AN IDENTIFICATION AND EVALUATION OF MAJOR GULLY EROSIONS IN ANKPA, KOGI STATE, NIGERIA

BY

ABBA, FRANCIS MOHAMMED

M.TECH/SSSE/2006/1502

DEPARTMENT OF GEOGRAPHY

F.U.T. MINNA

NOVEMBER, 2009.

AN IDENTIFICATION AND EVALUATION OF MAJOR GULLY EROSIONS IN ANKPA, KOGI STATE, NIGERIA

BY

ABBA, FRANCIS MOHAMMED

M.TECH/SSSE/2006/1502

A PROJECT SUBMITTED TO THE POSTGRADUATE SCHOOL, FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF A DEGREE OF MASTER OF TECHNOLOGY (M.TECH) IN GEOGRAPHY (ENVIRONMENTAL MANAGEMENT)

DEPARTMENT OF GEOGRAPHY

FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA

NOVEMBER, 2009.

DEDICATION

his project is dedicated to God Almighty.

DECLARATION

\bba Francis Mohammed with the Registration Number, M.Tech/SSSE/2006/1502 of Department of Geography, School of Science and Science Education, Federal iversity of Technology Minna do hereby declare that this research project titled, "An ntification and Evaluation of Major Gully Erosion in Ankpa, Kogi State, Nigeria" has en carried out solely by me under the supervision and guidance of Dr. A. S Abubakar.

The research work has been carried out in accordance with the regulations verning the preparation and presentation of project in the Department of Geography. ereby declare that this work has not been presented anywhere for any certificate.

However, relevant works by other authors have been duly acknowledged in the oject.

ME: Abbr Francis Moh'd

SIGN:

DATE: 01/02/2010

CERTIFICATION

his thesis titled: An Identification and Evaluation of Major Gully Erosion in Ankpa, Kogi tate, Nigeria by: Abba, Francis Mohammed (M.Tech/SSSE/2006/1502) meets the egulations of governing the award of the degree of M.Tech of the Federal University of echnology, Minna and is approved for its contribution to scientific knowledge and erary presentation.

r. A.S. Abubakar | 04/02/10
lame of Supervisor | Signature & Date

r. A.S. Abubakar | 04/02/10
lame of Head of Department | Signature & Date

rof. M. Galadima | 11/2/2010
lame of Dean, SSSE | Signature & Date

rof. S.L. Lamai | 9/4/2010
lame of Dean, Postgraduate School | Signature & Date

ACKNOWLEDGEMENTS

is pertinent to note that the success of any time is associated with the guidance of iod almighty to whom my unalloyed gratitude goes. I am greatly indebted to my esearch supervisor, Dr. A.S. Abubakar, whose discussions, criticisms, comments and ooperation made the entire research work a successful one.

ly appreciations and thanks go to the Head of Department, Dr. A.S. Abubakar who ıspired me in the course of my programme. The entire staff of Geography Department re highly acknowledged for knowledge impacted on me. My special thanks go to Dr. ?.S. Akinyeye, Salihu & Matazo.

am also grateful to my wife and the children for their cooperation and understanding hroughout my programme. May God bless you all.

The inspiration and encouragement of Prof. E.A. Okosun, Prof. G.D. Momoh, Dr. M.T. Jsman and my great friend Mal. U.S. Onoduku cannot be acknowledged with mere vords but remain blessed.

I will also thank and appreciate the effort of the following who have assisted me morally or otherwise, Abba Suleiman, Abba Fred, Mr. T.A. Ako, Charles Umoru, Miss Naomi T. Kolo, Suleiman Mohammed, Yusuf Atiku, Mal. Badegi, Maimuna and the entire staff of Geology Department FUT Minna.

My greatest regards to the various authors whose work I have used in writing my thesis. Finally, I appreciate and thank the management of Federal University of Technology Minna for the opportunity given to me to pursue a Masters Degree Programme in Environmental Management.

ABSTRACT

This study was based on identification and evaluation of major gully erosions in Ankpa, Kogi State Nigeria using geotechnical investigation, field survey and rainfall information. This was done with a view to identifying the causes and extent of erosion in the area of study such that amongst other things, the erosional features occurring in the study area could be assessed, the soil characteristics could be examined and the threat the gullies pose to the settlement, structures and farmlands in the study area could be estimated and some technical remedial actions applied. The geotechnical method was employed to determine the grain size distribution of the soil, natural moisture content, plastic limit, while the field survey method was employed to determine the geomorphology of the study area like gully site locations, elevations, longitude and latitude, average widths, approximate depths and gully cross – sections. The results of this study indicate that the study area has high elevation which makes water to run down the slope with high velocities thus washing soil particles down to the streams and rivers. Also, the poor vegetation cover due to bad farming practice coupled with unconsolidated sandstone nature of the study area makes it prone to erosion. To control erosion in Ankpa area, proper environmental and land use management polices should be initiated at all levels and some technical remedial actions applied such as the check dams, shelter belts and vegetative barriers as these would check the causes and mechanisms of land erosion in Ankpa area.

LIST OF FIGURES

LIST OF TABLES

LIST OF PLATES

ABBREVIATION

.O.	Food and Agricultural Organization
.A.L.R.	Federal Department of Agriculture and Land Resource
.P.A.	Federal Environmental Protection Agency
.A.	Ibadan International Institute of Tropical Agriculture Ibadan

CHAPTER ONE

GENERAL INTRODUCTION

Man and his environment have witnessed and will continue to witness several changes. The environmental changes, if not checked or mitigated, can result into permanent deformation of the environment. Such environmental changes are in several forms and magnitude and one of such enigma is land erosion.

No soil phenomenon is more destructive worldwide than the erosion caused by wind and water. Since pre-history times people have brought the scourge of soil erosion upon themselves; suffering improvishment and hunger in its wake. Past civilizations have disintegrated as their soils, once deep and productive, washed away, leaving only thin, infertile, rocky relics of the past. (T.S. Elliot, 1977).

The current threat of soil erosion is more ominous than at any time in history. In our generation, farmers have led to more than double world food output to feed the unprecedented numbers of people on Earth. In the low income countries, the ratio of people to available cropland is already very high and rising rapidly.

While intensified cultivation of fertile, relatively level lands has helped produce much of the needed food, many nations have had to expand the area of land under cultivation, clearing and burning steep, forested slopes and plowing grasslands. Population pressures have also led to overgrazing range lands and overexploiting timber resources. All these activities degrade or remove natural vegetation, causing the underlying soils to become much more susceptible to the destructive action of erosion. The result is a vicious download cycle of deterioration – land and reduced vegetative protection for the soil which in turn accelerates erosion and drives even more desperate people to clear, cultivate and degrade more land.

The degraded productivity of farm, forest, and rangelands tell only past of the sad erosion story. Soil particles washed or blown from the eroding areas are subsequently deposited elsewhere – in a nearby low-lying landscape sites; in streams, and rivers, or in downstream reservoirs, lakes and habours. The environmental and economic damages suffered by sites on which the eroded soil materials are deposited may be sometimes as great as or greater than that incurred on the sites from which the soil material was removed. The displaced soil material (sediment and dust) lead to major water and air pollution problems, bringing enormous economic and social costs to society (T.S. Elliot, 1977).

Soil erosion is everybody's business. Fortunately recent decades have seen much progress in understanding the mechanisms of erosion and in developing techniques that can effectively and economically control soil loss in most situations. This project work is aimed at identifying and evaluating the major gully sites in the research area.

1.1 DEFINATION OF BASIC CONCEPTS

Some important concepts and terminologies used in this write up have been briefly explained thus;

Land Erosion: This can be defined as the removal of top layers of soil by natural forces chiefly wind and rain water aggravated by certain destructive human activities such as dry farming, overgrazing, bush burning etc (Buchman, 1974)

Deposition: The laying down of the eroded materials deposition is complementary to erosion, both being phases of land culturing.

Soil Structure: This is an important characteristic of soil which relates to the way soil particles coagulate into bigger pieces held together by one colloid. I determines and influences the rate at which water is absorbed.

Intensity of Rainfall: This is the rate at which rainfalls. It varies from light drizzle to heavy down pour.

Sheet Erosion: Splashed soil is removed moved more or less uniformly except that tiny columns of soil often remain where pebbles intercept the rain drop.

Rill Erosion: Results when surface runoff concentrates forming small yet well defined channels. These channels are called rills when they are small enough not to interface with field machinery operation.

Gully Erosion: where the volume of runoff is further concentrated, the rushing water cut deep into the soil, deepening and coalescing the rills into larger channels termed gullies.

1.2 BACKGROUND TO THE STUDY

The perception for the utilization of environmental resource such as land depends on the need to which the resource could be put to. A good example of this could be the forest resources. This resource may have timber, which serves to support tourism, protect watershed from erosion and preserve aesthetic or religious significance.

By and large, these perceptions can vary from time to time at a point in time as different groups of land erosion can adversely affect the yield of labour, in term of capacity building and production. Notably, the product of work on degraded land is less than that of same land resource free from degradation.

The importance of land resources cannot be overemphasized as our food and mineral resources are obtained from it. Sustainable development which implies intergenerational equity, is concerned with the distribution of environmental resources between present generations of mankind without compromising the needs of future generation (Baba, 1992).

This calls for conscious planning and well managed land resource utilization. Since man derives his needs from the environment, therefore, it then depends on his ability to exploit the numerous resources in the environment to his advantage. These activities of man and the environment include the following: agricultural practices, mining, water resources exploitation, deforestation etc. These are contingent values arising from environmental resources. However, the dependence on the environmental resources has translated into a number of negative impacts such as, land erosion/degradation, flooding, overgrazing etc. (Otiende Ezaza and Boisveet, 1991).

Land as a resource provides medium for vegetation cover and effective growth for agricultural activities, but the mismanagement of it can affect production activities such as food upon which Nigeria depends on for livelihood.

1.3 STATEMENT OF THE PROBLEM

Ankpa is situated at the south eastern past of Kogi State, Nigeria (Fig. 1). Ankpa is experiencing on the increase the impact of natural and man induced environmental hazard on her natural resources (soil and vegetation). It has demonstrated serious effects of land degradation in the form of erosion. This research work is therefore set out to evaluate and identify the impacts of erosion and;

(i) The physical problem of cratered surface, which has seriously broken down beneficial structures like the roads, bridges and buildings all over the area.

(ii) Larger proportion of the farmland and other activities are continuously (year after year) being claimed by soil erosion, resulting in gullies of high magnitude.

According to Nkem (1999), the international committee on decade for reduction of disasters has declared that erosion is a silent ecological problem which slowly and steadily etas up the basis of man's livelihood through the incursion into agricultural productivity by its capacity to reduce the fertility and cultivability of the soil.

(iii) The economic activities is consequently been reduced to bare subsistence in Ankpa area.

1.4 AIM AND OBJECTIVES

This research is aimed at carrying out detailed field survey, data capture, and analyzing the data as they relate to erosion in Ankpa area. This is with a view of identifying the causes and extent of some identified gullies in the study area.

The specific objectives of the research including the following:

(i) Identifying some gully sites in the study area.

(ii) Identifying the causes and extent of the gullies.

(iii) Measure the extent and dimensions of the gullies.

(iv) Assess the threat the gullies pose to some farmlands, settlement and structure in the study area.

(v) Propose some remedial actions that can be applied

1.5 JUSTIFICATION FOR THE STUDY

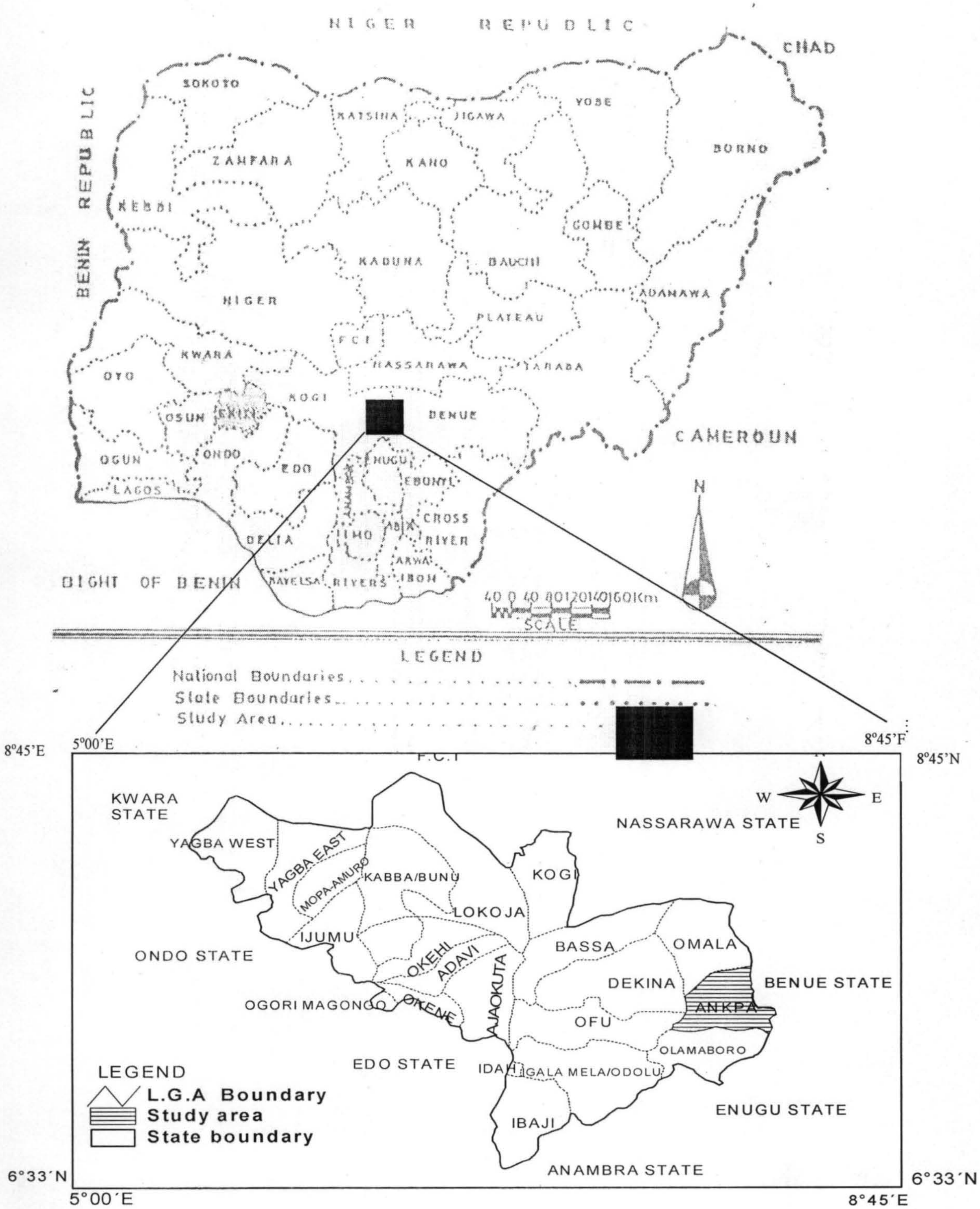
It is an understanding that there is need to address man's environmental problem, erosion inclusive. Erosion is a product of several factors and combined agents hence the need to address them from a targeted and detailed research point of view. The research can be meaningful if proper stock of the nature, type and area of such environmental degradation are obtained. The task of obtaining an accurate stock of this nature can only be through a well documented environmental research studies, a survey of erosional features, types and level as the case may be. The above study will give rise to the data base as regards area prone to erosion, their intensities, geomorphological specifics and various technical ways to address them. The above academics strategies will not minimize the gross amount of fund needed to address the environmental problems but will also direct the Nation's fund to the right places of usage of solving ecological problems.

1.6 DESCRIPTION AND LOCATION OF STUDY AREA

Ankpa is located in Kogi state of Nigeria. It is located South Eastern direction of the state capital with a bearing of 135^{o} from Lokoja (Fig 1).

The study area includes Ankpa and its environs. Ankpa is located on longitude $7^{o}30^{oi}$E and $7^{o}45^{i}$E and between latitude $7^{o}15$N and $7^{o}30^{i}$N. The study area is 30 square kilometers and accessible by road from Makurdi and Otukpo on the eastern flank.

About 90% of the inhabitants are Igala speaking people, while the remaining 10% constitute other tribes. Farming and trading are the major occupation of the people.

