بسم الله الرحمن الرحيم

Sudan University of Science and Technology
College of Postgraduate Studies

Study of Some Soil Physical Properties at a Farming Area West Omdurman –Khartoum state

دراسة بعض خواص التربة الفيزيائية بمنطقه زراعية غرب أم درمان– ولاية الخرطوم

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آية من القران الحكيم

قال تعالى:

﴿نَسُوقُ الْمَاءَ إِلَى الأَرْضِ الْجُرُزِ فَنُخْرِجُ بِهِ زَرْعًا تَأْكُلُ مِنْهُ أَنْعَامُهُمْ
وَأَنْفُسُهُمْ أَفَلَا يُبْصِرُونَ﴾ (27)

صدق الله العظيم
سورة السجدة الآية(27)

DEDICATION

This research is dedicated to my parents (mother, father, brothers and Sisters. and all the team soil survey). To my entire honorable teacher especially those who taught me in Soil and Water Sciences Department and in particular Dr. El abbes DOKA MOHMMED ALI who supervised the completion of this research.

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Firstly, I would to thank Dr. El Abbes DOKA MOHMMED who supervised this research project and offered all his experience and efforts to complete this study. Also my thanks go to the family of the environment

Many thanks are also extended to all the people who gave me advice in this study. Finally my appreciation and deep thanks go to all my fellow graduate students, friends, and family especially my parents, who without their support I could not have achieved the results of this research project.

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Abstract

This Farm is located west of Omdurman close to the highway Dongola Omdurman at bench mark - 43 km the farm was developed to use modern farming techniques to grow vegetables and fruits. It occupies an area of 140 feddans (58.8 ha).The study area is almost a flat plain, 0—1% slope, the surface is covered by common gravel and sand sheet on the surface(20--35%), and very few short annual grass. The soils of the scheme area were grouped according to their geomorphic units, parent material, and mode of formation, surface features, vegetation and topography.

The Objective of the research was to study some physical soil properties that affect soil moisture conditions and plant, and indicate which is the best irrigation system for the study area soils based on the soil physical properties. The Research problem there is a large amount of gravel and coarse sand in the soil surface and deep in the soil that affect the soil moisture characteristics and irrigation practices. Four profile were dug out to test how free even include all the styles in the farm , and the study found that the percentage of gravel in the first profile (Pt. 1) 25% in the surface and in the depth of 40 cm 15 % and in the depth of 120cm 10% and the textures of sand clay loam. In the second profile (Pt. 2) the proportion of gravel is 10% at the surface and in the depth of 30 cm 10 % and in the depth of 120 cm 15 % and the texture is sand clay loam. In the third profile (Pt. 3) at a depth of 35 cm the gravel was 10% at a depth of 100 cm was 10 %. In the fourth profile (pt4) the gravels percent at depth of 100cm was 15%. The results of infiltration rate tests and permeability for four sites .indicated that the first site has a moderate infiltration rate (2.0 cm/hr.) and a medium permeability in a depth of 50 cm (1.2 cm/ hr). at the second site the infiltration rate was relatively high (3.0 cm/hr.) and a moderate permeability in a depth of 50 cm (1.4 cm/hr.). In the third site infiltration rate was high (2.8 cm / hr). And a low permeability in the depth of 50 cm (1.0 cm /hr.) in while the fourth site was gave a very high dropout rate (3.5 cm/hr.) and very low permeability in the depth of 50cm (0.9 cm/hr.).

According to the results it could be concluded that the different proportions of gravel affect soil physical properties as it affect the movement of water within the soil and as well the other soil physical properties. Accordingly, choosing of the appropriate irrigation system should consider these properties and not only this, but relevant crop management practices should as well be based on soil physical properties.

مستلخص البحث

أجريت هذه الدراسة في مزرعة تقع غرب ام درمان على الطريق السريع أم درمان- دنقلا عند (الكيلو 43) بمساحة 140 فدان, (58.8 هكتار)، تم تطوير المزرعة لاستخدام التقنيات الزراعية الحديثة لزراعة الخضروات والفواكه. منطقة الدراسة سهل منبسط يتراوح الانحدار بين ، 0-1 ٪يغطى سطح التربة الحصى و الرمال يتراوح ما بين(20 - 35 ٪) ، توجد نسبة قليله من الإعشاب قصيرة ,تكونت تربة المنطقة وفقا للتكوينات الجيومورفولوجية ، للمادة الأصل ، وطريقة تشكيل ، السمات السطحية ، والغطاء النباتي والتضاريس.الهدف الاساسى من البحث دراسة خواص التربة الفيزيائية التي تؤثر على ظروف رطوبة التربة و النبات، واختيار أفضل نظام ري لتربة منطقة الدراسة بناء على الخواص الفيزيائية للتربة .مشكلة البحث وجود كمية كبيرة من الحصى الخشن الرمال في سطح التربة وفى أعماق مختلفة في التربة التي تؤثر على خصائص رطوبة التربة و ممارسات الري .لإجراء الدراسة تم حفر أربعة قطاعات حتى تشمل كل الأنماط الموجودة في المزرعة. من نتائج الدراسة وجد أن نسبة الحصى في القطاع الأول (pt 1) 25% في السطح وفى عمق 40سم 15% وفى عمق 120سم , 10% , والقوام (sand clay loam) طمي طيني رملي, وفى القطاع الثاني (pt 2)نسبة الحصى 10% في السطح وفى عمق 30سم 10% وفى عمق 120سم 15% والقوام(sand clay loam) طمي طيني رملي) , وإما فئ القطاع الثالث(pt 3) في عمق 35سم كانت نسبه الحصى 10% وفى عمق 100سم 10% وفى القطاع الرابع(pt 4) في عمق 100سم 15% .

إما نتائج اختبار معدل التسرب (infiltration rate) في المواقع الاربعه و التي تم بعمقين مختلفين (في السطح وعمق 50 سم) , حيث كانت نسبه التسرب في الموقع الأول عالية في السطح (20 mm/hr) و متوسطة في عمق 50سم 12 mm/hr, وفى الموقع الثاني كانت نسبة التسرب في السطح عالية (30 mm/hr) و متوسطة في عمق 50سم14mm/hr، وأما الموقع الثالث أعطي نسبة تسرب متوسطة في السطح ,28 mm/hr ومنخفضة في عمق 50سم 20 mm/hr , في حين أن الموقع الرابع أعطي نسبة عالية جداً في السطح (35 mm/hr) ومنخفضة في عمق 50سم9mm/h ,

نلخص نتائج هذه الدراسة إلى أن نسبة مختلفة من الحصى تؤثر على الخواص الفيزيائية للتربة لأنها تؤثر على حركة المياه داخل التربة والخصائص الفيزيائية الأخرى. ووفقا لذلك ، ينبغي اختيار نظام ري يناسب هذه الخصائص الفيزيائية ، وليس هذا فقط ولكن يجب أن تتوافق الإدارة الحقلية للمحاصيل مع الخواص الفيزيائية للتربة .

CHAPTER ONE

INTRODUCTION

1.1 INTRODUCTION

The main challenge in future is that 83 percent of global population (8.5 billion by the year 2025) will be living in developing countries. Accordingly, agriculture has to meet this challenge mainly by increasing production on land already in use and by avoiding further encroachment on land that is only marginally suitable cultivation (FOA 2002).Since 1950, nearly 500 million hectares of land were subjected to soil erosion, 65 percent of which is agricultural land during 1980 – 1995 Africa lost 49 million hectares of forest (FOA 2002).Sudan economy depends largely on agriculture most developing countries. About70 percent of the economically active population of the country works in agriculture, 90 percent of them live in rural areas. Therefore we it could safely be stated that rural communities need agricultural development. So the priority must be on maintaining and improving the capacity of the higher potential agricultural lands to support an expanding population.

To achieve sustainable development objectives, the integration of economic, environment, institutional and social components are required. These objectives cannot be carried out without greater integration at all policy making and operational level i.e. local communities and NGOs. Many efforts have been done by the government of the Sudan to integrate environmental, economic and social objectives into decision making by elaborating new policies and strategies for sustainable development and adopting existing policies and plans. An environmental impact assessment should be conducted before development projects receive final approval; it is the most important of the requirements. In Sudan, like eve loping countries, population growth has led to an increasing demand of basic needs such as food, employment, and cash income. Furthermore, in Sudan, a large proportion of the population live in rural areas (90 percent out of the total population) making them subject to rapid economic development such as logging and agricultural development. There are positive impacts of any rural development, but also there are negative impacts such as deforestation, soil erosion, and flooding. Agriculture plays a great role on different aspects of our lives. It provides the foundation through which people survive through the provision of food to both humans and their animals. Without agriculture, chances of survival would be minimal as both people and livestock would die out of starvation. As a result of this, agriculture has gained interest among many people, ordinary, policymakers and even researchers due to its important contribution to humanity.

Soil covers the vast majority of the exposed portion of the earth in a thin layer. It supplies air, water, nutrients, and mechanical support for the roots of growing plants. The productivity of a given soil is largely dependent on its ability to supply a balance of these factors to the plan community. Soil is a natural body consisting of layers (soil horizons) of primarily mineral constituents, which differ from their parent materials in their texture, structure, consistency, color, chemical properties, biological and other physical characteristics.

