CHARACTERISTICS AND AGRICULTURAL POTENTIALS OF A DEGRADED ULTISOLS IN THE HUMID ECOLOGICAL ZONE OF EDO STATE, NIGERIA

BY

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BENIN CITY

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JUNE, 2021.

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A RESEARCH PROJECT SUBMITTED TO THE DEPARTMENT OF GEOGRAPHY AND REGIONAL PLANNING IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF BACHELOR OF SCIENCE (B.Sc.) DEGREE IN GEOGRAPHY AND REGIONAL PLANNING, UNIVERSITY OF BENIN, BENIN CITY, NIGERIA.

JUNE, 2021.

CERTIFICATION

We the undersigned, certify that this research project was carried out by OBARO AFELEMOH in partial fulfillment of the requirements for the award of Bachelor of Science (B.Sc.) Degree in Geography and Regional Planning of the University of Benin, Benin City, Nigeria.

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DEDICATION

This research work is dedicated to God Almighty for His abundant love and faithfulness. Also, I dedicate it to my loving parents who sacrificially supported me to ensure successful conclusion of this Research.

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ABSTRACT

The study was designed to investigated the agricultural potentials of a degraded Ultisols in a humid ecological zone of Edo State. The objectives of the study is to investigate the agricultural potentials of the soil.

A reconnaissance survey was undertaking to identify the field characteristics, and a representative profile was dug at the University of Benin Agriculture farm. The morphology, physical and chemical properties of the soil was evaluated. Soil sample was collected from the profile horizons and analyzed using standard procedures. Generally, the soil was well drained, deep, absence of rock. The soil was generally sandy loam in texture. Soil reaction was acidic (5.2 – 5.3), ECEC was low (1.29 – 1.64Cmol kg^{-1}) and base saturation was high (84.96 – 90.00%). Correlation analysis was employed to show the relationship between the physical and chemical parameters of the soil. Six soil properties were positively significant while two were negatively significant. The study provided baseline information for future research efforts on soil quality. The study recommended sound agronomic practices especially erosion control measures should be encouraged that further detailed studies could be conducted to examine soil quality in specific time period for sustainable land use.

CHAPTER ONE

INTRODUCTION

1.0 Background of the Study

Soils are the substrate for plant growth. It is the uppermost layer of the earth crust and a complex mixture of minerals, water, air and organic matter. Kellogg (1974) considers soil to be a collection of natural bodies occupying a portion of the earth crust that support plant growth and contains characteristics due to the combined effect of climate and vegetation action upon parent material conditioned by relief over a long period of time. According to Soil Science Society of America (1987), soil is the unconsolidated mineral or organic minerals on the immediate surface of the earth that serves as a medium for the growth of land plant. It is a resource that plays crucial role in sustaining the ecosystem and human society. Soil constitute of physical, chemical and biological characteristics that are important for plant growth and productivity.

Globally, the natural area of productive soil is limited and the available area is under increasing pressure of intensification and competing uses for cropping, forestry, pasture/ rangeland and urbanization. Soil as a core component of land resources for agricultural development and ecological sustainability and it is the bases for food, fuel and fibre production and for many critical ecosystem services.

Soil differs from one part of the world to another, even from one part of the plot of land to another part of the same plot. This may be due to the location where they are formed, climatic condition of the area, organism activities, relief, parent materials and time. According to Oko-Oboh (2014) every soil is suitable for specific purposes. Therefore, using the soil for the purposes they are best suited for is required for precision management and conservation. Land evaluation involves determination of the land potential for agricultural purposes and its main objective is to manage and improve land in a sustainable way to increase its potential for human uses. Land suitability status is built on the inherent properties of soils, such as parent materials, soil colour and depth and also those characteristics that can be affected by human interference (salinity and vegetation cover etc.).

Soil information is an integral part that enables more numerous, accurate, and useful prediction to be made for specific purposes that could not have been possible otherwise (SSS, 2014).Agriculture is a key player in the development of any country, especially countries in the Sub Saharan region and Nigeria in particular. The performance of agricultural sector can be used to determine to a large extent the development of the people such as reduction in poverty level and general improvement in the human development index.

In the 1960s, Nigeria was the world's leading producer of oil palm (*Elaeis guineensis*) even at independence, agriculture sustained Nigeria's economy and held the promise for the country of her transforming into a vibrant agrarian economy of which oil palm was a major key player (Akande, 1998). In fact, Adedipe (1999) opined that agriculture contributed 67 per cent of the Gross Domestic Product (GDP) in the 1960/1961 period. However, with the discovery of crude oil in Nigeria and the subsequent oil boom in the 1970s, far less attention was given to agricultural sector, which consequently led to the failure of this sector to perform its traditional functions effectively.

According to Azad-Hossain (2013), the humid ecological zone is generally resource rich land that possesses abundant water supply, naturally fertile soils and a favourable terrain and climate. He also stated that such an area ranges from flat lowland delta to river valleys associated with gently rolling uplands. An example is the Niger delta region of south-south Nigeria. Verheye (2018) had described the soil of the humid tropical region and according to him, the minerals in the parent rocks generally undergo strong chemical weathering. The tendency is to hydrolyze and leach away the silica and to accumulate iron and aluminum oxides. As a result, the soils are typically coloured red. The surface zone tends to be somewhat darker, but as a rule these soils do not exhibit distinct horizons.

In the 2015,Status of the World's Soil Resources reported that soil erosion was identified as one of the ten major soil threats (FAO and ITPS, 2015). Soil erosion is defined as the net long-term balance of all processes that detach soil and move it from its original location through three major pathways: water, wind and tillage (FAO, 2019). Erosion hampers the provision of many vital ecosystem services normally provided by healthy soils (Adhikari and Hartemink, 2016). Borrelli *et al.*, (2017) observed that although soil erosion is a natural process that is part of landscape development, it is importantly accelerated by human activities such as removal of vegetation cover, down slope tillage, overgrazing, etc. Climate change, land levelling, continuous mechanical tillage of agricultural land, deforestation, and some changes in land use pattern are also leading drivers of increasing soil erosion with consequences of extreme events such as landslides, increased emissions of greenhouse gases and soil organic carbon losses (Borselli *et al.*, 2007; Lal, 2019).

Soil erosion is a serious challenge for agriculture (Al-Kaisi, 2000). Many farmers are unaware of the increasing problem of soil erosion on farmland. Usually, awareness occurs only when properties are damaged (Jim, 2012). On farmlands, soil erosion reduces soil water infiltration capacity, moisture availability, drainage capacity, plant rooting depth, and loss of soil nutrients. The displaced soil particles from eroded sites cause sedimentation and pollution of surface water storage, blockage of waterways, and destruction of infrastructures (Lal, 2019). Therefore, our ability to reduce and further reverse the rates at which our soils are currently eroding will determine our ability to feed and live in an ecologically stable environment now and in the future (Poesen, 2018). Control and prevention of soil erosion is key to combating climate change and contribution towards Sustainable Development Goal (FAO, 2019).

1.1. Statement of Research Problem

Nigeria is privileged to have agriculturally suitable climate and abundance of fertile soil. Currently, Nigeria has 75 per cent of its land suitable for agriculture but only 40 percent is cultivated (Omorogiuwa, O., Zivkovic, J. and Ademoh, F., 2014). That indicates that there is much room for the country to focus on how to move agriculture forward. However, to move forward, the country must increase agricultural productivity.

