بسم الله الرحمن الرحيم

Sudan University of Science and Technology

College of Agricultural Studies

Department of Soil and Water Science

Characterization and Evaluation of Malam Elwedian Land area for Agricultural Development North Darfur - Sudan

خصائص وتقييم التربة في منطقة ملم الوديان واستخداماتها الزراعية بولاية شمال دارفور

A dissertation submitted to Sudan University of Science and Technology in fulfillment of the requirement of the degree of B.sc Honors in Soil and Water Science

By:

Rowida Eissa Ahmed Hamid

Supervisor:

Prof. Dr. El-Abbas Doka Mohamed Ali

2018

الآية

قال تعالى:

(وَهُوَ الَّذِي يُرْسِلُ الرِّيَاحَ بُشْرًا بَيْنَ يَدَيْ رَحْمَتِهِ حَتَّى إِذَا أَقَلَّتْ سَحَابًا ثِقَالًا سُقْنَاهُ لِبَلَدٍ مَيِّتٍ فَأَنْزَلْنَا بِهِ الْمَاءَ فَأَخْرَجْنَا بِهِ مِنْ كُلِّ الثَّمَرَاتِ كَذَلِكَ نُخْرِجُ الْمَوْتَى لَعَلَّكُمْ تَذَكَّرُونَ)

صدق الله العظيم

سورة الأعراف الآية (57)

DEDICATION

This research is heartily dedicated for

My treasured father and mother,

Brothers, sisters

Friends,

Teachers,

And every one who is interested in sciences

ACKNOWLEDGEMENTS

First, I would like to express my deepest gratefulness for Allah for giving me the strength and health throughout this period in completing my bachelor degree project. My heartfelt gratitude goes to my supervisor **Prof. Dr. Elabaas Mohamed Ali Doka** for his continued guidance and support as well as assisting me with the process. To willingness in exchanging opinions, give me flexibility in performing my task.

I would like also to express my proformed gratitude to my teacher and my class mates and in the special way to **Dr. ALsamoal Mohamed Marghani Osman** for his support and encouragements to complete my bachelor degree in this university.

Furthermore, I would like to extend my sincere thanks to the persons whose effort made this work possible and all the student of my supervisor for their suggestion and helpful comments.

I am thankful to all my class mates and other friends in Sudan University of science and technology- College of agricultural studies for their brotherly and friendly encouragements.

Last but not least greatly appreciates the fellow up all supporting provided my family.

ROWIDA EISSA AHMED HAMID

Sudan University of science and technology

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABBREVIATIONS

CEC	Cation exchange capacity
EC	Electrical conductivity
ESP	Exchangeable sodium percentage
FAO	Food and Agriculture Organization of the United Nation
CSS	Soil Structure- Physical Properties the corperative Soil Survey Retrieved
ILRI	Institute for Land Reclamation and Improvement
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
SAR	Sodium adsorption ratio
USDA	United States Department of Agriculture
WRB	World Reference Base for Soil Resources

مستخلص البحث

أجريت هذه الدراسة للتربة في ملم الوديان بمدينه الفاشر ولاية شمال دارفور الواقعة بين خط العرض 085درجة شمالا وخط طول 926 درجه غربا للتربه الطينيه ،وخط عرض 854 درجه شمالا وخط طول 825درجه غربا للتربه الرمليه. الطريق الرئيسي الذي يربط بين مدينه الفاشر ومدينه كتم يمر بجانب القيزان. مصادر المياه بالمنطقة سطحيه وجوفيه.استخداماتها في الزراعة التقليدية(مطري) وتربيه حيوان. طبوغرافية الأرض بالمنطقة منبسطة تقريبا. المناخ الجاف هو السائد في المنطقة كما توجد بالمنطقة نباتات لبعض المحاصيل والتوصية بعمليات الإدارة الملائمة. تهدف هذه الدراسة لمعرفة خصائص التربة بمنطقة ملم الوديان وعرض اختلافاتها وتقييم درجة صلاحيتها.بالإشارة تم تطبيق طريقة الحصر الشبكي بهذه الدراسة وتضمنت الوصف الحقلي واخذ عينات التربة التمثيلية بالبريمة تبعد كل منها 90سنتمتر عينات التربة تم جمعها لإتمام التحاليل الفيزيائية والكيميائية وعرضها، نتائج الوصف الحقلي والتحليل المعملي أثبتت أن تربه المنطقة ذات نفاذية عاليه بسبب نوع القوام مع وجود مشكله الخصوبة. بناءا على نظام تحديد صلاحية الأراضي قدرت الدراسة أراضي المنطقة ذات صلاحية متوسطه (S2) لوجود محدد الخصوبه($S2_f$) وصلاحية هامشيه S3 لوجود محددين الخصوبة والنفاذيه $S3_{fp}$ أوصت الدراسة بإضافة المادة العضوية لتربة منطقة ملم الوديان بالكمية المناسبة لتحسين جوده وصحة التربة، تطبيق نظام ري جيد ومياه ذات نوعيه جيدة في الوقت المناسب، تطبيق النتائج والتوصيات في المنطقة وفي ترب مشابهه ومماثلة للمنطقة , يجب أن يكون للتربة من الإضافات المناسبة من المواد العضوية التي تؤدي إلى بناء التربة جودة صحية وعالية والتي سيكون لها تأثير إيجابي كبير على النباتات.

الكلمات المفتاحية: تقييم التربة – صلاحية التربة –شمال دارفور.

Abstract

This study was conducted in the El-Fasher (Malam Elwedian) which is located in North Darfur State latitude 085 Degree north and longitudes 926'degree east for clay soil, and latitude 854 degree north and longitudes 825 degree east for sand soil. The main road which connects EI-Fasher to Kutum and other important towns runs beside the Malam Elwedian area. The area is dominated by flat topography within the undulating sandy plain. The climate of the study area is arid and the main types of vegetation in the study area. The water resources were Surface water and underground water. The major land use types are traditional farming (rain fed) and animal breeding. This study aimed to characterize the soils EL-Fasher, Malam Elwedian area and show their variability. As well, the study indicated the suitability of the land for some selected crops and recommended the proper management practices. The Grid soil survey method was followed in this study which involved field descriptions and taking of representative soil samples at intervals of (0 – 30), (30- 60), -(60 – 90)cm) apart, tow soil auger sample ware dug to 90cm depth, soil sample Collected and complete routine analysis were carried to show the chemical and physical. The area is generally composed of one map unit with consociations of minor inculcations of similar sandy soils. The results of field description and laboratory analysis revealed that the soil of the farm has high filtration due to the texture classes with fertility limitation. According to land suitability system the study rated the soils in class two with fertility limitation ($S2_{f}$), and class ($S3_{fp}$) with fertility and moisture deficiency ($S3_{fm}$). The study recommended the soil of the EL-Fasher Malam Elwedian should have proper additions of organic matter which leads to building of healthy and high quality soils which will have great positive influence on plants. Applying a good system of irrigation methods with good quality water in appropriate time is required for these sandy soils. Results and recommendations of the trials and experiments carried on this farm should only be applied to similar sandy soils.

Key word: Soil Evaluation – Soil Validity – North Darfur.

CHAPER ONE

INTRODUCTION

1. Introduction

Soils differ greatly in their morphological, physic-chemical and mineralogical properties. These differences affect crop response to management inputs. Improper use of soils may reduce yields and as well aggravate degradation. it is, therefore, essential to understand the soil to ensure suitable sustainable agriculture and proper conservation. The soil differences are due to variations in soil forming factors and processes operating on different parent materials, under different climatic, topographic, and biological conditions over varying periods of time (Soil survey Staff, 1993). Different soil types support different land use and require different management options for sustainable productivity (Ogunkunl.,1986). According to (Fagbam., 1990). the diversity nature of soil is a major reason behind allocation of land to wrong uses. Soil characterization and classification contribute to the alleviation of the adverse effect of soil diversity and aid precision agriculture. Soil characterization and classification is the main information source for precision agriculture, land use planning and management (Ogunkunl., 1986). This is because characterization and classification provide information for the understanding of the micro-morphological, physical, chemical, mineralogical and microbiological properties of the soil (Ogunkunl, 1986). A soil survey describes the characteristics of the soils in a given area, classifies the soils according to a standard system of classification, plots the boundaries of the soils on a map, and makes predictions about the behavior of soils. The different uses of the soils and how the response of management affects them are considered in designing and carrying out the survey. The information collected in a soil survey helps in the development of land-use plans and evaluates and predicts the effects of land use on the environment (USDA, 1993). In agricultural research, it turn to be a fundamental necessity to the soil of the research plots and field so as to transfer the research finding on them to similar regional soil of a like climate under the specified management packages.

