بسم الله الرحمن الرحيم

كلية الدراسات العليا

Sudan University of Science and Technology

College of Graduate studies

Sodium Adsorption Ratio and Mineral Content of Soil and Water Samples at Alseleit Agricultural Scheme

نسبة امتزاز الصوديوم والمحتوى المعدني لعينات من التربة والمياه بمشروع السليت الزراعي

A Thesis Submitted in Partial Fulfillment of the Requirements
of Master Degree in Chemistry

By

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Approval page

إستهلال

بسم الله الرحمن الرحيم

﴿وَسَخَّرَ لَكُمْ مَا فِي السَّمَاوَاتِ وَمَا فِي الْأَرْضِ جَمِيعًا مِنْهُ إِنَّ فِي ذَلِكَ لَآيَاتٍ لِقَوْمٍ يَتَفَكَّرُونَ﴾ صدق الله العظيم سوره الجاثية (آية ١٣)

Dedication

To my Parents,

My Husband and daughters,

My Brothers and sisters,

Acknowledgment

First of all, my endless thanks and praise to Allah Almighty, who gave me the strength, health and patience to complete this work.

I am deeply indebted to my supervisor Dr. Omer Adam Gibla for his valuable guidance suggestions and encouragement during the study.

My thanks would be extended to the family of Central Petroleum Laboratories, and the director of AlSeleit Agricultural Scheme, for their contribution during this work.

Abstract

The aim of this study was to measure sodium adsorption ratio (SAR) and minerals content for irrigation water and soil samples at AlSeleit Agricultural Scheme.

Soil samples were collected from different parts of the scheme depending on the type of crop in each area. The cultivated crops include tomatoes, palm, orange, lemon, grapefruit, beans, hot pepper and three types of animal feed. Irrigation water samples were obtained from ten different pumps, withdrawing from the main Tura’ a.

Inductively coupled plasma spectrometry (ICPS), was used to measure the minerals content in soil and water samples. UV-VIS Spectrophotometry was used for determining the concentrations of anions (chloride, nitrate and sulfate) in soil and water samples.

The results show high average values of sodium adsorption ratio (SAR) in soil samples (16.21) compared with that in water samples (0.161) which were found to be lower than the accepted guideline values (3-10).

Water samples showed relatively high average concentrations for calcium (43.82ppm), magnesium (11.61ppm), potassium (3.80ppm) and silicon (21.89) but very low average concentrations of sodium (0.87ppm). All the micro minerals showed low average concentrations in water samples except iron (Fe) which showed relatively high concentration (59.2ppm) in sample (No1). All the toxic minerals concentrations were found to be very low in water samples.

Soil samples showed high average concentrations for calcium (15999.9ppm), magnesium(6552.8ppm), potassium(2183.74ppm), sodium(1781.32ppm)

iron(29168.6ppm), manganese(510.22ppm), nickel (65.51ppm), titanium (4817.9ppm) and Zink (43.24ppm.

The average concentrations of toxic minerals aluminum, barium, strontium and vanadium were high in soil samples, but the average concentrations of arsenic, lead and cadmium were found to be of very low in all soil samples.

UV-VIS Spectrophotometric results showed low average concentrations of anions chloride, nitrate and sulfate in water and soil samples, chloride and Nitrate concentrations were almost similar, but sulfate ions concentrations were relatively high.

المستخلص

الهدف من هذه الدراسة هو قياس نسبه امتزاز الصوديوم(SAR)والمحتوى المعدني لعينات من مياه الري والتربة بمشروع السليت الزراعي.

جمعت عينات التربة من أجزاء مختلفة من مشروع السليت الزراعي اعتمادا على نوع المحصول في كل منطقه. المحاصيل المزروعة شملت الطماطم، النخيل ، البرتقال ، الليمون، القريب فروت، الفاصوليا، الفلفل الحار، وثلاث أنواع من أعلاف الحيوانات، عينات مياه الري تم الحصول عليها من عشرة مضخات مختلفة تسحب جميعها من الترعة الرئيسية.

استخدم جهاز طيف بلازما الحث المتلازم(ICPS) لقياس المحتوى المعدني لعينات التربة والمياه. استخدم جهاز مطيافيه الضوء فوق البنفسجي والمرئي لتقدير تراكيز ايونات الكلوريد والنترات والكبريتات في عينات التربة والمياه.

