x 1m Quadrat using a pair of random numbers that were picked for the pair coordinates making sure no pair will fall outside the area mapped on the horizon.

The random point was determined by tracing the random number at one of the coordinate points and the quadrat placed at the point of interception of the coordinates.

From the result of the ecological sampling, abundance measures calculated include specie density, frequency, relative density, relative frequency, and importance value.

PLANT PARAMETERS

The formular used for obtaining the Above abundance measure is

$$\text{DENSITY} = \frac{number\ of\ each\ specie}{Total\ area\ sampled}$$

$$\text{FREQUENCY} = \frac{number\ of\ times\ a\ specie\ ocuured}{total\ number\ of\ times\ seacrched\ for\ it} \times \frac{100}{1}$$

$$\text{RELATIVE DENSITY} = \frac{Density\ of\ each\ specie}{Total\ densities} \times \frac{100}{1}$$

$$\text{RELATIVE FREQUENCY} = \frac{Frequency\ of\ each\ specie}{Total\ frequency\ of\ all\ specie} \times \frac{100}{1}$$

IMPORTANCE VALUE = Relative frequency + Relative density

- Species diversity will also be calculated using Shannon Wiener index of species diversity
  H^1_{max} =Lns   where S = Total number of species
  Equitability, $E = \frac{H^I}{H_{max}}$ H_{max}^{1} = max equitability
  E= Summation sign
  PI = Proportion of species in the community
  Ln = Natural log
  S = Number of species

DATA ANALYSIS

The data collected was subjected to statistical analysis using 2-way analysis of variance for the effect of location on the root proliferation and some percentage cover of some plants species present were determined and data collected were subjected to analysis of variance which were related to depth.

ANALYSIS OF VARIANCE (ANOVA) TABLE

Source of variation	**Sum of square (SS)**	**Degree of freedom**	**Mean square(MS)**	**F* Ratio**
Sum of square treatment	SS_T	K-1	SS_t/d_f	MS_t/MS_E
Sum of square Error/within	SS_E	K(N-1)	SS_E/d_f	
Total		N-1	SS_t/d_f	

Computational Formulas

SS between (Trt) = $\frac{(\sum X1)^2}{n1} + \frac{(\sum X2)^2}{n2} + \frac{(\sum X3)^2}{n3} - \frac{(\sum X)^2}{N}$

SS TOTAL = $\sum x^2 - \frac{(\sum X)^2}{N}$

SS Within = SS Total – SS Between(Trt)

Degree of freedom between = K-1

Degree of freedom within = N-K

Degree of freedom Total = N-1

$MS_{trt} = \frac{SS\text{trt}}{df\text{trt}}$, $MS_E = \frac{SS\text{E}}{df\text{E}}$, $F^* = \frac{MS\text{trt}}{MS\text{ E}}$

Where $X_{1,2,3}$ = Lth observation for the row in the replicates

L =1,2……

T = total for all observations from the row 1,2,3

N = Numbers of observation/treatment in each locations

SS_{Total} =Total sum of square

$SS_{trt/btw}$ =Treatment sum of square

SS_{within} =Within/Error sum of square

MS_{Trt} =Mean square treatment

MS_E =Mean square within/error

F* = Fischer’s calculated variance ratio

HYPOTHESIS TESTED

(1) For location, H_o: α (no significant difference)

H_1: α (Significantly difference)

(2) For %cover, H_o: α (no significance difference

H_1: α (Significantly difference)

(3) For root proliferation

H_o: α (No significant difference)

H_1: α (Significantly difference)

RESULTS

VEGETATIVE DEVELOPMENT AT THE GULLY PROFILE

Table 1 shows the vegetative development at the gully profile by location. The table indicates that plants root proliferation cut and counted in the gully sites is higher in rural location (961.56) and lower in the Urban location (295.28). The analysis of variance indicates a significant difference in the root proliferation on the gully profile among locations (p=.05). The table also indicates that the number of plant species on the gully surface is highest in rural location (2.72) and lowest in Urban locations (0.94). The analysis of variance indicates a significant difference in the number of plant on the gully profile between locations (p=.05).

TABLE 1: Root Distribution/Proliferation at the Gully Profile by Location

Location	Root Proliferation	No of plant spp at the Gully Surface
Urban	295.28±5.024c	0.94±0.305c
Semi-Urban	403.33±5.447b	1.83±0.724b
Rural	961.56±5.070a	2.72±1.493a
p-value	0.000	0.026

Table 2 shows the root distribution at the gully profile at given horizons. The table indicates that plant root proliferation cut and counted horizon by horizon in the gully sites, when added together is highest at the surface horizon D1 (1007.22) and lowest at the subsoil horizon D3 (162.44). The analysis of variance indicates a significant difference in the root proliferation on the gully profile between horizons ($p<0.05$). The table also indicates that the number of plant species on the gully surface is highest at horizon D1 (3.722) and lowest at the subsoil horizon D3 (1.237). The analysis of variance indicates a significant difference in the number of plant on the gully profile between locations ($p<0.05$).