The study area is a farm situated in a tract of land with its natural features and configuration assumed to be formed by denudation processes which involve erosion and deposition of materials that form the present superficial deposits. The field observations showed that the area is located in the middle of a region which experienced extended series of peneplantion-pediplantation erosion cycles of Nubian sandstone rock formations. At present, the arid condition coupled with persistent wind features of sand deposition characterizes the whole area. The superficial deposits rest on slightly weathered rock fragments at a depth ranging from (120 – 200 cm). These features might indicate that the area represents a trough in which fluvial/colluvial materials were deposited.

1.2 The Reserch problem

There is a large amount of gravel and coarse sand in the soil surface and deep in the soil that affect the soil moisture characteristics and irrigation practices. The determination of the soil physical properties through field and laboratory testsis essential to advice on the suituable irrigation methods according to soil chacteristics so as to ensure suitable crop production and proper land management .

1.3 Objectives

1. To study the physical soil properties that affects soil moisture conditions and plant growth.
2. To predict which is the best irrigation system for the study area soils based on the soil physical properties
3. Due to the lack the information on soil physical properties for the soils of the study area and vicinity, this study will stand as a guide for planning and designing irrigation methods in the area**.**

CHAPTER TWO

ENVAIROMENTAL SETUP

2.1. Locationand Extent

This Farm is located west of Omdurman close to the highway Dongola - Omdurman at bench mark – 43km. The farm was developed to use modern farming techniques to grow vegetables and fruits. It occupies an area of 140 feddans (58.8 ha).

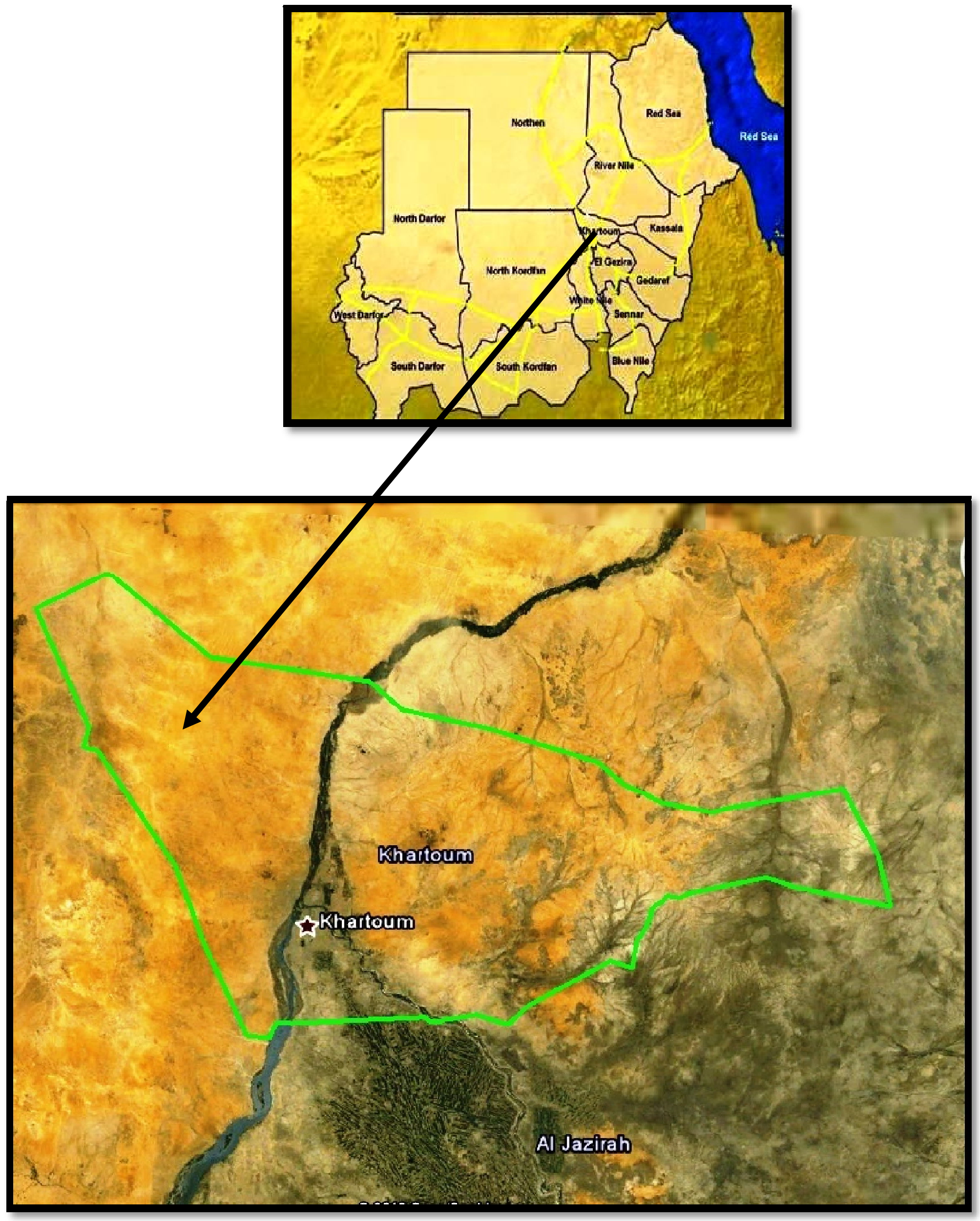


Figure (2, 1): Location map

2.2 Geomorphology

The farm is a tract of land with its natural features and configuration assumed to be formed by denudation processes which involve erosion and deposition of materials that form the present superficial deposits. The area is located in the middle of a region which experienced extended series of peneplatin- pediplain erosion cycles of Nubian sandstone rock formations. At present, the arid condition and persistent wind features of wind erosion characterize the whole area. The superficial deposits rest on slightly weathered rock fragments at a depth ranging from 120 – 200 cm. These features might indicate that the area represents a trough in which fluvial/colluvial materials were deposited.

2.3 Climate

Representative meteorological data represented by Khartoum meteorological station which is the nearest source to the location of the farm (Doka *et al* 2013).The classification of climate by Papadakis which is based on water balance, using monthly rainfall and potential evapotranspiration is adopted by Van der Kevel (1976) for classifying climate zones of Sudan. Van der Kevie made some changes in the criteria that are significant for agriculture. The farm in Papadakos classification falls in the semi –desert climate with summer rains, warm winter. The climate is hot almost throughout the year, except the cooler short winter season (December, January). Mean annual temperature is 29.9 ^{o}C. Average maximum temperature in the hottest months (April – June) ranges from 40^{o}C to 42 ^{o}C, while the minimum temperatures in that period are between 21 ^{o}C and 26 ^{o}C. During winter (December—January) the minimum temperature reaches 13^{o}C.

Relative humidity shows some variations with GMT during the year. At 60 00 GMT it ranges from 30-40% during January to February, decreases to 20-27 in March to June and increases 30-45% from July to December. The average annual rainfall is about 100mm, with most of the rain falling in July -August. The amount is quite variable and distribution is rather erratic and irregular. The combined effect of high temperature, and strong solar radiation caused the potential evapotranspiration to be very high and significantly exceeds the rainfall in months. This means that the soil water available for the plants is deficient and crop production must be base on irrigated farming system according to the requirements of the adapted crops.

The average wind speeds (at 2m) is about 5 M.P.S. and increases to maximum in the hot dry summer (April - June) causing dust storms (Haboob) and erosion hazards. The wind occurs frequently in northerly direction in October through May. By late June the wind move to south westerly direction due to the approach of inter –tropical convergence zone causing

Slight and variable rainfall. As control measure, wind breaks and shelter belts are prerequisites to protect the rangelands, agricultural land and crops.

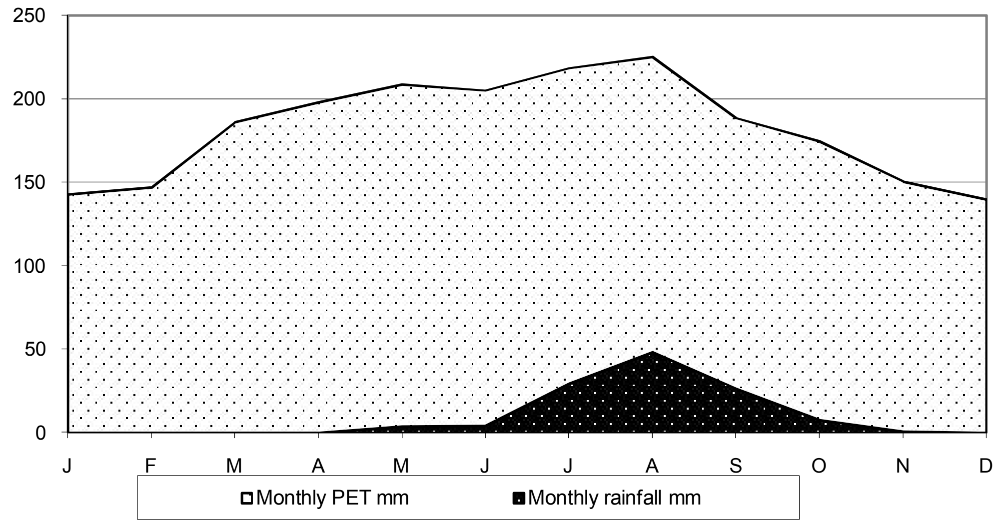


Figure (2.2): Rainfall and potential evapotranspiration for Khartoum town representation south- west Omdurman area and both situated within the semi-desert climate.
(Source: Doka, and Hamid, Amna H. 2013.)

