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Website: www.aarf.asia Email : editor@aarf.asia , editoraarf@gmail.com

AN EVALUATION OF THE ANTHROPOGENIC FACTORS OF SOIL EROSION PROBLEMS IN NEKEDE IMO STATE

CHUKWU, Kevin Ejike (Ph.D).

Department of Geography and Meteorology,
Faculty of Environmental Sciences
Enugu State University of Science and Technology (ESUT), Enugu State

Abstract
This research seeks to examine the following topic "an evaluation of the anthropogenic features that lead to soil erosion problems in nekede imo state". Soil erosion constitutes the major ecological problem in south-eastern 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 behavior and distribution over time and space are fully understood. The objective of this research is to examine the anthropogenic features of the study area, and to identify the locations of ditches, ponds, streams, roads in order to aid the design of appropriate control measure. The study revealed that economic activities have been put to a halt due to the cut-off of the road, farm lands have been eroded ,water for domestic use contaminated, thus posing great threat to the lives of the residents in the area. However, incorrect information, incomplete data or wrong concepts in the application of either method of erosion control have aggravated gully erosion problems. Many of the erosion control measures put in place in the study location 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. Apart from the Engineering solutions being considered for the control of erosion at Nekede Town, some recommendations were made based on the study of the sites. Emphasis now should be geared towards the prevention of erosion as the cost of controlling the expansion of these are becoming unbearable and also considering the losses and their effects on the environment.
Keywords: Anthropogenic, Soil, Erosion, Problems, Nekede

Introduction

Soil erosion can be regarded as merely a geomorphological process, whereby the surface layer of weathering rock is loosened and carried away by natural agents like wind or running water and a lower horizon in the soil is exposed (Federal Government of Nigeria Ecological Fund Office; July 2012). This is synonymous to fluvial erosion which is the removal of rocks and other mineral particles from the channel bed and banks by water flow from streams, rivers, creeks etc. Under natural conditions, transport of material down slope or in the direction of the wind usually goes on intermittently, and each movement is so slight that erosive processes are very slow and appear to be continuous. Soil erosion which is simply a systematic removal of soil, including plant nutrients, from the land surface by the various agents of denudation occurs in several parts of Nigeria under different geological, climatic and soil conditions. But the degree of occurrence varies considerably from one part of the country to the other. Thus, while it is true to observe that soil erosion is one of the most striking features on the land surface of South Eastern Nigeria, especially in Anambra and Imo States, only rare occurrences of the phenomenon are recorded in some other States of the Federation. Equally varied are the factors responsible for the inception and development of erosion, as well as the types that exist in several parts of the country. . Imo State as one of the States witnesses severe gully erosion and flooding as well as landslides in recent times. Erosion problem in Imo State has assumed such an alarming proportion that almost all communities have been affected. The result of this is that vast lands have been lost while Agriculture activities have been adversely affected; residential buildings are being consumed by the gully.

With recent rapid development and industrialization taking place at Nekede Town, in Owerri West L.G.A of Imo State as a result of the presence of the Federal Polytechnic, Nekede, Owerri which is also located very close to the Federal University of Technology, Ihiagwa, Owerri and its closeness to Owerri Municipal Capital Territory, and other fast developing towns, vast land have been cleared, roads constructed, buildings and industries/factories erected but little or no attention have been given to the consequent effect of these infrastructural development to the environment. The Soil Erosion problem in this area is linked to a number of factors, which include sand dredging (mining) in Otamiri River, neglect of the old Owerri – Port Harcourt Road, use of drainages as refuse dumps. Flood flowing through the roads, neighboring towns and other villages also contribute to erosion. The solution to the problem therefore will involve finding logical discharges for the flood to safe locations without causing further damages and devastation to lives and properties.

Statement of the Problem

A visit to the site revealed that the soil erosion problem in the area commenced as runoff from high grounds unto roads and was noticed as natural drainage track but no attention was paid before it escalated. Though much has been done in the past to alleviate the problems in the location such as construction of drains, culverts and other remedial measures, which is not enough to take care of the runoff from the adjoining roads within the connecting communities. The problems continued even after the previous studies leading to the development of a major

gully. Therefore, the essence of this study is to consider those areas not captured previously that will lead to a more permanent and sustainable solution.