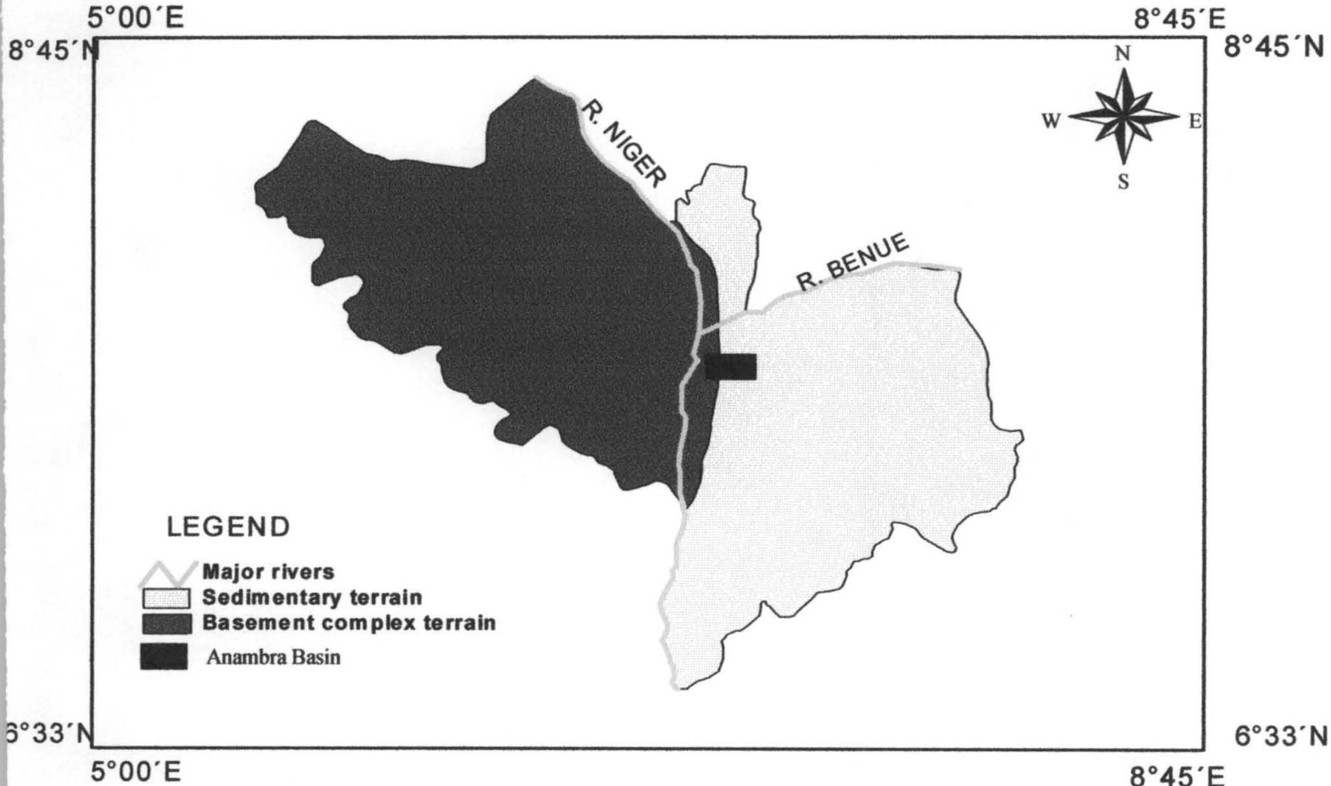


Source: Kogi State Ministry of Environment; (2005)

Fig. 1: Map of Nigeria showing the study area.

1.7 GEOLOGY OF THE STUDY AREA

On the regional geology, the study area is part of Anambra Basin and is located at the midpoint of intersection of Bida Basin, Benue Trough and Niger Delta.



Source: Kogi state ministry of environment. (2005)

Fig.2: Geological Map of Kogi State.

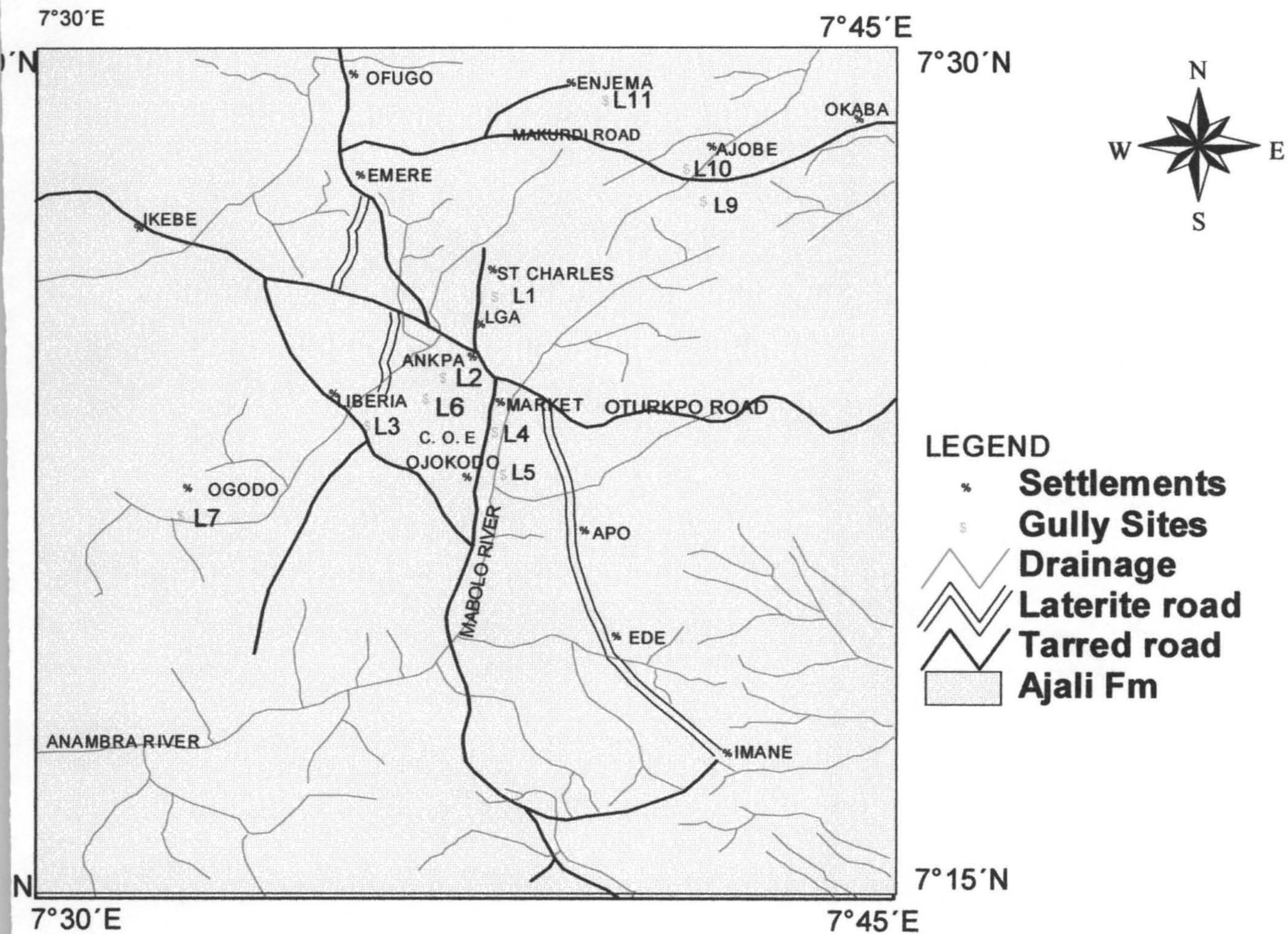
Stratigraphically, Anambra Basin is filled with companion-Aeocen sediments which are deposited in a stratigraphical sequence.

Two lithostratigraphic units have been identified by Rayment (1965) as unconsolidated coarse grained, moderately to poorly sorted sandstone. One of the most conspicuous features of the Ajali-sandstone is its cross-stratification.

The Forset beds alternate between coarse and fine-grained sands. Murat (1972) regarded the Ajali sandstone as a continental sequence interdigitating with parallic mamu formation. Maestrichitian has been assigned to this formation.

The Nsukka formation which has been reported by Wilson and Bain (1928) as being similar to that of mamu formation which is of strand plain marsh origin with occasional fluvial incursion. And that consists of alternating sequence of laminated very fine grained sandstone and siltstone at times brown and greyshale and mudstones with numerous coal seams at various horizons.

On the local geology, Ankpa lies on a gently undulating plateau bisected by the River Anambra valley which drains most of the area (Wilson and Bain, 1978). The River is however, called by the natives (Mabolo River). The geology of the study area shows that, Ankpa plateau consists of sandstone (Ajali formation) and an upper coal measure of lower Paleocene completely covered by a layer of soil, Murat (1972). The false bedded-sandstone is coarse grained, about 450meter thick and dates from the upper senonian age. The upper coal measure is 60meters thick with levels of siltstone, sandstones and coal and serves as aquiclude. The strata dip at a long angle towards the South-West. Water can be obtained from the false bedded sandstone by drilling wells at a depth of 70-80meters. This is so as the coal serves as aquiclude as the aquifers exists at a great depth.

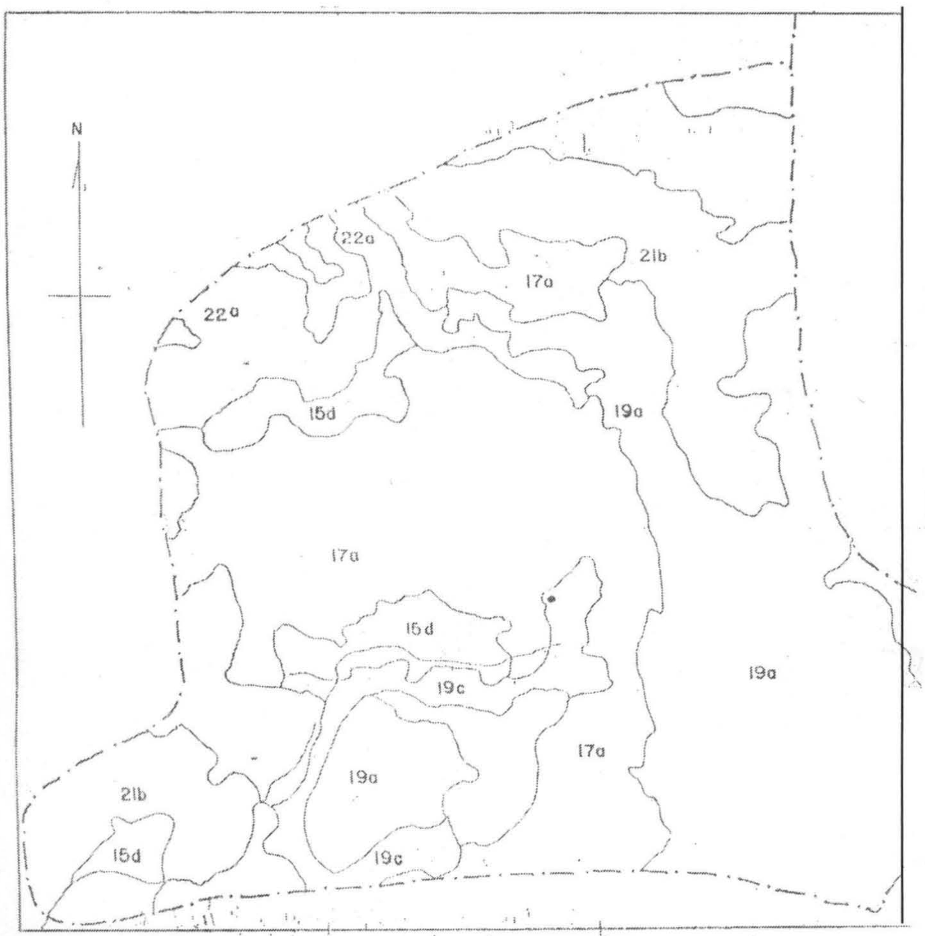


rce: Federal Survey Agency, Lagos (1980)

3: Topo map of Ankpa and Environs.

1.8 Geomophology of the Study Area

The bed rock in the area is entirely covered by impoverished soil due to the action of erosion. The rocks here have deeply weathered and oxidized or laterized, the weathering profile consists mainly of red and yellow earth and loose poorly sorted sands intermixed in places with clay deposits. Soils here therefore, are the weakly consolidated sediments of the tertiary cretaceous lignite formation. The soils are methyl loams, sandy and some places sandy clay loams.



Source:- Soil survey division (FDALR) Kadena 1990 Scale 1:250,000

GEOLOGY	RELIEF	SOIL DISCRIPTION
19a Sandstone	Gently undulating	Mostly sandy loam
19c Sandy material	" "	Loamy sand
17a Shales	" "	Sandy loam
15d Sandstone	" "	" "
21b Sandstone	" "	Mostly sandy loam
22a Sandstone	" "	" " "

Fig. 4 Soil Map of Ankpa

1.9 CLIMATE

Ankpa area is located within the tropics; hence, most of the types of climate and weather of Nigeria is being experienced by it. These however, bring about the influence of atmospheric systems controlling the whole area.

The area is located longitudinally within the tropics which makes the area to experience high temperature all the year round as observed in the state Headquarters, Lokoja. The mean month temperature ranges between 21^0C to 26^0C in some years (Adefolalu, 2001). This means, the annual range is about 3^0C as can been seen in table 1 below. The highest temperature 25.7^0 C occurs just before the rainy season sets in by April (Adefolalu, 2001).

Table 1: Temperature (T), Effective Temperature (E.T), and Relative Humidity (R.H) at Lokoja station.

Month	T	ET	R.H
Jan	21.4	22.8	83
Feb	23.8	28.9	79
Mar	25.7	28.3	81
Apr	25.6	28.9	85
May	24.9	30.0	90
June	23.9	30.0	92
July	23.5	30.0	93
Aug	23.3	30.0	93
Sept	23.3	30.0	94
Oct	23.4	30.0	94
Nov	23.2	23.4	93
Dec	20.6	23.4	89
Mean	23.6	28.0	89

(Adefolalu 2001)

The essence of this table is that Temperature and relative humidity play important role in erosion control.

From the table, there is considerable spatial and seasonal variation in the relative humidity throughout the year. All the months have monthly mean over 80% except for February. Iloeje (1981) concluded that, the characteristics of harmattan season in the dry and dust laden North-East trade wind blowing from the Sahara under cloudless dusty condition; the diurnal value may fall from 30% in the morning of 20% in the afternoon during the dry season.

The effective temperature value derived from relative humidity and air temperature at the area, the evaporative power of the ambient air is very high at the time of maximum insulation. This goes to show that the area can equally experience appreciable wind erosion over time.

1.10 MEAN RAINFALL FEATURES

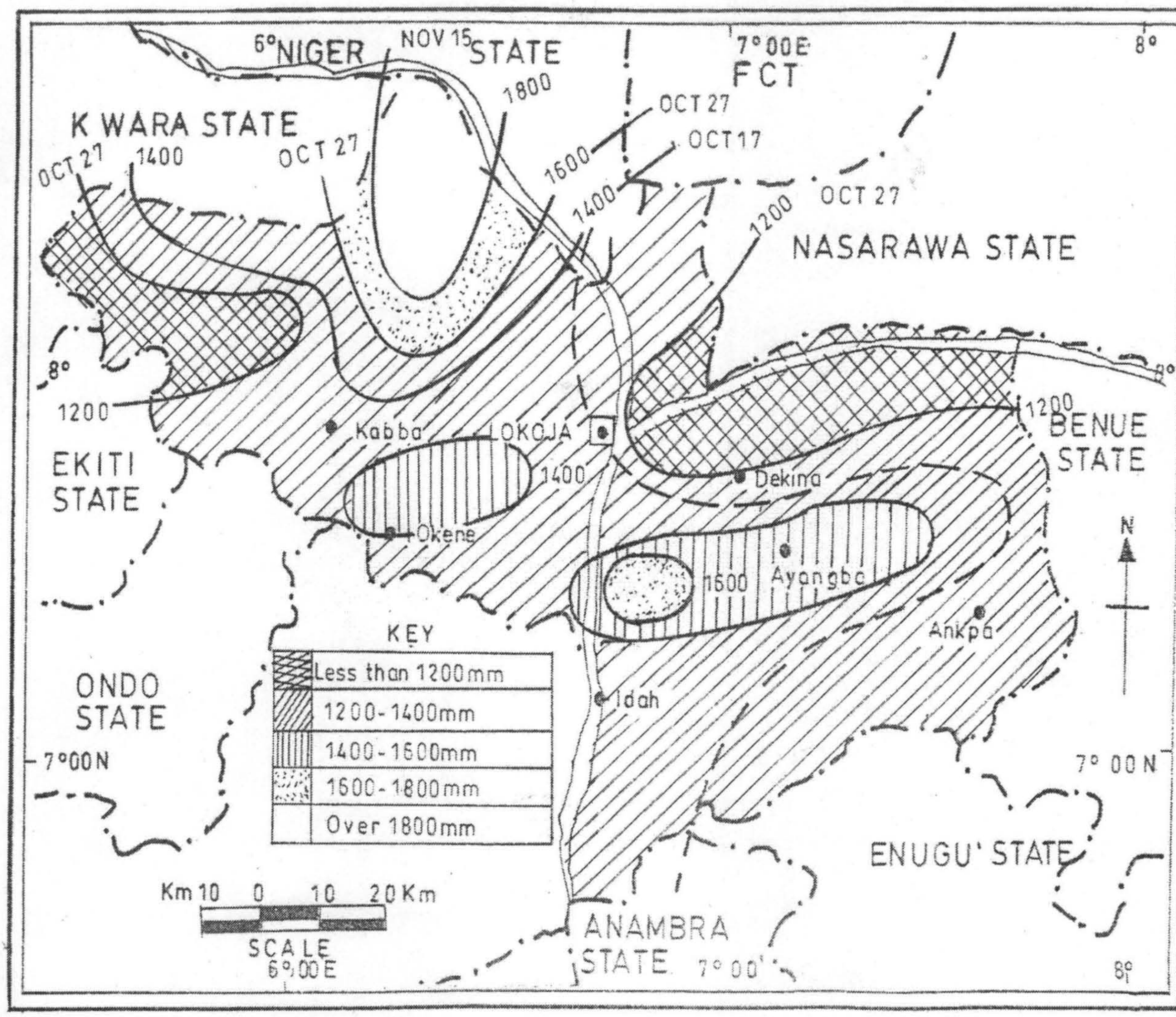
The rainfall features in Ankpa area is a good reflection of the seasonal variation of the inter-tropical convergent zone (ITCZ). This is illustrated in the mean rainfall pattern of Kogi state. These figures as seen represent the amount of rainfall for annual, (fig 5) rainfall intensity (fig 6) and (fig 7) shows early cessation date of rainfall in Kogi State (Adefolalu 2001).

Annual rainfall within the transition axis is about 1200mm. It is also crucial to note that main channels of rivers Niger and Benue particularly as wet season in any year is a critical factor in a relation to tree-crop production because it determines soil moisture surplus or deficit in between rainfall season.

Rainy season in the area generally occur between April and October with its peak in September (Appendix III). The rainfall in the area is seasonal. Extreme variations in total rainfall for July and August sometimes referred to as "August break".