أظهرت النتائج قيم عالية لمتوسط نسبه امتزاز الصوديوم (SAR) في عينات التربة (16.4) مقارنه مع عينات مياه الري (0.161) التي وجد انها اقل من القيم المسموح بها (10-3).

عينات المياه أظهرت متوسط تراكيز عالي نسبيا لكل من الكالسيوم(43.82ppm)، المغنيزيوم (11.61ppm)، البوتاسيوم (3.80ppm)، السيلكون(21.89ppm) بينما متوسط تراكيز الصوديوم كان منخفض جدا(0.87ppm). جميع العناصر الأثرية أظهرت متوسط تراكيز منخفض في عينات المياه ماعدا الحديد الذي أظهر تركيز عالي نسبيا(56.2ppm) في العينة (رقم1).تراكيز كل المعادن السامة وجدت منخفضة جدا في المياه .

عينات التربة أظهرت متوسط تراكيز عالي لكل من الكالسيوم(15999.9ppm)، المغنيزيوم (6552.8ppm)، البوتاسيوم(2183.74 ppm)، الصوديوم(1781.38ppm)، الحديد (29168.6ppm)، المنجنيز(510.22ppm)، النيكل(65.51ppm)، التيتانيوم (4817.9ppm) والزنك(93.24ppm).

متوسط تراكيز المعادن السامة الألمنيوم، الباريوم، الاسسترانشيوم والفانيديوم عالي في عينات التربة، بينما متوسط تراكيز الارسينك ، الرصاص، والكادميوم منخفض جدا في كل عينات التربة.

أظهرت نتائج مطيافية الضوء فوق البنفسجي والمرئي انخفاض متوسط تراكيز ايونات الكلوريد، النترات والكبريتات في عينات المياه والتربة ، تراكيز الكلوريد والنترات متشابهة تقريبا بينما تراكيز ايونات الكبريتات عالية نسبياً.

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List of Abbreviations

SAR	Sodium Adsorption Ratio
ICPS	Inductively coupled plasma spectrometry
GPS	Global positioning system
EC$_W$	Electrical conductivity of water
CFC	Critical flocculation concentration
PAR	Potassium adsorption ratio
LEPA	Low energy precision application
CROSS	Cation ratio of structural stability

Chapter One

Introduction

Chapter one

1. Introduction

1.1The study area

This study was conducted in Alseleit agricultural scheme; it’s located in the north-east part of Bahri city in Khartoum state (Figure 1.1).
It is one of the oldest and important irrigated agricultural schemes that contribute to food insurance in the state.

The scheme was started in(1970) with an area of 265,000 acres. It was aimed to grow 5million palm trees. There are 2100 farms working in the scheme.

The scheme uses surface and pivotal irrigation system (Figure1.2) from pumps on the Blue Nile for agricultural irrigation.

The scheme produce animal feed, vegetables and crops for export including cantaloupe, okra, medicinal plants and many horticultural crops such as oranges, lemons, mangoes, tomatoes grapefruit and palms.

The scheme is also concerned with dairy, poultry, fish farming and protected homes system which provide a suitable environment for some crops. (Figure1.3)

The scheme has large dairies producing 60 tons of milk daily. It has 320 barns providing vaccination systems and veterinary services aimed to free animals from disease.