Objectives of the Study

The objectives of this study are:

i. To examine the anthropogenic features of the study area.
ii. To identify appropriate strategies that will aid the design of appropriate control measure in the study area.

LITERATURE REVIEW

Geologic erosion can be caused by a number of natural agents including rainfall, flowing water and ice, wind and the mass movement of soil bodies under the action of gravity which cause the loosened or dissolved earthy and rock materials to be removed from a place and eventually deposited to a new location (Lal, 1990; Morgan and Davidson, 1986).

Extremes of climate and wide variety of parent materials cause great contrast of soil properties in the tropics from soils in other temperate regions. In the tropics soils are highly variable and diverse like the vegetation .The main soil types are alfisols, oxisols, ultisols and inceptisols. Tropical soils low in weatherable minerals and basic cations (sodium, calcium, magnesium, and potassium) resulted from continuous weathering of parent materials (Lal, 1990). The ability of these soils to keep plant nutrients is largely dependent on the humus content found in plant biomass and the organic matter. Crop production in tropical soils is constrained by primarily aluminum-derived soil acidity and infertility but generally their physical properties are favorable. Tropic soils have moderate to high permeability under natural conditions, but susceptible to slaking and development of impermeable crust upon action of raindrops and as a result increases with continuous cultivation. This crusting cause insignificant reduction of filtration rate, increasing water runoff which leads to acceleration of soil erosion (Lal 1979). In the tropics, removal of forest vegetation causes excessive leaching and accelerated soil nutrient loss. Being highly weathered soil types, their constrained minerals generally have poor ability to retain sorbed nutrients against leaching.

RESEARCH METHODOLOGY

Research Design

The design of a study defines the study type (descriptive, correlational, semi-experimental, experimental, review, and meta-analytic). In our present study we would use the experimental design.

- **Descriptive Research Design** is used to describe characteristics of a population or phenomenon being studied. It does not answer questions about how/when/why the characteristics occurred
- In statistics, dependence refers to any statistical relationship between two random variables or two sets of data. **Correlation** refers to any of a broad class of statistical relationships involving dependence.
- **Semi-Experimental Research Design** is something that is experimental, based on or derived from experience or functioning as an experiment or used for experimentation. A research design that does not include a control group.

- In general usage, design of experiments or **experimental design** is the design of any information-gathering exercises where variation is present, whether under the full control of the experimenter or not. However, in statistics, these terms are usually used for controlled experiments.
- The **review** is created after reviewing and combining all the information from both published and unpublished studies (focusing on clinical trials of similar treatments) and then summarizing the findings.
- In statistics, a **meta-analysis** refers to methods that focus on contrasting and combining results from different studies, in the hope of identifying patterns among study results, sources of disagreement among those results, or other interesting relationships that may come to light in the context of multiple studies

Experimental research design is an attempt by the researcher to maintain control over factors that may affect the result of an experiment. In doing this, the researcher attempts to determine or predict what may occur. It is a blueprint of the procedure that enables the researcher to test his hypothesis by reaching valid conclusions about relationships between independent and dependent variables. It refers to the conceptual framework within which the experiment is conducted.

An **independent variable** is exactly what it sounds like. It is a variable that stands alone and isn't changed by the other variables you are trying to measure. For example, someone's age might be an independent variable. Other factors (such as what they eat, how much they go to school, how much television they watch) aren't going to change a person's age. In fact, when you are looking for some kind of relationship between variables you are trying to see if the independent variable causes some kind of change in the other variables, or dependent variables.

Just like an independent variable, a **dependent variable** is exactly what it sounds like. It is something that depends on other factors. For example, a test score could be a dependent variable because it could change depending on several factors such as how much you studied, how much sleep you got the night before you took the test, or even how hungry you were when you took it. Usually when you are looking for a relationship between two things you are trying to find out what makes the dependent variable change the way it does.

It is important to state here that in Environmental, we are concerned with experimental method; therefore, in conducting this study, we set out to Identify and define the problem, by conducting field investigation on the root cause of the problem.