1.1 Research problem:

The hypothesis guiding this research study at El-fasher Malam Elwedian could be described as follows:

1. Absence of detailed information on the soils of Farm.
2. The soils of the farm might be similar to the surrounding soils and other dominant soils of the state.
3. Soil management practices based on soil properties need to be established based on soil properties of El-Fasher Malam Elwedian to guide the extension officers so as to advise local farmers.
4. Inappropriate land use and management practices lead to inefficient exploitation and degradation the land resource which consequently results in low productivity and destruction of- the land resource.

1.2 Objectives of the study

The objectives of this study are:

1. To characterize the physical and chemical properties of the soils and show their variability and distribution in the Malam Elwedian at El Fasher.
2. To determine the land suitability classes and their limitations (subclasses) for growing of local and adapted crops in similar soils.

3. To provide guidelines for use and management of the farm soils and similar soils in the State to investigate how much the research farm soils are representative of the surrounding soils.
4. Soils of the farmers so as to extend soil related research results to local farmers.

CHAPTER TWO

LITERATURE REVIEW

2. Literature Review

The vast importance of the soil in the development of varies agricultural system and types of civilizations has long been recognized but it is only within the last few decades that soil as such have been studied in a scientific manner. During thousands of years mankind has looked upon soils mainly from the utilitarian point of view, today it is being realized more and more, that the soil parse is worthy of scientific study. Theoretical research and thought, there is every reason to believe that any advance in the fundamental knowledge of soils will immediately stimulate practical phases of soil investigations (Michael , 2012).

2.1 Soil Forming Factors

Soil is a 3-dimensional body with properties that reflect the impact of (1) parent material, (2) climate, and (3) topography on the soil's (4) Soil Living Organisms (5) time. The nature and relative importance of each of these five 'soil forming factors' vary in time and in space. With few exceptions, soils are still in a process of change; they show in their 'soil profile' signs of differentiation or alteration of the soil material incurred in a process of soil formation or 'pedogenesis' (Driessen, *et al*. 2001).

2.1.1 Soil parent material

The Material from which soil forms is called parent material**.** It includes: weathered primary bedrock; secondary material transported from other locations, namely colluviums and alluvium; deposits that are already present but mixed or altered in other ways old soil formations, organic material; and anthropogenic materials, such as landfill or mine waste.

(Milford. *et al,* 2001). Soils that develop from their underlying parent rocks are called "residual soils", and have the same general chemistry as their parent rocks. The soils found on mesas, plateaus and plains are residual soils but few other soils are residual, most soils derive from transported parent materials that have been moved many miles by wind, water and gravity, Aeolian processes are capable of moving fine sand and silt many hundreds of miles .forming loess soils, common in the Midwest of North America and in central Asia clay is seldom moved by wind as it forms stable aggregates cumulate parent material includes peats and mucks and may develop in place from plant residues that have been preserved y the low oxygen content of a high water table. Weathering is the first stage in the transforming of parent material in to soil material. In soil forming from bedrock- a thick layer of weathered material called saprolite may form. Coprolite is the result of weathering processes that include: hydrolysis (the division of a mineral solution of minerals in water with resulting cation, anion, pairs), and physical processes that include freezing and thawing, the mineralogical and chemical composition of the primary bedrock material, its physical features, including grain size and degree of consolidation, plus the rate and type of weathering, transforms the parent material into the different mineral components of soils. Texture, pH and mineral constituents are inherited by a soil from its parent material, (Milford *.et al*, 2001).

2.1.2 Climate

Soil formation greatly depends on the climate, and soils show the distinctive characteristics of the climate zones in which they form, temperature and moisture affect the rate of weathering and leaching, wind moves sand and smaller particles, especially in arid regions where there is little plant cover. The type and amount of precipitation influence soil formation by affecting the movement of ions and particles through the soil, and aid in the development of different soil profiles, the effectiveness of water in weathering parent rock material depends on seasonal and daily temperature fluctuations, cycles of freezing and thawing constitute an effective mechanism that breaks up rocks and other consolidated materials, temperature and precipitation rates affect vegetation cover, biological activity, and the rates of chemical reactions in the soil (Gove Hambidge, 1941).

2.1.3 Topography

The topography or relief characterized by the inclination of the surface determines the rate of Precipitation runoff and rate of formation and erosion of the surface soil profiles; steep slopes allow rapid runoff and erosion of the top soil profiles and little mineral deposition in lower profiles. Depressions allow the accumulation of water, minerals and organic matter and in the extreme; the resulting soils will be saline marshes or peat bogs, intermediate topography affords the best conditions for the formation of an agriculturally productive soil, (Gove Hambidge, 1941).

2.1.4 Soil Living Organisms

Plants, animals, fungi, bacteria and humans affect soil formation, animals and microorganisms mix soils as they form burrows and pores, allowing moisture and gases to move about. In the same way, plant roots open channels in soils; plants with deep taproots can penetrate many meters through the different soil layers to bring up nutrients from deeper in the profile, plants with fibrous roots that spread out near the soil surface have roots that are easily decomposed, adding organic affect chemical exchanges between root and soil and act as a reserve of nutrient. Human can impact soil formation by removing vegetation cover with erosion as the result they can also mix the different soil layer. Restarting the soil formation process as less weathered material is mixed with the more developed upper layers. Some soils may contain up to one million species of microbes per gram, most of those species being unknown, making soil the most abundant ecosystem on earth, Vegetation impacts soils in numerous ways. It can prevent erosion caused by excessive rain and the resulting surface runoff, plants shade soils, keeping them cooler and slowing evaporation of soil moisture, or conversely, by way of transpiration, plants can cause soils to lose moisture, plants can form new chemicals that can break down or build up soil particles, the type and amount of vegetation depends on climate, land form topography, soil characteristics, and biological factors. Soil properties such as density, depth, chemistry, pH, temperature and moisture greatly affect the type of plants that can grow in a given location. Dead plants and dropped leaves and stems fall to the surface of the soil and decompose, there; organisms feed on them and mix the organic material with the upper soil. Layers these added organic compounds become part of the soil formation process, (Copley and Jon, 2005).

2.1.5 Time

Time is a factor in the interactions of all the above, over time, soils evolve features dependent on the other forming factors. Soil formation is a time-responsive process that is dependent on how the other factors interplay with each other. Soil is always changing. It takes about 800 to 1000 years for a 2.5 cm thick layer of fertile soil to be formed in nature, for example, recently deposited material from a flood exhibits no soil ’development because there has riot been enough time for soil-forming activities. The original soil surface is buried, and the formation process must begin anew for this deposit, the long periods over which change occurs and its multiple influences mean that simple soils are rare, resulting in the formation of soil, while soil can achieve relative stability of its properties for extended periods, the soil life cycle ultimately ends in soil conditions that leave it vulnerable to erosion, despite the inevitability of soil retrogression and degradation, most soil cycles are long and productive. Soil-forming factors continue to affect soils during their existence, even on "stable" landscapes that are long-enduring, some for millions of years, materials are deposited on top and materials are blown or washed from the surface, with additions, removals and alterations, soils are always subject to new conditions. Whether these are slow or rapid changes depend on climate, landscape position and biological activity (Copley and Jon, (2005). 3.3 Physical and chemical properties Physical properties are those that can be observed without changing the identity of the substance, the general properties of matter such as color, density, hardness, are examples of physical properties. Properties that describe how substance changes into a completely different substance are called chemical properties, flammability and corrosion oxidation resistance are examples of chemical properties. The difference between a physical and chemical property is straightforward until the phase of the material is considered. When a material changes from a solid to a liquid to a vapor it seems like them become a difference substance, however, when a material melts, solidifies, vaporizes, condenses or sublimes, only the state of the substance changes, consider ice, liquid water, and water vapor,. They are all simply H_2O, phase is a physical property of matter and matter can exist in four phases, solid, liquid, gas and plasma.

2.2 Physical Properties of soil

The physical properties of the soil are its texture, structure, density, porosity, consistency, temperature and color, these determine the availability of oxygen in the soil and ability of water to infiltrate and be held in the soil, soil texture, characterized by the different soil particles, called soil "separates" sand, silt and clay is the relative proportion of those three. Larger soil structures are created from the separates when iron oxides, carbonates, clay and silica with the organic constituent humus, coat particles and cause them to adhere into relatively stable secondary structures called "pds", soil density, particularly bulk density, is a measure of the soil compaction. Soil porosity consists of the part of the volume occupied by air and water, consistency is the ability of soil to stick together, soil temperature and color are self-defining (Alfred Sefferud, 1957).