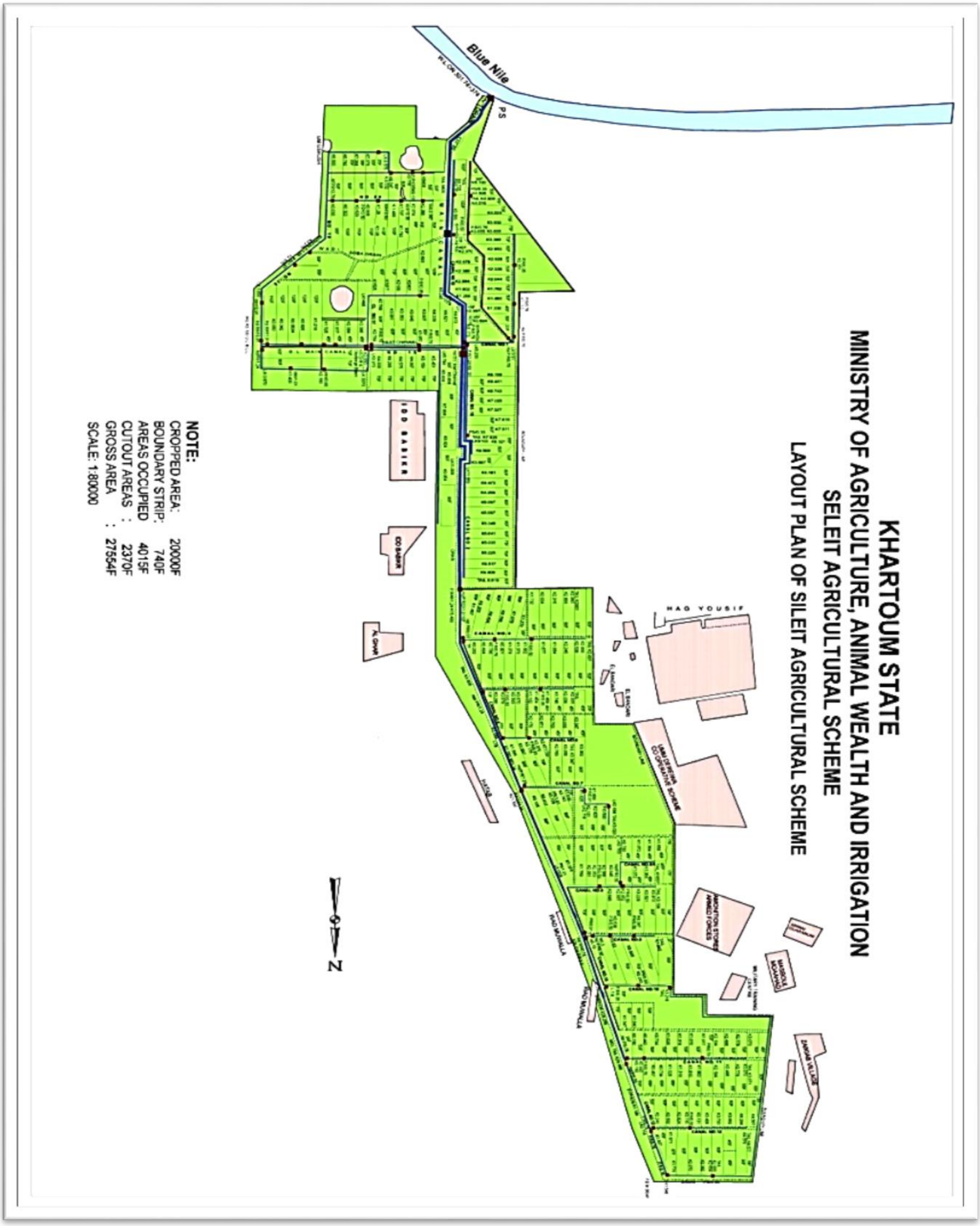

Figure (1.1) Map of the study area

Figure (1.2) Surface irrigation

Figure (1.3) protected homes system

1.2 Irrigation

Irrigation is an application of controlled amounts of water to plants at needed intervals. Irrigation helps to grow agricultural crops, maintain landscapes, and revegetate disturbed soils in dry areas and during periods of less than average rainfall. Irrigation also has other uses in crop production, including frost protection (Snyder and melo,2005) suppressing weed growth in grain fields and preventing soil consolidation. Agriculture that relies only on direct rainfall is referred to as rain-fed or dry land farming. (Williams.et.al,2007).

Irrigation systems may be used for livestock cooling, dust suppression, disposal of sewage, and in mining. Irrigation is often studied together with drainage, which is the removal of surface and sub-surface water from a given area.

Irrigation has been a central feature of agriculture for over 5,000 years ago a practice and is the product of many cultures. Historically, it was the basis for economies and societies across the globe, from Asia to Southwestern United States

The year 2000, the total fertile land was 2,788,000 km² and it was equipped with irrigation infrastructure worldwide. About 68% of this area is in Asia, 17% in the Americas, 9% in Europe, 5% in Africa and 1% in Oceania (Siebert. et al; 2006).

The largest contiguous areas of high irrigation density are found, in Northern India and Pakistan along the Ganges and Indus rivers, in the Hai He, Huang He and Yangtze basins in China, along the River Nile in Sudan and Egypt and in the Mississippi-Missouri river basin, the Southern Great Plains, and in parts of California

Almost all populated parts of the world later, in the 2008; area of irrigated land had increased to an estimated total of 3,245,566 km², which is nearly the size of India (Siebert, et.al.2006).