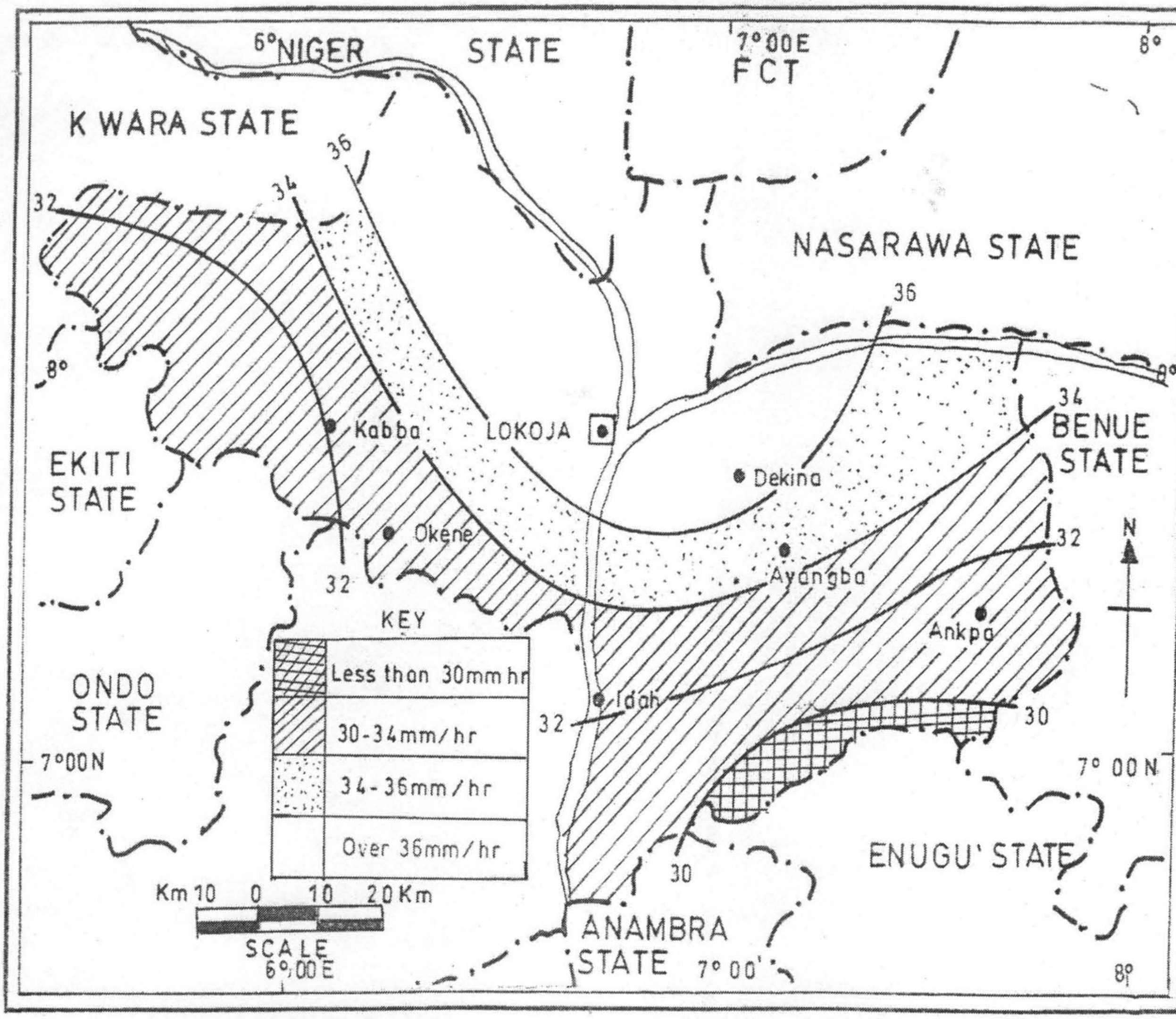
This is also a general characteristic of rainfall here. Heavy rains of conventional type fall here and this sometimes amount up to 978.5m or more. The pattern of rain days (mean) follows basically the same pattern as for mean rainfall amount. The mean rain days for the area are approximately between 73 to 90days (Adefolalu, 2001).

A graph of annual mean rainfall against year was used to produced a histogram as shown in fig. 8 with 1999 having the peak of the rainfall.



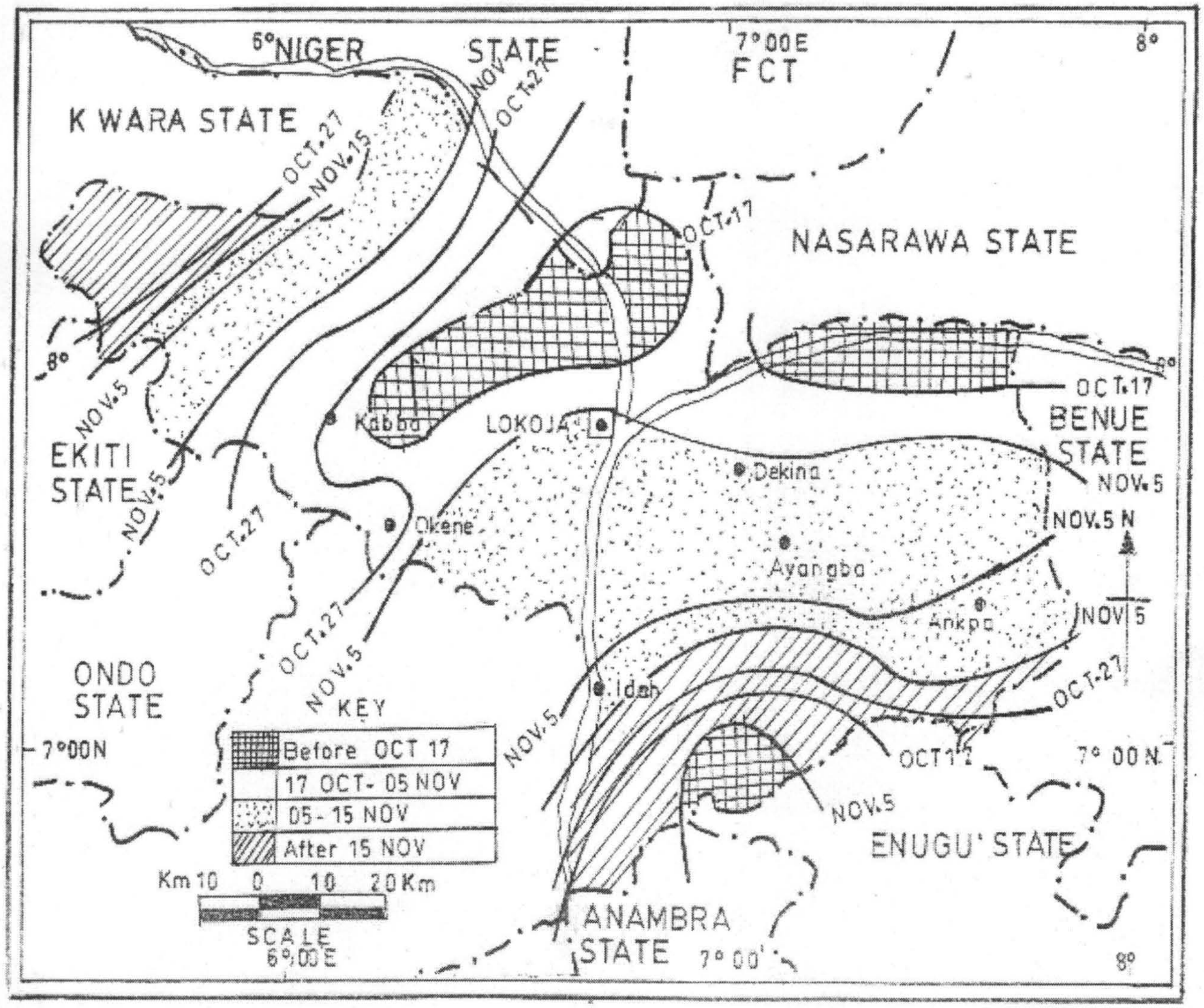
Source: Adefolalu, 2001

Fig. 5: Mean Annual Rainfall in Kogi State



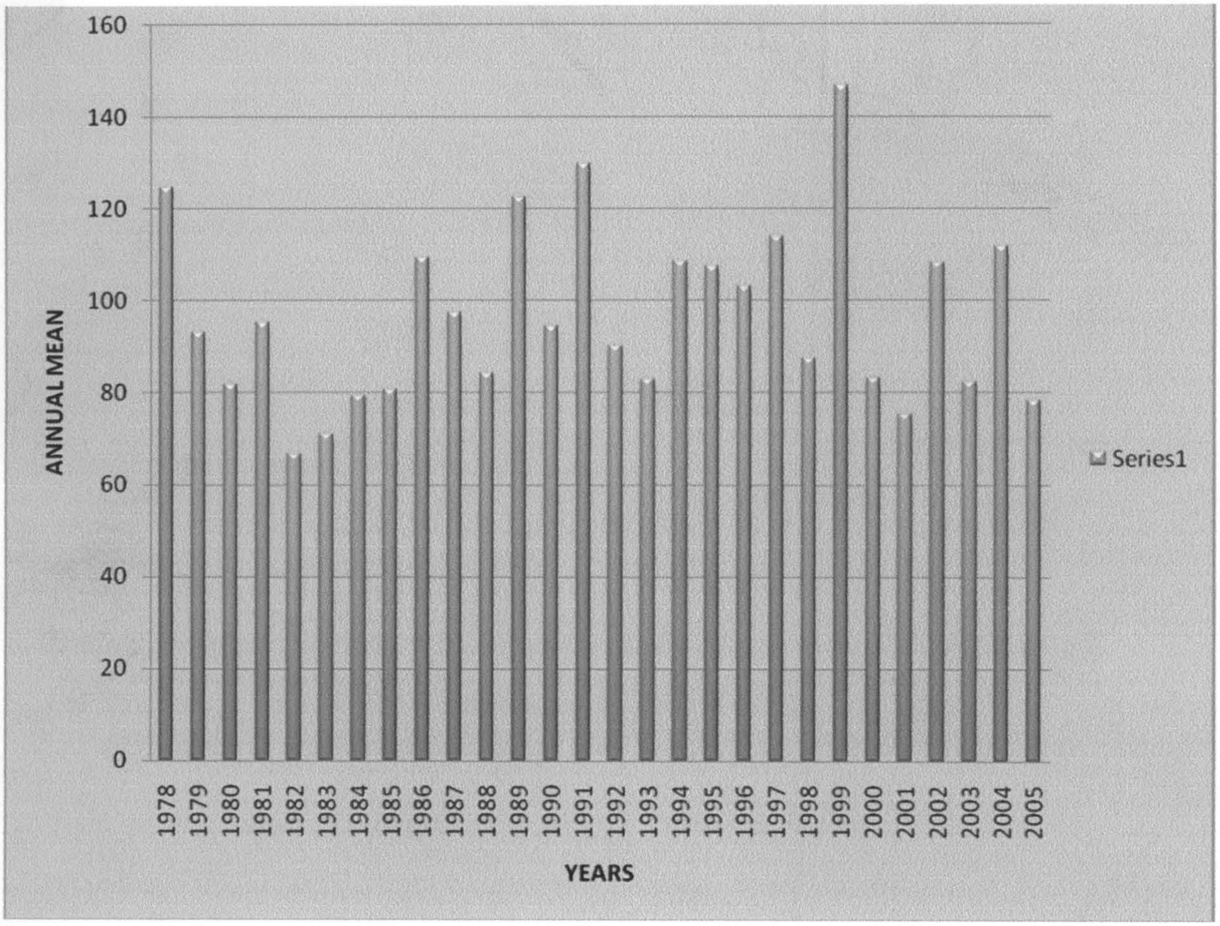
Source: Adefolalu, 2001

Fig. 6: Rainfall Intensity (mmhr) in Kogi State



Source: Adefolalu, 2001

Fig. 7: Early Cessation Dates In Kogi State (Rainfall)



Source: Nigeria Meteorological Agency, Lokoja (2005)

Fig. 8: Histogram showing Rainfall from 1997 – 2005

The histogram is produced from the rainfall data over 28 years (Appendix III).

1.11 RELIEF

The study area falls within the lowland category in Nigeria and specifically it is the lowland and scarp land of south-eastern Nigeria (Iloeje 1981). The study area lies at the western part of Enugu where the two plateaus like clusters are being separated by the Anambra Oji River Valley. The area is on the south-west dipping layers of the cretaceous sandstones which stretch in the south-west direction.

The relief region is also composed of rounded to flat-topped hills and seen as ferrogenised sandstone.

1.12 VEGETATION

The study area is located within the southern guinea savanna zone. The distribution of actual or contemporary vegetation type is determined by factors such as clearing, bush fire, demographic pressure, cultivation pattern, topography etc. It could be noted in the study area, there exists tress such as *Aflelia, Africana, soberlinia, swartzia, butyeuspes mum parki, Adanzonia digitate* etc (Areola, 1978). These trees adapt to dry conditions (deciduous) as they shed their leaves and backs to retain water that would have been lost through evaporation / transpiration.

The study area has seasonably thick vegetation most especially in rainy season. In areas with the grass undergrowth, the soil is exposed to leaf falls and occasional rain drop impact.

Despite all these, there is break up of soil surface and subsequent transportation by runoff. This is as a result of the nature of the soil which is one of the objectives of the research to determine.

1.13 LAND USE

A greater proportion of the inhabitants of Ankpa depend primarily upon farming as their means of livelihood. Land use within the area is mostly agricultural. According to F.A.O (1976), classification of land use in the area is identified as follows:

i. Intensive cultivation 80% (recurrent cultivation).

ii. Scattered or locally dense cultivation (35-60%) and the growing season is relatively long which is about 8 months and has this range of crops such as (yams, cassava, maize, millet, groundnuts, melon, guinea corn etc).

The farmers are occupied for about ten months of the year. However, most of their farms are not free from the danger of soil erosion, despite the continuous cultivation of crop on the land. The annual practice of burning vegetation as means of clearing land for cultivation and other activities devoid the land of its vegetative cover so that the first rains are often accompanied by devastating soil erosion. Other types of land use in the study area include grazing animals, lumbering and settlement.

CHAPTER TWO

LITERATURE REVIEW

Soil is a vital resource for the production of renewable resources for the necessities of human life, such as food and fibre. Soils however, essentially are non-renewable resources (Golubev, 1982)

2.1 EROSION CONCEPTS

According to Golubev (1982), the area of cultivated land in the world is 14.3 million km^2. In cultivated areas, the drastic changes in vegetation have occurred and instead of dense natural vegetation cover, bare soil often is exposed for most of the year with sparse crop vegetation existing for a few months. These changes in vegetation cover are the main reasons for the increase of soil erosion on cropland as compared to natural landscapes. His computation showed that soil erosion in the world is 5.5 times more than the pre-agricultural period.

According to Brown (1984), the world is currently losing 23 billion tones of soil from crop land in excess of new soil formation each year. Therefore, accelerated soil erosion is a serious problem to consider for the development of a sustainable agriculture. Accelerated soil erosion often makes the soils in a landscape more heterogeneous. An increased heterogeneity occurs as overgrazed semi arid grassland degrades into shrub ecosystem. Another example may be seen in the difference in surface colour that develop as ridge top soils are truncated thereby exposing material from the 'B' horizon to 'C' horizon at the land surface, while soils lower in the landscape are buried in organic matter enriched sediment.

2.1.1 EROSION ON REGIONAL AND LOCAL SCENE

On the regional and local scene, accelerated erosion has been studied in eastern Nigeria among others by Ofomata (1995) and Grove (1951). In most of these studies, soil erosion has been related to the local geology, the physical and chemical properties of the soils, rainfall intensities, high population density and the attendant pressure on the land in the form of deforestation, overgrazing, mining activities and farming practices.

2.2 BAD AGRICULTURAL ACTIVITIES

Esu (1984) reported that the introduction of mechanization into agricultural tillage and land clearing have the effect of pulverizing the soil (where the soil aggregates are destroyed) especially in inherently weak structured soil. The soil is made more vulnerable to splashing, surface sealing or reduction in infiltration and hence, peak runoff.

Edward (1993) reported that with the advert of improved weed control via herbicides the soil environment is degraded and the aggregate stability is reduced, increased bulk density, reduced soil organic matter and thus, soil pulverization and subsequent erosion.

Bush burning as a method of land clearing is a popular practice in Nigeria. Davis (1977) reported that bush burning practice is destructive to the ecological system. Apart from removing the protective cover of the soil, it destroys the liters and the organic residues which normally decompose and thereby enhances the activities of soil fauna.

According to Blevin et al., (1992), the features responsible for the causes of erosion depend on the amount of land exposed, the slope of the land, the nature of the soil, method of land management, intensity and duration of rainfall.

They stressed that soil erosion has damaging effects on land and agricultural production.

Hudson (1995) concluded that runoff is one of the critical factors controlling rill erosion and gully development.

Moore and Foster (1990) established that concentrated flow erosion occurs where flow discharge and velocity exceed critical values.

In semi-arid zones, runoff from hill slopes occurs in the form of Horitonian overland flow (Dunne 1978) because rainfall intensities often exceed the infiltration capacity of the soil. The overland flow yield is significantly non-uniform in space due to high spatial variability of infiltration capacities of the soil surface and in time, due to vegetative growth during the rainy season – variability in surface crusting, vegetation and roughness can all produce different hydrologic regions at different spatial scales

Burnet (1973) identified the causes of soil erosion as being caused by the action of man and his domestic animals. Most of it affects the removal of the natural vegetation which tends to expose the soil since vegetation protects the soil from the action of wind, rain and human activities.