2.2.1 Texture

The mineral components of soil are sand, silt and clay, and their relative proportions determine a soil's texture. Properties that are influenced by soil texture include porosity, permeability, infiltration, shrink-swell rate, water-holding capacity, and susceptibility to erosion. In the illustrated USDA textural classification triangle, the only soil in which neither sand and silt nor clay predominates is called "loam". While even pure sand, silt or clay may be considered a soil, from the perspective of food production a loam soil with a small amount of organic material is considered ideal. The mineral constituents of a loam soil might be 40% sand, 40% silt and the balance 20% clay by weight. Soil texture affects soil behavior, in particular its retention capacity for nutrients and water (Nyle and Ray ,(2009).

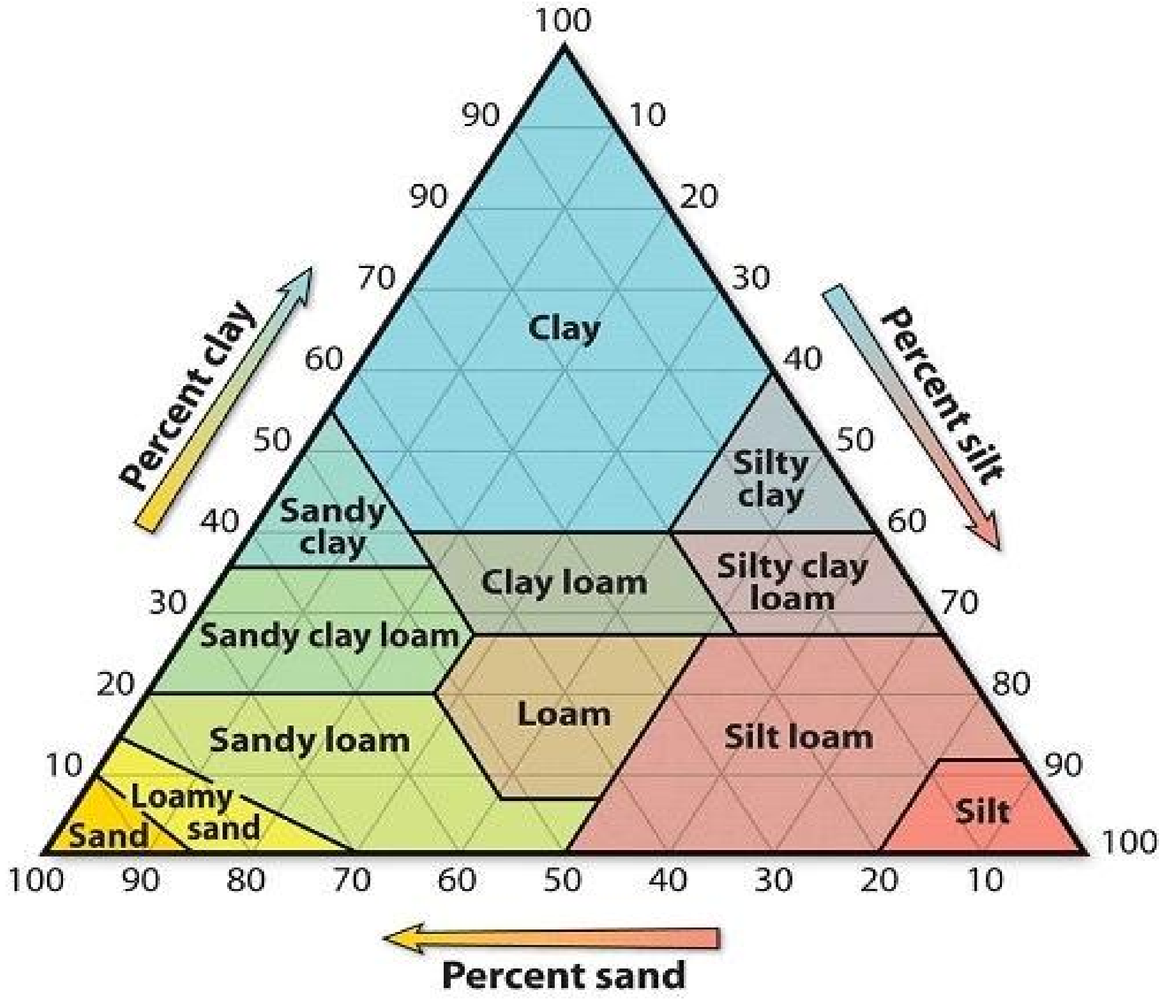

Figure 2.1: Texture triangle. As used by the USDA (Soil Survey Division Staff, 1993).

Sand and silt are the products of physical and chemical weathering of the parent rock, clay, on the other hand, is a product of the precipitation of the dissolved parent rock as a secondary mineral. It is the large surface area to volume ratio (specific surface area) of soil particles and the unbalanced ionic charges within those that determine their role in the cation exchange capacity of soil, and hence its fertility. Sand is least active, followed by silt; clay is the most active. Sand's greatest benefit to soil is that it resists compaction and increases a soil's porosity. Silt is mineralogical like sand but with its higher specific surface area it is more chemically active than sand. But it is the clay content of soil, with its very high specific surface area and generally large number of negative charges that gives a soil its high retention capacity for water and nutrients. Clay soils also resist wind and water erosion better than silty and sandy soils, as the particles bond tightly to each other. Sand is the most stable of the mineral components of soil; it consists of rock fragments, primarily quartz particles, ranging in size from 2.0 to 0.05 mm (0.0787 to 0.0020 in) in diameter. Silt ranges in size from 0.05 to 0.002 mm (0.002 to 0.00008 in). Clay cannot be resolved by optical microscopes as its particles are 0.002 mm (7.9×10^{-5} in) or less in diameter. In medium-textured soils, clay is often washed downward through the soil profile and accumulates in the subsoil. Soil components larger than 2.0 mm (0.079 in) are classed as rock and gravel and are removed before determining the percentages of the remaining components and the texture class of the soil, but are included in the name. For example, a sandy loam soil with 20% gravel would be called gravelly sandy loam. When the organic component of a soil is substantial, the soil is called organic soil rather than mineral soil. A soil is called organic if: – Mineral fraction is 0% clay and organic matter is 20% or more – Mineral fraction is 0% to 50% clay and organic matter is between 20% and 30% – Mineral fraction is 50% or more clay and organic matter 30% or more (Donahue. *et al*,1977).

2.2.2 Soil Structure

The clumping of the soil textural components of sand, silt and clay causes aggregates to form and the further association of those aggregates into larger units creates soil structures called pedoliths or peds. The adhesion of the soil textural components by organic substances, iron oxides, carbonates, clays, and silica, and the breakage of those aggregates from expansion- contraction, caused by freezing-thawing and wetting-drying cycles, shape soil into distinct geometric forms. The peds evolve into units which may have various shapes, sizes and degrees of development (Soil Survey Division Staff., 1993). A soil clod, however, is not a ped but rather a mass of soil that results from mechanical disturbance of the soil. Soil structure affects aeration, water movement, and conduction of heat, plant root growth and resistance to erosion. Water, in turn, has its strongest effect on soil structure due to its solution and precipitation of minerals and its effect on plant growth. Soil structure often gives clues to its texture, organic matter content, biological activity, past soil evolution, human use, and the chemical and mineralogical conditions under which the soil formed. While texture is defined by the mineral component of a soil and is an innate property of the soil that does not change with agricultural activities, soil structure can be improved or destroyed by the choice and timing of farming practices. Soil structural classes are defined as follows (Donahue. *et al*,1977).

2.2.3 Types: Shape and arrangement of pads

1. Platy: Peds are flattened one atop the other 1–10 mm thick. Found in the A- horizon of forest soils and lake sedimentation.
2. Prismatic and Columnar: Prism like peds are long in the vertical dimension, 10– 100 mm wide. Prismatic peds have flat tops, columnar peds have rounded tops. Tend to form in the B-horizon in high sodium soil where clay has accumulated.
3. 3Angular and sub angular: Blocky peds are imperfect cubes, 5–50 mm, angular has sharp edges, sub angular have rounded edges. Tend to form in the B-horizon where clay has accumulated and indicate poor water penetration.
4. Granular and Crumb: Spheroid peds of polyhedrons, 1–10 mm, often found in the A-horizon in the presence of organic material. Crumb peds are more porous and are considered ideal. Classes: Size of peds whose

ranges depend upon the above type 1. Very fine or very thin: 10 mm platy, granular; >50 mm blocky; >100 mm prism-like. Grades: Is a measure of the degree of development or cementation within the peds that results in their strength and stability.