Table (2.1): Khartoum Climatic Data for the Years 1971 to 2000.

(Lat.: 15^{o} 36 N; Long.: 32^{o} 33 E; Alt. 380 m.)

Month	Mean relative Humidity (%)	Total rainfall (mm)	Potential Evapo-transpiration (mm)	Mean wind speed and direction (m/s)	Air temperature		Mean daily temp.(^{o}C)	Bright Sun shine duration (%)
					Mean daily maximum	Mean daily minimum		
January	26	0.0	143	4. 5 -N	30.7	15.6	23.2	86
February	21	0.0	147	4. 9-N	32.6	16.8	24.7	85
March	16	0.1	196	4. 9-N	36.5	20.3	28.4	82
April	15	0.0	198	4 .5 -N	40.4	24.1	32.7	84
May	20	3.9	205	4 -N	41.9	27.3	34.6	74
June	26	4.2	201	4. 5 - SW	41.3	27.6	34.4	68
July	42	29.6	189	4. 9 - SW	38.5	26.2	32.3	63
August	48	48.3	177	4. 5 -SW	37.6	25.6	31.6	66
September	41	26.7	162	4. 0-SW	38.7	26.3	32.5	71
October	29	7.8	167	3. 6 -N	39.3	25.9	32.6	83
November	26	0.7	150	4. 5 -N	35.7	21.0	28.1	91
December	29	0.0	140	4. 5-N	31.7	17.0	24.4	90
Year	28	121.4	2065	4. 5	37.0	22.8	29.9	79

(Source: Doka, and Hamid, Amna H. 2013).

2.4 Geology

The geological map (Whiteman 1971), shows that the Nubian sandstone is the main consisting of conglomerate grits, sandstone, sandy mudstone and mudstones that rest uncomfortable on Basement Complex. The cementing agent is commonly iron or iron carbonates. The Nubian sandstone formations date to cretaceous age. Adam, A.L, et al (1975) stated that the Nubian sandstone formation north east of Khartoum consist of consolidated sedimentary rocks of brown and reddish brown ferruginous sandstones, sandstones with intercalation of mudstone, mudstones and pebble conglomerates.(Adam, A.L, et al (1975)

The superficial deposits occur in the form of the alluvial materials transported and deposited during Quaternary period in mass movements (Adam, et al. 2002).The thickness of the superficial deposits is about 5 feet in deep boring dug in different parts around the area. Windblown sand sheets are manifestation of Aeolian erosion and deposition It is expected that the weathering of the Nubian sandstone results in mixing materials consisting of variable proportions of pebbles, gravels, sand, silt and clay. The Nubian sandstone constitutes the best aquifer in the Sudan (Whitman, 1971). The underground water is expected to be of large quantities and good quality.

2. 5 Human acrtivity and infrastructure

2. 5.1 Vegetation

The desert climate which prevails in this area is reflected in the natural vegetation species, density and distribution. The Study area is generally bare land except sparse, bushes of *Acacia ehrinbergiana* (Salaam) and the flat-topped *Acacia tortillas* (Samar) with under growth of grasses *Aristida spp.*

2.5.2 Land use and agriculture resource

Crop production in the Khartoum State is oriented towards the major kind of land use which is irrigated agriculture. The main land use categories are:

1. Horticulture: Intensive cropping of fruits (citruses, dates, mangoes and guava) and vegetables (tomatoes, potatoes, onions, cucumbers, etc…..)
2. Arable Crops: Mainly winter crops (wheat, beans, peas, chick peas and alfalfa).
3. Grazing: unimproved grazing of natural tree shrubs and grasses by sheep's and goats.

2.5.3 Cropping seasons:

Khartoum area is considered one of potential agricultural areas in Sudan for the production of different Kinds of tropical fruits beside most winter vegetables and field crops. As well, fodders crops are widely grown throughout the year.

There are three cropping seasons in this area:

- **Winter Seasons (Showy) November - February:-**

  The most active season, arable crops include wheat, broad beans, onions and vegetables include tomatoes, eggplant potatoes, carrots, beans.

- **Flood Season (Damera) July - September**:-

  Arable crops include sorghum, maize fodders and summer vegetables.

- **Summer season (Sayfi) March - June:-**

  The arable crops include sorghum, and summer vegetables.

CHAPTER THREE
LITERATURE REVIEW

3.1 Land Use

The main land use in the area that governed the economy is livestock rising. The animals raised are camels, goats and sheep where they grazed the natural vegetation. Traditional agriculture is practiced on a very small scale and done as a secondary activity to animal rising. The settlement pattern found in west Omdurman area reflects the typical spatial distribution of semi-nomadic societies (tribe and tribal branch).Most of the study area was found to be bare rocky or sandy land without any vegetative cover. Patches of shrubs and trees exist along drainage ways where sparse grass cover confined to the sandy area. (Adam 2002).

3.2 Soil Physical characteristics

3.2.1 Soil Texture

Soil texture is the relative proportions of sand, silt, or clay in a soil. The soil textural class is a grouping of soils based upon these relative proportions. Soils with the finest texture are called clay soils, while soils with the coarsest texture are called sands. However, a soil that has a relatively even mixture of sand, silt, and clay and exhibits the properties from each separate is called a loam. There are different types of loam, based upon which soil separate is most abundantly present. If the percentages of clay, silt, and sand in a soil are known (primarily through laboratory analysis), you may use the textural triangle to determine the texture class of your soil. **(**El Tom, (2004).

Soil texture is determined in the field by feeling of moist soil when rubbed between the fingers. Each texture type has characteristic feel. To help classify texture soil scientists have defined the border lines between the various groups of line soil particles. Fine particles include only those particles less than 2mm in diameter. Particles larger than this are known as stones and gravel .soil texture is an important characteristic as it affects the amount of water available to plants, soil aeration, permeability and root penetration. The textural classes of study area in topsoil are mainly loam and silt loam textures dominated by silt and sand. In subsoil textures are mainly silt textures (silt clay, silt clay loam and silt loam) dominated by silt and clay. This is due largely to the sedimentary materials (sandstone) which constitute the main parent material in the area. The soil moisture properties are highly affected by these textures.

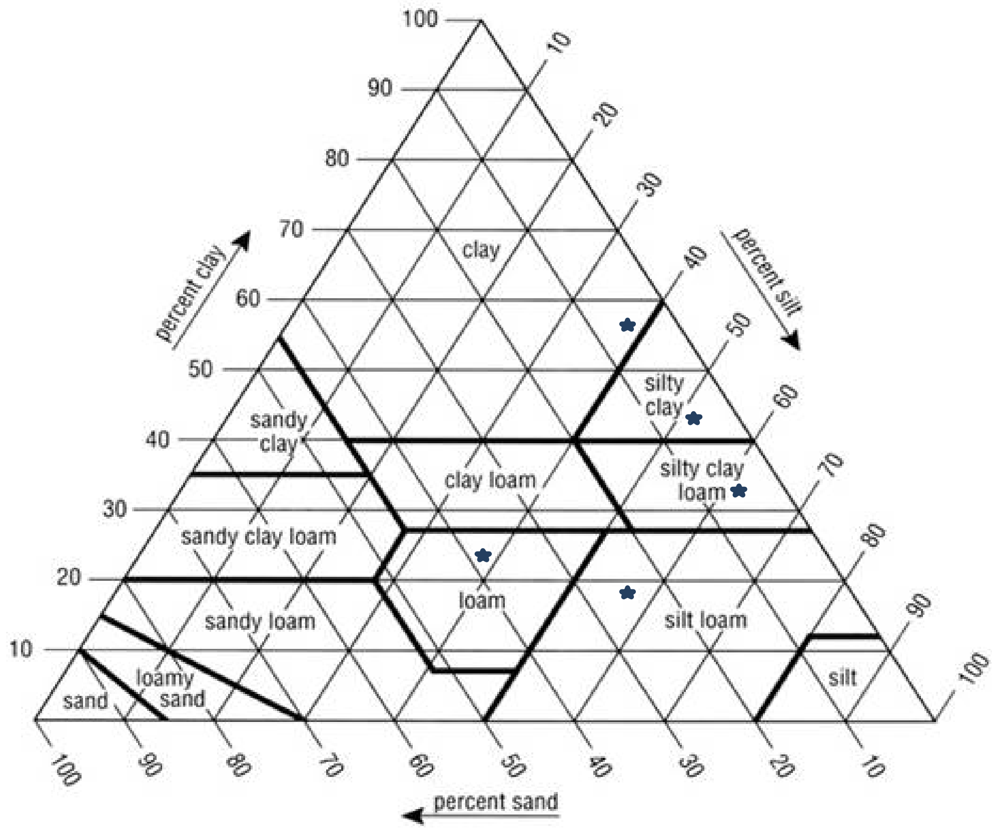


Figure3. 1: Soil Texture Triangle (USDA 2003)

- **Gravels in the soil**

The Soil Survey Division staff (1993) indicated that phases of the smaller rock fragments accommodate most of the detailed phase distinctions that generally can be made accurately by field methods. The term "gravelly" is used in the examples of the names that follow, but the adjectives for each of the other kinds of rock fragments, such as cobble or channery, are substituted as appropriate. Fine gravel on the use of arable soil, for example, is quite different from the effect of 20 percent flagstones; therefore, the phase limits may differ for larger fragments.. For other uses such as forestry, range, or recreation the sizes, shapes, amounts, and mixtures of rock fragments have different significance. Pebbles, cobbles, and stones influence forestry much less than they do cultivation, the following definitions are applicable to arable soils. Although they could affect access and reforestation.