- Formulate hypotheses and deduce their consequences i.e. the null (The null hypothesis reflects that there will be no observed effect for our experiment. In a mathematical formulation of the null hypothesis there will typically be an equal sign. This hypothesis is denoted by $H_{0)}$. And alternative hypotheses (The alternative or experimental hypothesis reflects that there will be an observed effect for our experiment. In a mathematical formulation of the alternative hypothesis there will typically be an inequality, or not equal to symbol. This hypothesis is denoted by either H_a or by H_1.).
- Construct an experimental design that represents all the elements, conditions, and relations of the consequences. i.e. selecting sample of subjects, group or pair subjects, identify and

control non experimental factors, select or construct and validate instruments to measure outcomes, conduct pilot study, and determine place, time, and duration of the experiment.

- Conduct the experiment either in the laboratory or in the field.
- Compile raw data and reduce to usable form. And
- Apply an appropriate test of significant.

Area of Study

Location and Position

Nekede is a town in south-eastern Nigeria; it is located in Owerri West L.G.A of Imo State, about 4km from Douglas Road (West end) the main city of Owerri. This is an Igbo speaking town that is made up of three distinct villages, viz Umuoma, Umualum, and Umudibia (Federal Polytechnic Nekede host). This town also hosts the Imo State new Owerri Capital, the Imo state Ministry of Agriculture and Natural Resources, and the Botanical Zoo. The Federal University of Technology Owerri (FUTO) is 20 minutes' drive from Nekede. It lies on the junction of the Nworie River and the Otamiri River which are the major rivers in the area. According to 2006, National Population Commission Census (NPC) the population of Nekede is 180,215 and using the population estimate of 2.5% annual increase the population of Nekede in 2013 will be 211,753, with a population density of 52 people / sq. km. its population makes up 5.4% of Imo state's total population, and it is fast developing into a city with increasing population due to the citing of Federal Polytechnic there.

Fig 1: **Map of Owerri, Imo State showing the location of Nekede**

Source: Map data (2013) Google

The study area lies at Latitude 5.43^{o} North and Longitude 7.03^{o} East.

The road was built in the Forties as the only road that connects Owerri province and Port Harcourt province. (Federal Government of Nigeria Ecological Fund Office; July 2012). The soil erosion started in the early Seventies. It was initially noticed as natural drainage track but no attention was paid to it until it escalated.

Relief and Drainage

Preliminary analysis of the soil of the area within a depth of 2 meters indicates high percentage of sand and low percentage of the particles (silt and clay). Federal Government of Nigeria

Ecological Fund Office (July 2012). The parent materials (according to geological study report) are of basement complex of false bedded sand stone. This type of soil is highly prone to erosion because of its loose nature.

Climate and Vegetation

Rainfall

Rainfall is an important element of far reaching consequences to the problem of soil erosion. The period for rainy season is between April and October. The average annual rainfall of the study area is about 2300mm. Rainfall in the study area stops within the month of November while March is usually sporadic and only regularized from April with May to July as the climax. Heavy rains are also witnessed in September. The heavy rainfall of this period and its frequency which witnessed large run-offs from the residential, pavement and farmland areas are instrumental to the erosion phenomenon in the place.

Sunshine

Maximum sunshine hours are usually recorded in the dry months of January to April and November to December, when the mean monthly maximum is about 6 hours. Lower values of about 2 hours are recorded for the wet months of May to October.

Temperature and Evaporation

Nekede have tropically dry and wet climate. Average daily minimum temperature is about $19^{o}C$. Evapotranspiration is estimated at 1450mm per year.

Relative Humidity

Relative humidity is lower in the dry period of January to March and November to December with values of about 95% for wet periods, the value increases up to 97% or more.

Occupation and Population of the People

The people of Nekede town are predominantly farmers, but with the citing of a Federal Institution (Federal Polytechnic Nekede Owerri) in the area and its nearness to the city center, it has fast metamorphosed into a commercial center.

Data Collection Method

Data collection is an important aspect of any type of research study. Inaccurate data collection can impact the result of a study and ultimately lead to invalid results. Data collection methods for impact evaluation vary along a continuum. At one end of this continuum are Quantitative methods and at the other end of the continuum are Qualitative methods for data collection.