1. Weak: Weak cementation allows peds to fall apart into the three textural constituents, sand, silt and clay.

2. Moderate: Peds are not distinct in undisturbed soil but when removed they break into aggregates, some broken aggregates and little un-aggregated material. This is considered ideal.

3. Strong:Peds are distinct before removed from the profile and do not break apart easily.

4. Structure less: Soil is entirely cemented together in one great mass such as slabs of clay or no cementation at all such as with sand. At the largest scale, the forces that shape a soil's structure result from swelling and shrinkage that initially tend to act horizontally, causing vertically oriented prismatic peds. Clayey soil, due to its differential drying rate with respect to the surface, will induce horizontal cracks, reducingk columns to blocky peds. Roots, rodents, worms, and freezing-thawing cycles further break the peds into a spherical shape. At a smaller scale, plant roots extend into voids and remove water causing the open spaces to increase, and decrease physical aggregation size. At the same time roots, fungal hyphae and earthworms create microscopic tunnels that break up peds. At an even smaller scale, soil aggregation continues as bacteria and fungi exude sticky polysaccharides which bind soil into small peds. The addition of the raw organic matter that bacteria and fungi feed upon encourages the formation of this desirable soil structure.

At the lowest scale, the soil chemistry affects the aggregation or dispersal of soil particles. The clay particles contain polyvalent cations which give the faces of clay layers a net negative charge. At the same time the edges of the clay plates have a slight positive charge, thereby allowing the edges to adhere to the faces of other clay particles or to flocculate (form clumps). On the other hand, when monovalent ions such as sodium invade and displace the polyvalent cations, they weaken the positive charges on the edges, while the negative surface charges are relatively strengthened. This leaves a net negative charge on the clay, causing the particles to push apart, and by doing so to prevent the flocculation of clay particles into larger, open assemblages, (CSS 2012). As a result, the clay disperses and settles into voids between peds, causing those to close. In this way the soil aggregation is destroyed and the soil is made impenetrable to air and water. Such sodic soil tends to form columnar structures near the surface, (CSS 2012).

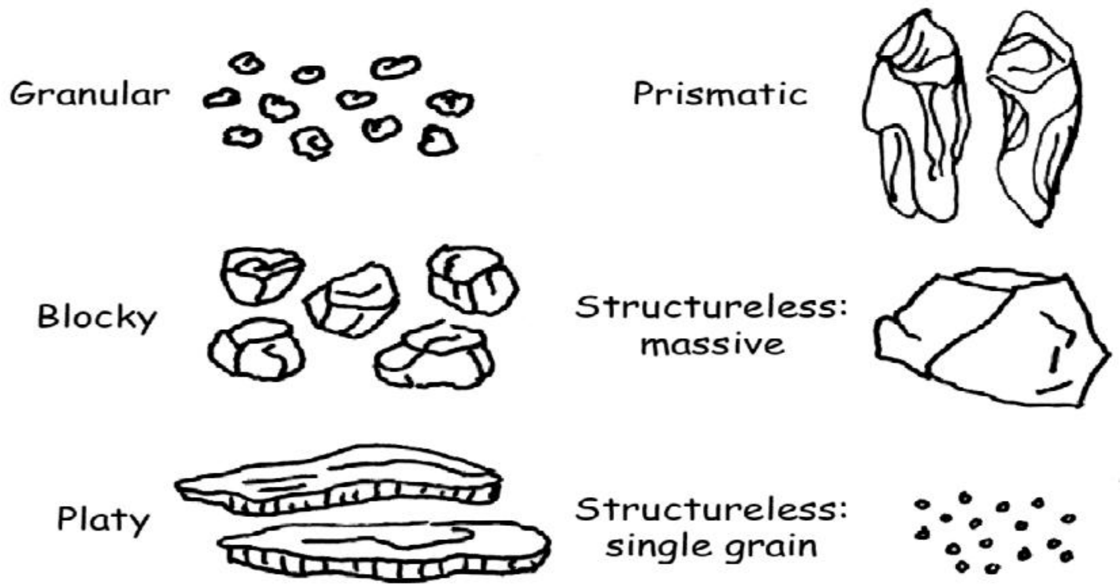

Figure 2.2: common type of soil structure

2.2.4 Density

Soil particle density is typically 2.60 to 2.75 grams per cm3 and is usually unchanging for a given soil. Soil particle density is lower for soils with high organic matter content, and is higher for soils with high Fe-oxides content. Soil bulk density is equal to the dry mass of the soil divided by the volume of the soil; it includes air space and organic materials of the soil volume. The soil bulk density of cultivated loam is about 1.1 to 1.4 g/cm^3 (for comparison water is 1.0 g/cm^3) (Johnson. *et al*, 2013). Abbreviations Soil bulk density is highly variable for a given soil. A lower bulk density by itself does not indicate suitability for plant growth due to the influence of soil texture and structure. A high bulk density is indicative of either soil compaction or high sand content. Soil bulk density is inherently always less than the soil particle density.

Table 2.1: Representative bulk densities of soils, the percentage pore space was calculated using 2.7 g/cm3 for particle density except for the peat soil, which is estimated.

Soil treatment and identification	Bulk Density g/cm^3	Pore space %
Tilled surface soil of a cotton field	1.3	51
Trafficked inter-rows where wheels passed surface	1.67	37
Traffic pan at 25 cm deep	1.7	36
Undisturbed soil below traffic pan, clay loam	1.5	43
Rocky silt loam soil under aspen forest	1.62	40
Loamy sand surface soil	1.5	43
Decomposed peat	0.55	65

Source: David, 1982.

2.2.5 Porosity

Pore space is that part of the bulk volume of soil that is not occupied by either mineral or organic matter but is open space occupied by either gases or water. Ideally, the total pore space should be 50% of the soil volume. The gas space is needed to supply oxygen to organisms decomposing organic matter, humus, and plant roots. Pore space also allows the movement and storage of water and dissolved nutrients. This property of soils effectively compartmentalizes the soil pore space such that many organisms are not in direct competition with one another, which may explain not only the large number of species present, but the fact that functionally redundant organisms (organisms with the same ecological niche) can co-exist within the same soil.(Johnso. *et al* ,2013).

Table 2.2: Categories of soil pores

1	Coarse pores	0.2 mm -200 microns
2	Medium pores	200-20 microns
3	Fine pores	20-2 microns
4	Very fine pores	<2 microns

In comparison, root hairs are 8 to 12 µm in diameter. When pore space is less than 30 µm, the forces of attraction that hold water in place are greater than the gravitational force acting to drain the water. At that point, soil becomes water-logged and it cannot breathe. For a growing plant, pore size is of greater importance than total pore space. A medium-textured loam provides the ideal balance of pore sizes. Having large pore spaces that allow rapid gas and water movement is superior to smaller pore space soil that has a greater percentage pore space. Soil texture determines the pore space at the smallest scale, but at a larger scale, soil structure has a strong influence on soil aeration, water infiltration and drainage (Donahue, Miller and Shicklun.,1977). Tillage has the short-term benefit of temporarily increasing the number of pores of largest size, but in the end those will be degraded by the destruction of soil aggregation. Clay soils have smaller pores, but more total pore space than sand.

2.6 Soil Color

Is often the first impression one has when viewing soil? Striking colors and contrasting patterns are especially noticeable. The Red River (Mississippi watershed) carries sediment eroded from extensive reddish soils like Port Silt Loam in Oklahoma. The Yellow in China carries yellow sediment from eroding loess soils. Podzols in boreal forests have highly contrasting layers due to acidity and leaching. In general, color is determined by the organic matter content, drainage conditions, and degree of oxidation. Soil color, while easily discerned, has little use in predicting soil characteristics. It is of use in distinguishing boundaries within a soil profile, determining the origin of a soil's parent material, as an indication of wetness and waterlogged conditions, and as a qualitative means of measuring organic, salt and carbonate contents of soils. Color is recorded in the Mensal color system as for instance 10YR3/4 Dusky Red. Soil color is primarily influenced by soil mineralogy. Many soil colors are due to various iron minerals. The development and distribution of color in a soil profile result from chemical and biological weathering, especially redox reactions. As the primary minerals in soil parent material weather, the elements combine into new and colorful compounds. Iron forms secondary minerals of a yellow or red color, organic matter decomposes into black and brown compounds, and manganese, sulfur and nitrogen can form black mineral deposits. These pigments can produce various color patterns within a soil. Aerobic conditions produce uniform or gradual color changes, while reducing environments (anaerobic) result in rapid color flow with complex, mottled patterns and points of color concentration (USDA 2008).