At any given location, there are aspects of natural environment that are invariant and stable examples include landform, soil types etc. and there are aspects that vary with seasons among this include temperature, rainfall and incidence of pest and diseases even the remaining area for crop production has some environmental impediments such as erosion hazards, inherent soil infertility and shallow soil depths. Lack of information on both the constant and varied characteristics or aspects of each specific location can frequently influence crop productivity which may lead to disaster.

A Food and Agriculture Organization of the United Nations (FAO) report reveals that the absence of scientific knowledge on soil by Nigerian farmers has led to a lot of soil damage and abuses. However, there are growing interests in the importance of providing significant information on the quality of Nigerian soil resources for sustainable agricultural production and to understand the degree of soil degradation resulting from their misuse. In Nigeria, as in most developing countries, agricultural production has been continually declining over the years leading to increasing food insecurity issues and deteriorating quality of life especially among the rural dwellers.

Besides, this work examines the soil quality in the study area in order to known the implication to agricultural potentials. The report of Ugwa *et al*. (2017) and the few workers were not extensive enough on agricultural potentials and certainly not on eroded Ultisols of the humid areas of southern Nigeria. They did not examine the weathering potentials of the area.

Ultisols are acidic red soils that are always found in warm, temperate, humid climates and in regions occupied with deciduous forests (Yu *et al.,* 2016). These special soil landscapes are majorly spread across the tropical and subtropical areas. In Nigeria, it is preponderantly in some southern states such as Edo state, occupying about seven zones, including central Benin and extreme north (Dayou*et al*., 2017). Ultisols are therefore naturally poor in physical conditions and are also characterized by low pH, cation exchange capacity, and fertility. Ultisols also have low concentrations of phosphorus (P) in soil solution and results in frequent P deficiency of plants (Wang *et al.,* 2014). They are usually poor growing soils with low water holding capacity. It can lead to anti-plant growth properties such as stunted growth and low plant yield. The declining food production and rapidly increasing global population and particularly the Sub-Saharan African countries poses a serious challenge to farmers and governments (Ahmed, 2000). All these constitute a major developmental constraint to crop production and food security.

1.2. Aim and Objectives

In view of the problem associated with Ultisol, it is important therefore to investigate its agricultural potential and provide necessary recommendation for profitable agricultural management. The main aim of this research work is to examine the soil of humid ecological zone of Benin City, Nigeria especially, the eroded soils of the Faculty of Agriculture, (AGR 305) farm land in the University of Benin, Benin City so as to ascertain its Agricultural potentials. In pursuit of this main goal, the specific objectives are to:

i. determine the different characteristics of the soil and
ii. suggest alternative land use(s) suitable for the area, and
iii. advice farmers on the best management options of the study area.

1.3 Scope of the Study

The main thrust of this work is to examine the agricultural potential of Ultisol in the humid ecological zone of Edo state, Nigeria, as well as the physico-chemical soil properties which include: sand, silt, clay, bulk density, soil pH, manganese, magnesium, sodium, total organic carbon, soil organic matter, phosphorous, exchangeable acidity, total nitrogen, iron, zinc, potassium, copper and effective cation exchangeable capacity. The statistical tool employed for this study is correlation analysis using SPSS 16.0 version. The clay activity of the soil shall be examined using the graph method.

1.4 Significance of the Study

Edwards (1984) explained that the knowledge of the soil physico-chemical properties and the crop yield potential is more important to the farmer than the hectarage of the land. Oko-Oboh (2014) asserts that the variation in the physic-chemical properties of soil allows for the suitability of specific purposes. Orobator and Odjugo (2015) reported that knowledge of land use produces impact on soil quality is essential for sustainable agricultural production. The methods of determining the most suitable use of any area is the knowledge of the inherent potentials of the soil resources.

Soil suitability for various crops is usually estimated from the physical and chemical characteristics of the soil together with observations of the crops grown on a particular field. This study of soil agricultural potential will serve as a soil management strategy tool in helping farmers in the study area. This study may also help soil scientists understand the factors that pose serious threat to the increase in crop production under rain-fed conditional as well as different land use types. This will lead to a holistic adoption of suitable land management practices and schemes. A comprehensive knowledge on soil quality leads to land management systems that optimize soil functions for both the present and future intension.

1.5 Study Area

The Study area is in Benin City. Benin City is the state Headquarters of Edo state. It is in the lowland rain forest humid ecological zone of Nigeria. The geologic structure of the city comprises of two principal formations; the crystalline rock of the Precambrian basement complex and the sedimentary rock of the cretaceous tertiary and quaternary formation of Miocene-Pleistocene age (Balogun and Okoduwa, 2000)

Rainfall, temperature, wind and relative humidity are the most significant climatic elements in Benin City. The rainfall element most often determines the occurrence of the wet and dry seasons (Agboola and Hodder, 1979). According to Ikhile (2005), the convective and relief types of rainfall are widely received throughout the city owing to its unique solar energy reception, and the hilly terrains. The relative humidity is high throughout the year while the rainfall is fairly well distributed from the middle of March to early November of the year with a short spell within the month of August (Ugwa *et al*, 2016). This is known in the local palace as the August break. Recently, the August break has not been consistent due to emerging global climate change. According to Ugwa *et al*, (2017) a mean annual temperature of 27.5^0C occurs in the area throughout the year. While the mean annual rainfall is 2,255mm. These climatic elements have stimulated the growth of tropical rainforest.

The specific study area is the Faculty of Agriculture farm (AGRIC 305 farm). It is located within latitudes 06° 24’ 01.9” N and longitudes 005° 37’ 32.9” E in the University of Benin main campus at Ugbowo, Benin City Nigeria. AGRIC 305 farm lies at 97 meters above sea level. The study is a plain which gently sloped from west to east with moderate erosion activities and occupies five hectares of land. A field observation shows that the area was previously used for arable crop cultivation. However, at the time of observation, it was a fallowed area with overgrown weeds and creeping legumes such as Pueraria phaseoloides and Centroseme pubescens.Esekhade, Orimoloye, Ugwa and Idoko (2003) reported that leguminous covers in a fallow area is essential for maintenance of soil fertility and soil conservation. There was also signs of cleared shrubs. Towards the eastern boundary of the study area are few strands of wild palm.