Slightly-gravelly: The surface layer may contain enough pebbles to affect special uses that tolerate few if any rock fragments, but the pebbles do not interfere with the tillage of such field crops as corn. The volume is less than 15 percent. A slightly gravelly phase can be recognized for soils that are used for special purposes, such as growing turf.

Gravelly: The surface layer contains enough pebbles to interfere with tillage of common field crops. Generally, however, tillage is performed in the same manner and with the same equipment as for soils free of fragments. The pebbles are a nuisance. They may cause some equipment breakage, but they cause few major delays in field operations. The effects of the pebbles on the quality of tillage are small or moderate, depending on the kind of operation. The volume of pebbles is 15 to 35 percent.

Very gravelly: The surface layer contains enough pebbles to interfere seriously with the tillage of common field operations. The quality of tillage operations is affected. The kinds of crops that can be grown are restricted, the precision of planting and of fertilizer placement is reduced, and young plants are frequently covered during tillage. The volume of pebbles is 35 to 60 percent.

Extremely gravelly: The surface layer contains so many pebbles that tillage of the common field crops is often impractical, although not necessarily impossible. Tillage implements must force their way through a mass of pebbles that have fine earth between them. The volume of pebbles is more than 60 percent.

- **Importance of Clay and Other Particles of Similar Size**

  Clay particles, as well as other particles of similar size, are important components of a soil. There is a fundamental difference between soils that contain large amounts of sand particles and soils that contain large amounts of very small particles, such as clay. That difference is surface area. The total surface area of a given mass of clay is more than a thousand times the total surface area of sand particles with the same mass. To put this idea into perspective, imagine a single cube with 6 sides. This cube represents a sand particle. Now, imagine that you break this single cube up into 100 smaller cubes, which represent 100 clay particles. These 100 cubes each have 6 sides. Essentially, by breaking up the larger cube, you have exposed many more surfaces. Thus, the total surface area of the smaller cubes will be much greater than the surface area of the single cube. This increase in surface area has an important implication in nutrient management because it provides many places for soil particles to retain and supply nutrients (such as calcium, potassium, magnesium, phosphate) and water for plant uptake (Marshall et al, 1979).

3.2.2 Soil Structure

Soil structure describes the arrangement of the solid parts of the soil and of the pore space located between them .The structure depends on what the soil developed from. The practices that influence soil structure will decline under most forms of cultivation—the associated mechanical mixing of the soil compacts and shears aggregates and fills pore spaces; it also exposes organic matter to a greater rate of decay and oxidation A further consequence of continued cultivation and traffic is the development of compacted, impermeable layers or pans within the profile (Figure3.2) (Young 2001).

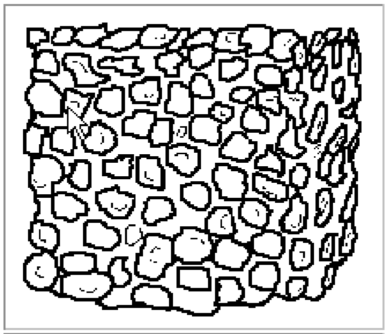
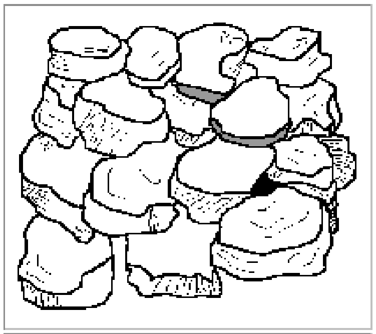
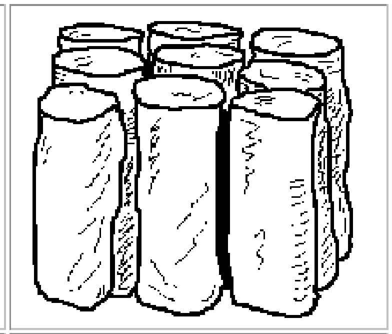
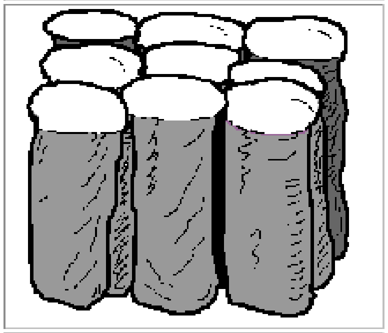
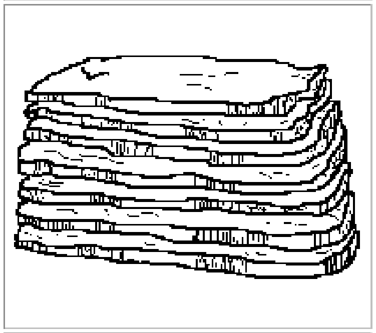
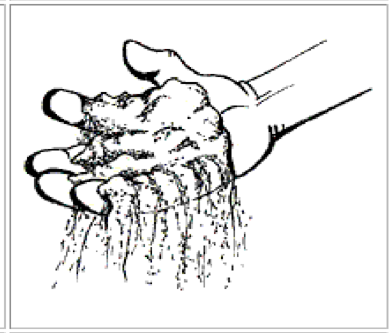
		
Granular: Resembles cookie crumbs and is usually less than 0.5 cm in diameter. Commonly found in surface horizons where roots have been growing.	**Blocky**: Irregular blocks that are usually 1.5 - 5.0 cm in diameter.	**Prismatic**: Vertical columns of soil that might be a number of cm long. Usually found in lower horizons.
		
Columnar: Vertical columns of soil that have a salt "cap" at the top. Found in soils of arid climates.	**Platy**: Thin, flat plates of soil that lie horizontally. Usually found in compacted soil.	**Single Grained**: Soil is broken into individual particles that do not stick together. Always accompanies a loose consistence. Commonly found in sandy soils.

Figure. 3. 2 Types of Soil Structures in Soils (**USDA (2003).**

- **Mechanisms of soil aggregation**

Soil microorganisms excrete substances that act as cementing agents and bind soil particles together. Fungi have filaments, called hyphen, which extend into the soil and tie soil particles together. Roots also excrete sugars into the soil that help bind minerals. Oxides also act as glue and join particles together. This aggregation process is very common to many highly weathered tropical soils and is especially prevalent in Hawaii. Finally, soil particles may naturally be attracted one another through electrostatic forces, much like the attraction between hair and a balloon. **(**Marshall and Holmes, 1979**).**

- **Aggregate Stability**

  Stable soil aggregation is a very valuable property of productive soils. Yet, the stability of soil aggregation is very reliant on the type of minerals present in the soil. Certain clay minerals form very stable aggregates, while other clay minerals form weak aggregates that fall apart very easily. (Young, 2001).

  Highly weathered silicate clays, oxides, and amorphous volcanic materials tend to form the most stable aggregates. The presence of organic matter with these materials improves stable aggregate formation. In nutrient management, the aggregate stability is important because well-aggregated minerals are well drained and quite workable.

  In contrast, less weathered silicate clays, such as montmorillonite, form weak aggregates.

3.2.3 Soil density

Soil density is expressed in two well accepted concepts as particle density and bulk density. In the metric system, particle density can be expressed in terms of mega grams per cubic meter (Mg/m3). Thus if 1 m3 of soil solids weighs 2.6 Mg, the particle density is 2.6 Mg / m3 (since 1 Mg =1 million grams and 1 m3 =1 million cubic centimeters) thus particle density can also be expressed as 2.6 g / cm3\ (Marshall and Holmes 1979).

3.2.3.1 Particle Density:

The weight per unit volume of the solid portion of soil is called particle density. Generally particle density of normal soils is 2.65 grams per cubic centimeter. The particle density is higher if large amount of heavy minerals such as magnetite; limonite and hematite are present in the soil. With increase in organic matter of the soil the particle density decreases. Particle density is also termed as true density (Table 3.2) (Marshall and Holmes 1979).

Table 3.2 Particle density of different soil textural classes

Textural classes	**Particle density (g/ cm3)**
Coarse sand	2.655
Fine sand	2.659
Silt	2.798
Clay	2.837

(Source: Marshall and Holmes 1979).

3.2.3.2 Bulk Density:

The oven dry weight of a unit volume of soil inclusive of pore spaces is called bulk density. The bulk density of a soil is always smaller than its particle density. The bulk density of sandy soil is about 1.6 g/ cm3, whereas that of organic matter is about 0.5. Bulk density normally decreases, as mineral soils become finer in texture. The bulk density varies indirectly with the total pore space present in the soil and gives a good estimate of the porosity of the soil. Bulk density is of greater importance than particle density in understanding the physical behavior of the soil. Generally soils with low bulk densities have favorable physical conditions. (Table 3.3) (Marshall and Holmes 1979).

Table 3.3 Bulk density of different textural classes

Textural class	**Bulk density (g/cc)**	**Pore space (%)**
Sandy soil	1.6	40
Loam	1.4	47
Silt loam	1.3	50
Clay	1.1	58

(Source: Marshall and Holmes 1979).