Pastorialism which encourages grazing of animals is usually very destructive to natural vegetal cover of the soil. This activity together with the semi-arid climate as explained by Davis (1977) is characterized by dry strong winds of the worth which is occasioned by desert encroachment.

According to FEPA (1999) improper discharge of hazardous wastes on streets, overflowing sewage, deforestation, overgrazing, bush burning induces and aggravate soil erosion.

2.2.1 MINING ACTIVITIES

Mining activities have been among the land degradation process which has resulted in erosion menace all over the world and Nigeria inclusive. Tsuzon and Amoka (1997) reported that the use of large modern equipments such as draglines, hydraulic giants in mining in plateau state, has resulted in long steep sided ridges of soil with conical peaks up to 20 meters high and deep gullies down to 25meters after mining. Bakkuk (1995) reported that by 1976, about 250059km of plateau land surface had been damaged due to mining activities.

FEPA (1999) argued that ignorance of environmental issue is largely responsible for the low public interest in curbing environmental problems.

Isuzon (1999) concluded by saying that, some of the erosion problems sites are still with little or no solution which can be attributed to the poor land management, construction and maintenance culture in Nigeria.

2.3 CLIMATE AND HYDROLOGICAL FACTOR

The climatic and hydrological condition of an area are characterized by geological position, attitude, atmospheric temperature, precipitation, evaporation, air humidity, direction and force of wind current and surface runoff.

For proper erosion control, it is necessary to investigate the occurrence, distribution and intensity of precipitation and the formation and course of surface runoff.

2.3.1 EFFECT OF TEMPERATURE AND RELATIVE HUMIDITY

Investigation involves erosion processes should take cognize of the evaluation of the atmospheric temperature and Relative Humidity with regard to their effect on the soil surface and the runoff caused thereby. The erosion effects on liquid and solid precipitation differ. The effects of heavy rainfall causing high intensity surface runoff are intensified by the effects of the kinetic energy of raindrops on the soil surface. The raindrops falling on the soil surface cause a splatter of soil particles in the soil aggregate which are then carried away by the surface runoff.

With regards to water erosion, the most unfavourable rainfall in the temperate climate zone are heavy rains with duration of up to 180 minute and a level of 10-80mm or more.

According to Areola (1978); gully erosion is predicted by means of the universal soil loss equation derived by the United States Department of Agriculture, (U.S.D.A).

The equation is given as

A=R x K x L x S x I x C x P

Where A = soil loss per unit area

R = Rainfall intensity index

K = Soil erodibility factor

L = Slope length factor

S = Slope factor

I = Infiltration

C= Crop management factor

P= Conservational practice factor.

The equation contains factors relating to the natural soil, slope in addition to land use factor prevalent in a given area. The erositivity of rainfall under the climatic condition of the savanna is said to be very high (Jones and Wild 1975) which is accompanied by a correspondingly high rate detachment and transportation of soil materials by rains. The soil erodibility of the savanna is believed to be very high and such soils are mostly sandy, low in organic matter and of unstable structure. The soil principles are easily dispensed in water, rendering savanna soil particularly vulnerable to accerated erosion (Kowal and Kassam, 1978). Generally, when land is exposed and unprotected due to the removal of vegetal cover, it is attacked by the natural agent of water (e.g. runoff from rainfall, rivers and flood) which initiates the process of removing, mobilizing and transporting soil fertility and crop nutrient from one location to the other. Human activities notably those of the land uses and government contribute to soil erosion. Land uses initiate soil erosion through various activities such as overgrazing, deforestation, and repeated cultivation, bush burning, and cleaning e.t.c.

A combination of water agent and human activities have brought about most of the rural areas to their present plight in relation to include

(a) Drastic reduction in land productivity for agriculture. Fubara (1988) reported that about 30 million tones of soil are lost annually to soil erosion. This has resulted in a total decline in agricultural production through losses in soil fertility and crop nutrients.

Going by the studies of other erosion areas in the country from reviewed works, the accumulation of sediment and siltation resulting are condition found in Ankpa area of Kogi State of Nigeria. Here very severe soil erosion is prevalent and has assumed proportions destroying livelihoods, building and social infrastructures such as roads; from this, one will ask why has soil erosion in Ankpa area most pronounced.

2.3.2 MORPHOLOGICAL FACTORS

Water erosion is conditional on surface runoff from slopes. With increasing slope gradient and slope length and with continuing rainfall, water running off the slopes gains higher velocity and tangential stress and the action of its destructure force on the surface increase. The intensity of erosion process usually decreases with a drop in slope gradient where the particle so detached begin to settle down. The cause of erosion shows that most of the water erosion happens within a rugged relief which enhances the concentration of surface runoff and accelerated runoff.

(i) The Effects of Slope Gradient:

Theoretical studies and analysis of the effects of slope gradient on water erosion and a number of field observations and measurements as well as laboratory experiments have shows that slope gradient is one of the major erosion factors. Its effects on the initiation and subsequent causes of erosion processes may be reduced by other factors such as soil properties, the vegetative cover e.t.c. but never fully suppressed.

The interdependence of slope gradient and the erosion intensity as given by a number of authors shows that the intensity of the erosion process increase with growing tangential states and surface runoff velocity which are prevalently the function of slope gradient. The importance of slope gradient for erosion intensity was proved by Bennet (1955) in field's measurement.

2.3.3 ASSESSMENT OF EMPIRICAL MODELS OF EROSION PROCESSES:

The erosion process is most frequently expressed by the relation between resulting intensities determined by the gravity or volume of soil loss from a unit area over a given time unit and the erosion agents. The general relation may be written as SP = F(Xk, XH, XM, XS, XG, XV, XT, XEK)

Where SP = erosion intensity (soil loss)

XK is the climate factor

XH is the hydrological factor

XS is the soil factor

SG is the geological factor

XV is the vegetative factor

XT is the technical factor

XEK is the socio-economic factor.

A detailed analysis of these factors will show that their interactions are extremely complex and it may be difficult to model the erosion process. This is mainly because the interactions are manifested in extremely varied conditions.

Hudson (1973) reported that the individual members of the equation on erosion intensity is assessed with regard to their effects on a unit plot with specified parameters, the length of the unit plot is 22.13m, slope gradient 9%, the plot continually follow and tilled up and down the slope gradient.

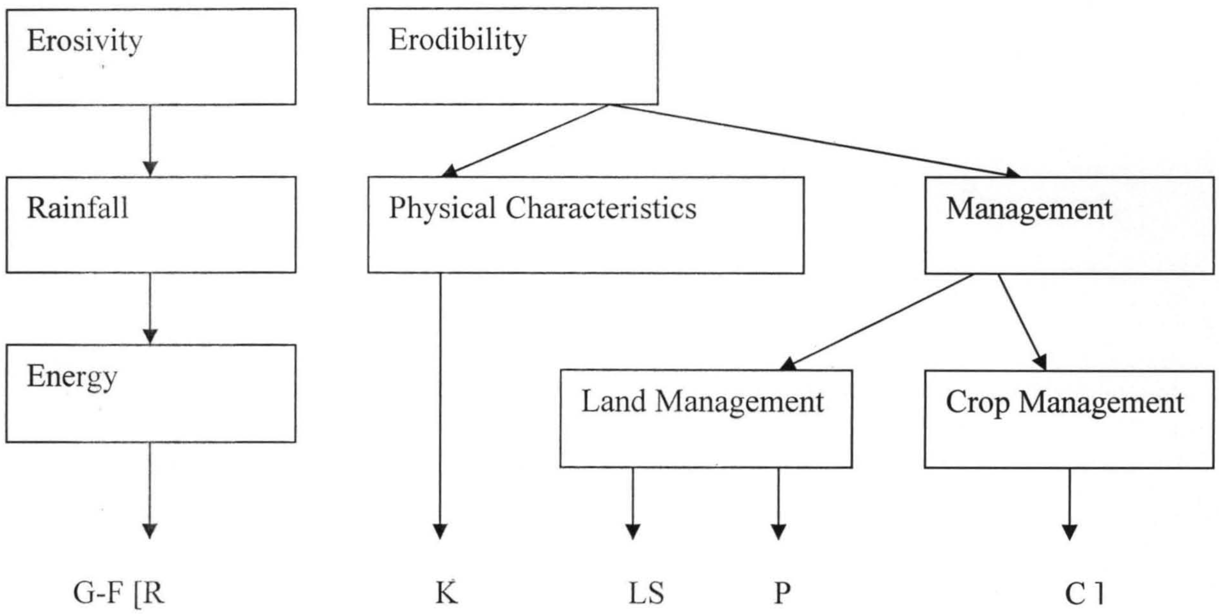


Fig. 9 Diagram expressing erosion intensity in dependence on the erosivity of rainfall and soil erodibility, after N. Hudson (1973).

From the review of related works by other authors, the evaluation of land erosion in Ankpa and its environ can be assessed using a geotechnical technique to examine the characteristic(s) of the soil and necessary information from the field survey to know the geomorphology of the study area.

CHAPTER THREE

MATERIALS AND METHODS

3.1 INTRODUCTION

Geotechnical method offers the possibility of studying field features, data capturing and analyzing the data as they relate to erosion. The use of geotechnical studies is to determine the grain size distribution of soil since this grain shows if a soil is fragile or compact. By this method, the natural moisture, content, plastic Limit (PL) are determined to know if water and wind as agents of erosion can play a principal role in the erosion processes of the study area.

The field survey was undertaken to determine the geomorphology of the study area. In order to achieve the expected objectives of this study, the methodology explained below was adopted to reach the conclusion made in this study. The adopted methodology for carrying out this study ranged from the field survey, laboratory analysis to the collection of relevant data.

3.2 FIELD SURVEY

Field survey was embarked upon to investigate and assess the types and effects of land erosion in Ankpa and environs. In the process of this survey a number of gully sites within the area of study (Ankpa) were visited. Field measurements regarding the gullies were taken using the recoding sheet as appropriate. The necessary details needed in each of the gully sites include, the gully site location, elevation, longitude and latitude, average width, approximate depth, and the gullies cross section (slope).

Each site visited fresh soils samples were collected from the exposed horizons at a depth of 3m on each of these three locations of the gullies sites for laboratory analysis. Samples collected from each of the sites were stored in polythene bags and labeled accordingly for easy sorting in the laboratory.

Samples collected from St Charles	A
Samples collected from Ajobe	B
Samples collected from COE labeled	C

Photographs were taken at various gully sites visited to show the extent of erosion on farmland, structures and roads.

Topographic map of Ankpa was used for proper field survey. Each site of the gully visited was properly located on the map.

Some documented facts about the area of study were used such as the soil map of the area.

Instruments Used:

- Geological / topographical maps
- Global positioning system (GPS)
- Measuring tape
- Recording sheet
- Digital camera
- Hand trowel

Field survey calculations

The recorded values of latitude and longitude as indicated in (Table 2) were recalculated in order to convert the seconds to minutes. The elevation values were recorded against each latitude and longitude to produce a contoured topographical map of the terrain of the study area. The value is presented in (Table 3).

3.3 LABORATORY ANALYSIS

The samples collected from the field were analyzed to determine the following; particles size distribution, bulk and dry density, Atterberg limit test, specific gravity and natural moisture content.

The analysis was carried out in the Civil Engineering Laboratory, F.U.T Minna.

3.3.1 SIEVE ANALYSIS (GRAIN SIZE DISTRIBUTION)

The soil samples were oven-dried and set for grain size analysis. The equipment in use in this case were beam balance (about 0.1 sensitivity), automated sieve shaker, metal trays, set of sieve and brush for clearing the sieve. The sieves were arranged in order of reducing aperture size. 300g of each of the soil sample was used throughout the analysis.

The oven dry sample was necessary to reduce the moisture content for easy passage of the grain size through the sieve. The set of sieves were allowed to be shaken for five minutes for proper sieving of the soil sample. After this time, the material retained on each sieve was transferred to the pan of weighing balance and logged particles in the aperture of the sieve were removed with a brush. The mass of soil sample retained on each sieve was recorded against the sieve aperture size. The data obtained is presented in Tables 4, 5 and 6.

Particle Size Distribution Curve: -

The results of mechanical analysis are generally presented on a semi-log graph known as particle size distribution graph.

The particle diameters are plotted on the log scale and the corresponding percentage finer are plotted on the arithmetic scale.

The general slope has the shape of the distribution and it is described by the means of some constants such as effective sizes, uniformity coefficient, coefficient of graduation, these terms are denoted as D10, Cu, and Cc respectively.

Effective size

This is the diameter of the particle size distribution curve corresponding to 10% finer passing.

Uniformity Coefficient

Cu = $\frac{D_{60}}{D_{10}}$ Where D_{60} is = effective size

D_{10} is = effective size

Coefficient of Gradation

Cc $\frac{D_{30}}{D_{10}.D_{60}}$ Where D_{30} is Effective size

Sorting Coefficient

So = $\frac{(D_{75})^{1/2}}{D_{25}}$ Where D_{75} is Effective size

D_{25} is Effective size

Particle size distribution shows the range of particles size present in the soil as well as the way these size variation occurs.

A coarse grained soil is described as well graded if there is no excess of particles in any size range if no intermediate are lacking. A coarse grained soil is described as poorly graded

(i) A high proportion of the particles have size narrow limits.

(ii) Particles of both large and small sizes are present but with a relative low proportion of particles of intermediate size.

A well graded soil will have a uniformity coefficient Cu =4 and Coefficient of gradation Cc = 1 to 3. A graph of percentage finer passing against sieve sizes (particular diameter) to conventional scale is plotted. flattened slopes show finer sands or poorly graded soils. A gentle slope shows intermediate sands, while steep slope show coarse sandy soil, well graded.

The calculations entail

$$\text{\% Retained on any sieve} = \frac{\text{Wt of soil retained}}{\text{Total Wt of sample}} \times 100$$

3.3.2 NATURAL MOISTURE CONTENT

Geologists, the engineers have noted that water serves as crucial constituent of the soils. By this it is assumed that soil has phases namely, the solid phase, liquid phase and the gaseous phase. The solid phase is stable while there is interchange in the voids found in the soil.

The amount of water present in each sample is equal to the amount over dried at 105°C. That is natural moisture content of the soil is the sample calculated weighed percentage.

Therefore, if natural moisture content is represented by W, the equation is thus stated as:

$$w = \frac{w_1 - w_2}{w_2 - w_c} \times 100$$

Where w_1 = weight of container + moist soil

w_2 = weight of container + oven-dried soil

w_c = weight of container

Each weight is noted and used in subsequent calculation for sample A as shown in Table 9 and this procedure is used for the remaining samples B and C respectively.

3.3.3 ATTERBERG LIMITS TESTS

Liquid Limit Test (LL)

A quantity of soil sample was oven – dried and pulverized which was then sieved through a 425μ (micrometer) B.S. No. 40 sieve. The sieved soil material was then mixed with water to have a uniform paste. The paste was placed on the cup of liquid limit device. The paste was smoothened and the grooving tool was drawn throughout the sample along the symmetrical axis of the cup, with the tool perpendicular to the cup at the point of contact. The crack of the device was then turned and the number of blows was noted, necessary to close the groove. Care was taken to ensure close that the groove was closed by a flow of soil and not by slippage between the soil and the cup.

Plastic Limit (PL)

The plastic limit (PL) is the percentage of moisture content at which the soil crumbles when rolled into a thread of 3.2mm in diameter.

This test was carried out using some amount of the pulverized soil sample got from a sieved soil using 425μm screen.

The sieved soil was thoroughly mixed with water content which allowed a thread of 3.2mm to be rolled. The test was done repeatedly by rolling an ellipsoidal soil mass by the finger on a glass plate. By this rolling a thread like of about 3.2mm in diameter was produced which showed sign of crumbling. Some of the crumbling materials were taken for the water content determination and when arranged gives the plastic limit. Average values of these determinations were used to give the plastic limit.

Plastic Index

This gives the difference between the liquid and the plastic limit of any particular disturbed sample (i.e. LL – PL).

The result of Atterberg's Limit tests for samples A, B and C are as shown in Table 7, 8 and 9.

Note: All these calculations are shown in appendix I and II.

3.3.4 SPECIFIC GRAVITY

The specific gravity is the ratio of the unit weight of soil particles to the unit weight of water at a given temperature (usually 4^0C) and range numerically from

2.60 to 2.80. Within this range, the lower values are typically specific gravity of fine grained selt types. Values of specific gravity not within the range of the given values may be occasionally be encountered in soils derived from parent materials that usually may contain heavy minerals or light ones.

$$\text{Specific gravity} = \frac{\text{wt of soil particle}}{\text{wt of an equal VOL of } H_2O}$$

i.e. S.G =

Where w_1 = wt of empty bottle (g)

w_2 = wt of empty bottle + 1/3 of soil (g)

w_3 = wt of empty bottle + 1/3 of soil + water (g)

w_4 = wt of empty bottle + water only (g)

3.4 DATA SOURCES AND THEIR CHARACTERISTICS

The study area has a typical wet and dry climate characterized by 5 to 6 mouths of wet season. There are no synoptic stations within the study area. The meteorological data was got from meteorological station at Lokoja on the western part of the project area. The climate of the study area is the same as that of the middle belt of Nigeria with high temperature and excessive humidity during the greater part of the year. This is indicated in the introductory chapter of this work.

3.4.1 Demographic Data

Population increase has been cited as one of the great contributors to the causes of land erosion. According to Baba (1992), the Malthusian or more recently Neo-Malthusian view is that increasing demographic pressure results in over use of reasonable quality of land. If population increase has that effect, the impact is double edged as simultaneous increase in demand made upon the environment in order to support growing numbers of people has led to the destruction of the resource base.

For a better understanding of the effects population pressure has on land, the population data of the study area and environs was collected from the National Population Commission (NPC) Kogi State Headquarters Lokoja (2006). The entire population for both males and females stood at 267,353.