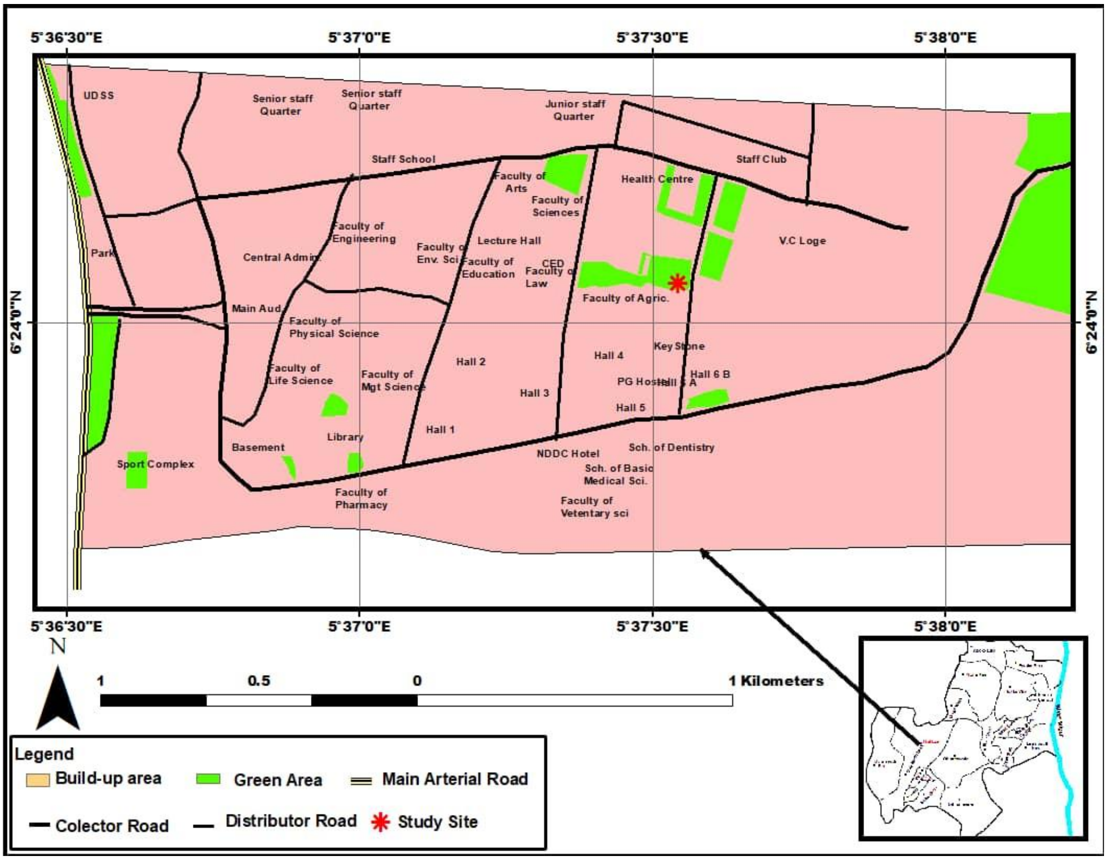

Figure1.1: Map of University of Benin showing Faculty of Agric farm

Source: Google Earth Imagery modified by Author, 2021

CHAPTER TWO

CONCEPTUAL FRAMEWORK AND REVIEW OF THE LITERATURE

CONCEPTUAL FRAMWORK

2.1 SOIL CHARACTERISTICS

Soil characteristics consist of those soil physical, biological and chemical attributes that can be used to describe a soil (Ugwa *et al.* 2018). These various Physical, biological and chemical processes taking place in the soil are difficult to understand (Schulte *et al*. 2005). Doran and Parkin (1994) observed that the physical and chemical properties of soils could be used to assess the soil quality worldwide. Soil physical properties affect the appearance and feel of a soil. Some of the major soil physical properties are: soil texture, soil structure, soil color, soil permeability and soil temperature. Soil chemistry is dominated by the interaction between its solid components and its water phase. The major soil chemical properties include, organic carbon, phosphorous, potassium, soil pH, and total nitrogen. All these characteristics collectively affect every agriculture producers' decision about how to manage the land. (Foster *et al.* 2013).

2.1.0 Soil Texture

Texture refers to the relative proportions of particles of various sizes such as sand, silt and clay in the soil (FAO,). It is commonly used to estimate soil properties. According to Martin *et al,*(2017), soil texture is one of the essential controls of soil structure and function as well as soil specific features. Soil texture affects physical and chemical properties that influence crop growth. Generally, soil texture refers to the “feel” of the soil, its coarseness or fineness. In the field, soil texture can be determined by feeling the soil with the fingers. A good soil texture protects the soil organic matter from decomposition by chemical and biological factors. Orobator *et al* (2018) reported that soil texture influences nutrient availability and sandy soils shows low water holding capacity.

2.1.1 Soil Colour

Soil colour gives an indication of the various processes going-on in the soil as well as the type of minerals in the soil. For example the red colour in the soil is due to the abundance of iron oxide under oxidised conditions (well-drainage) in the soil; dark colour is generally due to the accumulation of highly decayed organic matter; yellow colour is due to hydrated iron oxides and hydroxide; black nodules are due to manganese oxides; mottling and gleying are associated with poor drainage and/or high water table. The colour of the soil could be determined by comparison of the soil sample with a standard set of colour chips in a note-book called Munsell Colour Charts. Ugwa *et al.* (2017) reported that soil development often gives rise to changes in colour due to iron oxide minerals and as the weathering continues, kaolinite and quartz are mainly left behind. This may give rise to low basic cations.

2.1.2 Soil Bulk Density

Soil bulk density reflects the soil's function for structural support, water and solute movement and soil aeration. Low soil porosity and compaction are indicators of high bulk density. It may cause restriction to root growth and poor movement of air and water through the soil. Compaction can result in shallow plant rooting and poor plant growth may be as a result of soil compaction. Compaction can lead to increased runoff and erosion from sloping land. Soil bulk density depends on soil characteristics such as texture, soil organic matter content, soil structure and gravel content. Bulk density varies between and within the year due to the action of several processes such as freezing and thawing, root action and animal activity. Bulk density shows significant differences among different land use types and soils (Buol *et al*, 1973; Brady, 2002).

2.1.3 Soil Structure

The arrangement of soil particles into aggregates of definite shape is known as soil structure. Soil structures are also known as peds (Natural Resources Conservation Service, 2010). Peds persist through cycles of wetting and drying. Soil structure is important because it affects water movement into and through the soil, root penetration, porosity or aeration, and bulk density of the soil.

Soil structure describes the arrangement of the solid parts of the soil and the pore spaces located between them. Soil structure controls the amount of water and air present in soil. A soil with good soil structure facilitates the movements of air and water. Soil structure is defined by the way individual particles of sand, silt, and clay are assembled (Buol *et al.* 1973). Single particles when assembled appear as larger particles. They are called aggregates. Aggregation of soil particles can occur in different patterns resulting in different soil structures.

2.2 Degraded Soils

Soil degradation is a decline in soil quality which is usually induced by human activities or agents of denudation. Degradation impairs or destroys the potential of the soil to properly sustain and perform its agricultural and economic function (FAO, 2000). Soil degradation includes physical, chemical and biological deterioration, for instance, soil degradation may be loss of organic matter, decline in soil fertility, decline in structural condition, adverse change in salinity, acidity or alkalinity and the effect of toxic chemical pollutants or excessive flooding (Van Lynden and Oldeman,1997).

Human beings' interaction with the environment has led to the extent of abuse of the land. Resource management is therefore necessary to provide ecological balance for eroded land and soil degradation as well as soil productivity. Eroded land is implicated in degradation which Areola (1991) explained as the loss of utility of land or loss of soil quality caused through misuse of humans.

2.3 Importance of Soil

Soil is important to life support system. It plays a vital role in the earth ecosystem. The importance of soil cuts beyond agriculture to include all aspects of human existence on earth. A healthy soil is vital for vigorous plant growth and it negates much impact on drought, bush fire and flood. Brady (2002) reported that soil is capable of storing large amounts of organic carbon and protects groundwater quality.

There are many organizations in the soil that help to decompose organic matter and fix nitrogen as well as provide nutrient cycling (carbon, nitrogen, phosphorus) for plant and animals. Soil function as biological habitat, raw materials, food and some biomass production (Dobrovolsky and Nikitin, 1990).