The **Quantitative data collection methods** rely on **Random sampling** (the selection of a random sample; each element of the population has an equal chance of being selected) and structured data collection instruments that fit diverse experiences into predetermined response categories. They produce results that are easy to summarize, compare and generalize. Quantitative research is concerned with testing hypotheses derived from theory and/or being able to estimate the size of a phenomenon of the interest. Depending on the research question, participants may be randomly assigned to different treatments. If this is not feasible, the researcher may collect data on participant and situational characteristics in order to statistically control for their influence on the dependent, or outcome, variable. If the intent is to generalize

from the research participants to a larger population, the researcher will employ probability sampling to select participants.

Typical quantitative data gathering strategies or methods include:

- Experiments / clinical trials.
- Observing and recording well-defined events (e.g., counting number of gully's or damages done by gully's at the study locations or counting the number of patients waiting in emergency at specified times of the day in a hospital).
- Obtaining relevant data from management information systems.
- Administering surveys with closed-ended questions (e.g. face-to-face and telephone interviews, questionnaires etc.).

Interviews

In quantitative research (survey research), interviews are more structured than in qualitative research. In a structured interview, the researcher asks a standard set of questions and nothing more.

Face-to-face interviews have a distinct advantage of enabling the researcher to establish rapport with potential participants and therefore gain their cooperation. These interviews yield highest response rates in survey research. They also allow the researcher to clarify ambiguous answers and when appropriate, seek follow-up information. Disadvantage include impractical when large samples are involved time consuming and expensive.

Telephone interviews are less time consuming and less expensive and the researcher has ready access to anyone on the planet that has a telephone. Disadvantages are that the response rate is not as high as face-to-face interview as but considerably higher than the mailed questionnaire. The sample may be biased to the extent that people without phones are part of the population about whom the researcher wants to draw inferences.

Computer Assisted Personal Interview (CAPI) is a form of personal interviewing, but instead of completing a questionnaire, the interviewer brings along a laptop or hand-held computer to enter the information directly into the database. This method saves time involved in processing the data, as well as saving the interviewer from carrying around hundreds of questionnaires. However, this type of data collection method can be expensive to set up and requires that interviewers have computer and typing skills.

Method of Data Analysis

The methods used in analyzing the accuracy of data collected include:

Statistical Test: the data that has been collected are being analyzed by doing various statistical tests, by selecting the type of statistical test on the basis of data collected. For example data has been collected through observation therefore correlation statistical method should be selected.

Other methods used are interpretations of interviews, data presentation, moving average method, and the rational formula or method. The study of soil erosion at Nekede Town revealed that gully erosion emanated as a result of very steep slopes causing very high flow velocities.

Methods to be employed in the control will include:

- The use of inlet structures, discharge channels, concrete stilling basins, chutes, sills etc. to channel water from the steep slopes into the channels.

- Reclamation of the gullies will be carried out where these are inevitable. This will be carried out where gullies cut or tend to cut off access to buildings and roads. Discharge channels will be constructed after this to protect the reclaimed portions. Planting of choice vegetation will then be undertaken where necessary.
- On sloping ground, interceptor channels would be constructed to discharge flood logically from the high ground to the stream bed without further threat.
- Roadside drains would also be provided where faulty discharge from roads or that due to high gradients occurs. Areas with flooding would be identified and the flood discharge adequately.
- Attempt would also be made to reconstruct the road already rendered unmotorable.

Standard Methods of Gully Erosion Control

Basically, there are two anthropogenic standards for the control of gully erosion:

1. The gully could be reclaimed by artificial means through filling with selected materials. This method is however expensive and can only be used where this is inevitable for example to save a roadwork and put the road back into use as well as to save a building from collapse or being rendered inaccessible. The problem does not end with the filling of the gullies but a clear understanding of what triggered the erosion in the first place. This may require the construction of a diversion channel which ensure that the run off does not remove the fill material and thereby reactivate the gully. The reclaimed gully is thereafter protected with vegetation cover.
2. The flood is dropped down the gully bed via drainage structures and safely discharged into nearby streams or rivers. The sides of the gullies are then stabilized by cutting to appropriate slopes and these slopes protected by wicker work fencing, grassing and re-afforestation.