CHAPTER FOUR

RESULTS

4.1 FIELD OBSERVATION AND MEASUREMENTS

The most serious soil erosion is undoubtedly caused by gullies in the area under study and has a reputation for gully erosion.

The various characteristics regarding gully sites representative measurements are shown in the table below

Table 2: Showing Geometric Characteristics of some Gully Sites in Ankpa and Environs.

S/N	Location	Gully site(s)	Elevation (m)	Latitude	Longitude	Average width (m)	Approx. depth (m)	Cross section
1	L1	Behind St. Charles Sec. School, Ankpa	460	$07^0$24'28.8"	$007^0$38'23.8"	12	12	V - shaped
2	L2	Ogwuchekpo Street, Ankpa	350	$07^0$24'23.3"	$007^0$37'42.23 "	11	5	U - shaped
3	L3	Liberia Street	225	$07^0$23'41.1"	$007^0$37'25.11 "	5	3	V – shaped
4	L4	Opp. Chairman Qtrs – Ankpa	430	$07^0$23'02.2"	$007^0$37'51.5"	20	11	V – shaped
5	L5	OPP COE Ankpa	508	$07^0$22'22.3"	$007^0$37'44.7"	15.50	7.60	U - shaped
6	L6	Behind General Hospital Ankpa	525	$07^0$23'49.3"	$007^0$37'36.3"	3.30	1.30	U - shaped
7	L7	Ogodo Ankpa	330	$07^0$24'16.7"	$007^0$37'36.3"	1.0	0.60	Not defined
8	L8	Ajobe – Ankpa	430	$07^0$26'03.6"	$007^0$43'25.0"	3.0	6.2	Not defined
9	L9	Mkd Road Ajoba – Ankpa	400	$07^0$26'16.9"	$007^0$43'42.5"	13	8.3	V - shaped
10	L10	Mkd Road Ajobe – Ankpa	363	$07^0$26'16.9"	$007^0$43'42.5"	8.0	4.0	U - shaped
11	L11	Enjema Sec. School	190	$07^0$24'19.7"	$007^0$39'43.7"	2.0	3.0	V - shaped

Table 3: Values of calculated latitude and longitude from table 1 with the appropriate elevation and locations

S/N	LOCATIONS	LATITUDE	LONGITUDE	ELEVATION (M)
1	L_1	$07^0 24.5'$	$007^0 38.4'$	460
2	L_2	$07^0 24.4'$	$007^0 34.7'$	350
3	L_3	$07^0 23.03'$	$007^0 25.4'$	225
4	L_4	$07^0 23.03'$	$007^0 37.9'$	430
5	L_5	$07^0 24.4'$	$007^0 37.7'$	508
6	L_6	$07^0 23.8'$	$007^0 37.6'$	525
7	L_7	$07^0 24.3'$	$007^0 34.6'$	330
8	L_8	$07^0 26.06'$	$007^0 43.4'$	430
9	L_9	$07^0 26.3'$	$007^0 43.7'$	400
10	L_{10}	$07^0 26.3'$	$007^0 43.7'$	363
11	L_{11}	$07^0 29.3'$	$007^0 39.7'$	190

Values on the table were used to produce a contoured map based on the terrain of the study area as indicated in Fig. 10. The plates as seen in (Li – Lxii), represent the magnitude and dimensions of gully erosion sites of the study area.

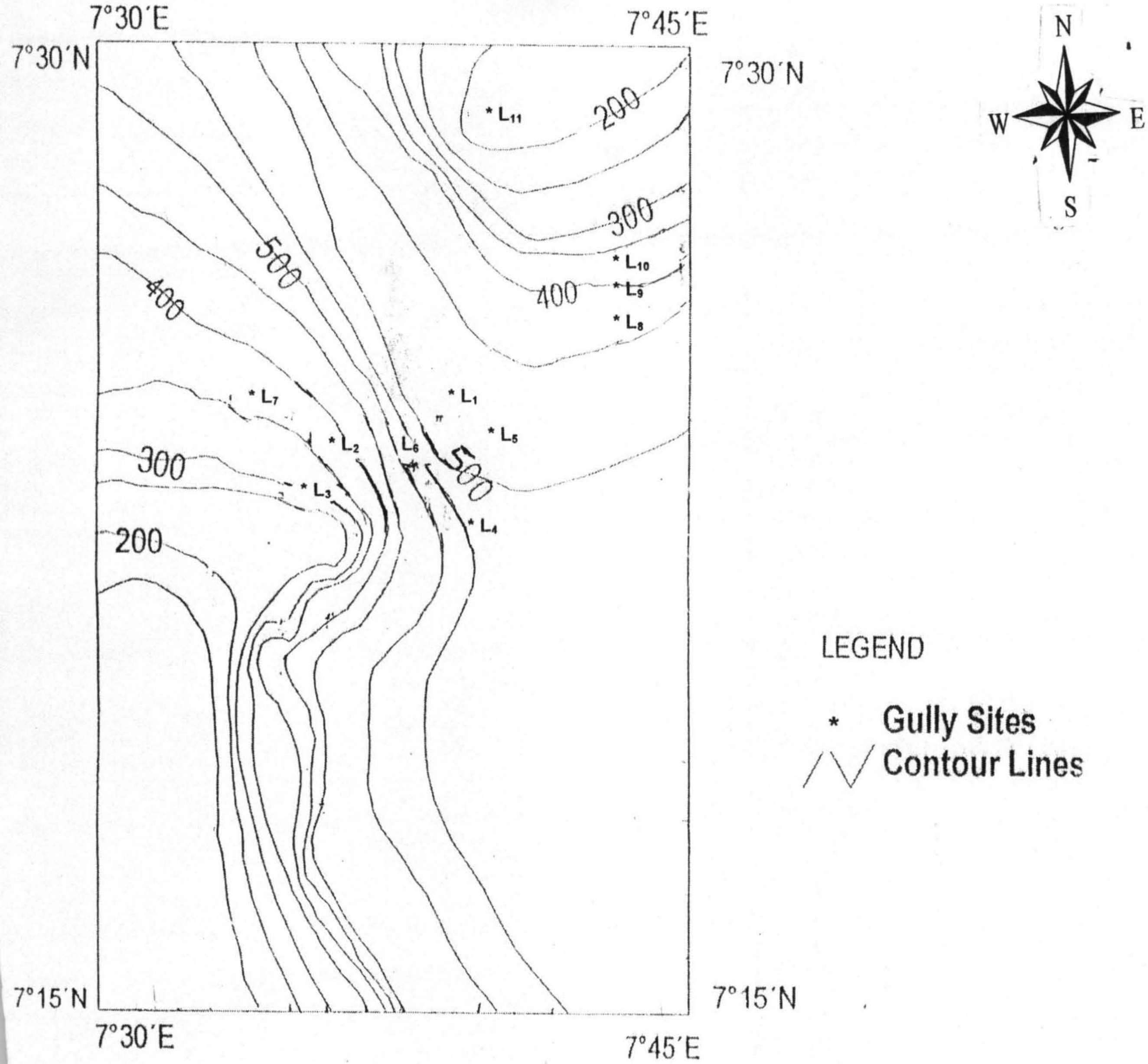


Fig. 10: A contoured map of the study area.

Plate i: Devastating Gully behind St. Charles SEC. School, Ankpa (L1)

Plate ii: Gully Erosion at Liberia, Ankpa (L2)

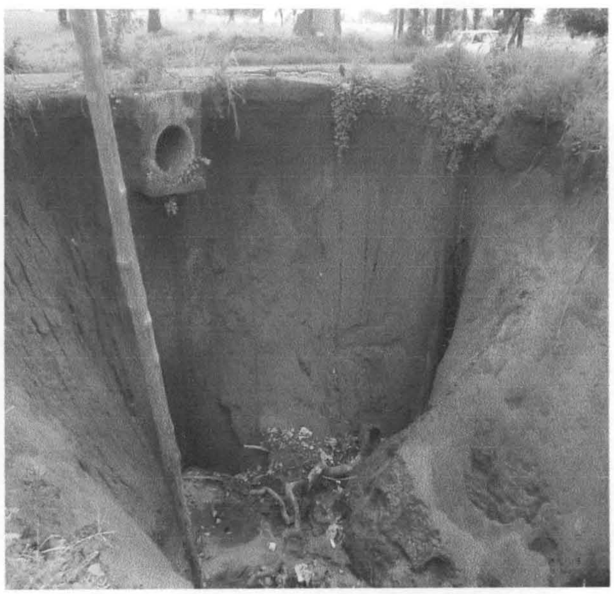


Plate iii: Menace of Gully Erosion Opposite C.O.E. Ankpa (L3)

Plate iv: Gully Erosion at Ogwuchekpo Street, Ankpa. (L4)

Plate v: Destructive effect of gully erosion on Structures opposite Chairman Quarters, Akpa (L5)

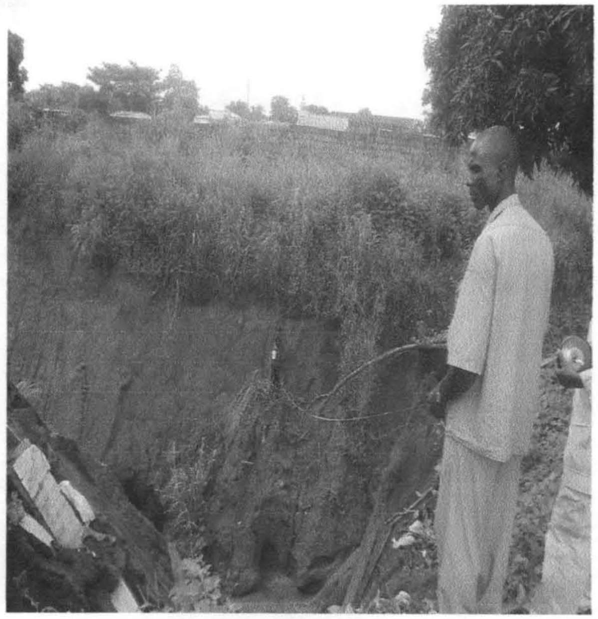


Plate vi: Measurements taking on Gully, Opposite Chairman Quarters Ankpa. (L6)

Plate vii: Deep Gully in Ankpa. (L7)

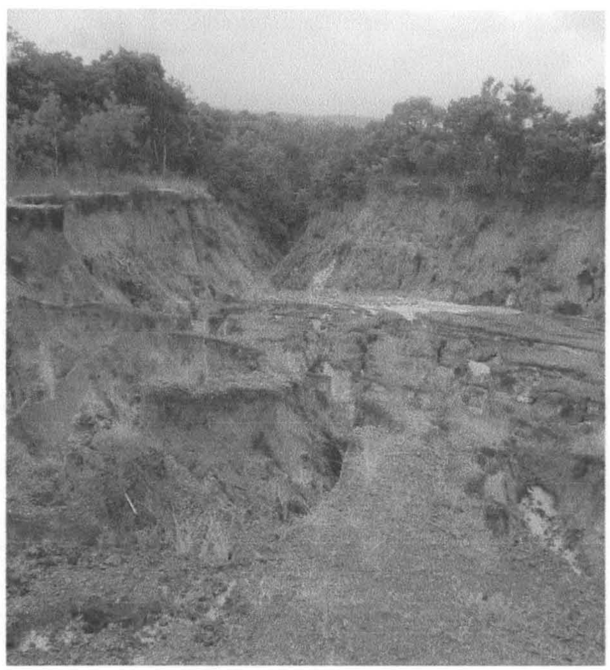


Plate viii: Terrible gully at Ajobe, Makurdi Road, Ankpa (L8)

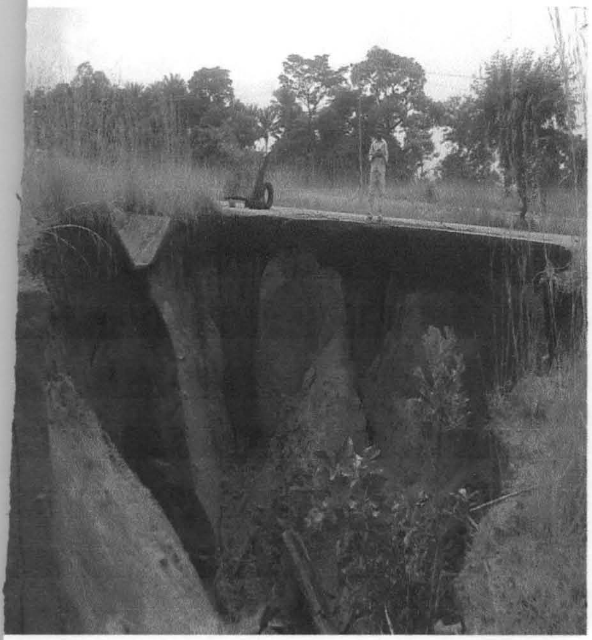


Plate ix: Gully erosion destroying Makurdi Road, Ajobe, Ankpa.(L9)

Plate x: Gully at Ajobe Ankpa destroying farm land. (L10)

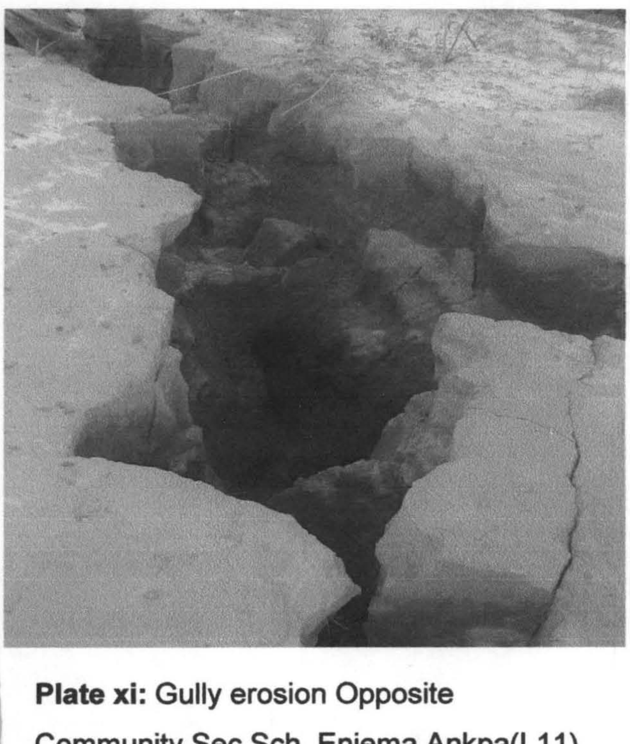


Plate xi: Gully erosion Opposite Community Sec Sch. Enjema Ankpa(L11)

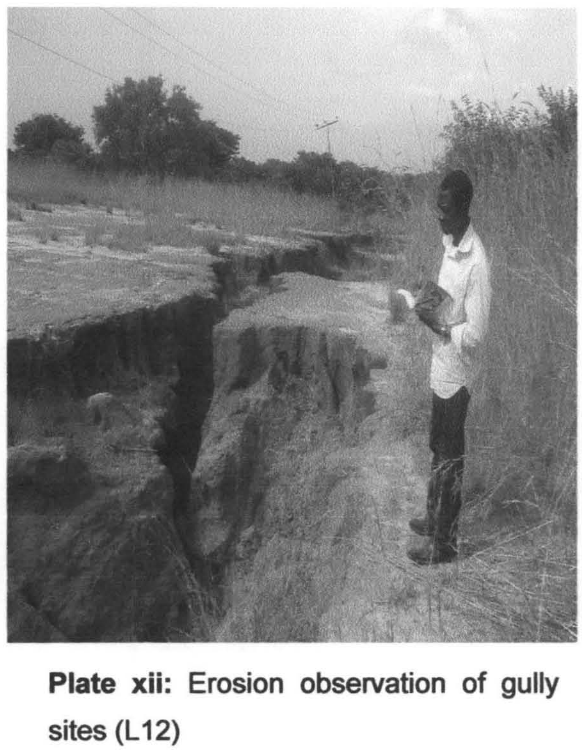


Plate xii: Erosion observation of gully sites (L12)

All photos after Abba F. M., (2008)

4.2 RESULTS FORM LABORATORY ANALYSIS

4.2.1 Particle Size Distribution (Sieve Analysis): This table 4 shows the result of sieve analysis of sample A and it is graphically presented in Appendix I as Figure 11. However, all calculations based on the particle size analysis on factors such as Uniformity Coefficient, CU; Coefficient of Curvature Cc and Sorting Coefficient SO; for Sample A are obtained from the graph as shown in Appendix 1.

Table 4: Sample A sieve analysis

Sieve size (μm)	Wt of sieve (g)	Wt of sieve + soil (g)	Wt of soil retained (g)	Percentage retained %	Cumulative percentage retained %
5.00	477.3	477.5	0.2	0.09	100.0
3.35	470.7	470.8	0.1	0.04	99.92
2.00	418.2	418.4	0.2	0.09	99.88
1.18	387.3	394.3	7.0	3.0	99.80
850	357.4	373.8	16.4	7.1	96.80
600	467.2	498.0	30.7	13.3	89.70
425	434.7	474.6	39.9	17.3	76.4
300	313.4	365.7	52.3	22.7	59.1
150	419.9	494.9	75.0	32.5	36.4
75	403.6	412.1	8.5	3.7	3.9
Pan	270.5	270.9	0.4	0.21	.

Wt of day sample A = 230.6

4.2.2 Particle Size Distribution (Sieve Analysis): This table 5 shows the result of sieve analysis of sample B and it is graphically presented in Appendix I as Figure 12. All calculations based on the particle size analysis on factors such as Uniformity Coefficient, CU; Coefficient of Curvature Cc and Sorting Coefficient SO; for Sample B are obtained from the graph as shown in Appendix 1.