The methods of irrigation vary in how water is supplied to plants. The goal is to apply water to plants as uniformly as possible, so that each plant has the amount of water it needs, neither too much nor too little.

1.2.1Surface irrigation

This is the oldest form of irrigation which had been in use for thousands of years. In surface irrigation systems water moves across the surface of an agricultural lands, in order to wet it and infiltrate into the soil. Surface irrigation can be subdivided into furrow, borderstrip or basin irrigation. It is often called flood irrigation when the irrigation results in flooding or near flooding of the cultivated land. Historically, this has been the most common method of irrigating agricultural land and still used in most parts of the world.

When water levels from the source permit the levels are controlled by dikes, usually plugged by soil. This is often seen in terraced rice fields where the method is used to flood or control the level of water in each distinct field. In some cases, water is pumped, or lifted by human or animal power to the land level water application efficiency of surface irrigation is typically lower than other forms of irrigation.

Surface irrigation is used to water landscapes in certain areas, for example, in and around Arizona. When the irrigated area is surrounded by water wall and the water is delivered according to a schedule set by a local irrigation district (Frenken, 2005).

1.2.2Drip(micro) irrigation

In this system water–falls drop by drop just at the position of roots. Water is delivered at or near the root zone of plants. This method can be the most water-efficient method of irrigation, if managed properly when evaporation and runoff are minimized. (Mader and Shelli, 2010).

The field water efficiency of drip irrigation is typically in the range of 80 to 90 percent. In modern agriculture, drip irrigation is often combined with plastic mulch, further reducing evaporation, and also by means of delivery of fertilizer. The process is known as fertilization

Deep percolation, where water moves below the root zone, can occur if a drip system is operated for too long or if the delivery rate is too high. Drip irrigation methods, range from very high-tech and computerized to low-tech and labor-intensive. Lower water pressures are usually needed than for most other types of systems, with the exception of low energy center pivot systems and surface irrigation systems, and the system can be designed for uniformity throughout a field or for precise water delivery to individual plants in a landscape containing a mix of plant species. Although it is difficult to regulate pressure on steep slopes, pressure compensating emitters are available, so the field does not have to be leveled. High-tech solutions involve precisely calibrated emitters located along lines of tubing that extend from a computerized set of valves.

1.2.3Sprinkler irrigation

In sprinkler or overhead irrigation, water is piped to one or more central locations within the field and distributed by overhead high-pressure sprinklers or guns. A system utilizing sprinklers, sprays, or guns mounted overhead on permanently installed risers is often referred to as a solid-set irrigation system. (Stephanie and Andrew,2014)

Higher pressure sprinklers that rotate are called rotors and are driven by a ball drive, gear drive, or impact mechanism. Rotors can be designed to rotate in a full or partial circle. Guns are similar to rotors, except that they generally operate at very high pressures and used not only for irrigation, but also for industrial applications such as dust suppression and logging.

Sprinklers can also be mounted on moving platforms connected to the water source by a hose. Automatically moving wheeled systems known as traveling sprinklers may irrigate areas such as small farms, sports fields, parks, pastures, and cemeteries unattended as the tubing is wound on the drum powered by the irrigation water or a small gas engine, the sprinkler is pulled across the field. When the sprinkler arrives back at the reel the system shuts off. This type of system is known to most people as a "waterwheel" traveling irrigation sprinkler and they are used extensively for dust suppression, irrigation, and land application of waste water

1.2.4Center pivot irrigation

Center pivot irrigation is a form of sprinkler irrigation utilizing several segments of pipes joined together and supported by trusses, mounted on wheeled towers with sprinklers positioned along its length. The system moves in a circular pattern and is fed with water from the pivot point at the center of the arc. These systems are found and used in all parts of the world and allow irrigation of all types of terrain. Newer systems have drop sprinkler heads as shown in the image that follows. As from (2017) most center pivot systems have drops hanging from au-shaped pipe attached at the top of the pipe with sprinkler heads that are positioned a few feet (at most) above the crop, thus limiting evaporative losses. Drops can also be used with drag hoses or bubblers that deposit the water directly on the ground between crops. Crops are often planted in a circle to conform to the center pivot. This type of system is known as Low Energy Precision Application (LEPA).