2.4 Agricultural Potentials

According to Akinwumi (2008) the future of food in the world will depend on what Africa does with agriculture. According to him Africa holds 65% of the uncultivated arable land left to feed 9 billion by 2050. Its' vast savannas are the world's largest agriculture frontier, estimated at 400 million hectares. But only 10% of this is cultivated. That's a mere 40 million hectares. According to FAO, the potential level of agricultural production is generally considered to be determined by physical factors such as quality of the soil, quality and availability of water and the prevailing climate. The influence of the available technology is another factor that explains production levels and production potentials.

In economic terms, agriculture accounts for around 35%of the gross regional domestic products. It is also a cornerstone for developing export capacities of the nation. Agriculture contributes to the financing of export of consumer goods capital goods and semi-finished goods for industry. It is estimated that Nigeria has lost USD 10 billion in annual export opportunity from groundnut, palm oil, cocoa and cotton alone due to continuous decline in the production of those commodities. Food (crop) production increases have not kept pace with population growth, resulting in rising food imports and declining levels of national food self-sufficiency (FMARD, 2008).

An efficient agricultural sector helps the country by reducing food dependent on the rest of the world and improves the current unfavourable terms of trade by processing products and increasing value-added. In terms of employment, agricultural sector is still the number one supply of labour. More than 60% of the working population works in agriculture despite low remuneration compared to other sectors of the economy. Agriculture also plays a key role in ensuring food security for households.

2.5 Literature Review

Of late, the Federal Government of Nigeria procured 100 units of SoilDoc kits and trained 65 extension agents on their use to farmers (Chude, 2016). The soil parameters analyzed include soil pH, soil organic matter, extractable macro-nutrient and electrical conductivity and physical characteristics such as aggregate stability and soil compaction. He was further reported that the Federal Ministry of Agriculture and Rural Development developed National Agricultural Resilience

Framework in 2013 to help in innovation production strategies and risk management mechanism to promote resilience in the agricultural sector. Omorogiuwa *et al.* (2014) observed that Nigeria needs to raise its standards to a level with other developing economics of the world. These workers are also of the opinion that Nigeria has 75% of its land suitable for agriculture but only 45% is cultivated. There is the need therefore to evaluate the historic efforts in terms of agriculture that Nigeria has engaged in order to avoid the mistake of the past. All these are pointers that soils should be tested and characterized for effective decision making. Soil is a non-renewal resources yet, it is often overlooked.

The World Bank (2008) report on agriculture noted that 75 percent of the world's population lives in rural areas and they heavily depend on the agricultural sector for their livelihoods. Agriculture is the most important enterprise in the world. It plays a decisive role in the entire life of a given economy. According to World Bank (2020), agriculture is the backbone of the economy system of a given country. In addition to providing food and raw materials, agriculture also produces employment opportunities to a very large percentage of the population (FAO, 2000). About 70 percent of the populations rely directly on agriculture as a means of livelihood. Agriculture contributes a smaller percentage to the national income of developed countries but for most developing countries, agriculture is the main source of national income. According to Nehu *et al*. (2014), about 43percent of all exports globally consist of agricultural goods. The largest share of contribution to the development process of every developed nation was derived from agricultural output. It accounts for the largest share of national income, employment and exports (IFPRI, 2006).While agriculture is generally important for Africa's development, its ability to generate growth and reduce poverty varies across and within countries as well as across different agriculture subsector. Thus, the importance of agriculture need not be over-emphasized.

When there is interaction with the environment that has led to the mismanagement or abuse of the soil, then there is soil degradation. Decline in soil quality commonly caused through improper use by humans in defined as physical, chemical and biological deterioration, which ISSS (1996) include among others to be loss of organic matters, decline is soil fertility, erosion and excessive flooding. Van Lynden and Oldeman (1977) and FAO (2007) further explained that land degradation is a group of natural or human-induced processes that impaired or destroy the potential of land to sustain properly an economic function or the original ecological function.

Biswas and Mukherjee (1994) further explained that land degradation is a process which lowers the current and or potential capability of soil to produce goods or services. The process could be slow or short-lived between various states of ecological equilibrium. The difference between soil degradation and land degradation is very subtle, and according to Biswas and Mukherjee (1994), it is largely of academic interest. The soil is part of the land and any effect on it is also an effect on the land.

Soil degradation is a global process, but affects arid and semi-arid zones in sub-Saharan Africa most (Lal, 1997). Soil degradation is increasing worldwide, especially in the countries within the tropics. Soil degradation can be defined as a process by which intrinsic physical, chemical, and/or a biological quality of the soil is loss (Fabio *et al*., 2020). Soil degradation is a process that lowers the current and/or future capacity of the soil to produce goods and services.

Elements like decline in soil fertility, adverse change in alkalinity, acidity or salinity, extreme flooding, use of toxic soil pollutants, erosion, and deterioration of the soil's structural condition, contribute significantly to soil quality depreciation and thus gives rise to immediate and long-term impacts which translate into serious global environmental challenges (Lal, 1997).

Land degradation is a major problem in Southern Nigeria and its major features include eroded landscape (rills and gullies). This makes land degradation the most critical and severe environmental challenge facing Nigeria s it affects over 70% of the population (Chokor and Odemerho, 2007). A multidisciplinary and multidimensional approaches may be imperative in reducing this menace. Yet in Nigeria land degradation has been alluded to more of a social issue rather than an environmental one as the latter has been exaggerated and based on insufficient data (Chokor and Odemerho, 2007).

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Types and Sources of Data

This study depended on both primary and secondary sources of data. Primary Data was sourced primarily through direct field observation, soil depths with reference to the nature of the vegetation and land use types and the physico-chemical properties of soils. Secondary sources of data include; textbooks, articles, academic journals and other source materials online.

The soil physico-chemical characteristics were obtained from the laboratory analyses of soil samples taken from different depts of a single profile of 15m apart (sampling points) and at two depths of 0-15cm (topsoil) and 15-30cm (subsoil).

3.2. Reconnaissance Survey

Prior to the fieldwork, a reconnaissance field survey was conducted with the aim of:

i. Getting familiar with the study area.
ii. Identifying the potential challenges to be encountered.
iii. Reviewing existing environmental information on the study area in published and unpublished literature.
iv. Planning and programming the fieldwork, and the selection of required instruments.

The instruments used for this research work included; hoe, cutlass, measuring tapes, polythene bags, white masking tape, global positioning system (GPS), a field notebook and a pen.

3.3. Field work and soil sampling

The available soil survey report in the soil science and Land Management department executed by Okonsebor (2014) was in order to get dependable soil details of the study site Pedon. That was correlated with Ultisol was geo-referenced using hand held Global Positioning System (GPS) receiver to co-ordinate the reference points and then dug. Various soil horizons of the pedon were identified and their boundaries marked. Morphological characteristics and field observation were carried out according to FAO (1990) guidelines.

A total of five samples soils were collected from different horizons of the soil, identified in the profile, from the top to the bottom into a well labeled polyethylene. The soil samples were then taken to the laboratory for analysis.