Table 5: Sample B sieve analysis

Sieve Size (μm)	Wt of Sieve (g)	Wt of Sieve + Soil (g)	Wt of Soil Retained (g)	Percentage Retained %	Cumulative Percentage Retained %
5.00	477.3	534.3	57.0	23.5	99.90
3.35	470.7	503.5	32.8	13.5	76.4
2.00	418.2	468.3	50.1	20.6	62.9
1.18	387.3	420.4	33.1	13.6	42.3
850	357.4	369.3	11.9	4.9	28.7
600	467.2	478.0	10.8	4.4	23.8
425	434.7	445.0	10.3	4.2	19.4
300	313.4	326.0	12.6	5.2	15.2
150	419.9	440.0	20.1	8.3	10.0
75	403.6	407.4	3.8	1.6	1.7
Pan	270.5	207.4	0.2	0.08	0.1

Wt of day sample B = 242.7

4.2.3 Particle Size Distribution (Sieve Analysis): This table 6 shows the result of sieve analysis of sample C and it is graphically presented in Appendix I as Figure 13. All calculations based on the particle size analysis on factors such as Uniformity Coefficient, CU; Coefficient of Curvature Cc and Sorting Coefficient SO; for Sample C are obtained from the graph as shown in Appendix 1.

Table 6: Sample C sieve analysis

Sieve size (μm)	**Wt of sieve (g)**	**Wt of sieve + soil (g)**	**Wt of soil retained (g)**	**Percentage retained %**	**Cumulative percentage retained %**
5.00	477.3	477.3	0.0	0.0	100.0
3.35	470.7	470.7	0.0	0.0	100.0
2.00	418.2	418.2	0.0	0.0	100.0
1.18	387.3	393.7	16.4	2.6	100.0
850	357.4	379.4	22.0	8.9	97.4
600	467.2	500.2	33.0	13.4	88.5
425	434.7	486.5	51.8	20.9	75.1
300	313.4	372.2	58.8	23.8	54.2
150	419.9	487.8	67.9	27.5	30.4
75	403.6	410.4	6.8	2.8	2.90
Pan	270.5	270.7	0.2	0.08	*

Weight of day Sample C = 246.9

4.2.4 Determination of Atterberg Limit for sample A: from the study area as obtained from the tests. This is graphically presented on Appendix II as Figure 14. The calculations for each constant such as moisture content, Liquid Limit, Plastic Limit and Plasticity Index are shown also in Appendix II for Sample A.

Table 7: Determination of Atterberg Limit for Sample A from the study area

	DETERMINATION OF ATTERBERG LIMIT		
			Lab:- No
Construct site			
Construction section			
Project			
Sample No	A	Location BEHIND ST. CHARLES, ANKPA	Date: 28.8.08

	LIQUID LIMIT							PLASTIC LIMIT		
Container No	1	2	3	4	5	6	7			
Penetration (mm)	90	125	150	197	265					
Wet sample + Container Wd + We (g)	43.39	32.20	36.10	29.88	28.95	/	/	22.9	23.25	/
Dry sample + Container Wd + We (g)	40.34	29.60	34.00	27.62	25.86	/	/	21.99	22.55	/
Container weight We (g)	28.63	12.74	16.33	16.24	15.91	/	/		/	/
Weight of water Ww / Wt – Wd	3.05	2.6	20.1	2.3	30.09	/	/		/	/
Dry sample Wd (g)	11.71	16.86	17.67	11.38	9.95	/	/			/
Moisture content $W = {}^{ww}/_{wd} \times 100$	26.0	13.4	11.9	20.2	31.1	/	/			/
Average for plastic limit										

4.2.5 Determination of Atterberg Limit for sample B: from the study area as obtained from the tests. This is graphically presented on Appendix II as Figure 15. The calculations for each constant such as moisture content, Liquid Limit, Plastic Limit and Plasticity Index are shown also in Appendix II for Sample B.

Table 8: Determination of Atterberg Limit for Sample B

	DETERMINATION OF ATTERBERG LIMIT		
			Lab:- No
Construct site			
Construction section			
Project			
Sample No	B	Location MKD RD AJOBE, ANKPA	Date: 28.8.08

	LIQUID LIMIT							PLASTIC LIMIT		
Container No	1	2	3	4	5	6	7			
Penetration (mm)	50	105	140	182	206					
Wet sample + Container Wd + We (g)	38.95	40.88	41.40	39.99	35.52	/	/	28.42	29.38	/
Dry sample + Container Wd + We (g)	36.64	36.65	37.89	36.31	31.48	/	/	27.59	28.71	/
Container weight We (g)	29.44	26.23	29.27	28.68	22.70	/	/	24.25	26.08	/
Weight of water Ww / Wt – Wd	2.31	4.03	3.51	3.48	4.04	/	/	0.83	0.67	/
Dry sample Wd (g)	7.20	10.42	8.62	7.83	8.78	/	/	3.34	2.63	/
Moisture content $W = {ww}/{wd} \times 100$	32.1	38.7	40.	44.4	46.0	/	/	24.9	25.5	/
Average for plastic limit								**25.2%**		

4.2.6 Determination of Atterberg Limit for sample C: from the study area as obtained from the tests. This is graphically presented on Appendix II as Figure 16. The calculations for each constant such as moisture content, Liquid Limit, Plastic Limit and Plasticity Index are shown also in Appendix II for Sample C.

Table 9: Determination of Atterberg Limit for Sample C

	DETERMINATION OF ATTERBERG LIMIT		
			Lab:- No
Construct site			
Construction section			
Project			
Sample No	C	Location OPP. COE, ANKPA	Date: 28.8.08

	LIQUID LIMIT							PLASTIC LIMIT		
Container No	1	2	3	4	5	6	7			
Penetration (mm)	52	61	202	245	258					
Wet sample + Container Wd + We (g)	37.09	44.93	33.01	41.57	50.12	/	/	30.45	31.10	/
Dry sample + Container Wd + We (g)	35.68	42.45	31.37	39.20	45.38	/	/	29.95	30.99	/
Container weight We (g)	24.62	27.06	23.67	29.39	25.96	/	/			/
Weight of water Ww/Wt – Wd	1.41	2.48	1.64	2.37	4.74	/	/			/
Dry sample Wd (g)	11.06	15.39	7.7	9.81	19.42	/	/			/
Moisture content $W = {ww}/{wd} \times 100$	12.7	16.1	21.2	24.2	24.4	/	/			/
Average for plastic limit										

From the introductory part of chapter 3, it is stated that the soil is described as well graded if the uniformity coefficient Cu, is greater than 4 and the coefficient of curvature Cc is between 1 and 3.

Therefore, since calculations in Appendix I for all constants and shown in Table 10, Cu > 4 and Cc is within the range of 1 and 3 for samples A, B, and C, these indicated well graded soil samples.

From the particle size distribution curve for sample A, B, and C as shown in figs. 12, 13 and 14, indicate that the samples are well graded.

5.1.1 Atterberg's Limit Test Results

The results of the Atterberg's Limit tests are as shown in Appendix II

The liquid limits for sample A, B, and C as shown in figures 15, 16, and 17 are high which indicates that the soils are soft.

Plastic limit results show that sample A and C indicate no plasticity due to their loose sandy nature.

The plasticity limit for sample B is moderately high which shows that the soil is moderately stiff.

The results above have shown that all the soil samples contain moderate percentage of water.

From the result of specific gravity, samples A and C are very loose soil particles (light), while sample B contains some heavy minerals and is lateritic in nature. The calculations are shown on appendix II.

5.1.2 ANKPA LAND EROSION AND ITS CAUSES

Land erosion in Ankpa as revealed by the study is as a result of a combination of natural factors and human activities. From the field study and the geotechnical investigation, some characters from the factors were responsible for the land erosion. These include, the heavy rainfall, accelerated runoff, the unconsolidated nature of the soil, steep slopes of the escarpment. All these natural factors induce gullies in the study area and its environs. The evidence of such gullies are shown on the plates as reported in chapter four. Erosion are gulling in the study area mainly caused by both surface and ground water. The evidence from the rainfall data and laboratory analysis of the soil shows that, the soil is well graded and poorly sorted suggesting, that, it is highly unconsolidated which allows water to freely dislodge the material. By the nature of the soil, from the analysis, under heavy rainfall intensity, there will be increased flow velocity which erodes the soil materials producing gully.

It can also be inferred that the increase in soil erosion and consequent loss of fertile soils around the place are responsible for the drastic decline in the quality and quantity of agricultural production in the study area.

Fig 10, shows the nature of the topography of the area. From the average gradient of river Ankpa (Mabolo), it shows that the slope is a great factor to accelerated soil erosion in the study area.

From the geological type, relief and soil description in the entire study area, it is observed that the area is mostly composed of unconsolidated sandstone as indicated by plastic limit results for sample A and C while sample B shows high plastic limit due to the latertic nature of the area. With the absence of vegetal cover, when rain falls, the concentrated run-off contribute in initiating erosion process.

So geology, relief and soil type contributed to the enhancement of land erosion in the study area, Fig. 5 shows the soil map of Ankpa establishing the unconsolidated nature of Ankpa.

Human activities such as bush burning, bush clearing and lumbering have accelerated land erosion in the area. The removal of vegetation and gradual change to grass/shrub and change from vegetal wet land cultivated to degraded lateritic sandy surface are responsible for the increased impact of rain drops and runoff also that area bare of vegetation generate more runoff than areas of thick vegetal cover.

The analysis reveals that the soil is loose sandy, unconsolidated sandstones, therefore, farming practice in the study area such as cultivation between moulds and ridges create favourable zone for concentrated surface runoff. It was observed that the poor agricultural practice by farmers is partly due to lack of conviction regarding the conservation measures.

From our discussion therefore, it can be said that remediation approach to erosion control will be crucial in the study area. These include planting of trees, improved vegetation and recommendation on guided agricultural land. This will go along away in arresting the menace of land erosion. However, some remediation measures can be introduced to arrest the situations.

5.1.3 SOME REMEDIATION MEASURES

1. **Check Dam**

This check dam measure as explained below is used to arrest erosion menace. Whether made from rock, bush, concrete, or other materials, a check dam should have the general features as explained below. The structure should be dug into the walls of the gully to avert water from going around it. The centre of dam should be lower so that the water will spill over there to avoid washing out the soil of the gully walls. An erosion resistant apron made from densely bundled brush, concrete, large rocks or similar material should be installed beneath the centre of the dam to prevent the overflow from undercutting the structure.

In contrast to the gully healing effect of a well designed check dam, the haphazard and indiscriminate dumping of rocks, brush, or car junks into a gully should be avoided and this attitude will make the matter worse, not better.

2. **Shelter Belts:** shelter belts shade the slopes of gullies or deep river valleys and by that protect and allow the regeneration of the natural vegetative cover. The shelter belt will reduce the temperature in the clouded area and will create favourable moisture conditions for the growth of pioneer species. Shading, increase soil moisture, reduces the differences in temperature between the sunny bank and the bank with air humidity at ground level.

Shelter belts consist normally of 8-10 strips of trees spaced 1.5m apart with trees in the strips space 0.6-0.7m apart. The most effective shelter belts are those which are planted in the lower part of the bank.

3. **Vegetative Barriers**

Narrow rows of permanent vegetation (usually grasses or shrubs) planted on the contour can be used to slow down runoff, trap sediment, and eventually building up “natural’ or “living” terraces. In some situation, tropical grasses (e.g. deep rooted, drought-tolerant species called vetiver grass) have shown considerable promise as an affordable alternative to the construction terraces.
The deep rooted vetiver planted have dense, stiff stem that tend to filter out soil particles from the muddy runoff. This sediment builds up on the up slopes side, the grass barrier and in time, actually creates a terrace that may be more than 1m above the soil surface on the down slope side of the plants. Vetiver grass is

particularly well suited to survive under harsh conditions, as its root system can forage deeply for water and its foliage is not palatable to wandering cattle.

The vetiver grass has been found to grow favourably in Nigeria by the IITA Ibadan. Also, elephant grass can be used to create natural terraces in the absence of vetiver grass.

5.2 SUMMARY

The highlights of the result of the study can be summarized as set out below:

The root cause and spread of land erosion in Ankpa (the study area) of Kogi State is yet to be adequately addressed.

It can be summarized that, the study has revealed a combination of water agent and human activities have brought Ankpa area to:

- Drastic reduction in land productivity for agriculture due to accelerated soil erosion.
- Loss of soil fertility and crop nutrient with the organic matters washed off from farmlands.
- Increased cost in developing, maintaining infrastructures as eroded sites such as roads, bridges, buildings etc have to be reclaimed.
- The soil texture, structure, the topography of the terrain (study area) all have contributed to sediment accumulation resulting from soil erosion.
- The increase in population has led to serious pressure on the land thereby affecting the land use/vegetation.

- A proactive soil erosion control and other remediation measures are suggested for the area.

5.3 CONCLUSION

Several conclusions could be arrived at from the results of this study and such conclusions may include the following:

It has been shown that geotechnical analysis is a useful investigation method in the studying of soil erosion. It allows the assessment of the nature of soil and its characteristics that makes an area prone to erosion due to the unconslidating nature of the soil.

It could also be concluded that the nature of the soil, rainfall intensities topographic characteristics, and poor agricultural practice are the major factors responsible for the accelerated erosion in the study area.

It is evident from the foregoing that land erosion problem in the study area can partly be blamed on farmer's ignorance and carelessness in the use of the soil as well as their social and economic limitations. To control this erosion menace, a proper land use management should be carried out by Government at all levels to sensitize the public on how human activities induce erosion.

From the foregoing, the study has shown that land erosion has very serious effect on farmlands, township roads, and threats to lives and properties. The view that land erosion has severe effect on the study area cannot be disputed from the information collected as indicated in the various plates. The erosion in Ankpa has not only destroyed the landscape but has left death traps on some major streets and roads within the township.

It could be viewed that efforts by the community to ameliorate this havoc by the construction of drainage channels to stop the hazard of gully erosion have not yielded fruitful results as these controlled channels are substandard. Inspite of the magnitude of the occurrence of this erosion, government has not yet shown any keen interest in arresting the menace.

It must be stressed here that serious attention should be paid to erosion menace by organization and government in this study area as further increase from the recent state of the erosion will be disastrous.

5.4 RECOMMENDATIONS

It is recommended that the result of the study can be used to prevent, and control land erosion in Ankpa and environs.

The ways of checking erosion is by knowing the causes. The inhabitants of the area understudy should cultivate the culture of protecting the vegetal cover and desist from those activities that will promote soil erosion such as deforestation, bush burning and indiscriminate clearing which are destructive to soil. Efforts should be made towards monitoring the collection of runoff from wide area by creating diversions at intervals. This in effect means shortening the stream length so as to diminish drainage density.

Farmers should be made to understand that natural forest, planting, ought to be protected from fire.

In furtherance to combat the menace of land erosion, civil engineering work, especially road construction should be properly monitored and carried out in recognition with, hydro-meteorologists, and geologists. Drainage channels are encouraged.

Efforts should be made to eliminate ignorance among farmers through various educational and training programmes. In this course, farmers may be kept abreast of the dangers of the erosion caused through anthropogenic factors.

At the end of a study like this, it is crucial and pertinent to make suggestion for further studies.

Land erosion studies are multi-disciplinary in nature and therefore, require the combined efforts of meteorologist, geomorphologist, geologist, padeologist etc.

The remediation measures highlighted in chapter four have proved effective in other countries of the world. It would be necessary if the government can release enough fund for the measures to be employed in combating erosion menace in the study area and Nigeria in particular.

REFERENCES

Adefolalu D. O (2001) Impact Assessment of climate on fadama of woodland savannah Belt Nigeria, A paper submitted to the university Board of Research FUT Minna PP 16-27.

Areola A. (1978) Essentials of soil study. Cambridge University Press, PP40-45.

Baba J M (1992) Sustainable Development and the Environments. The Nigeria Geographical Forestation Journal Vol 1, No. 7 P. 8 – 20.

Bakkuk S. G (1995) Mined land reclamation of Environment protection: A case study of Jos. Unpublished HND thesis, Kaduna Polytechnic PP 44-50.

Bennt, H.H. (1955) Elements of soil conservation *New York – Toronto Journal.* Pp. 50-70

Blevins R.L. and W.W. Frye (1992) Conservation Tillage: An Ecological Approach to Soil Management. Advance in Agronomy 51: 33 – 78.

Brown L. R (1984) Conserving state of the world, 1984 Ed Brown L. R PP 53-60, New York ,Norton City, U.S.A.

Buchman R. C. (1974) An illustration dictionaries of geography Singapore. International Ltd.

Burnet H. H (1973) Soil Conservation, New York – London Journal 19379. Pp. 40 – 60.

Davis R. M (1977) Soil conservation on Agricultural land, *Journal of soil and water conservation* Vol 32 PP 5 -8.

Dunne T. (1978) Field studies of hillslope flow processes in Kirkby M. J. (Ed). Hillslope hydrology Wiley New York NY pp. 227 -280

Edward K (1993) Soil erosion and conservation in Australia in D. pimental (Editors) world soil erosion and Cambridge University press PP 147-159

Elliot T.S. (1977) Environmental Education 2; Conservation of Natural Resources study and teaching. (Ed) James E. Otiende, Williams P. Ezaza and Brother Raymond Boisvert, Nairobi University Press Pp. 40 – 45.

Esu I. E (1984) Effects of tillage on soil physical condition: A paper presented at a workshop on farm machinery and mechanization under the auspices of the Franco – Nigeria technical cooperation at Kaduna polytechnic, PP 19-20 march 1984

F. A. O (1978) The application of landsat imagery to soil degradation mapping F. A. O Rome PP 22

F DALR (1990) Soil survey division, Kaduna. Bulletin 30 Pp. 50 – 60.

FEPA (1999) Lecture notes on Environmental Education, Geography Dept, FUT, Minna (2000).

Fubara M. J. D (1988) The menace of flood and Erosion. An Environmental disaster Crubat plan in signs V. O et al (eds). Ecological disaster in Nigeria soil, Lagos CSS press.