Originally, most center pivots were water-powered. These were replaced by hydraulic systems and electric-motor-driven systems many modern pivots feature (GPS) devices. (Peters and Troy, 2013).

1.2.5 Irrigation by Lateral move

Side roll, wheel line and wheel move, this is series of pipes, each with a wheel of about 1.5 m diameter permanently fixed to its midpoint, and sprinklers along its length, are coupled together. Water is supplied at one end using a large hose. After sufficient irrigation has been applied to one strip of the field, the hose is removed, the water drained from the system, and the assembly rolled either by hand or with a purpose-built mechanism, so that the sprinklers are moved to a different position across the field. The hose is reconnected. The process is repeated in a pattern until the whole field has been irrigated (Hill and Robert,2014).

This system is less expensive to install than, the center pivot, but much more labor-intensive to operate. It does not travel automatically across the field. It applies water in a stationary strip, must be drained, and then rolled to a new strip. Most systems use 4 or 5-inch diameter aluminum pipe. The pipe doubles both as water transport and as an axle for rotating all the wheels. A drive system (often found near the centre of the wheel line) rotates the clamped-together pipe sections as a single axle, rolling the whole wheel line. Manual adjustment of individual wheel positions may be necessary if the system becomes misaligned.

Wheel line systems are limited in the amount of water they can carry, and limited in the height of crops that can be irrigated. One useful feature of a lateral move system is that it consists of sections that can be easily disconnected, adapting to field shape as the line is moved. They are most often used for small, rectilinear, or oddly-shaped fields, hilly or mountainous regions, or in regions where labor is inexpensive.

1.3Water sources

Irrigation water can come from groundwater extracted from springs or by using wells from surface water withdrawn from rivers, lakes or reservoirs or from non-conventional sources like treated wastewater, desalinated water, drainage water, or fog collection. A special form of irrigation using surface water is spate irrigation, also called floodwater harvesting. In case of a flood, water is diverted to normally dry river beds using a network of dams, gates and channels and spreading over large areas. The moisture stored in the soil will be used thereafter to grow crops. Spate irrigation areas are in particular located in semi-arid or arid, or mountainous regions. While floodwater harvesting belongs to the accepted irrigation methods, rainwater harvesting is usually not considered as a form of irrigation.

Until 1960s, the common perception was that water was an infinite resource. (Chartres and Varma,2010). At that time, there was fewer than half the current number of people on the planet. People were not as wealthy as today, consumed fewer calories and ate less meat, so less water was needed to produce their food. They required a third of the volume of water we presently take from rivers. Today, the competition for water resources is much more intense. This is because there are now more than seven billion people on the planet, their consumption of water-thirsty meat and vegetables is rising, and there is increasing competition for water from industry, urbanization and biofuel crops. To avoid a global water crisis, farmers will have to strive to increase productivity to meet growing demands for food, while industry and cities find ways to use water more efficiently (Chartres and Varma,2010).

However, water scarcity is already a critical constraint to farming in many parts of the world. With regards to agriculture, the World Bank targets food production and water management as an increasingly global issue that is fostering a growing debate.

Physical water scarcity is where there is no enough water to meet all demands, including that needed for ecosystems to function effectively. Arid regions frequently suffer from physical water scarcity. It also occurs where water seems abundant but where resources are over-committed. This can happen where there is overdevelopment of hydraulic infrastructure, usually for irrigation. Symptoms of physical water scarcity include environmental degradation and declining groundwater. Economic scarcity, meanwhile, is caused by a lack of investment in water or insufficient human capacity to satisfy the demand for water. Symptoms of economic water scarcity include a lack of infrastructure, with people often having to fetch water from rivers for domestic and agricultural uses. Some 2.8 billion people currently live in water-scarce areas. (Molden,2007). Water use efficiency in the field can be determined as follows:

Field water efficiency (%) =

$$\frac{\text{Water Transpired by Crop}}{\text{Water Applied to Field}} \text{ x } 100\%$$

1.4 Irrigation water quality criteria

Soil scientists use the following categories to describe irrigation water effects on crop production and soil quality:

- Salinity hazards – total soluble salt content
- Sodium hazards – relative proportion of sodium to calcium and magnesium ions
- pH – acid or basic
- Alkalinity – carbonate and bicarbonate
- Specific ions: chloride, sulfate, boron, and nitrate.