TABLE 2: Root Distribution/Proliferation at the Gully Profile at given Horizons

Horizon	Root Proliferation	No of plant spp at the Gully Surface
D1	1007.22±18.17c	3.722±0.994c
D2	490.50±11.413b	1.667±0.237b
D3	162.44±15.785a	1.237±0.323a
p-value	0.000	0.000

Table 3 shows the root distribution at the gully profile by aspect. The table indicates that plant root proliferation in the gully site is higher towards the West aspect of the gully (559.037) than the East aspect (547.741). There is also no significant difference in the root proliferation on the gully profile between gully aspect ($p>0.05$). The table also indicates that the number of plant species on the gully surface is higher towards the East aspect of the gully (2.00) than towards the West aspect (1.237). There is also no significant difference in the number of plants on the gully profile between gully aspects ($p>0.05$).

TABLE 3: Root Distribution/Proliferation at the Gully Profile at Given Aspect

Gully Aspect	Root Proliferation	No of plant spp at the Gully Surface
East	547.741±28.325	2.000±0.881
West	559.037±27.120	1.667±0.148
p-value	0.931	0.547

Table 4 shows the analysis of variance of the vegetative development on the gully profile. The table indicates a significant difference in the root proliferation and number of plants on the gully surface between location and gully horizon ($p<0.05$) but not between aspect of the gully ($p>0.05$). There is interaction between location and gully horizon for both root proliferation and number of plants on the gully surface ($p<0.05$). there is however no interaction between aspect and location or between aspect and gully horizon ($p>0.05$).

TABLE 4: Analysis of Variance of the Vegetative Development on the gully profile

Vegetative Development		Main Effect: Location	Aspect	Horizons	Interaction Effect: Location and Aspect	Location and Horizon	Aspect and Horizon	Location Aspect and Horizon
Root Proliferation	F-ratio	1098.39	0.822	1558.04	1.327	84.782	1.033	1.799
	p-value	0.000*	0.371	0.00*	0.278	0.000	0.366	0.150
Number of Plant species	F-ratio	10.521	1.110	43.685	0.493	2.301	0.041	0.534
	p-value	0.000*	0.299	0.000*	0.615	0.077	0.960	0.711

*significant difference exists at $p<0.05$

Table 5 shows the species abundance status of the gully site by location and aspect. The table indicates that the gully site by location and aspect is dominated by *Panicum maximum* with the exception of the East aspect of the semi-urban location which was dominated by *Aspillia Africana*.

TABLE 5: Species dominance Status of the Gully Site by Location and Aspect

Abundance Plant Species	IVI	Aspect	Location
Panicum Maximum	51.11	East	Urban
Panicum Maximum	66.7	West	Urban
Aspillia Africana	46.67	East	Semi-Urban
Panicum Maximum	66.86	West	Semi-Urban
Panicum Maximum	37.01	East	Rural
Panicum Maximum	46.00	West	Rural

Table 6 shows the species diversity status of the gully site by location. The table indicates that species diversity of the site is highest in rural location (2.34). There was a higher distribution of the species in the rural gully site than in the other gully sites, which is lowest in the urban location (1.73).

TABLE 6: Species diversity Status of the Gully Sites by Location

Location	No of Species	H^1	H_{max}	Equitability

Urban	8	1.73	2.08	0.83
Semi-Urban	8	1.85	2.08	0.89
Rural	13	2.34	2.56	0.91

Table 7 shows the species diversity status of the gully site by location and aspect. The table indicates that the species diversity is higher towards the east aspect of the gully than the west aspect in all the gully sites. There was also more even distribution of species in the east than in the west aspect of the gully sites.

TABLE 7: Species diversity Status of the Gully Sites by Location and Aspect

Location	Aspect	No of Species	H^1	H_{max}	Equitability
Urban	East	8	1.82	2.08	0.877
	West	6	1.47	1.79	0.82
Semi-Urban	East	8	1.89	2.08	0.911
	West	6	1.19	1.79	0.66
Rural	East	13	2.56	2.56	0.92
	West	13	2.27	2.56	0.866

H^1 = Shannon-wiener's diversity index,

H_{max} = Maximum diversity possible/equitability

DISCUSSION AND CONCLUSION

The study examined the vegetative abundance and root proliferation on the gully profile of some selected erosion sites in Imo State with respect to locations, aspect and horizon. The study indicated that the gully horizons has different vegetative abundance on it, which is higher towards the upper part of the horizon than the lower part. The upper horizon was observed to have the highest root proliferation and number of plant species than the lower/deeper part of the gully horizon. This is as a result of water content of the topsoil that affects the root growth in that layer (Nambiar, 1977); and of high nutrient content of the topsoil which decreases as you go down from the topsoil.

In conclusion human activities through Urbanization can alter Ecological characteristics and vegetative development of any gully site. Kohli et al. (2012) studies confirms the findings of this study, showing that urbanization and other destructive man activities reduce the species diversity of many plant communities.

This is seen in the number of roots and vegetation seen growing on the gully horizon which is higher in the rural than the Urban areas of the locations. The vegetative development at the gully site was particularly different across location and gully horizon. The plants species thriving well in these sites can be used in erosion control measures across Africa and beyond. This is because from the study, for any plant to be able to survive and thrive in erosion ravaged soils, it must have some peculiar characteristics that enhances its survival and can be very useful in soil reclamation.

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