Golubev G. N (1982) Soil erosion and agriculture in the world; an assessment and hydrological implication. Recent Development in the Explanation and Predictions of erosion and sediment yielded Walling, D.E. IAHS Publ. No. 137 pp. 261 – 268 IAHS Press Wallingford.

Grove A. T. (1951) Land use and conservation in parts of Onitsha and Owerri provinces. Bulletin No 22 Geological survey of Nigeria PP 28-32.

Hudson N. (1973) An Introduction to the mechanics of soil erosion condition of tropical rainfall. Prev. Trans. Road Science Ass. Vol. 49(1).

Hudson N. (1995) Soil conservation 3rd Ed. London: B.T.Battford Pp. 391

Iloeje N. P. (1981) A new geography of Nigeria MacMillan pub. Co. PP23-25

Isuzom J. N. (1999) Soil erosion problem in Nigeria. A communial diability. A paper presented at the workshop on the impact of erosion in Nigeria at Owerri 22 - 27 March 1999.

Jones M. I. and Wild A. (1975) Soil of the west African Savanna Tech. Comm. No CAB Halpends.

Kogi state ministry of environment (2005) 1984 Geological Survey Agency Publication Bulletin 34.

Kowal J. M. and Kassam A. H. (1976) Agricultural ecology of savanna. Oxford University press PP 20-25.

Moore I. D. and Foster G. R. (1990) Hydraulic and overland flow. In Andeeson M. G. Burt, T. P. Eds, Process studies in Hillscope hydrology, Wiley Chichester pp. 125 – 205.

Murat R. C (1972); Stragigraphy and paleogeography of the cretaceous and lower tertiary in solution in Nigeria. In African geology (ed)by Dessauvagie T. F and Whitman A. J PP 251 Ibadan university press Ibadan Nig.

National Population Commission Kogi State Headquarters Lokoja (2006). Population Census.

Nigeria Meterological Agency Lokoja 2005. publication on Annual monthly rainfall for 1978 to 2005.

Nkem, O. (1999) Early warning system and modern technologies in Erosion Management. A paper presented at the Workshop on Economic Impact of erosion in Nigeria at Owerri 4 – 7 March 1999.

Ofomata G. E. K. (1995) Factors of soil erosion in Enugu areas of Nigeria: Nigeria *Geographical Journal* Vol 8 No 1 PP39-42.

Olowu, J. (1989) Identifying and assessing problem areas in soil erosion survey using photographs, Photo seconds PP 70-75

Raiment, R.A. (1965) *Review of Nigerian Cretaceous ceriozoic stratigraphy. Jour. Nig. Min. Geo. Met. Soc.* Vol. 1 No. 2 Pp. 61 – 80.

Tsuzon, J. W and Amoka I. S (1991) Reclamation of mined lands for Agricultural Purposes: A case study of Jos minefield. Proceedings of Jos fourth National Engineering conference held at Kaduna Polytechnic 11 – 12 De. PP 310-314.

Wilson R. C and Bain A. D. I (1928) The Nigerian coalfield selt 2, parts of Onitsha and Owerri provinces Geo survey Nigeria Bull No 12 PP 54.

APPENDIX I

FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA, NIGERIA

DEPARTMENT OF CIVIL ENGINEERING

Particle Size Distribution

Location L1 st Charles col; Boring No ______ Sample No A Date of Test 20/08/2008

Description ______

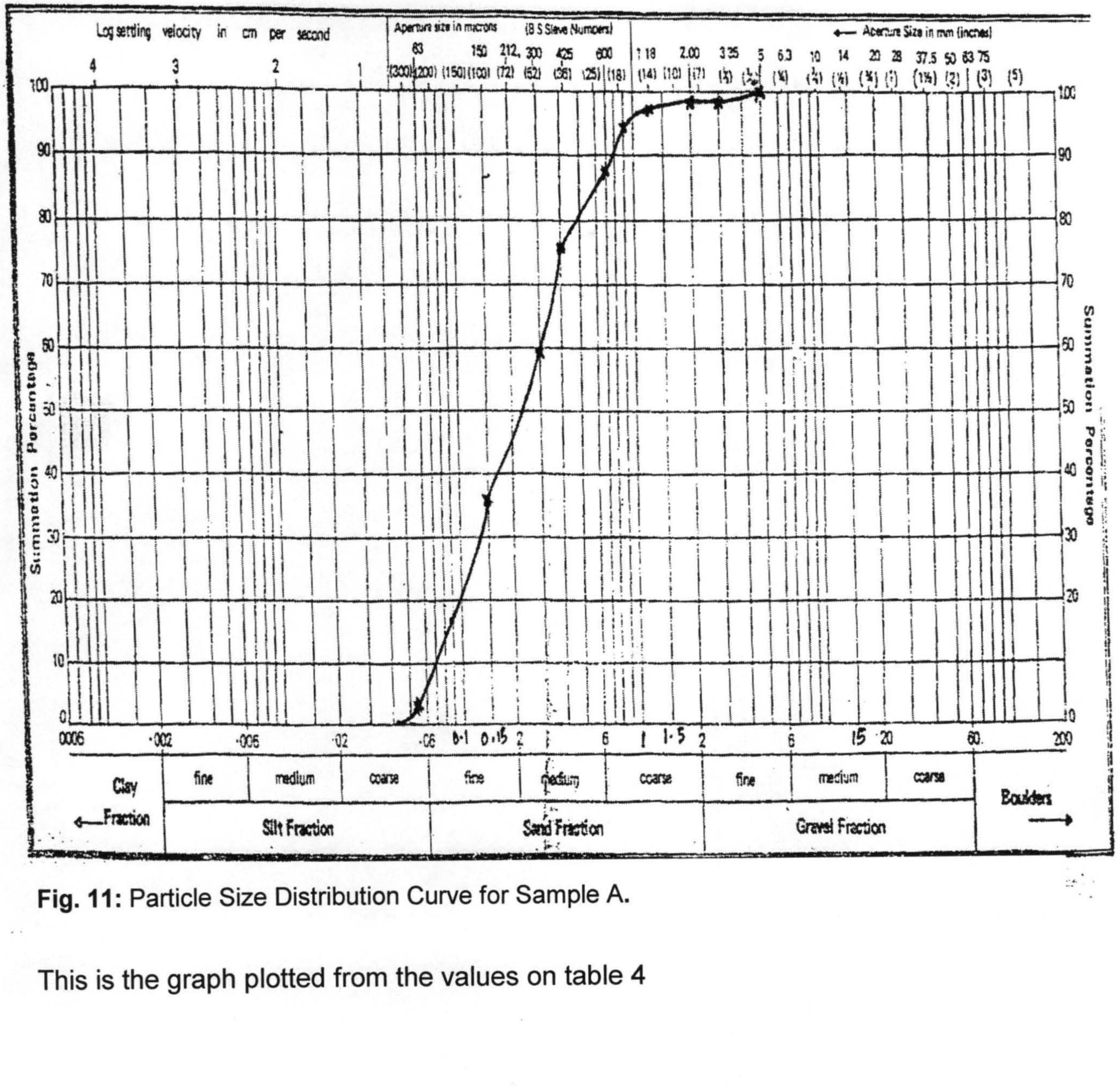


Fig. 11: Particle Size Distribution Curve for Sample A.

This is the graph plotted from the values on table 4

Sample A

Uniformity Coefficient, $Cu = \frac{D60}{D10}$

$$= \frac{0.3}{0.07} = 4.3$$

$\therefore$ Cu = 4.3

Coefficient of curvature, $C_c = \frac{(D_{30})^2}{D_{60}.D_{10}}$

$$= \frac{(0.15)^2}{(0.3 \times 0.07)}$$

$$C_c = \frac{0.0225}{0.021} = 1.1$$

$\therefore$ $C_c = 1.1$

Sorting coefficient, $S_0 = \left(\frac{D_{75}}{D_{25}}\right)^{1/2}$

$$S_0 = \left[{}^{0.3}\!/\!{}_{1.15}\right]^{1/2} = (0.260)^{1/2}$$

$$S_0 = \sqrt{0.260}$$

$S_0 = 0.5$

FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA, NIGERIA

DEPARTMENT OF CIVIL ENGINEERING

Particle Size Distribution

Locatic L8 Mkd Rd Ajobe,Ankpa ing No ______ Sample No B ______ Date of Test. 20/08/2008

Description ______

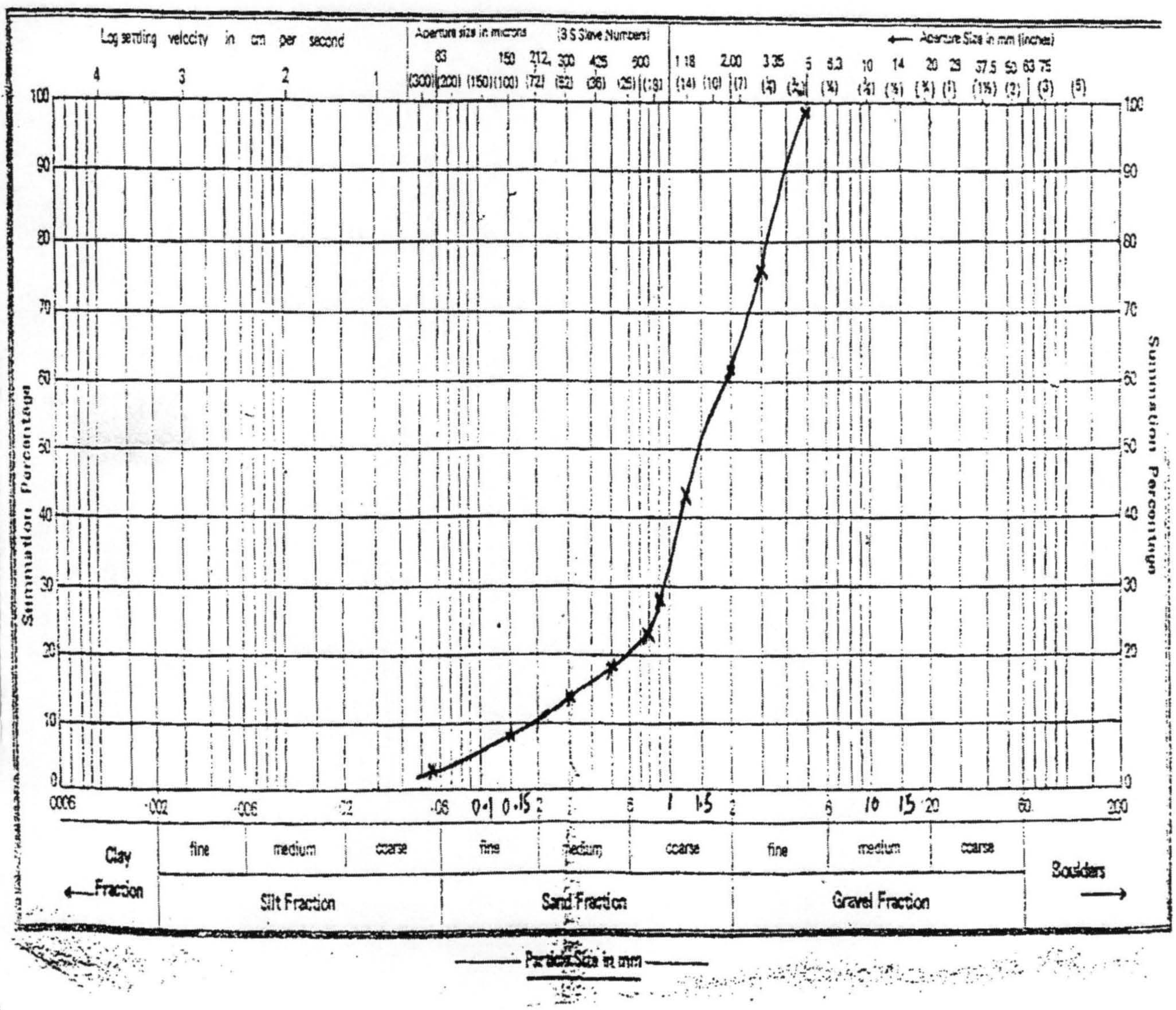


Fig. 12: Particle Size Distribution Curve for Sample B.