ANALYSIS OF DATA AND DISCUSSION OF RESEARCH FINDINGS

DATA PRESENTATION

Maximum Discharge: For the determination of maximum discharge a 10 year Return Period is adopted. Discharge is calculated using the Rational Method which is generally reliable for estimating peak rate of run-off. The Mean annual Rainfall for Nekede Town is taken to be 2000mm. the formula is generally adopted for drainage areas of up to 200 hectares and assume that rainfall intensity is uniform over a given period.

The Rational Formula is given by:

$$Q_{max} = \frac{C.I.A}{360}$$

Where Q = discharge in m^3/s

C = run-off coefficient

I = intensity of rainfall in mm/hr.

A = area of watershed in ha.

The amount of, and the rate at which rain water reaches the channels is dependent on the extent of the area to be drained and the relative permeability of the surface over which it has to flow. Apart from the first rain, it is expected that with the nature of the ground slope, the rain water will discharge from the catchments into the channel inlets in 3 – 5 minutes. In small basins and

on hillsides slopes an appreciable part of the time required for rainwater to reach the inlet may be spent on over land flow.

Results Presentation

Return Period: This is the interval between occasions when the given value of variables (precipitation) is equalled and exceeded A 10 year Return Period is adopted for this design. This takes into account of the design life of the facilities provided and also depends on which damage frequency is considered acceptable. In the Rational method, assumption is made that peak discharge frequency and the rainfall frequency are the same. This tends to provide a good factor of safety as the run off value is generally over estimated.

Run off Co-efficient: run off co-efficient varies with land characteristics of the drainage area e.g. infiltration capacity of soil, slope, vegetation cover and general precipitation characteristics. The drainage area can be described as a cropland; open scrub and woodland with permeable soil, having slopes of up to 15% (see Table 1)

Channel Design (using Manning Formula): This is the formula generally used in the design of channels and is given by:

$$V = \frac{R^{2/3} \cdot S^{0.5}}{N}$$

Where V = mean velocity in the channel in m/s

N = a constant

R = hydraulic mean depth (m)

S = Surface slope

N = 0.015 for a concrete (Concrete channel)

$$R = \frac{A}{P}$$

Where A = cross sectional area of channel

P = wetted perimeter of channel

Table 1: Run-off Co-efficient 'C' in the Rational Formula

Topography	Soil Type	Infiltration Rate	Cultivated Lands	Vegetation Cover	
				Pasture	Wood
Flat (5%) Slope	Sand, Gravel	High	0.20	0.15	0.19
	Loam and similar soils No clay pan	Average	0.40	0.35	0.30
	Heavy clay soil; soil with clay pan near the surface; shallow soils above impervious rocks	Low	0.50	0.45	0.40
Rolling	- do –	High	0.30	0.25	0.20
(5% to 15%)	- do –	Average	0.50	0.45	0.40
Slope	- do -	Low	0.60	0.55	0.50
Hilly	- do –	High	0.40	0.35	0.30
Above 15%	- do –	Average	0.60	0.55	0.50
Slope	- do -	Low	0.70	0.65	0.60

(Source: Federal Government of Nigeria Ecological Fund Office, 2012)

Typical Anthropogenic Erosion Control Structures:

Stilling Basins

Stilling basins were used at drop positions and at areas requiring the reduction of flow velocities. Lengths of stilling basins should be less than the drop height; the width is determined by the anticipated storage capacity of the basins and the width of the connecting channels.

Outlet Structures

These will be provided with energy dissipaters and other structures to help slow down the force of the flowing water as it approaches the stream. Different forms of outlet structures exist and those will be used appropriately in the different gullies.