Figure 2.3: Soil color measure by mencil color

2.3.1 Chemical Properties of Soil

A soil test provides information about a soil's chemical properties; the soil test report indicates the levels of the various nutrient elements in our sample as well as soil pH, buffer pH, cation exchange capacity, base saturation and organic matter.

2.3.2 Essential Elements

There are thirteen essential mineral for plant growth, six of these are called major or macro elements because the plant uses them in rather large amounts, they are nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg) and sulfur (S). Sometimes Ca, Mg and S are referred to as secondary elements because they are used in somewhat smaller amounts than N, P and K. Seven more are called minor, micro or trace elements, these are every bit as important as major elements, but are used in very small amounts, these elements include iron (Fe), Manganese (Mn), zinc (Zn), boron (B), copper (Cu), molybdenum (Mo) and chlorine (CD. Nickel (Ni) is accepted by many scientists as the 14th nutrient element derived from soils. In addition to mineral elements, carbon (C), hydrogen (H) and oxygen (0) are essential elements; plants take these elements from air and water. We don't apply fertilizer materials to the soil in order to supply C, H and 0, but our soil management practices have an effect on their availability. (Brady, 1974).

2.3.3 Cation Exchange Capacity (CEC)

Cation exchange capacity should be thought of as the soil's ability to remove cations from the soil water solution and sequester those to be exchanged later as the plant roots release hydrogen ions to the solution. CEC is the amount of exchangeable hydrogen cation (H^+) that will combine with 100 grams dry weight of soil and whose measure is one milliequivalent per 100 grams of soil (1 meq/100 g). Hydrogen ions have a single charge and one-thousandth of a gram of hydrogen ions per 100 grams dry soil gives a measure of one milliequivalent of hydrogen ion. Calcium, with an atomic weight 40 times that of hydrogen and with a valence of two, converts to (40/2) x 1 milliequivalent = 20 milliequivalents of hydrogen ion per 100 grams of dry soil or 20 meq/100 g. The modern measure of CEC is expressed as centimoles of positive charge per kilogram (cmol/kg) of oven-dry soil. Most of the soil's CEC occurs on clay and humus colloids, and the lack of those in hot, humid, wet climates, due to leaching and decomposition respectively, explains the relative sterility of tropical soils. Live plant roots also have some CEC (Donahue. *et al*, 1977).

2.3.4 Base Saturation

Richards, (1954), said that the cations Ca ++,Mg++,K+ and H+ normally account for nearly all cations adsorbed on soil particles, although trace elements that are cations are also present in minute quantities. Cal-F ,me-, and IC- are called bases and Fr and Ari- are acidic cations that lower soil pH, if all of the adsorbed cations are bases and none are acidic, there would be a 100% base saturation, and the soil pH would be about 7 (neutral) or above. In acid soils there are acid cations present and the per cent base saturation is less than 100. Besides having sufficient quantities of Ca, Mg and K, it is important that they be in balance with each other because an excess of one of these can suppress the uptake of another, as a general rule a Ca: Mg: K ratio of about 20:4:1 is desirable. When expressed as percent base saturation, desired levels are: Ca 65-80%; Mg 5-15%; and K 2-5%, (John, 1997).

2.3.5. Soil pH

Soil reactivity is expressed in terms of pH and is a measure of the acidity or alkalinity of the soil. More precisely, it is a measure of hydrogen ion concentration in an aqueous solution and ranges in values from 0 to 14 (acidic to basic) but practically speaking for soils, pH ranges from 3.5 to 9.5, as pH values beyond those extremes are toxic to life forms. At 25 °C, an aqueous solution that has a pH of 3.5 has 10−3.5 moles H+ (hydrogen ions) per liter of solution (and also 10−10.5 mole/liter OH−). A pH of 7, defined as neutral, has 10−7 moles hydrogen ions per liter of solution and also 10−7 moles of OH− per liter; since the two concentrations are equal, they are said to neutralize each other. A pH of 9.5 has 10−9.5 moles hydrogen ions per liter of solution (and also 10−2.5 mole per liter OH−). A pH of 3.5 has one million times more hydrogen ions per liter than a solution with pH of 9.5 (9.5 - 3.5 = 6 or 106) and is more acidic. The effect of pH on a soil is to remove from the soil or to make available certain ions. Soils with high acidity tend to have toxic amounts of aluminum and manganese. Plants which need calcium need moderate alkalinity, but most minerals are more soluble in acid soils. Soil organisms are hindered by high acidity, and most agricultural crops do best with mineral soils of pH 6.5 and organic soils of pH 5.5 (Chang ,1984). In high rainfall areas, soils tend to acidity as the basic cations are forced off the soil colloids by the mass action of hydrogen ions from the rain as those attach to the colloids. High rainfall rates can then wash the nutrients out, leaving the soil pore. Once the colloids are saturated with H+, the addition of any more hydrogen ions or aluminum hydroxyl cations drives the pH even lower (more acidic) as the soil has been left with no buffering capacity. In areas of extreme rainfall and high temperatures, the clay and humus may be washed out, further reducing the buffering capacity of the soil. In low rainfall areas, un-leached calcium pushes pH to 8.5 and with the addition of exchangeable sodium, soils may reach pH 10. Beyond a pH of 9, plant growth is reduced. High pH results in low micro-nutrient mobility, but water-soluble cheated of those nutrients can supply the deficit. Sodium can be reduced by the addition of gypsum (calcium sulphate) as calcium adheres to clay more tightly than does sodium causing sodium to be pushed into the soil water solution where it can be washed out by an abundance of water (Donahue. *et al*, 1977).

2.3.6 Soil Salinity (Electrical Conductivity – E.Ce.)

Electrical conductivity (EC) of a soil Solution or extract indicates the concentration of total soluble salts in solution-thus reflecting the degree of soil salinity. The unit of measurements called millimhos per centimeter (mmhos/cm) or deci-Siemen per meter (ds/m). The EC is reported to a standard temperature of 25°C, Salinity affects plants at all stages of development. And for some crops sensitivity varies from one growth stage to another. For example barley, wheat, and maize are more sensitive to salinity during early seedling growth than during germination or at advanced stages of growth and grain development (Maas and Hoffman, 1977).

2.3.7 Soil solutions

Soils retain water that can dissolve a range of molecules and ions, these solutions exchange gases with the soil atmosphere, contain dissolved sugars, fulvic acids and other organic acids, plant nutrients such as nitrate, ammonium, potassium, phosphate, sulfate and calcium, and micronutrients such as zinc, iron and copper. These nutrients are exchanged with the mineral and humic component that retains them in its ionic state by adsorption. Some arid soils have sodium solutions that greatly impact plant growth, soil pH can affect the type and amount of anions and cations that soil solutions contain and that be exchanged between the soil substrate and biological organisms (Dan, 2000).

2.4 Soil organic matter

Soil organic matter is made up of organic compounds and includes plant, animal and microbial material, both living and dead. A typical soil has a biomass composition of 70% microorganisms, 22% macro fauna, and 8% roots. The living component of an acre of soil may include 900 lb. of earthworms, 2400 lb. of fungi, 1500 lb. of bacteria, 133 lb. of protozoa and 890 lb. of arthropods and algae (Foth,1984). A small part of the organic matter consists of the living cells such as bacteria, molds, and actinomycetes that work to break down the dead organic matter. Were it not for the action of these micro-organisms, the entire carbon dioxide part of the atmosphere would be sequestered as organic matter in the soil. Chemically, organic matter is classed as follows:

1. Polysaccharides

2. Cellulose

3. Hemicelluloses

4. Starch

5. Pectin

6. Lignin

7. Proteins

Most living things in soils, including plants, insects, bacteria, and fungi, are dependent on organic matter for nutrients and/or energy. Soils have organic compounds in varying degrees of decomposition which rate is dependent on the temperature, soil moisture, and aeration. Bacteria and fungi feed on the raw organic matter, which are fed upon by amoebas, which in turn are fed upon by nematodes and arthropods. Organic matter holds soils open, allowing the infiltration of air and water, and may hold as much as twice its weight in water. Many soils, including desert and rocky-gravel soils, have little or no organic matter. Soils that are all organic matter, such as peat (Histosols), are infertile. In its earliest stage of decomposition, the original organic material is often called raw organic matter. The final stage of decomposition is called humus. In grassland, much of the organic matter added to the soil is from the deep, fibrous, grass root systems. By contrast, tree leaves falling on the forest floor are the principal source of soil organic matter in the forest. Another difference is the frequent occurrence in the grasslands of fires that destroy large amounts of above ground material but stimulate even greater contributions from roots. Also, the much greater acidity under any forests inhibits the action of certain soil organisms that otherwise would mix much of the surface litter into the mineral soil. As a result, the soils under grasslands generally develop a thicker A horizon with a deeper distribution of organic matter than in comparable soils under forests, which characteristically store most of their organic matter in the forest floor (O horizon) and thin A horizon.