- **Factors affecting bulk density**

1. **Pore space**: Since bulk density relates to the combined volume of the solids and pore spaces, soils with high proportion of pore space to solids have lower bulk densities than those that are more compact and have less pore space. Consequently, any factor that influences soil pore space will affect bulk density.
2. **Texture**: Fine textured surface soils such as silt loams, clays and clay loams generally have lower bulk densities than sandy soils. This is because the fine textured soils tend to organize in porous grains especially because of adequate organic matter content. This results in high pore space and low bulk density. However, in sandy soils, organic matter content is generally low, the solid particles lie close together and the bulk density is commonly higher than in fine textured soils (Young, 2001).
3. **Organic matter content:** More the organic matter content in soil results in high pore space there by shows lower bulk density of soil and vice-versa.

3.2.4 Soil Infiltration

Infiltration rate is the rate at which water inters the soil under specific conditions the vertical movement of water into a soil usually at the surface .The subsurface movement is usually referred to as permeability,

Evaluation of infiltration Results

A – Slow infiltration ratio:

Which basic infiltration rate one less than about 0.3cm /h.

B- Fast infiltration ratio:

Basic infiltration rates became faster than about 6.5 cm/h .

The infiltration rate is the velocity or speed at which water enters into the soil. It is usually measured by the depth (in mm) of the water layer that can enter the soil in one hour. An infiltration rate of 15 mm/hour means that a water layer of 15 mm on the soil surface will take one hour to infiltrate. In dry soil, water infiltrates rapidly. This is called the initial infiltration rate. As more water replaces the air in the pores, the water from the soil surface infiltrates more slowly and eventually reaches a steady rate. This is called the basic infiltration rate (FAO. 1976).

The infiltration rate depends on soil texture (the size of the soil particles) and soil structure (the arrangement of the soil particles, the most common method to measure the infiltration rate is by a field test using a cylinder or ring infiltrometer. (Figure 3. 3) (Young, 2001)

Table 3.4 basic infiltration rates for various soil types

Soil type	**Basic infiltration rate (mm/hour)**
sand	More than 30
sandy loam	20 – 30
loam	10 – 20
clay loam	5 – 10
clay	1 – 5

(**Source: *Young, 2001***)

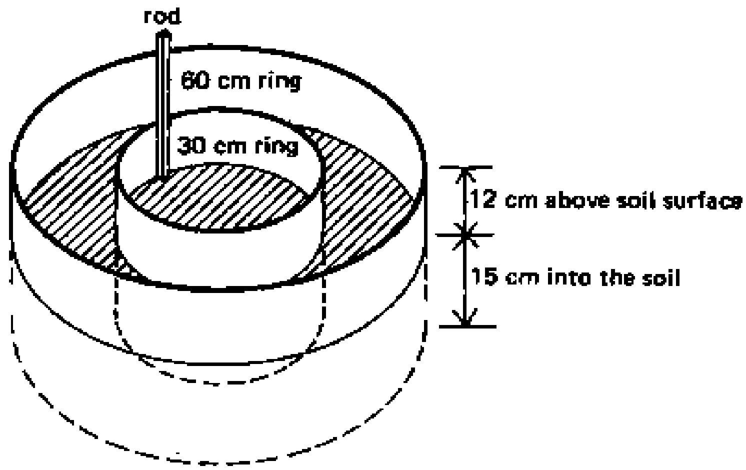


Figure. (3.3) Double ring infiltration rate. (Source: FAO. 1976).

3.2.5 Hydraulic conductivity

Hydraulic conductivity the rate at which a liquid water will flow through a soil mass under Augier hydraulic head.

Table 3.5 Classification Hydraulic conductivity (HC) values

Hydraulic conductivity (HC) cm/hr	Conductivity class
< 0.8	Very slow
0.8 – 2	Slow
2 – 6	Moderate
6 – 8	Moderately rapid
8 – 12.5	Rapid
>12.5	Very rapid

Source FAO (1963)

3.26 Permeability

Permeability is the speed of air and water movement in a soil this is affected by texture and structure**.** The rate at which water moves through the soil) and Water-Holding Capacity (WHC); the ability of a soils micro pores to hold water for plant use) are affected by the amount, size and arrangement of pores Macro pores control a soil's permeability and aeration. Micro pores are responsible for a soil's WHC**.** Porosity is in turn affected by:

Soil texture: The relative proportions of sand, silt, and clay is important in determining the water-holding capacity of soil: Fine-textured soils hold more water than coarse-textured soils but may not be ideal Medium-textured soils (loam family) are most suitable for plant growth. **San**ds are the largest particles and feel gritty **Silt**s are medium-sized and feel soft, silky, or floury **Clay**s are the smallest sized particles and feel sticky and are hard to squeeze. Relative size perspective: Sand (house) > Silt > Clay (penny)

Soil structure: The arrangement of aggregates in a soil. The **Platy**– common with pudding or ponding of soils; **Prismatic** (columnar) – common in sub soils in arid and semi-arid regions; **Blocky** common in sub soils especially in humid regions; **Granular** (crumb) – common in surface soils with high organic matter content (Hillel, D. 1980**.**)

Table (3. 6) Some Soil physical properties as related to soil particle size

	Sand	Silt	Clay
Porosity	mostly large pores	small pores predominate	small pores predominate
Permeability	rapid	low to moderate	slow
Water holding capacity	limited	Medium	very large
Soil particle surface	small	Medium	very large

Soil Compaction destroys the quality of the soil because it restricts rooting depth and decreases pore size. The effects are more water-filled pores less able to absorb water, increasing runoff and erosion, and lower soil temperatures. To reduce compaction: Add organic matter Make fewer trips across area Practice reduced-till or no-till systems Harvest when soils are not wet.

3.2.6 Water Movement in Soils

Water movement in soil takes place in response to a force, or potential. The types of forces that act on water moving through a soil include:

a) positive forces, such as gravity and pressure
b) negative forces, such as suction and osmosis

These forces, in conjunction with the water content of the soil, dictates whether the soil water moves through the soil by “saturated” or “unsaturated” flow.

Saturated flow:

- driving force is positive (gravity or pressure)
- soil water is conducted by all pores
- the rate of flow is greatest through the large connective pores, so saturated flow is higher in sandy soils

Unsaturated flow:

- driving force is suction
- soil water is conducted only by the smaller pores; large connective pores are filled with soil air
- Soil water tends to only occupy the smaller pores, so unsaturated flow tends to be higher in clayey soils (Hillel, D. 1980.)

3.2.6.1 Soil Physical Properties that Control Water Movement

In addition to the above forces, water movement in some soils is controlled by the type of soil structure present within the soil horizons. Water moving downward vertically through a soil profile is transported in the pore space that exists between the structural aggregates, or "peds", that make up a particular soil horizon. The shape and arrangement of the peds dictates the size and continuity of the pores. Typically, angular blocky, sub angular blocky and granular structure creates large pores that allow water to move through the soil. Prismatic and platy structures have long but narrow pores that tend to slow down vertical water movement

Some soils contain a hydraulically restrictive horizon, such as a fragipan or clay layer, that can impede the vertical movement of water down through the soil. Water that is held up by a hydraulically restrictive horizon is called a "perched water table". Soils that do not have a hydraulically restrictive horizon present are considered to have a "regional water table" that extends vertically without interruption. (Buckman, N.G. 1990**.)**

3.2.7 Soil Consistence

Soil consistence refers to the ease with which an individual ped can be crushed by the fingers. Soil consistence, and its description, depends on soil moisture content. Terms commonly used to describe consistence are:

- **Moist soil**:

Loose – non coherent when dry or moist; does not hold together in a mass

Friable – when moist, crushed easily under gentle pressure between thumb and forefinger and can be pressed together into a lump

Firm – when moist crushed under moderate pressure between thumb and forefinger, but resistance is distinctly noticeable

- **Wet soil:**

Plastic – when wet, readily deformed by moderate pressure but can be pressed into a lump; will form a "wire" when rolled between thumb and forefinger

Sticky – when wet, adheres to other material and tends to stretch somewhat and pull apart rather than to pull free from other material

- **Dry Soil:**

Soft – when dry, breaks into powder or individual grains under very slight pressure

Hard – when dry, moderately resistant to pressure; can be broken with difficulty between thumb and forefinger (Brady, N.C. 1990).

CHAPTER FOUR

MATERIALS AND METHODS

4. 1 Materials

1. Maps location
2. GPS(Global Positioning System)
3. Double ring infiltrometer test
4. Auger
5. Sieve
6. Shovel
7. Munsell color
8. Clinometers for measuring of site slop
9. Digital camera.

4. 2Methods:

4.2.1Field methods

Description and characterization of the soils of the study area was needed to identify the different types of soil to enable soil physical investigation for each type of soil being identified in the study area. In this regard the field soil characteristics selected to study the soils are:

- Texture
- PH
- Calcareousness'
- Pores and root distribution
- Depth to weathered sandstone
- Calcium carbonate aggregates
- Soil colour
- Soil structure
- Surface and subsurface gravels
- Wind and water erosion
- Physiographic
- Infertilities Rate

A. **Method infiltration rate**

1 Hammer the 30 cm diameter ring at least 15 cm into the soil. Use the timber to protect the ring from damage during hammering. Keep the side of the ring vertical and drive the measuring rod into the soil so that approximately 12 cm is left above the ground.

2 Hammer the 60 cm ring into the soil or construct an earth bund around the 30 cm ring to the same height as the ring and place the hessian inside the infiltrometer to protect the soil surface when pouring in the water (Figure3.3).