Fig 2.1: Profile measuring
Source: Author's Field Work, 2021

3.4. Laboratory Analysis

Soil Samples gotten from the genetic horizons of the pedon were air-dried, crushed and sieved through a 2-mm sieve for laboratory analysis. Particle size analysis was determined by hydrometer method using sodium hexametaphosphate as dispersing agent (Okalebo *et al*, 2002), Bulk density was determined by collecting undisturbed core samples from each horizon using core sampler ($216cm^3$). The untrimmed core samples were taken to the laboratory, trimmed with sharp knife and weighed. These were later oven-dried at 105^0C to constant weight, and the bulk density determined as described by Grossman and Reinsch (2002). Total porosity (%) was derived from the relationship of particle density to the bulk density using the formula; percentage pore space = $(1-D_b/D_p)$ x 100 Where; D_b = bulk density and D_p = particle density. The average Dp of mineral soils which is $2.65Mg\ m^{-3}$ was used for computation.

Soil pH was determined using a 1:1 soil to water suspension using glass electrode pH meter (Mclean, 1982). Organic carbon was determined by the method of Nelson and Sommers, (1982). While available P was extracted with Bray P-1 solution and measured using the molybdenum blue as indicator by the method modified by Olsen and Sommers (1982). Exchangeable acidity was extracted from a soil solution by IN KCI (Thomas, 1982) and determined by titration with 0.5M NaOH using phenolphthalein as indicator. Exchangeable bases (Ca, Mg, K, Na) were extracted within NH_4OA_Cbuffered at pH 7; K and Na were read on ELE flame photometer and Ca and Mg by Atomic Absorption Spectrometer (AAS). Effective cation exchange capacity ((ECEC) was determined by the summation of exchangeable base and exchangeable acidity. Also, the Percentage Base Saturation (BS%) was calculated as the sum of the exchangeable base divided by ECEC multiplied by 100. Available micronutrients (Lindsay and Norvell, 1978). With the clay content of the soil through the relationship: ECEC x 100% clay.

3.5 Soil Chemical Analysis

3.5.1 Soil pH

Soil pH was determined in 1:1 soil suspension ratio in water. The pH meter was calibrated using pH 7 buffer solution. Then, the meter was adjusted with known pH of buffer solutions 4.0 and 9.2. Soil weighing 20g was transferred into 100ml beaker. 40ml distilled water was added and stirred well with a glass rod. This was allowed to stand for half an hour with intermittent stirring. The glass electrode was immersed into the soil water suspension in the beaker and pH value was determined and recorded from the automatic display of the pH meter.

3.5.2 Total Nitrogen

Total nitrogen (TN) was determined by Marco Kjeldahl digestion method. Here, 1g of soil sample was weighed into a Kjeldahl digestion flask. 2ml of distilled water, a tablet of selenium catalyst and 5ml of concentrated H_2SO_4 was added and the flask was placed on the digestion block. After digestion, the digest, was transferred to a 50ml flask and 10ml distilled water was added with 0.02 NH_2SO_4. The exchangeable bases: Ca, Mg, K and Na were extracted with 1 NMH_4. The concentration of K^+ and Na^+ were determined by flame analyzer, while Ca^{++} and Mg^{++} were determined by EDTA titration.

3.5.3 Exchangeable Acid

Exchangeable acid (H^+ and Al^{3+}) were determined in KC1 extract by titration. Here, 5g of air-dried sample of each soil was weighed into a 45ml centrifuge tube. 50ml of IN KC1 was added and shaken for one hour in a reciprocal shaker. The tubes with their contents were centrifuged at 2000 RPM for 15 minutes and cleared 1 supernatant cleaver decanted volumetric flask. The flask was made up to mark with 3 NKC1. 25ml of the INKC1 extract was then pipetted into a 250ml Erlenmeyer flask and 100ml of deionized water added, followed by 5 drops of phenolphthalein indicator solution and titrated against a 0.05 NaOH to the total permanent end point with alternate stirring and standing.

The amount of NaOH (the base used in the titration) is equivalent to the amount of acidity (Al^{3+} and H^+) in the aliquot.

In determining Effective Cation Exchangeable Capacity (ECEC), the exchangeable acidity and the total exchangeable bases already determined were added.

ECEC = exchangeable acidity + total exchangeable bases.

3.5.4 Exchangeable bases:

(Ca, Mg, K, Na) were extracted within NILOAc buttered at pH 7 K and Na were read on ELE flame photometer and Ca and Mg by Atomic Absorption Spectrometer.

3.5.5 Available Phosphorus

Available Phosphorus was extracted by Brey P-1 solution and measured using the molybdenum blue as indicator by the method modified by Olsen and Sommers (1982).

3.5.6 Effective cation exchange capacity (ECEC)

This was determined by the summation of exchangeable base and exchangeable acidity (Anderson and Ingram, 1993)

3.5.7 Percentage Base Saturation (BS%)

Percentage Base Saturation was calculated as the sum of the exchangeable base divided by ECEC multiplied by 100.

3.6 Soil Physical Analysis

3.6.1 Bulk Density

The bulk density was determined by coring method. This was done by oven drying the collected undisturbed core samples to a constant weight at 105 ^{0}c and divide by the oven dried weight by the volume of the core sampler.

$$\frac{\text{WEIGHT OF OVEN DRY SOIL}}{\text{VOLUME OF CORE}}$$

$BD = \overline{\qquad\qquad}$

3.6.2 Particle Size

Particle size was determined by method described by methods described by Gee and Or, (2002). The percentage sand, silt and clay were determined by using the Bouyoucous hydrometer method allowing sedimentation of the various separates within interval. Sodium hexametaphosphate was applied as the dispersant.

3.6.3 Total Porosity

Total porosity was derived from the relationship of particle density to the Bulk density using the formula percentage

$$\text{Percentage pore space} = \left(\frac{1 - D_B}{D_P}\right) \times 100$$

3.7 Statistics Analysis

The descriptive and inductive statistical methods were applied in this research. Primary Data collected from the laboratory was subjected to statistical analysis using the SPSS 16.0 version. Pearson’s Correlation coefficient statistics test was used to measure the statistical relationship between the soil variable. This method was used because it is best for measuring continuous variables. It gives information about the magnitude of the association or correlation as well as the direction of the relationship. Correlation analysis was use in ranking the relationship between key physical and chemical properties of the soil sample of the study area. Meanwhile a graphical representation of clay activity across the profile was made as an indicator of the fertility, erodibility and water holding capacity of the soil.

Prior to statistics analysis, soil sample were analyzed in the laboratory, then statistical correlation (p) within the various physical properties and with the various chemical properties and between the physical and chemical properties were tested. Significant relationship was observed at 0.05 (2-tiled) level and 0.01 (2-tiled) level.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Morphological Properties

The soil occurs over unconsolidated sandstone, moderately leached, non-stony, deep (>145cm) and located on the upper slope (8%) in the toposequence. The profile is located at the coordinate of 06^{o} 24' 01.9" N and 005^{o} 37' 32.9" E at 97m above sea level. Table 4.1 reveals that the soils are weak, fine over a medium sub angular blocky structure with dark reddish brown colour (5YR 3/3, moist) in the first 42cm depth to dark yellowish brown (10YR ¾, moist) in the subsoil. There seems to be variety of colour and related properties of the soil (Plate 4.1). Biswas and Mukherjee (1994) and Soil Survey Staff (2014) observed that red and yellow colour indicate the presence of free iron ozide common in deep well -oxidized soil, while organic matter present indicates brown and dark colouration. The hue is a mixture of 2.5YR, 5YR to 10YR stipulating the dominant spectral colour of the soils of the area.