2.4.1 Soil degradation

Land degradation refers to a human-induced or natural process which impairs the capacity of land to function. Soils are the critical component in land degradation when it involves acidification, contamination, desertification, erosion or salinization. While soil acidification is beneficial in the case of alkaline soils, it degrades land when it lowers crop productivity and increases soil vulnerability to contamination and erosion. Soils are often initially acid because their parent materials were acid and initially low in the basic cations (calcium, magnesium, potassium and sodium). Acidification occurs when these elements are leached from the soil profile by rainfall or the by harvesting of forest or agricultural crops. Soil acidification is accelerated by the use of acid-forming nitrogenous and by the effects of acid precipitation, (Dooley, 2006).

2.4.2 Desertification

Is an environmental process of ecosystem degradation in arid and semi-arid regions, often caused by human activity. It is a common misconception that droughts cause desertification. Droughts are common in arid and semiarid lands. Well-managed lands can recover from drought when the rains return. Soil management tools include maintaining soil nutrient and organic matter levels, reduced tillage and increased cover. These practices help to control erosion and maintain productivity during periods when moisture is available. Continued land abuse during droughts, however, increases land degradation. Increased population and livestock pressure on marginal lands accelerates desertification, (Morgan,1979).

2.4.3 Erosion

Erosion of soil is caused by water, wind, ice, and movement in response to gravity. More than one kind of erosion can occur simultaneously. Erosion is distinguished from weathering; since erosion also transports eroded soil away from its place of origin (soil in transit may be described as sediment). Erosion is an intrinsic natural process, but in many places it is greatly increased by human activity, especially poor land use practices. These include agricultural activities which leave the soil bare during times of heavy rain or strong winds, overgrazing, deforestation, and improper construction activity. Improved management can limit erosion. Soil conservation techniques which are employed include changes of land use (such as replacing erosion-prone crops with grass or other soil-binding plants), changes to the timing or type of agricultural operations, terrace building, use of erosion-suppressing cover materials (including cover crops and other plants), limiting disturbance during construction, and avoiding construction during erosion-prone periods. A serious and long-running water erosion problem occurs in China, on the middle reaches of the Yellow River and the upper reaches of the Yangtze River. From the Yellow River, over 1.6 billion tons of sediment flow each year into the ocean. The sediment originates primarily from water erosion (gully erosion) in the Loess Plateau region of northwest China. Soil piping is a particular form of soil erosion that occurs below the soil surface. It causes levee and dam failure, as well as sink hole formation. Turbulent flow removes soil starting at the mouth of the seep flow and the subsoil erosion advances up-gradient (Jones, 1976). The term sand boil is used to describe the appearance of the discharging end of an active soil pipe (Dooley, 2006).

2.4.4 Salinization

Salinization is the accumulation of free salts to such an extent that it leads to degradation of the agricultural value of soils and vegetation. Consequences include corrosion damage, reduced plant growth, erosion due to loss of plant cover and soil structure, and water quality problems due to sedimentation. Salinization occurs due to a combination of natural and human-caused processes. Arid conditions favour salt accumulation. This is especially apparent when soil parent material is saline. Irrigation of arid lands is especially problematic (ILRI, 1989). All irrigation water has some level of salinity. Irrigation, especially when it involves leakage from canals and over irrigation in the field, often raises the underlying water table. Rapid salinization occurs when the land surface is within the capillary fringe of saline groundwater. Soil salinity control involves water table control and flushing with higher levels of applied water in combination with tile drainage or another form of subsurface drainage (Drainage Manual, 1993).

2.4.5 Soil classification

Soil is classified into categories in order to understand relationships between different soils and to determine the usefulness of a soil for a particular use, one .of the first classification system (1880). It was modified a number of times by American and European researchers, and' developed into the system commonly used since late sixties (USDA Soil Taxonomy 1999). It was based on the idea that soils have a particular morphology based on the materials and factors that form them. In the 1960s, a different classification system began to emerge, that focused on soil morphology instead of parental materials and soil-forming factors. Since then it has undergone further modifications. The World Reference

Base for Soil Resources (WRB) aims to establish an international reference base for soil classification, (Working Group WRB, 2007).

2.5 Soil Requirement for some Crops

2.5.1Groundnut

Groundnut is grown in a well-drained sandy loam, or sandy clay loam soil. Deep well- drained s oils with a pH of 6. 5 - 7. 0 and high fertility, are ideal for groundnut. Runner and Spanish types are better suited to heavy textured soils than the Virginia types. The loss of pods is usually high in heavier soils. An optimum soil temperature for good germination of groundnut is 30°C. Low temperature at sowing delays germination and increases seed and seedling diseases. (ICRISAT, 1995).

2.5.2 Millet

Millet can be grown in a wide range of soils, but prefers well drained sands or sandy loams. It is better suited to lighter soils, while sorghum occupies heavier and clay soils. In some parts of India, pearl millet is grown in shallow mixed black, red, and lighter colored upland gravelly soils of the Deccan. The crop is less tolerant to water logging and flooding than sorghum. Though grown in poor soils, it often responds well to improved management practices and fertilizer dressings, (Var and Scott, 2010).

CHAPTER THREE

MATEREALS AND METHODS

3.1 Materials

3.1.1The Farm Area and Extent

Malam elwedian El-Fasher area covered about 2.1kilometer and it's located between latitude 1316' degrees north and between longitudes 085'degrees east, in North Darfur State, east of El-Fasher city. The main road which connects El-Fasher city to kutum locality runs beside El-Fasher. The study area of the malam elwedian east of El-Fasher city (Figure 3.1)

Figure 3. 1: The study area of the malam elwedian east of El-Fasher city.

3.1.2 Site Information

The dominant climate of the study area Arid type, the summer season starts from middle February and continuous up to June, winter commences from middle of December and continuous up to the second week of February ,the monsoon starts from end of May and continuous up to October .Maximum temperatures of the hottest month (April or May) are 40 –42 C and mean minimum of the coldest month (January) is 8 - 13 C, the average annual rainfall, ranging from 225-400mm, is less than 50 % of the annual potential evapotranspiration in all months, but at least in one month the rainfall is more than 20 percent of the evapotranspiration. The main types of vegetation: in the study area: the Qoz vegetation, Basement vegetation, the Water resources were Surface water and Underground water, Major land use types are Traditional farming (rain fed),Traditional animal breeding.

3.1.3 Field Equipment and tools

- Auger (bucket).
- GPS (Global Positioning System).
- Digital camera.
- Description sheets, clip boards and markers.
- Water bottle.

3.2 Methods

3.2.1 Maps and satellite images

Image to Aid field Operation, Google Earth is used as the mapping base in the soil survey area A soil survey is a study of the geography of soil map detail geographic information. Aerial photographs, topographic maps, and other maps are useful refrains whether or not they are used as the mapping base.

3.2.2 Field Survey

The area site is surveyed in June 2018 using detailed soil survey with Grid method; this method involved taking of representative soil samples.

Augers and open pits were dug to examine the soil morphological characteristics.

4.2.3 Soil sampling

Methods Soil samples were taken by two methods which involve either auguring method at the different site in the field. (FAO *et al*, 2001).

3.2.4 Auger observation

The auger turning and pushing down on the hand bar. The auger boring methods is a way to obtain soil sampling from afferent depths (0-30, 30-60 and 60-90cm) by drilling (auger), without having to dig a pit. The Auger observation data includes auger number, GPS Coordinates, Landform, topography, slope, surface features, termitaria, trees, shrubs, land use, Water table, Soil drainage class, Samples, Soil type, Depth of cracking. Soil code, Soil horizon (for each: boundary, color and code, mottles, texture coarse fragments, reaction to dilute hydrochloric acid calcium carbonate, Iron-manganese, gypsum, and other features).