3 Start the test by pouring water into the ring until the depth is approximately 70-100 mm. At the same time, add water to the space between the two rings or the ring and the bund to the same depth. Do this quickly.

The water in the bund or within the two rings is to prevent a lateral spread of water from the infiltrometer.

4 Record the clock time when the test begins and note the water level on the measuring rod.

5 After 1-2 minutes, record the drop in water level in the inner ring on the measuring rod and add water to bring the level back to approximately the original level at the start of the test. Record the water level. Maintain the water level outside the ring similar to that inside.

6 Continue the test until the drop in water level is the same over the same time interval. Take readings frequently (e.g. every 1-2 minutes) at the beginning of the test, but extend the interval between readings as the time goes on (e.g. every 20-30 minutes). (FAO**,** 2000)

B. Pit method

Open test pits are the only means available actually to see and be able to examine a soil profile in its natural state. Open pits were dug and undisturbed samples were taken for laboratory analysis.

C. Auger methods

The auger boring method is a way to obtain soil samples from different depths (0-30, 30-60. 60 –90). The auger boring method is cheap and fast, you can quickly check the soil at several places at your site, but it provides only disturbed samples.

D. Surface features:

A fair correlation was initially established between the surface features and the kinds of existing soil in the farm. This permits limiting the number of auger observations normally required characterizing the soils and drawing soil map unit's boundaries. Morphological descriptions were done following the college standard format for soil profile description and sampled according to genetic horizons for routine analysis (FAO, 2000)

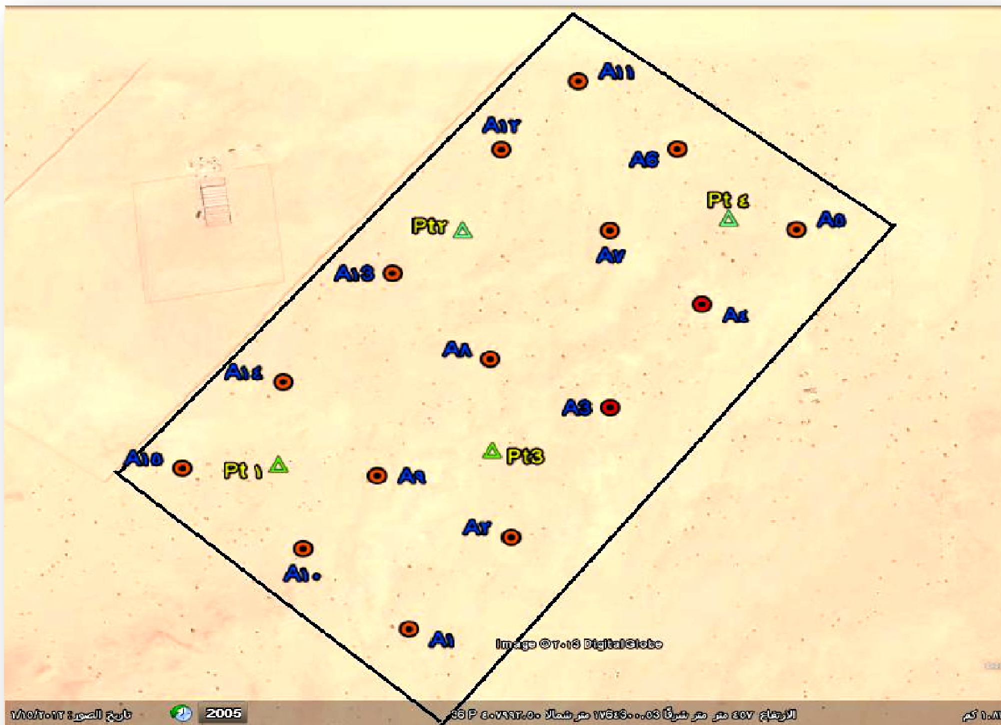


Figure (4. 1) Soil sampling sites map

4 .2 .2 Laboratory methods

For each soil sample collected from the profile pits the following laboratory analysis were made:

- Particle size distribution (sand, silt and clay)
- Soil reaction (pH, paste).
- Electrical conductivity (EC, saturation extract)

4.1.2.1 Soil laboratory analysis:

Following is a summary of analytical methods used in two laboratories to analyze soil samples collected from the study area, these laboratories are:

- Soil laboratory, College of Agricultural Studies – Shambat (SUST)
- Soil laboratory, Faculty of Agriculture – Shambat, (U of K)

Analytical methods used:

- **Soil analysis:**
  All results refer to oven dry soil sieved through 2 m/m sieve.
- **Soil Reaction (pH)** is determined by pH meter in soil saturation extract. A model WTW pH 422 pH meter is used
- **Total soluble salts (E.C.)**
  Saturation paste is prepared by adding soil to a known quantity of distilled water to the saturation point. Saturation extract is sucked off using vacuum. E.C. of saturation extract is read off an E.C. model WTW meter and expressed in dS/cm at 25^0C.

Mechanical analyses:

Results refer to oven dry soil sieved through a 2mm sieve. Fine soil was pretreated with HCl washed and dispersed with calgon. Pipette method was used for silt and clay and wet sieving for coarse sand. The sand fractions are:

Coarse sand 2-0.2 mm

Find sand 0.2 - 0.05 mm

Silt 0.05-0.002

Clay: less than 0.002 mm

Hydraulic conductivity (HC): the constant water head method on disturbed samples for measuring water conductivity in Soil (FAO, 2000).

CHAPTER FIVE

RESULTS AND DISCUSSION

5.1 General properties of the soil

The study area is almost a flat plain, 0—1% slope, the surface is covered by common gravel and sand sheet on the surface(20--35%), and very few short annual grass. The soils of the study area were grouped according to their surface features, parent material and mode of soil formation.

5.2 infiltration rate

The results of infiltration rate tests for four sites at different depth (in the surface and a depth of 50 cm) indicated that the first site has a high infiltration rate (2.0cm/hr) and a medium permeability in a depth of 50 cm 1.2 cm/ hr; at the second site was the infiltration rate was relatively high (2.2 cm/hr) and a moderate permeability in a depth of 50 cm (1.4 cm/hr.)In the third site infiltration rate was high (2.8 cm / hr and a low permeability in the depth of 50 cm (1.0 cm /hr) in while the fourth site was gave a very high dropout rate (3.5 cm/hr) andlowpermeabilityinthedepthof50cm (9 mm/hr) .

Their infiltration rate is moderate (2.5 cm/hr). as shown in table (5.2) and Figure (5.1)

Table 5.1 Results data of the four profiles Infiltration rate and permeability

Soil profile	Surface Infiltration rate cm/hr	50cm depth permeability cm/hr
P1	2.0	1.2
P2	2.2	1.4
P3	2.8	1.0
P4	3.5	0.9

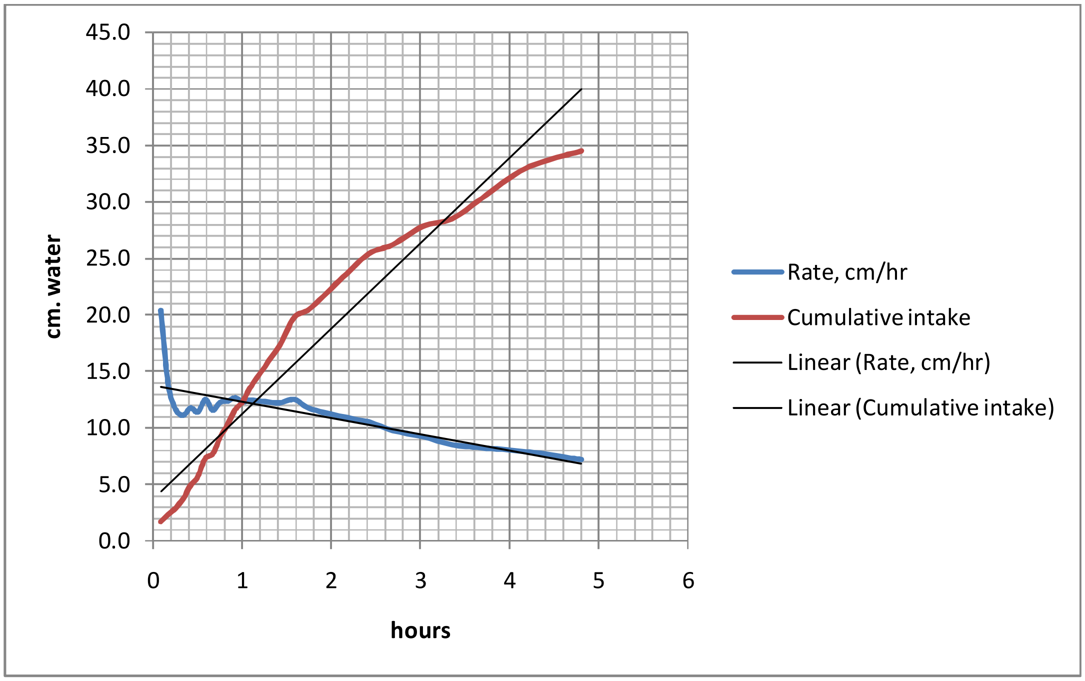


Figure 5.1 Results field test infiltration rate the study Are

5.3 percentage of gravel

Four profile were drilled to test how free even include all the styles in the farm, and the study found that the percentage of gravel in the first profile (pt 1) 25% in the surface and in the depth of 40 cm 15 % and in the depth of 120cm 10% and the textures of sandy loam. In the second profile (pt 2) the proportion of gravel is 10% at the surface and in the depth of 30 cm 10 % and in the depth of 120 cm 15 % and the texture is sand clay loam. In the third profile (pt 3) at a depth of 35 cm the gravel was 10% at a depth of 100 cm was 20 %. In the Fourth profile (pt4) the gravels percent 15% at the surface and depth of 100cm was 15%.as shown in table 5.3