The soil consistency (moist) ranges from loose at the topsoil to fine at the subsoil specifying a weak cohesion of the soil. A close observation of the field texture shows that it is almost sandy loam. Most of the horizon boundaries are wavy, while the top horizon has many coarse roots. A loamy sandy soil is usually loose, excessively drained and retain little water and nutrient for plant growth. It has very high permeability to downward water movement because of its loose structure (Soong and Lau, 1977). As it may be expected, there are few to none roots at the subsoils which is due to preponderance of grasses and few shrubs in the studied area. There were little or no fauna activities in the soil profile but there was evidence of mottles in the endopedon. This is an evidence of redox condition of the soil as has been observed by Ugwa*et al*. (2016).

4.2. Soil Physical Properties.

Table 4.2 shows the physical properties of the soil. The distribution of the soil fraction ranges from 650 g kg^{-1}. The distribution of an average mean of 678 g kg^{-1}. The distribution of sand in the profile shows no pattern and seems to be similar to the work of Okunsebor (2014) who worked in a similar soil. The same pattern follows the clay fraction that the A_p and B_{t2} had 250 g kg^{-1} each to the clay. In the endopedon, it fluctuates between 150 to 260 g kg^{-1}. This fluctuation in the clay fractions may be due to the erosional circle in the upper slope of the area in which the profile is situated.

Generally, the silt content of the soil increases from the topsoil (70 g kg^{-1}) to the subsoil (200 g kg^{-1}) influencing the texture of the soil to be sandy loam. Soong and Lau (1977) had indicated that based on the different combinations of sand, silt and clay, soil texture is grouped into various textural classes. Silt and sand fractions, according to Biswas and Mukherjee (1994) are of partially weathered primary minerals and the physically most inert. Silt often is a micro-sand.

Table 4.1: Morphological characteristics of soils of the study area.

Profile No.	Location	Horizon	Depth (cm)	Colour (moist)	Structure	Consistency (moist)	Texture	Boundary	Root	Mottles
FARM 305 (Upper slope 8%)	06^{0}24’01.9”N 005^{0}37’32.9”E	A_p	0 – 18	5YR, 3/3(dark reddish brown)	1, f	l	SL	s,d	c, m	-
		A_B	18 – 42	5YR, 3/3(dark reddish brown)	f, cr	fr	LS	w,d	c, fe	-
		B	42– 66	5YR, 4/4(reddish brown)	2, m,sbk	fr	SL	w,d	f,	fe, f
		B_{t1}	66 – 89	2.5YR, 2.5/3(dark red)	2, m, sbk	fr	SL	w,g	f	c, m
		B_{t2}	89 - 145	10YR, ¾(dark yellowish brown)	2, m, sbk	f	SL	-	n	-

Source: Author’s Field work

Key : Structure – 1 = weak, 2=moderate, m=medium, cr= crumb, f = fine, sbk = sub angular blocky

Consistency - L= Loose, f=fine, fr = friable

Texture - LS = Loamy Sand, SL= Sandy Loam

Boundary - s= smooth, d= diffuse, w= wavy, g = gradual

Root - c = coarse, f=fine, fe= few, m= many, n= none

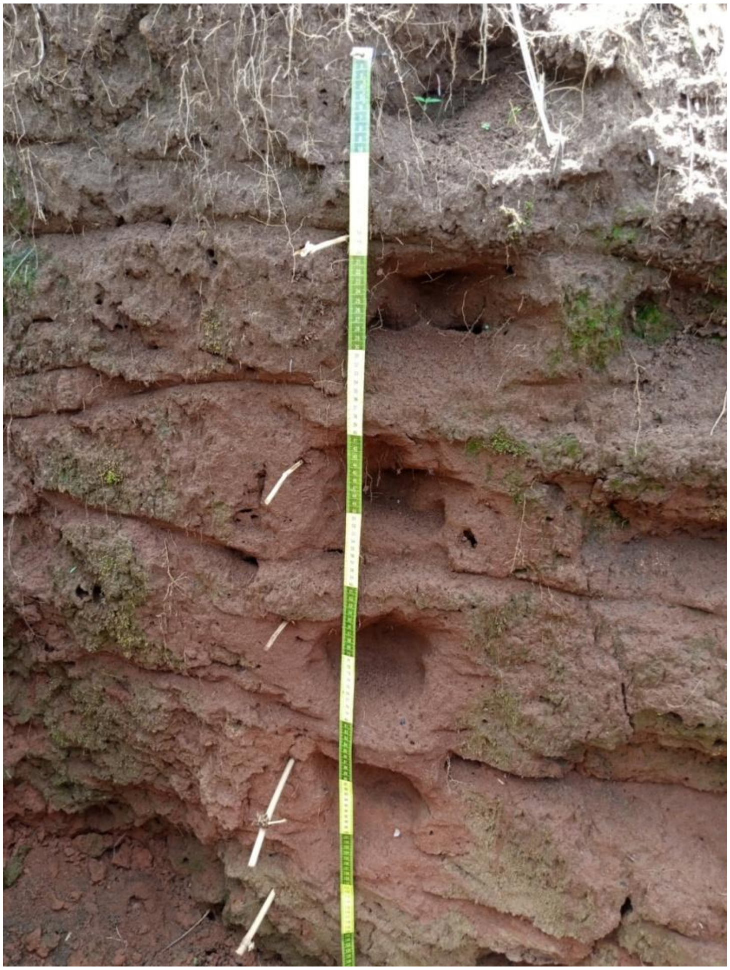

fig 4.1: Profile showing different horizons

Source: Author's Field Works, 2021

The bulk density values indicate that the soil was compact as they were generally high and ranged from 1.28 to 1.56m gm-3 with the lower value occurring at the topsoils and increasing gradually with soil depth. This might be due to decrease in soil organic matter content and compaction due to the upper soil layers (Brady, 2002). The porosity value was high (41 –52%) and it seems that it has an inverse relationship with the soil bulk density.

Table:4.2 Physical Characteristics of the soil in the study area.

PROFILE	Horizon	Depth (cm)	Colour (moist)	Silt(gkg^{-1})	Clay ($g\ kg^{-1}$)	Sand(g, kg^{-1})	Silt/ Silt + ClayRatio	ClayActivities	Texture	BD ($mg\ m^{-3}$)	TotalPorosity(%)
FARM 305	**A_p**	0 – 18	5YR, 3/3	70	250	680	0.22	6.56	SL	1.56	41
	A_B	18 – 42	5YR, 3/3	50	150	800	0.25	10.33	LS	1.38	48
	B_1	42– 66	5YR, 4/4	80	260	660	0.24	4.96	SL	1.28	52
	B_2	66 – 89	2.5YR, 2.5/3	200	200	600	0.50	6.66	SL	1.42	46
	B_t	89 - 145	10YR, 3/4	100	250	650	0.29	5.64	SL	1.42	46
		Mean		**100**	**222**	**678**		**6.84**		**1.41**	**46.6**

Key: LS= Loamy sand, SL= Sandy loam

4.3. **Evaluation of the Stage of Soil Development.**

Ugwa *et al*. (2016) had reported that clay activity is an index of weathering in a tropical humid region. Figure 4.2 shows the clay activity along the soil profile. The figure seems to show no regular pattern of clay migration but a sudden clay budge between 60 – 80cm depth, which eventually goes down at a greater depth of 90 cm depth. This may be that there was a movement of clay material into a portion of the soil profile and eventually complex of soil reaction in the form of eluviation took place. This compliments the work of Kamalu *et al.* (2014) that worked on the Ultisols of Akwete in Southern Nigeria. The low clay activity shows the stability of weathering in the area under study.