This is the graph plotted from the values on table 5

SAMPLE B

Uniformity Coefficient, $Cu = \dfrac{D_{60}}{D_{10}}$

$$Cu = \frac{2}{0.2} = 10$$

Coefficient of curvature, $Cc = \dfrac{\left(D_{30}^{2}\right)}{D_{60}.D_{10}}$

$$= \frac{(0.9)^2}{2 \times 0.2}$$

$$Cc = 2.0$$

Sorting coefficient, $S_o = \left(\dfrac{D_{75}}{D_{25}}\right)^{1/2}$

$$S_o = \left(\frac{3}{0.8}\right)^{1/2} = (3.75)^{1/2}$$

$$= \sqrt{3.75}$$

$$S_o = 2.0$$

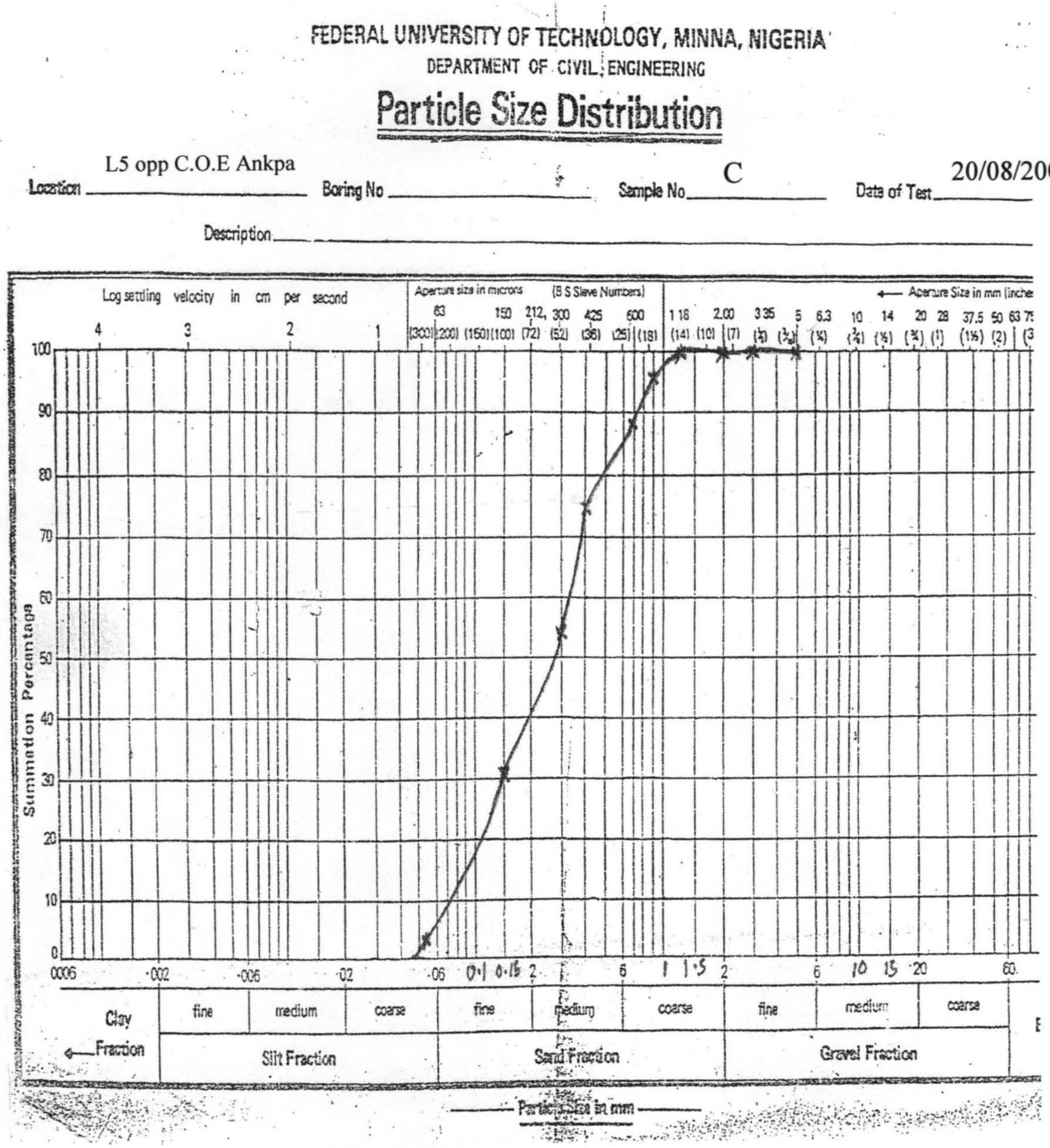


Fig. 13: Particle size distribution curve for Sample C

This is the graph plotted from the values on table 6

SAMPLE C

Uniformity Coefficient, $Cu = \frac{D_{60}}{D_{10}}$

$$Cu = \frac{0.36}{0.07} = 5.1$$

Coefficient of curvature, $Cc = \frac{\left(D_{30}^2\right)}{D_{60}.D_{10}}$

$$= \frac{(0.16)^2}{0.3 \times 0.07}$$

$$= \frac{0.0256}{0.0252}$$

$$Cc = 1.0$$

Sorting coefficient, $S_o = \left(\frac{D_{75}}{D_{25}}\right)^{1/2}$

$$S_o = \left(\frac{0.4}{0.3}\right)^{1/2} = (3.076)^{1/2}$$

$$= \sqrt{3.076}$$

$$S_o = 1.75$$

APPENDIX II

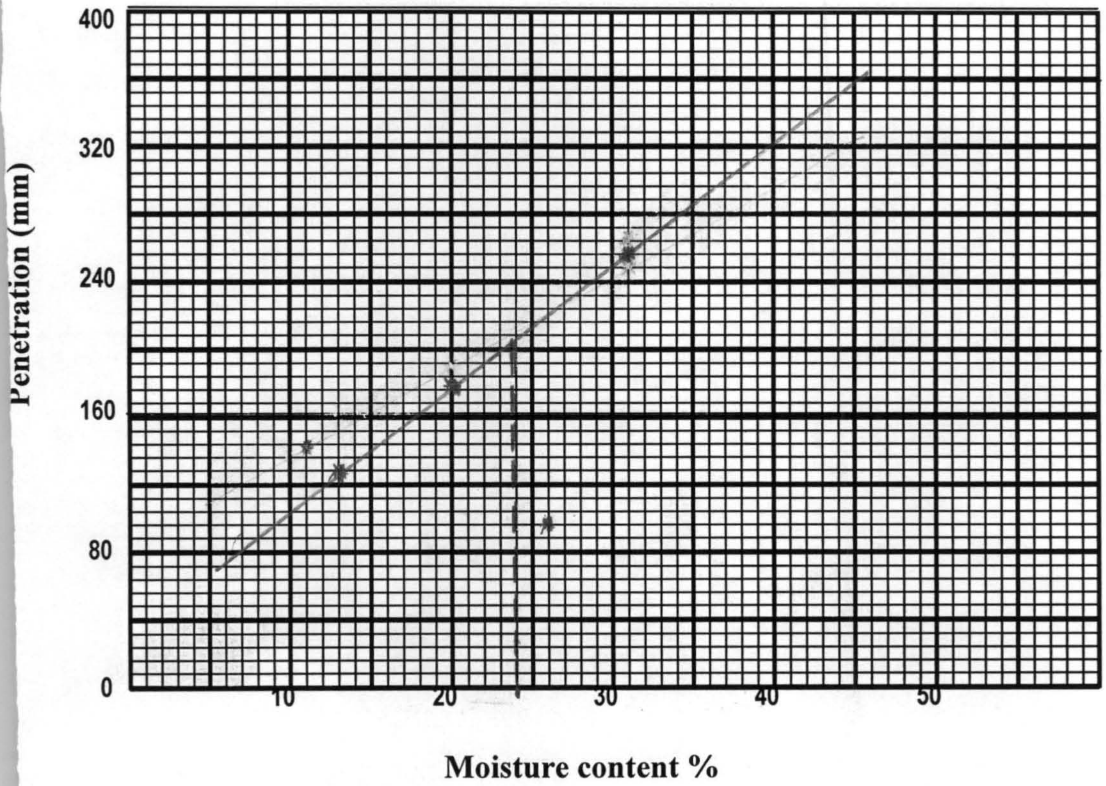


Fig. 14. **Showing Atterberg Liquid Limit for Sample A**

CALCULATION FOR ATTERBERGS LIQUID LIMIT FOR SAMPLE A

SAMPLE A

oisture
ontent
V = 6.8 %

iquid Limit
VI = 45.5%

'lastic limit
Vp 25.2

Plasticity Index
20.3%

Lp = Wl - Wp =

20.3%

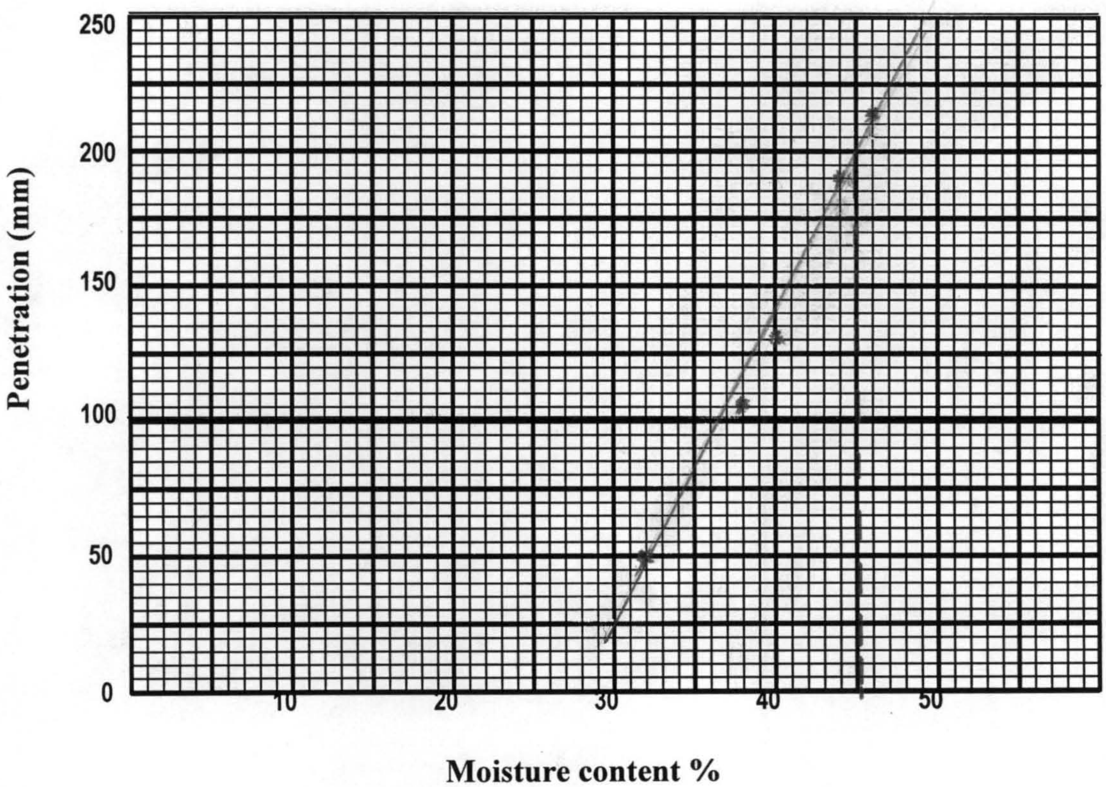


Fig. 15: Liquid Limit graph for Sample B

CALCULATION FOR ATTERBERGS LIQUID LIMIT FOR SAMPLE B

SAMPLE B

Moisture Content
W = 6.8 %

Liquid Limit
WI = 45.5%

Plastic limit
Wp 25.2

Plasticity Index
20.3%

Lp = Wl – Wp =

20.3%

Plastic Limit = Average of Moisture content of plastic limit

$$P.L = \frac{24.9 + 25.5}{2}$$

$$P.L = 25.2\%$$

Liquid Limit = 45.5%

Plasticity Index = Liquid Limit – Plastic Limit

$$P.I = 45.5 - 25.2$$
$$= 20.3\%$$

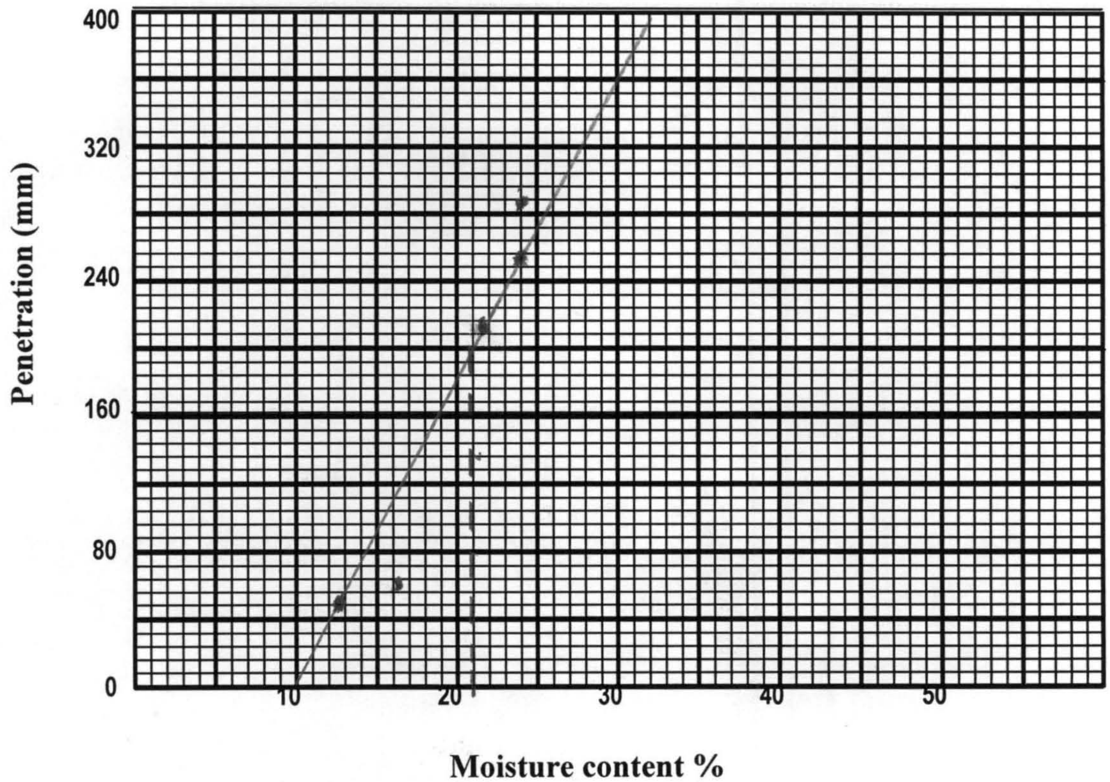


Fig. 16: Liquid Limit graph for Sample C

CALCULATION FOR ATTERBERGS LIQUID LIMIT FOR SAMPLE C

SAMPLE C

Moisture Content
W = 8.4 %

Liquid Limit
Wl = 21.0%

Plastic limit
Wp 0%

Plasticity Index
21.0%

Lp = Wl - Wp
= 21.0%

Table 11: Natural Moisture Content for Sample A

DETERMINATION OF NATURAL MOISTURE CONTENT

Can No	A2g	A1A
Wt of Can	9.5g	9.9
Wt of Can + Wet soil (g)	32.9g	24.9
Wt of Can + Dry soil (g)	31.5g	20.6
Wt of Water	1.4g/m^3	4.3
Wt of Dry soil (g)	22.0g/m^3	10.7

$$\text{Average for water} = \frac{1.4 + 4.3}{2}$$

$$= 2.85$$

$$\text{Average for dry soil} = \frac{32.7}{2}$$

$$= 16.35$$

$$\text{Natural Moisture Content} = \frac{2.85}{16.35} \times 100$$

$$= 17.43\%$$

Table 12: Natural Moisture Content for Sample B

Can No	A1	A44g	
Wt of Can	10.4	9.6g	
Wt of Can + Wet soil (g)	20.9	24.2g	
Wt of Can + Dry soil (g)	20.3	23.2g	
Wt of Water g/m^3	0.6	1g	$\frac{0.6+1}{2}=0.8g$
Wt of Dry soil (g)	9.9	13.6g	$\frac{9.9+13.6}{2}=11.75g$

$$\text{Average Moisture Content} = \frac{\text{Average Weight of Water}}{\text{Av. Wt of dry soil}} \times 1000$$

$$= \frac{0.8}{11.75} \times 1000$$

Natural M.C $= 6.9\%$

Table 13: Natural Moisture Content for Sample C

Can No	Z1	B1	
Wt of Can	23.9	100	
Wt of Can + Wet soil (g)	38.2	26.6	
Wt of Can + Dry soil (g)	36.9	25.5	
Wt of Water	1.3	1.1	$\frac{Av. 0.6+11}{2}=1.2$
Wt of Dry soil (g)	13.0	15.5	$\frac{13.0+15.5}{2}=14.25$

Natural Moisture Content = $= \frac{1.2}{14.25} \times 1000$

$= 8.4\%$

SPECIFIC GRAVITY (S.G)

SAMPLE A

Wt of bottle	= 126.3g(W_1)
Wt of bottle + dry soil	= 146.3g(W_2)
Wt of bottle + soil + water	= 386.4g(W_1)
Wt of bottle + water	= 374.3g(W_4)
Wt Addition of water	= ($W_4 - W_1$)
Wt of water added to soil	= ($W_3 - W_2$)
Wt of soil	= ($W_3 - W_2$)
Wt of water displaced by soil	= ($W_4 - W_1$) - ($W_3 - W_2$) = W
Specific Gravity of Soil Particles	=

$$S.G = 2.5$$

SAMPLE B

Wt of bottle	= 162.4(g) W_1
Wt of bottle + dry soil	= 152.4(g) W_2
Wt of bottle + dry soil + H_2O	= 390.4(g)W_3
Wt of bottle + water	= 374.0(g)W_4

$$W = (w_4 - w_1) - (w_3 - w_2)$$

$$S.G = \frac{w_2 - w_1}{w}$$

$$= \frac{152.4 - 126.4}{(374.0 - 126.4) - (390.4 - 152.4)}$$

$$= \frac{26}{247.6 - 238} = \frac{26}{9.6} = 2.7$$

$$S.G = 2.7$$

SAMPLE C

Wt of bottle w_1 (g) = 126.40

Wt of bottle + dry soil W_2 = 148.70g

Wt of bottle + soil + water W_3 = 387.20g

Wt of bottle + water W_1 = 373.70g

Wt of water = $(W_4 - W_1)$

Wt of water + soil = $(W_3 - W_2)$

Wt of water displaced = $(W_4 - W_1)$ - $(W_3 - W_2)$ = W

Specific Gravity of Soil Particles

$$= \frac{W_2 - W_1}{W}$$

$$= \frac{148.70 - 126.40}{(373.70 - 126.40) - (377.20 - 148.70)} \qquad = \frac{22.3}{247.6 - 238.5} = \frac{22.3}{8.8} = 2.5 \quad S.G = 2.5$$

APPENDIX III

Table 14: Annual and Monthly Mean Rainfall for 1978 to 2005

RAINFALL DATA

ears	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
978	0.0	0.0	42.2	256.8	226.8	129.8	165.4	174.4	281.8	207.8	13.1	0.0	124.817
979	0.0	0.0	109.1	114.1	149.1	161.1	95.2	152.6	179.5	125.7	32.5	0.0	93.2417
980	0.0	6.4	2.9	83.9	107.2	43.3	194.3	195.5	237.7	111.6	0.0	0.0	81.9
981	0.0	0.0	20.8	80.3	94.7	226.7	285.9	231.5	124.5	80.5	0.0	0.0	95.4083
982	0.0	3.6	25.7	141.9	97.7	75.3	122.3	91.7	157.9	83.4	0.0	0.0	66.625
983	0.0	0.0	47.5	61.8	99.6	193.3	120.0	191.2	125.3	15.0	0.0	0.0	71.1417
984	0.0	0.0	39.3	43.1	131.7	175.0	110.8	83.6	280.8	88.3	0.0	0.0	79.3833
985	0.0	0.0	54.7	41.3	131.7	175.0	110.8	83.6	280.8	88.3	0.0	0.0	80.7417
986	27.4	17.7	48.4	100.2	151.7	114.2	217.0	105.1	401.0	108.5	19.9	0.0	109.258
987	0.0	42.0	59.6	22.7	148.9	139.7	157.9	331.3	140.9	127.8	0.0	0.0	97.5667
988	8.6	75.3	17.3	82.9	121.3	261.2	103.5	121.2	164.7	55.4	0.0	0.0	84.2833
989	0.0	0.0	13.1	47.9	228.8	164.0	301.1	289.9	198.0	227.1	0.0	0.0	122.492
990	0.0	0.0	0.0	80.7	133.9	133.1	213.4	274.0	175.0	105.0	3.5	17.1	94.6417
91	0.0	0.0	60.4	159.8	238.4	231.6	205.9	323.3	248.1	91.1	0.0	0.0	129.883
92	0.0	0.0	4.7	86.3	251.6	145.2	131.5	151.6	245.2	60.2	7.5	0.0	90.3167
93	0.0	33.4	16.5	81.5	190.6	136.1	110.8	82.9	218.1	121.4	4.3	0.0	82.9667
94	0.8	0.0	12.4	152.7	186.4	135.0	154.7	397.8	178.9	83.3	0.0	0.0	108.5
95	0.0	0.0	88.7	112.4	188.9	93.9	301.4	201.4	80.4	205.4	18.6	0.0	107.592
96	0.0	10.3	0.3	168.8	108.2	107.5	160.8	235.6	322.3	122.8	0.0	0.0	103.05
97	1.8	0.0	0.0	169.3	116.5	304.1	76.1	126.6	303.3	267.6	3.5	0.0	114.067
98	0.0	0.0	0.0	70.9	98.2	227.9	169.9	107.9	226.4	149.8	0.0	0.0	87.5833
999	0.0	6.9	23.1	71.1	211.0	394.0	156.1	427.2	254.4	219.5	0.0	0.0	146.942
2000	0.0	0.0	0.0	162.6	97.2	142.5	97.2	190.1	216.6	91.8	0.0	0.0	83.1667
2001	0.0	0.0	4.0	112.0	77.3	125.1	199.3	157.9	182.1	0.0	0.0	0.0	75.325
2002	0.0	0.0	2.9	162.2	79.6	93.2	325.9	298.0	196.4	1.8	1.8	0.0	108.25
2003	0.0	15.3	9.4	38.5	92.7	180.9	271.0	52.4	163.7	147.1	14.7	0.0	82.2583
2004	0.0	0.0	3.4	157.5	246.0	168.2	225.5	78.6	252.9	208.1	0.0	0.0	111.683
2005	0.0	32.7	0.0	93.4	134.3	170.8	60.9	132.9	143.5	167.5	3.4	0.0	78.2833
Total	38.6	243.6	709.1	2956.6	4139.7	4647.7	4845	5290.8	5980.2	3545.2	122.8	17.1	2711.37
Max	27.4	75.3	109.1	256.8	251.6	394	325.9	427.2	401	267.6	32.5	17.1	146.942
Min	0	0	0	22.7	77.3	43.3	60.9	53.4	80.4	15	0	0	66.625

Source: Nigeria Meteorological Agency, Lokoja