It is also important to note here that the gullies in the study area are still very active and have continued to expand especially laterally. Most part of the road that connects other Nekede communities are being lost as even access to some residential buildings is becoming very difficult, buildings have collapsed while many are under serious threats. This has brought total hardship on the people of this area, economic activity has been put to a halt due to the cut-off of the road. Residents of the area now have to take a longer alternative route to assess the main Owerri capital territory and the neighboring towns and villages

Gully Dimensions

Length:	700m
Average top width:	100m
Average bottom width:	50m
Average Depth:	10m

Check Dams

These are structures constructed across the gully and they perform the function of reduction of flow velocity, stabilization of the water way and the storage of excess water which temporarily reduce flood damage. The flood water which is trapped by the dam is allowed to infiltrate into the soil. The dam also traps soil particles, silt and other sediment and after a period the gully is expected to fill up to a new level set by the dam height. There are different forms of check dams in use. The ones adopted in this project is the concrete sills and wickerwork check dams. The shapes and sizes of the sills used are as illustrated in the design drawing.

Wickerwork Fences

These are structures constructed using stakes of about 100mm thick, driven into the ground and interwoven with more flexible branches. Wickerwork fences are generally used as temporary control structures and in combination with other measures reduce erosion by impeding flow velocities and the capability of sediment transport. They also act as filters screening soil particles and other sediments from the erosion run off on slopes and the catchments basin as well as on gully banks. The screened off soil which is essentially top soil with appreciable humus content facilities development of vegetation to protect the slopes.

A chart as well as a table adopted from the “Handbook for the Operational Action Against Gully Erosion (March 1979) by Technosynesis SPA in conjunction with Niger Techno Limited, on “Soil Erosion Control in Anambra and Imo States” illustrate methods of ascertaining how many meters of wickerwork fences are required for any given situation. It also indicates the

relationship between the length of wickerwork fence (in meter/hectare) and the gradient of slope concerned assuming compensation of +0.60m between rows and an angle of zero.

The Table indicates the number of rows that can be installed per 100m of slope and the gradients as well as distance between the rows. (Table 2)

Table 2: Relationship between the number of rows of wickerwork fence per 100m of slope, the distance between the rows and the slope gradient

SLOPE GRADIENT	NO. OF ROWS / 100M	DISTANCE BETWEEN ROWS
0.20	33	3.30
0.30	50	2.00
0.40	66	1.66
0.50	83	1.20
0.60	100	1.00
0.70	116	0.86
0.80	133	0.75
0.90	150	0.66
1.00	166	0.60

(Source: Federal Government of Nigeria Ecological Fund Office, 2012)

Formation of Vegetal Covers

In order to stop erosion an ideal solution will be to totally cover the soil with ground cover plants. As long as this is done, there will be little or no erosion. This is due to the fact that roots of plants bind soil particles together. Grassing also helps reduce impact of rainfall on the soil and increases infiltration of rainwater into the soil. The removal of vegetal covers during construction e.g. buildings and roads disturb vegetal growth and formation of vegetal covers as vegetable soil responsible for plant growth are normally removed. Footpaths leading to farmlands and streams easily lose their vegetal covers and become vulnerable to erosion.

Conclusions

The gully at Nekede has continued to constitute great hazard to the indigenes and the adjoining communities living in the area. The recommended erosion control measure if properly implemented would bring the fear and suffering of the people to an end and cost of living improved, hence early implementation is therefore very necessary.

Recommendations

Apart from the Engineering solutions being considered for the control of erosion at Nekede Town, the following recommendations are hereby made based on the study of the sites. Emphases now should be geared towards the prevention of erosion as the cost of controlling the expansion of these are becoming unbearable and also considering the losses and their effects on the environment:

1. The destruction of ground covers should be discouraged. The people should be educated on the consequence of this. This can be achieved at the grass root with the help of the Traditional rulers, Town Union and Village heads.

2. Cultivation of farmlands should be restricted 3 – 4 meters from the edge of the road and on gully banks and edges. Farming should be discouraged on every steep slope.
3. Indiscriminate excavation and quarrying of sand on roadsides or from natural drains should be discouraged.
4. Over-grading of roads to make them motor able should be discouraged as these Roads are so converted to drainage and flow paths.
5. During land clearance for constructional purposes, efforts should be made to clear only the area of land required for development. The rest should be left with its vegetal cover to prevent erosion.
6. Early funding of erosion Control projects is solicited to reduce the escalation of costs and often change of scope of the gullies which at times make the original estimate unrealistic.

With care and good Land Use Practice, the erosion process could be reduced to the barest minimum.

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