The stages of soil development and age have been estimated in the past using some weathering ratios. Ajiboye, Ogunwale and Adeloju (2015), reported that silt/ silt + clay ratio of 0.7 indicates moderate weathering, <0.7 for severe weathering and >0.7 for incipient weathering. Table 4.2 also shows that the value, generally, increases with soil depth. The highest value was recorded at 66 to 89 cm soil depth and the observed pattern may be due to the absence of clay illuviation in the soil profile. All the values show that they were less than 0.7. Therefore, the soils in that area are prone to severe weathering, giving credence to the report of clay activities. It seems that the silt/ silt + clay ratio of these soils presented a better picture of weathering stage of the soil development. Such practices as soil organic matter management and regular soil tests and planting of leguminous creeping crops are necessary in the management of the soils.

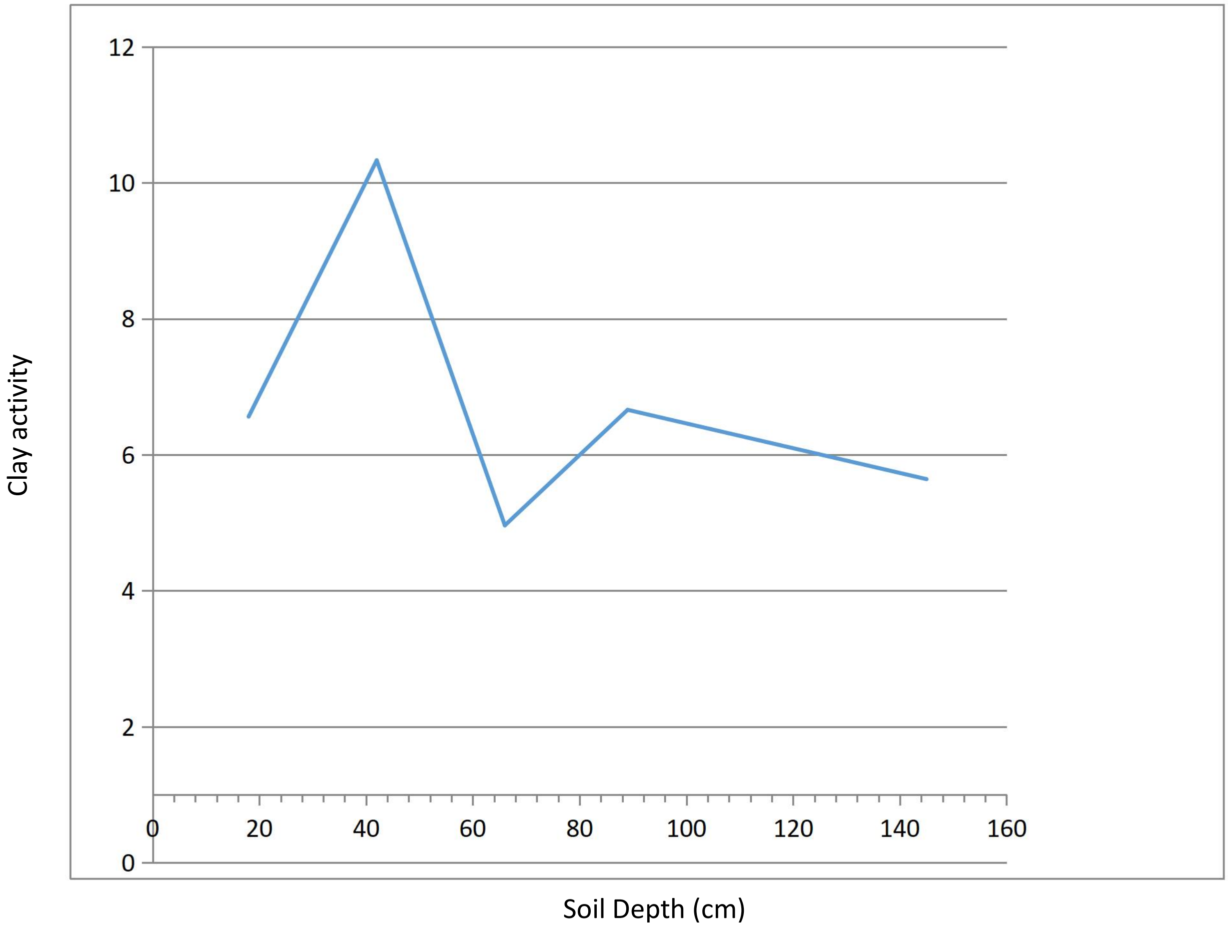

Plate 4.1: Clay activity with soil depth

4.4 Soil Chemical Properties.

Detailed chemical properties of the study site soil are presented in Table 4.3. the result shows that the pH of the soil ranges from 5.7 (topsoil) to 5.3 (subsoils). Generally, the soil is acidic in all the depth which might be due to the sandstone of the parent materials. The acidic nature of the soil may not pose any danger to crop production. Tree crops in Nigeria thrive better in soil with such range of pH (Esekhade *et al*, 2003).

The organic carbon gives an estimate of the organic matter in the mineral soil (Buol *et al*, 1973). Its values range from 2.8 to 18.8g kg^{-1} with a mean value of 14.8 g kg^{-1}. This value is considerable when compared with the threshold vale of 10 – 15 g kg^{-1} (moderate) for productive soils (Adiukwu and Ali, 2013). A good relationship between organic carbon and total N has been established by Brady (2002). They are reciprocal. Total N ranges from 0.3 to 1.6 g kg^{-1}. The moderate value of total N might have been due to the leguminous ground cover or perhaps, the previous intercropping in the study site. This has also been observed by Esekhade *et al.* (2003) and Ugwa *et al.* (2017).

Phosphorus is one of the macronutrients which is required by crop in large amount for its growth and also considered low in all the soil horizons when compared with the critical value (15mg kg^{-1}) as presented by Adiukwu and Ali (2013) as its mean value in the experimental site is 3.14mg kg^{-1}. Phosphorus is a problem nutrient in the soil as its highly fixed and unavailable to the crops. Brady (2002) emphasized that when fertilizers and manures are added to the soil, the phosphorus are changed to unavailable form and in time become highly insoluble. However, constant manuring and with time make the nutrient available to the crops to perform its role to humans and animals.

The soils effective cation exchange capacity (ECEC) ranges between 1.29 to 1.64 Cmol kg^{-1}. It decreases in value along the soil profile following the patter of the organic matter. This offers the contribution of organic matter to ECEC in the soils of the study area. The values of ECEC are lower than that reported by Kamalu *et al*. (2018). the low ECEC according to Kamalu *et al*. (2018) is attributed to kaolinitic nature of the clay minerals having cations in the coastal plain sands of southern Nigeria. The values of the exchangeable cations (Ca, Mg, K and Na) are also presented in Table 4.3. they cannot be said to be high in value but are influenced by the soil parent materials and organic matter. It might also be due to the high rate of rainfall prevalent in the area subjecting the soil to excessive leaching. The base saturation found in the study site soil is higher than 80% and according to Adiukwu and Ali (2013), it is rated very high. This value corresponds with the values in the works of Esekhade *et al* (2003), Ugwa *et at.* (2016) and Oko-Eboh *et al* (2018).