(Table 5.2) Results of percentage of gravel in study area

Soil profile	**Surface Gravels %**	**Depth**	**Gravels %**	**Textures**
Pt 1	**25%**	0-40 cm	15%	sandy loam
		40- 120 cm	10%	
Pt 2	**10%**	0 ---30 cm	10%	sand clay loam
		90 --120cm	15%	
Pt 3	**5%**	0---35cm	10%	sandy loam
		80---120cm	20%	
Pt 4	**15%**	0---80cm	0%	Sandy clay loam
		80---100cm	15%	

5.4 Chemical results: pH -- EC

Most of the soils of the area are underlain by poorly sorted gravel variable in depth. Generally speaking, all the soils of the semi desert region. The soils of the scheme are generally reddish brown loamy sands to sandy loam the soils are deep to moderately deep, strong brown to yellowish red and excessively drained. None calcareous, none saline and none sodic. The soil matrix is strongly calcareous and the soil reaction is mildly alkaline (pH 7.6). They are none saline as the EC ranges from 0.2 to 1.8dS/m.

Table (5.3) Analytical data for four profiles representing the study Area

Soil Parameters	Soil profile			
	P1	P2	P3	P4
Texture class	sandy loam	Sandy clay loam	sandy loam	Sandy clay loam
PH	7.7 -7.9	7.7 -7.8	7.3 -7.7	7.6 _ 7.8
EC (ds/m)	0.2 -0.7	0.4-0.5	0.2-1.2	0.4_ 1.8

5.5 Soil classification and correlation

The soil of the study is belonging to the order Aridisol which are, as their name implies, are soils in which water is not

Available to helophytic plants for long periods.

- **Physical data for representative profiles :**

Table 5.4: Physical data for profile 1

Depth (cm)	Silt	sand	Clay	Texture class	Hydraulic conductivity cm/hr	Infiltration rate cm/hr	internal permeability cm/hr
0 – 30	10	75	15	SL	4.0	2.0	
30– 80	15	65	20	SL	3.2		1.2
80 - 130	23	37	40	CL	3.1		
130- 190	35	25	40	CL	3.2		

Table 5.5: Physical data for profile 2

Depth (cm)	Silt	sand	Clay	Texture class	Hydraulic conductivity cm/hr	Infiltration rate cm/hr	internal permeability cm/hr
0 –40	5	80	15	SL	4.0	2.2	
40– 75	8	56	36	SC	2.5		1.4
75 - 110	35	30	35	CL	3.3		
110- 160	40	23	37	CL	3.4		

Table 5.6: Physical data for profile3

Depth (cm)	Silt	sand	Clay	Texture class	Hydraulic conductivity cm/hr	Infiltration rate cm/hr	internal permeability cm/hr
0 – 25	7	73	20	SL	3.5	2.0	
25– 60	14	56	30	SC	3.0		1.0
60 - 120	35	30	35	SCL	2.5		
120- 200	30	33	37	SCL	3.0		

Table 5.7: Physical data for profile 4

Depth (cm)	Silt	sand	Clay	Texture class	Hydraulic conductivity mm/h	Infiltration rate cm/hr	internal permeability cm/hr
0 – 20	10	70	20	SL	2.9	2.5	
20– 60	15	55	30	SC	2.5		0.9
60 - 100	30	34	36	SCL	25		
100- 190	32	30	38	SCL	30		

CHAPTER SIX
CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

1. The results indicated that the soils of the study area have high infiltration rate that requires the farm irrigation system be designed considering this soil physical limitation.
2. The presence of relatively high amounts of sand and gravel has adverse effects on soil moisture characteristics and as well on soil fertility since the soils texture tends to be coarser rendering these soils with low Cation exchange capacity (CEC) that lower their capacity to retain nutrients.
3. Most sub-soils are gravelly with rock fragments that occur below 60—90 cm depth from the surface. These gravelly layers will create frequent soil moisture deficiency (low AWC) which requires short intervals of irrigation.
4. The presence of the study area in dry climate (semi-desert zone) characterizes it by having high rates of evapotranspiration far higher than the annual rainfall. Accordingly, farming of crops could only be practiced under irrigation. In this regards farm management should put more emphases on soil moisture characteristics.
5. The soils parent materials are residuum Nubian sandstone gravelly deposits developed on the Pedi plain and they are moderately deep with less than 100cm depth. Soil depth, texture and amount of gravels are the main soil physical constraints limiting the use and management of these soils.

6.2 Recommendation

1. Irrigation system should be designed according to soil physical factors. Irrigation systems such as sprinkler irrigation are recommended to control water application in the study are which characterized relatively high rates of infiltration and permeability is.
2. Research project should be encouraged to investigate proper irrigation and management practices for new crops on the extensive residuum reddish gravely soils in the vicinity of the study area. This is highly needed since the prospects are high for developing large agricultural project in the area.
3. Proper tillage operations for land and seedbed preparation should be managed carefully on top 30—40cm where the soft brown loamy surface soil exists.

4. Shelter belts of parallel lines of trees and bushes planted at short distances across the wind direction inside the farms are essential to halt wind hazards and reduce evapotranspiration and reduce irrigation costs.

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Appendix

Profile Descriptions and Physical Data

Information on the site:

Profile No. : 1

Classification: TypicHaplargids, fine loamy, mixed*, isohyperthermic.

Soil Name: west Omdurman (wed Ail)

Date of examination: March 20/4/2012

Authors of description: Abo Algsim

Elevation: about 700 m

Landform:

Physiographic position: Flat Wadi bottom and sand sheet

Landform of surrounding country: gently sloping and (Sand dunes)

Micotopography: water rills

Vegetation/Land use:,Seyal. , Salam and Usher

Climate: semi-desert with summer rains and warm winters, compare Khartoum and Dongle meteorological station.

General information on the soils:

Parent material: Aeolian. Nubian Sandston

Permeability of subsoil: Moderate

Moisture conditions in the soil: increases with depth

Depth of ground water: unknown

Presence of surface stones: few gravel

Presence of salts or alkali: None

Evidence of erosion: Slight (wind)

Human influence: grazing with increasing intensity at some places

Profile description:

Horizon Depth **Description**

Flat site of Non cracking. Few gravel and sand sheet on the surface. Texture is silty clay loam to sand clay loam. Topsoil most probably loams sand; structure of weak coarse angular and sub-angular blocky predominates in surface soil and below that it is massive. Generally the profile is hard and compacted when it gets dry. The soil is slightly calcareous, mildly alkaline and moderately drained.

A1	0 – 30 cm	Strong brown (7.5YR 5/6) dry and brown to dark brown (7.5YR 4/4) moist; loam sand ; weak moderate and coarse sub-angular blocky; hard, friable moist,No sticky and plastic;very few gravle 5 %.Non cracks; slightly calcareous; common pores; common fine and few medium decayed roots; gradual smooth boundary; pH 7.5
B1	30 – 80 cm	Strong brown (7.5YR 5/6) dry and brown to dark brown (7.5YR 4/4) moist; silt loam; weak very coarse and coarse sub-angular blocky structure; hard, friable, sticky and plastic;few garvle 10%Non cracks;; slightly calcareous; common tubular pores; common fine and very fine roots; gradual smooth boundary; pH 7.7

BC 80 – 130 cm Strong brown (7.5YR 5/6) 75% and brown to dark brown (7.5YR 4/4) moist 25% both dry and moist; sand clay loam; massive; very hard, firm, sticky and plastic; slightly calcareous; few tubular pores; few fine coarse roots; diffuse smooth boundary; pH 7.5

C1130 – 200 cm Strong brown (7.5 YR 5/6) dry and brown to dark brown (7.5YR 4/4) moist sand clay loam; massive; very hard, firm, sticky and plastic; common iron and Mnmottles; few sand and gravel 15% pockets; slightly calcareous; few insect channels; clear smooth boundary; pH 7.2.

* The mixed clay mineralogy is composed mainly of montmorillonite, Kaolinite and plagioclase clay minerals.

Physical data for profile1

Depth (cm)	Silt	Sand	Clay	ESP	Hydraulic conductivity cm/hr	Infiltration rate cm/hr	internal permeability cm/hr
0 – 25	38	35	27	1	3.5	2.6	
25 – 80	40	38	22	2	3.0		0.9
80 - 200	45	25	30	3	3.1		

Figure 1:profile1

Information on the site:

Profile No. : 2
Classification: Typic Haplargids, sand loamy, mixed*, isohyperthermic
Soil Name: west Omdurman (wed Ail)
Date of examination: March 20/4/2012
Authors of description: Abo Algsim
Elevation: about 700 m
Landform:

Physiographic position: Flat Wadi bottom and sand sheet

Landform of surrounding country: gently sloping and (Sand dunes)

Micotopography: water rills

Vegetation/Land use: Seyal. , Salam and Usher
Climate: semi-desert with summer rains and warm winters, compare Khartoum and Dongle meteorological station.