3.3 Physical analysis

3.3.1 Mechanical analyses

Soil particle size was determined using the hydrometer method (Day, 1965). Depending on the degree of accuracy of separation required, and the particle sizes of interest, the hydrometer method is well adapted for fast determinations of general categories of sizes present and is used in our analyses.

3.3.2 Suspension

Suspension (SP) is calculated by dividing the total amount of water added (ml) by weight of the soil (g) used and _multiplying by 100.Soil, as determined on a separate sample, is taken into consideration by adding it to the amount of water used in preparing the suspension.

3.4 Chemical analyses

3.4.1 Soil pH

Is a measure of the activity of ionized H in the soil solution, the pH of a solution is defined as the negative logarithm to the base 10 of the, H ion activity. Soil pH can be measured using a pH meter or by adding a dye to the soil and observing a color change that can be compared with a chart for pH determination. (Michael, 2009).

3.4.2 Electrical Conductivity (EC)

(Richarcls,1954). reported that Soil EC is measured by EC meter.

3.4.3 Organic Carbon

Total carbon was determined by dry combustion in a medium-temperature resistance furnace (Nelson and Sommers, 1982). Organic carbon was calculated as the difference of total carbon and inorganic carbon as quantified in the $CaCO_3$ equivalent analyses.

3.4.4 Determination of Nitrogen Kjeidahl

The Kjeldahl method of nitrogen determination involves digestion and distillation. The soil digested in concentrated (H_2SO_4) with catalyst mixture to rise the boiling temperature and to promote the conversion from organic-N to ammonium-N. Ammonium-N from the digest in obtained by steam distillation, using excess NaOH to raise the PH. The distillate is collected in saturated (H_2BO_3) and then titrated with dilute (H_2SO_4) to PH 5.0 (Bremner and Mulvaney,1982).

3.4.5 Cation Exchange Capacity (CEC).

Is a measure of the quantity of readily exchangeable cations neutralizing negative charge in the soil, Ammonium acetate (pH 7.0) has been employed widely for determining soil, (Chapman, 1965).

3.4.6 Available Phosphorus (Olson)

Determined by sodium bicarbonate extract using spectrophotometer (Olsen. *et al,* 1954).

3.4.7 Soluble cations and anions

Calcium and magnesium by titration with ethylene di amine tetra acetic acid (Bray, 1951). Sodium and potassium determine by flame photometer model C410; Bicarbonate by titration with hydrochloric acid (Reitemeier, 1943), Chloride by titration with silver nitrate method (Reitemeier, 1943).

3.4.8 Exchangeable Sodium Percentage, (ESP)

Exchangeable sodium percentage (ESP) is used in the classification of saline and alkali soils or to determine if a sodium hazard exists, this method requires the determination of CEC and exchangeable sodium.

ESP = (Exchangeable Na X 100/CEC)

3.4.9 Sodium Adsorption Ration (SAR)

Sodium adsorption ratio (SAR) is used to estimate or predict ESP by analyzing for soluble Na, Ca, and Mg in soil extract, the soluble and exchangeable cations

$$SAR = \frac{Na/\sqrt{Ca+Mg}}{2}$$

Na: concentrations are in meq/liter.

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.1 Morphological Soil

4.1.1 Surface Soil

Topography flat; site flat land form plain, and Gently undulating (auger), Land use (cultivation, research program, Fallow), Drainage class well; Parent material The Aeolian Deposits, absence of cracks, the results of surface description auger are tabulated in appendix 1.

4.2 Physical Properties

4.2.1 Texture

The result of mechanical analysis of auger samples is tabulated in (table 1). The coarse fraction (2mm) which is formed mainly of sediment .silt +clay and sand content ranged between the extreme values. 75% (auger 1 = 0 - 90) in sandy soil, and 56% (auger 2 = 0 – 90) in clay soil The general trend for silt 12% in sandy soil and 16.6 in clay soil. No regularity in this trend is found in all augers, and no consistent relation between layers. The texture in certain auger constant with depth whilst an increase in (silt + clay and sand) content with depth is observed in some depth. Sand ranged between the extreme values of 78% (auger 1) and 66% (auger 2), and decrease with depth in some auger. The main textural class in the all farm augers are loamy sand result in (table 1),.

4.2.2 Color

The color is one of the Maine soil properties which recognizing soil horizon her use soil Munsel color book to determine the wet color of soil by comparing the soil to individual color chaps. Color ranging from yellowish brownm, orgreash brown to dark yellowish brown or red grech brown in topsoil. The color of the subsoil is either yellowish brown, to grayish brown, this reflect to the higher percentage of sand, and the lowest range of organic matter, result in(table 1).

5.2.3 Structure

The structure is very weekly topsoil week developed single grien, and subsoil ranged from medium developed single green to medium developed massive .but there are some correlation between structure and texture, result in (table 1).

Table 4. 1: Soil physical Properties

Auger No	**Soil depth**	**Structure**	**Color**	**Texture**		
				Silt	**sand**	**Clay**
Sand 1	0-30	Single grain	3/2 10YR	8	78	14
2	30- 60	Single grain	3/310YR	10	72	18
3	60-90	Single grain	3/310YR	8	76	16
Clay 1	0- 30	Single grain	3/2 10YR	18	34	48
2	30- 60	Single grain	3/3 10YR	18	26	56
3	30- 90	Single grain	3/3 10YR	14	20	66

4.3 Chemical Properties

4.3.1 Soil pH

The pH determination ware made on samples. The reaction of the soil is alkaline, ranged from 7.2 - 8.0 in sand soil to 7.5 - 7.9 in clay soil. Variation throughout the auger is quite significant and PH tends to rise with depth, result in (table 2).

4.3.2 Suspension

The suspension obtained from the samples were analyzed for the estimation of salinity and determination of soluble salts composition. The results of analysis are shown in (table 2).

4.3.3 Salinity

This property was determined in the entire disturbed pit and auger sample, being measured as the electrical connectivity of the suspension in ds/m. at 25-Centigrade degree. Percent salt is calculated from the electrical conductivity. In the most of the auger percent salt concentration similar. There appear thus to be define leaching process by rainfall. The electrical conductivity of the suspension ranged between 0.2 - 0.3ds/m in sand soil sample and to 0.6 - 0.1ds/m. for clay soil. According to the approximate limit of salinity classes, the soils of the area are belonging to class 0. The general pattern is non-saline or free soil.

4.3.4 Composition of Soluble Salts

The analyses were made to determine the ionic composition and concentration of soluble salt in the suspension each showed a range of values as could be seen from (table 2). Only four cations and two anions are investigated. Among the anions, determined chloride and bicarbonate are equally important**.**

4.3.5 Cation Exchange Capacity (CEC)

Cation exchange capacity was determined and the result are shown appendix i. values of cation exchange capacity(CEC) ranged from 15 -20 cmol (+) kg-1 in sand soil and to 47 – 62.9 cmol(+) kg-1in clay soil.

4.3.6 Soluble Sodium

The results as tabulated in (table 2) indicate the range is low between 2.2 – 3.9 for sand soil and to 0.2 – 6.16 for clay soil.

4.3.7 Exchangeable Sodium

Exchangeable sodium was determined due to the influence of this property of the permeability of soil to water and hence on soil fertility. The result expressed in (table 2), show general tendency for exchangeable sodium to increase markedly with depth. The values are relatively ranging from 0.4 to 0.8 cmol(+) kg-1 for sand soil and 0.4 for clay soil.

4.3.8 Exchangeable Sodium Percentage (ESP)

This property was determined for estimation of the alkali status of the soil. The results are shown in (table 2), they show a remarkable increase with depth. The Exchangeable Sodium Percentage (ESP) ranging from 3 – 20 in sand soil and 0.6 – 0.9 clay soil. According to the standards of the US soil survey manual, the farm area is non-sodic soil.

4.3.9 Sodium Adsorption Ratio (SAR)

This property has been determined for all samples. The results are shown in (table 2), thy show a positive correlation with exchangeable sodium percentage values, the highest sodium adsorption ratios are obtained in soil sample at auger 2.

4.3.10 Exchangeable Potassium

The results for exchangeable potassium are tabulated in (appendix 1), the values are relatively high rating from 1.3 – 1.5 cmol (+) kg-1 soil In sand soil and 1.2 – 1.6 in clay soil, Exchangeable potassium due to the influence of property on the permeability of soil to water and hence on soil fertility. Potassium (K) effects often similar to sodium (Na) depended soil type spatially texture.

4.3.11 Calcium Carbonate

The result for calcium carbonate in the soil of malam elwidian has non content.