Apart from Fe that shows the highest amount in the study site soils, the other available micronutrients seem to be low. They range in value as Fe>Zn> Mn>Cu. The critical value of the available micronutrient according to Amhakhian and Osenwota (2012) are Fe (5.0mg kg^{-1}), Mn (2.5mg kg^{-1}),Cu (2.0 – 3.0 mg kg^{-1}) and Zn (0.8 mg kg^{-1}). Zn is said to be high in the soils and may be prone to toxicity in the soil. Deficiencies in micronutrient are attributed to the nutrient imbalance by heavy depletion of basic cation and phosphorus in the soil complex.

Table 4.3: Chemical characteristics of the soilsof the study area.

Horizon	Depth (cm)	pH (H_2O)	OC	TN	Avail.P (mg kg^{-1})	EA	Ca	Mg	K	Na	ECEC	BS	Mn	Fe	Cu	Zn
			g kg^{-1}			Cmol kg^{-1}						(%)	mg kg^{-1}			
A_{p1}	0 – 18	5.70	12.80	1.60	2.94	0.20	1.00	0.24	0.13	0.07	1.64	87.80	2.42	59.2	1.00	11.20
A_B	18 – 42	5.20	16.80	1.40	3.58	0.18	0.96	0.23	0.12	0.06	1.55	88.39	2.25	96.3	0.95	10.76
B_1	42– 66	5.20	2.80	0.30	0.64	0.15	0,80	0.19	0.10	0.05	1.29	88.37	2.18	148.0	0.92	10.22
B_2	66 – 89	5.20	22.80	1.50	5.10	0.20	0.80	0.19	0.09	0.05	1.33	84.96	2.29	212.4	0.89	10.90
B_t	89 - 145	5.30	18.80	1.30	3.45	0.14	0.90	0.21	0.10	0.06	1.41	90.00	2.58	218.5	1.10	11.98
	Mean	5.32	14.80	1.22	3.14	0.17	0.89	0.21	0.11	0.06	1.44	87.90	2.34	146.88	0.97	11.01

Source: Author’s Field work, 2021

Table 4.4 shows the correlation matrix of the soil proportion in the study site. The matrix reveals that six soil properties were positively significant while two were negatively significant.

The positively correlated properties are silt with clay ($p<0.01$), bulk density with pH ($p<0.05$, organic carbon with available P ($p<0.01$), Mn with Cu ($p<0.05$), Mn with Zn ($p<0.01$) and Cu with Zn ($p<0.05$). The highly significant relationship between silt and clay suggests that at the topsoil the more there is silt, the more the clay would be in the soil complex. As the acid nature of the soil decreases, the more is the value of the bulk density. It signifies that the organic matter may not have been sufficient in the topsoils. Furthermore, low organic matter in the soil has a negative value on available phosphorus and according to Brady (2002), an increase in the organic matter content of the soil improves the readily available content of the phosphorus status of the mineral soil. Apart from Fe, there is preponderance of Mn than Cu and Zn. These are micronutrients. The significant positive relationship observed in these micronutrients that are essential for crop function indicate that they are complimentary.

Table 4.4 also shows the significant negative relationship that is between bulk density with total N ($p<0.01$) and between total N with pH ($p<0,05$). The significance of this is that the more the soil of the study site becomes alkaline the more organic matter is be made available and may lower the bulk density value. Compact soils have negative influence in root development. Generally, soil tests in this area and crop residue management may be essential in the management of this fragile Ultisols.

Table 4.4: Correlation Matrix of the soil properties

	Sand	Silt	Clay	BD	TN	pH	OC	Avail P	EA	ECEC	BS	Mn	Fe	Cu
Sand	1													
Silt	-0.613	1												
Clay	-0.613	1.000**	1											
BD	-0.070	0.079	0.079	1										
TN	0.107	-0.076	-0.076	-0.998**	1									
pH	-0.028	0.416	0.416	0.857*	-0.830*	1								
OC	-0.124	-0.507	-0.507	0.431	-0.479	-0.091	1							
Avail. P	-0.132	-0.554	-0.554	0.469	-0.511	-0.050	0.980**	1						
EA	0.017	-0.411	-0.411	0.602	-0.590	0.396	0.376	0.543	1					
ECEC	0.590	-0.234	-0.234	0.752	-0.719	0.737	0.138	0.166	0.461	1				
BS	0.406	0.301	0.301	-0.134	0.147	0.099	-0.350	-0.510	-0.773	0.206	1			
Mn	-0.229	0.355	0.355	0.587	-0.617	0.449	0.444	0.314	-0.231	0.303	0.450	1		
Fe	-0.647	0.137	0.137	-0.369	0.308	-0.603	0.408	0.316	-0.427	-0.786	-0.112	0.254	1	
Cu	0.046	0.377	0.377	0.365	-0.379	0.376	0.152	-0.012	-0.505	0.332	0.780	0.910*	0.104	1
Zn	-0.179	0.190	0.190	0.565	-0.602	0.340	0.588	0.458	-0.186	0.292	0.388	0.982**	0.316	0.869

Note: * = correlation is significant at the 0.05 level (1-tailed), ** = correlation is significant at the 0.01 level (1-tailed).

CHAPTER FIVE

SUMMARY OF FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

5.1 Summary of Findings

Soil properties vary from one place to another, and these variations suggest difference in crop suitability. The following research findings were derived from the study.

1. Erosion activities is the major problem facing the soil of the area. This is evidence in the level of soil organic matter as indicated by the soil colour. This implies that the addition of manure will be the best form of soil management to improve its productivity.
2. The soil is severely weathered. This has positive effect on root penetration and development, thereby making the soil very satisfactory for root crop production.
3. For bulk density, the study revealed that soils of the study area had the ability to hold and sustain crop for its growth and development.
4. The research also revealed that soil pH concentrations in the topsoil and subsoil (0-18cm and 18-145cm) were not significantly different as it was within moderate range for establishing tree crops like oil palm and rubber.
5. Exchangeable cations (Na, Mg, Ca and K) showed no significant variation between the topsoil (0-18cm) and subsoil (18-145cm). Concentrations of

exchangeable cations was higher in the topsoil (0-18cm), and decreased as soil depth increased. This does not have any negative implication on plant growth.

5.2 Conclusion

Many agricultural programs in different part of Southern Nigeria and indeed Edo State have failed because of decline to understanding the soil environment within which these programs are executed. It has also failed to reappraise the fertility of the soil. A fertile soil does not mean there will be need for fertilizer addition. There must be some limits in placing the expected production level of the soil. Hence, the need for periodic soil test in southern Nigeria. However, not every arable land will respond to all types of fertilizer, indeed, some soils will provide adequate yields without the application of fertilizers.

The various state government in Nigeria may as a matter of urgency, through their respective ministry of agriculture provide soil test kilts to the farmers.

5.3 Recommendation

The soils need to be improved upon to enhance its productivity and harness the full potentials of the soil to support food production. Erosional control should be the fundamental step towards achieving an improve soil quality in the study site because of the amount of precipitation in the area. Manuring, such as the application of rock phosphate and/ or limestone which are likely to release fixed P and therefore increase Ca and Mg levels.

Planting of cover crops and tree crops, such as rubber and cacao are recommended because of the deep nature of the soil and the slope nature of the area (8%). Intercroppingincreases the growth measurement of rubber seedlings.

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