General information on the soils:

Parent material: Aeolian/denudated .Nubian Sandston
Permeability of subsoil: Moderate
Moisture conditions in the soil: increases with depth
Depth of ground water: unknown
Presence of surface stones: few gravel
Presence of salts or alkali: None
Evidence of erosion: Slight (wind)
Human influence: grazing with increasing intensity at some places

Profile description:

Horizon Depth **Description**

Few gravel and sand sheet on the surface. Texture is silt clay loam to sand clay loam. Topsoil most probably loams sand; structure of weak coarse angular and sub-angular blocky predominates in surface soil and below that it is massive. Generally the profile is hard and compacted when it gets dry. The soil is slightly calcareous, mildly alkaline and moderately drained.

A1 0 – 40 cm Strong brown (7.5YR 5/6) dry and brown to dark brown (7.5YR 4/4) moist; loam sand ; weak moderate and coarse sub-angular blocky; hard, friable moist,No sticky and plastic;very few gravle 10 %.Non cracks; slightly calcareous; common pores; common fine and few medium decayed roots; gradual smooth boundary; pH 7.7

B1 40 – 75 cm Strong brown (7.5YR 5/6) dry and brown to dark brown (7.5YR 4/4) moist; silt loam; weak very coarse and coarse sub-angular blocky structure; hard, friable, sticky and plastic;few garvle 5%Non cracks;; slightly calcareous; common tubular pores; common fine and very fine roots; gradual smooth boundary; pH 7.5

BC75 – 110 cm

Strong brown (7.5YR 5/6) 75% and brown to dark brown (7.5YR 4/4) moist 25% both dry and moist; sand clay loam; massive; very hard, firm, sticky and plastic; slightly calcareous; few tubular pores; few fine coarse roots; diffuse smooth boundary; pH 7.4

C1110 – 160 cm

Strong brown (7.5 YR 5/6) dry and brown to dark brown (7.5YR 4/4) moist sand clay loam; massive; very hard, firm, sticky and plastic; common iron and Mnmottles; few sand and gravel 20% pockets; slightly calcareous; few insect channels; clear smooth boundary; pH 7.2.

* The mixed clay mineralogy is composed mainly of montmorillonite, Kaolinite and plagioclase clay minerals.

Table 3 Physical data for profile 2

Depth (cm)	Silt	sand	Clay	Hydraulic conductivity cm/hr	Infiltration rate cm/hr	internal permeability cm/hr
0 –40	5	80	15	3.0	2.4	
40– 75	8	56	36	2.7		0.7
75 - 110	15	30	55	3.0		
110- 160	30	18	52	2.5		

(Figure 2: profile2)

Information on the site:

Profile No. : 3

Classification: TypicHaplargids, sand loamy, mixed*, isohyperthermic

Soil Name: west Omdurman (wed Ail)

Date of examination: March 20/4/2012

Authors of description: Abo Algsim

Elevation: about 700 m

Landform:

Physiographic position: Flat Wadi bottom and sand sheet

Landform of surrounding country: gently sloping and (Sand dunes)

Micotopography: water rills

Vegetation/Land use:kiter. , Salam and Usher

Climate: semi-desert with summer rains and warm winters, compare Khartoum and Dongle meteorological station.

General information on the soils:

Parent material: Aeolian/denudated .Nubian Sandston

Permeability of subsoil: Moderate

Moisture conditions in the soil: increases with depth

Depth of ground water: unknown

Presence of surface stones: few gravel

Presence of salts or alkali: None

Evidence of erosion: Slight (wind)

Human influence: grazing with increasing intensity at some places

Profile description:

Horizon Depth Description

Few gravel and sand sheet on the surface. Texture is silty clay loam to sand clay loam. Topsoil most probably loams sand; structure of weak coarse angular and sub-angular blocky predominates in surface soil and below that it is massive. Generally the profile is hard and compacted when it gets dry. The soil is slightly calcareous, mildly alkaline and moderately drained.

A1	0 – 35 cm	Strong brown (7.5YR 5/6) dry and brown to dark brown (7.5YR 4/4) moist; loam sand ; weak moderate and coarse sub-angular blocky; hard, friable moist,No sticky and plastic;very few gravle 10 %.Non cracks; slightly calcareous; common pores; common fine and few medium decayed roots; gradual smooth boundary; pH 7.7
B1	35 – 75 cm	Strong brown (7.5YR 5/6) dry and brown to dark brown (7.5YR 4/4) moist; silt loam; weak very coarse and coarse sub-angular blocky structure; hard, friable, sticky and plastic;few garvle 5%Non cracks;; slightly calcareous; common tubular pores; common fine and very fine roots; gradual smooth boundary; pH 7.5

BC 75 – 110 cm Strong brown (7.5YR 5/6) 75% and brown to dark brown (7.5YR 4/4) moist 25% both dry and moist; sand clay loam; massive; very hard, firm, sticky and plastic; slightly calcareous; few tubular pores; few fine coarse roots; diffuse smooth boundary; pH 7.4

C1110 – 160 cm Strong brown (7.5 YR 5/6) dry and brown to dark brown (7.5YR 4/4) moist sand clay loam; massive; very hard, firm, sticky and plastic; common iron and Mnmottles; few sand and gravel 20% pockets; slightly calcareous; few insect channels; clear smooth boundary; pH 7.2.

C2 **160---** 200 Strong brown (5 YR 4/4) dry and reddish brown to brown (.5YR 4/4) moist sand clay loam; massive; very hard, firm, sticky and plastic; few sand and gravel 25% pockets; slightly calcareous; few insect channels; clear smooth boundary; pH 7.3

* The mixed clay mineralogy is composed mainly of montmorillonite, Kaolinite and plagioclase clay minerals.

Table 3 Physical data for profile 3

Depth (cm)	Silt	sand	Clay	Hydraulic conductivity cm/hr	Infiltration rate cm/hr	internal permeability cm/hr
0 – 25	7	83	20	2.5	2.0	
25– 60	14	56	30	2.8		0.6
60 - 120	18	32	50	2.5		
120- 200	22	30	48	3.0		

(Figure 3:profile3)

Information on the site:

Profile No. : 4
Classification: TypicHaplargids, sand loamy, mixed*, isohyperthermic
Soil Name: west Omdurman (wed Ail)
Date of examination: March 20/4/2012
Authors of description: Abo Algsim
Elevation: about 700 m
Landform:

Physiographic position: Flat Wadi bottom and sand sheet
Landform of surrounding country: gently sloping and (Sand dunes)
Micotopography: water rills

Vegetation/Land use:, Seyal. , Salam and Usher
Climate: semi-desert with summer rains and warm winters, compare Khartoum and Dongle meteorological station.

General information on the soils:

Parent material: Aeolian/denudated .Nubian Sandston
Permeability of subsoil: Moderate
Moisture conditions in the soil: increases with depth
Depth of ground water: unknown
Presence of surface stones: few gravel
Presence of salts or alkali: None
Evidence of erosion: Slight (wind)
Human influence: grazing with increasing intensity at some places

Profile description:

Horizon Depth **Description**

Few gravel and sand sheet on the surface. Texture is silty clay loam to sand clay loam. Topsoil most probably loams sand; structure of weak coarse angular and sub-angular blocky predominates in surface soil and below that it is massive. Generally the profile is hard and compacted when it gets dry. The soil is slightly calcareous, mildly alkaline and moderately drained.

A1	0 – 25 cm	Strong brown (7.5YR 5/6) dry and brown to dark brown (7.5YR 4/4) moist; loam sand ; weak moderate and coarse sub-angular blocky; hard, friable moist,No sticky and plastic;very few gravle 10 %.Non cracks; slightly calcareous; common pores; common fine and few medium decayed roots; gradual smooth boundary; pH 7.7
B1	25 – 60 cm	Strong brown (7.5YR 5/6) dry and brown to dark brown (7.5YR 4/4) moist; silt loam; weak very coarse and coarse sub-angular blocky structure; hard, friable, sticky and plastic;few garvle 5%Non cracks;; slightly calcareous; common tubular pores; common fine and very fine roots; gradual smooth boundary; pH 7.5

BC 60 – 100 cm Strong brown (7.5YR 5/6) 75% and brown to dark brown (7.5YR 4/4) moist 25% both dry and moist; sand clay loam; massive; very hard, firm, sticky and plastic; slightly calcareous; few tubular pores; few fine coarse roots; diffuse smooth boundary; pH 7.4

C1100 –190 cm Strong brown (7.5 YR 5/6) dry and brown to dark brown (7.5YR 4/4) moist sand clay loam; massive; very hard, firm, sticky and plastic; common iron and Mnmottles; few sand and gravel 20% pockets; slightly calcareous; few insect channels; clear smooth boundary; pH 7.2.

* The mixed clay mineralogy is composed mainly of montmorillonite, Kaolinite and plagioclase clay minerals.

Physical data for profile4

Depth (cm)	Silt	sand	Clay	Hydraulic conductivity mm/hr	Infiltration rate cm/hr	internal permeability cm/hr
0 – 25	7	83	20	2.0	2.0	
25– 60	15	55	30	2.8		0.6
60 - 100	20	31	49	2.5		
100- 190	23	31	46	3.2		

Figure 4: profile 4

Figure 5: permeability on depth 50cm

Figure 6: Soil profile and landscape at profile