Table 4. 2: Soil Chemical analysis of Soil

Soil property		**Depth cm 0- 30**	
		Sand soil	**Clay soil**
Sand-clay%	Average	75%	56%
pH suspension	Average	7.9	8
CEC 100g/L	Average	15.4	47.5
Na meq/L	Average	2.2	6.16
Ca+Mg meq/L	Average	5	3
Total N %	Average	0.001	0.002
O.C %	Average	0.010	0.015
C:N%	Average	10	8
$CaCO_3$ %	Average	0	0
Available P ppm	Average	0.01	0.02
EC. dS/m	Average	0.171	0.660
ESP %	Average	3	1
Na exch. meq/L	Average	0.44	0.44

4.3.12 Fertility Status

Rating of fertility status that shown in (table .3) are Organic carbon, Nitrogen, Phosphorus, has been analyses in the top soil, and Potassium, pH, Cation Exchangeable

Capacity (CEC), and Base saturation percentage In all horizon which were taken Rating 1 Adequate is pH, Rating 2 low are potassium, CEC, Organic matter, and Base saturation percentage, and Rating 3 is Deficient of Organic carbon, phosphorus, and nitrogen. The fertility status is classified in order suitable, class tow with subclass limitation of fertility and unit of minor management which expressed $S2_f$.

Table 4. 3: Fertility rating

Soil parameter	**Range**	**Degree**
pH suspension	7.7 -7.8	Adequate
O.C%	0.01	Low
O.M%	0.00	Low
N%	0.01	Low
Available P ppm	1	Low
CEC cmole9+)kg-1	15.4	Low
k cmole (+)kg-1	1.13	Low

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

1. The soil chemical analyses reflect minor differences in the soils of the area and this is due to the inherent properties from the parent materials (quartzitic mineralogy). Their low cation exchange capacity has affected their chemical properties particularly under the present arid conditions.
2. The soil texture properties and related characteristics were found to have some variations particularly in relation to particle size classes. Clay slightly loamy sand.
3. The area land was classified as moderately and marginally suitable with fertility and topography limitations. The fertility limitation was due to clay and sandy nature of most of the soils, but topography limitation is confine to the undulating parts of the area.

5.2 Recommendations

1. Additional of organic matter which leads to building and minting health soils which will have great positive influence on plant.
2. Applying a good system of irrigation method with good quality water in appropriate time to avoid soil filtration.
3. Conducting experiments crops suitable for the climate and soil of El Fasher, Malam Elwedian area.
4. Use crop ration to protect the soil.
5. Experiments and research recommendations on the soil of Malam Elwedian, El Fasher applied in soils similar to area rations such as

fallow and ridding should be practiced to allow the soil nutrient replenishment, these measures are very important to avoid soil degradation and nutrient loss.

References

Alfred Sefferud. (1957). Yearbook of agriculture. The United States Department of Agrecultur, pp.32-33.

Bardy N. C .(1974). The Nature and Properties of soil 8th edition. Macmillan publishing Co. INC. New York.

Bower. (1952). Exchangeable cation Analysis of saline and alkali soils.

Bray C.A.(1951) .The chemical amendments for improving sodium soils. Agric Info Bull NO195 .USDA, Washington DC.

Bremner, J. M, and C.S.Mulvaney. (1982). Nitrogen total. p.595 – 624. In A.L.Page(ed), Methods of soil analysis. Agron. No. 9,Part 2:Chemical and microbiologica properties, USA.

Chapman, H. D. (1965). Cation-exchange capacity No. 9, Methods of Soil Analysis, Part 2, Black, C. A. ed, pp.891[901.

Copley and Jon .(August 25,2005). "Millions of bacterial species revealed underfoot". New Scientist.

Dan .(2000). Ecology and management of forest soil, New York: John Wily, pp.88- 92, 04711942363, http//book.google.coml/?id =SAbMIJ O8Dmc&pg=PA91&dq- soil+and+solution.

9.David.(1982). Essentials of Soil Mechanics and Foundations Pedophere.com

Donahue, Roy Luther; Miller, Raymond W. Shickluna, John C. (1977). Soils: An Introduction to Soils and Plant Growth. Prentice-Hall.

Dooley, Alan .(June 2006). Sandboils 101: Corps has experience dealing with common flood danger". Engineer Update. US Army Corps of Engineers. Archived from the original on 18 April 2008. Retrieved 14 May 2008.

Foth, Henry D. (1984). Fundamentals of soil science. New York: Wiley. p. 151.

Gove Hambidge,"Climate and Man_A Summary", in Erwin Raisz, U.S. Department of Agriculture, Climate and Man, Part One Yearbook of Agriculture (1941), Repr.Honolulu:University Press of the Pacific, 2004, ISBN 978-1-4102-1538-3. Pp.1_66, p.27.

ICRISAT.(1995). Groundnuts Production Practices, Training and Fellowships Program. Patancheru 502 324, Andhra Pradesh, India

ILRI .(1989). Effectiveness and Social/Environmental Impacts of Irrigation Projects: a Review. In: Annual Report 1988 of the International Institute for Land Reclamation and Improvement (ILRI). Wageningen, the Netherlands. pp. 18–34.

Johnson, T.A., T.R. Ellsworth, R.J.M. Hudson, and G.K. Sims. (2013). Diffusion Limitation for Atrazine Biodegradation in Soil. Advances in Microbiology.

Jones, J. A. A. (1976). "Soil piping and stream channel initiation". Water Resources Research 7 (3): 602–610. US.

Michael E. Ritter, Factors Affecting soil Development, Soil System, The Physical Environment: an Introduction to Physical Geography. University of Wisconsin, Steven Point. (October 1, 2009), retieved January 3, 2012.

Milford, H. B., McGaw, A. J. E. & K, J.Nixon, Soil Data Entry Handbook for the NSW Soil and Land Information system (SALIS),3rd e New South Wales Department of land and water Conservation Resource Information System Group, Parramatta, (2001). pp.30-32.

Milford. H. B, A. J. E. McGaw and K. J. Nixon, (2001). Soil Data Entry Handbook for the NSW Soil and Land Information System(SALIS), 3rd ed. New Sowth Welth Department of land and water conservation Resource Systems Grop.

Morgan, R. P. C. (1979).Topic in applied geography – soil erosion, Longman group Inc, New York. USA.

Nelson, D. W. and L. E. Sommers. (1982). Total carbon, organic

Nyle C. Brady & Ray R. Weil .(2009). Elements of the Nature and Properties of Soils (3rd Edition). Prentice Hall.

Olson S. R. C. V. Cole, F. S. Atonable and L.A Dean. (1954). Estimation of available phosphorus in soil by extraction with sodum bicabonate. U S D A. Circ.no.939.pp 19.

Reitemeier, RF (1943) Semimicro Analysis of saline soil solution.

Richards L. A (Ed). (1954). Diagnosis and improvement of saline and alkali soil. Handbook No.60. USDA, Washington, D. C.

Richards L. A. (1954). Diagnosis and improvement of saline and alkali soils. Handbook NO 60. USDA, Washinton, D.C.

Soil Structure - Physical Properties. The Cooperative Soil Survey. Retrieved (19 October 2012).

Soil Survey Division Staff .(1993). "Soil Structure". Handbook 18. Soil survey manual. Soil Conservation Service.

Soil Survey Staff. (1993). Soil Survey Manual. Soil Conservation Service U.S. Department of Agriculture Handbook 18. U.S. Govt. Printing Office, Washington, D.C. 871.

The Color of Soil". United States Department of Agriculture - Natural Resources Conservation Service. Archived from the original on (16 March

Vara, P.V. Prasad & Scott. A. Staggenborg, (2010). Growth and Production of Sorghum and Millet. Department of Agronomy, Kansas University.

APPENDICES

Appendix 1: Auger descriptions And Laboratory data (auger)

Information on the site:

auger No.: 01sandy,02clay

Classification: Typic Quartzipsamments, loamy sand, isohyperthermic

Date of examination: June 2018

Authors of description Rowida Eissa

Location : N 1316(clay soil)

N 1315(sandy soil)

El-Fasher Malam Elwedian North Darfur.

Landform: Physiographic position: flat site

Landform of surrounding country: Plain

Vegetation : scattered Accacia

Land use: cultivation Sesame

Climate: Arid.

General information on the soils:

Parent material: aeolian sand deposits

Permeability of subsoil: well drainage

Moisture conditions in the soil: dry almost

Presence of surface stones: Nil

Evidence of erosion: Nil

Human influence cultivation (Traditional Rain fed)

Appendix 2: Sampling area in malam elweidian north Darfur.