Another potential irrigation water quality impairment that may affect suitability for cropping systems is microbial pathogens. (T.A. Bauder. et.al 2014)

1.4.1. Salinity hazards

The most influential water quality guideline on crop productivity is water salinity hazard as measured by electrical conductivity (EC_w). The primary effect of high EC_w water on crop productivity is the inability of the plant to compete with ions in the soil solution for water (physiological drought). The higher the EC, the less water is available for plants, even though the soil may appear wet. Because plants can only transpire “pure” water, usable plant water in the soil solution dramatically decreases as EC increases. The amount of water transpired through a crop is directly related to yield; therefore, irrigation water with high EC_w reduces yield potential.

Table (1.1) Salinity hazard of irrigation water based on conductivity

Limitations for use	Electrical Conductivity
	(dS/m)*
None	≤0.75
Some	0.76 – 1.5
Moderate[1]	1.51 – 3.00
Severe[2]	≥3.00

Actual yield reductions from irrigating with high EC water vary substantially. Factors influencing yield reductions include soil type, drainage, salt type, irrigation system and management. Beyond effects on the immediate crop is the long term impact of salt loading through the irrigation water. Water with an EC_w of only 1.15 dS/m contains approximately 2,000 pounds of salt for every acre foot of water.

Table (1.2) Potential yield reduction from saline water for selected irrigated crops.

	% yield reduction			
Crop	**0%**	**10%**	**25%**	**50%**
	ECw2+			
Barley	**5.3**	**6.7**	**8.7**	**12**
Wheat	**4.0**	**4.9**	**6.4**	**8.7**
Sugarbeet3	**4.7**	**5.8**	**7.5**	**10**
Alfalfa	**1.3**	**2.2**	**3.6**	**5.9**
Potato	**1.1**	**1.7**	**2.5**	**3.9**
Corn (grain)	**1.1**	**1.7**	**2.5**	**3.9**
Corn (silage)	**1.2**	**2.1**	**3.5**	**5.7**
Onion	**0.8**	**1.2**	**1.8**	**2.9**
Dry Beans	**0.7**	**1.0**	**1.5**	**2.4**

Source (Ayers.et al, 1994)

1.4.2 Sodium hazards

Although plant growth is primarily limited by the salinity (EC_w) level of the irrigation water, the application of water with a sodium imbalance can further reduce yield under certain soil texture conditions. Reductions in water infiltration can occur when irrigation water contains high sodium relative to the calcium and magnesium contents. This condition, termed “sodicity,” results from excessive soil accumulation of sodium. Sodic water is not the same as saline water. Sodicity causes swelling and dispersion of soil clays, surface crusting and pore plugging. This degraded soil structure condition in turn obstructs infiltration and may increase runoff. Sodicity causes a decrease in the downward movement of water into and through the soil, and actively growing plants roots may not get adequate water, despite pooling of water on the soil surface after irrigation. The most common measure to assess sodicity in water and soil is called the Sodium Adsorption Ratio (SAR). The SAR defines sodicity in terms of the relative concentration of sodium (Na) compared to the sum of calcium (Ca) and magnesium (Mg) ions in a sample. The SAR assesses the potential for infiltration problems due to a sodium imbalance in irrigation water. The SAR is mathematically written below

$$\boldsymbol{SAR = Na^{+} / \sqrt{[(Ca^{2+} + Mg^{2+})/2]}}$$

Where Na, Ca and Mg are the concentrations of these ions in mill equivalents per liter. Concentrations of these ions in water samples are typically provided in milligrams per liter to convert Na, Ca, and Mg from mg/L to meq/L, you should divide the concentration by 22.9, 20, and 12.15 respectively.

For most irrigation waters standard SAR formula provided above is suitable to express the potential sodium hazard. However, for irrigation water with high bicarbonate (HCO_3) content, an "adjusted" SAR (SAR_{ADJ}) can be calculated. In this case, the amount of calcium is adjusted for the water's alkalinity, is recommended in place of the standard SAR. Your laboratory may calculate an adjusted SAR in situations where the HCO_3 is greater than 200 mg/L or pH is greater than8.5. The potential soil infiltration and permeability problems created from applications of irrigation water with high "sodicity" cannot be adequately assessed on the basis of the SAR alone. This is because the swelling potential of low salinity (EC_w) water is greater than high EC_w waters at the same sodium content (Table 3). Therefore, a more accurate evaluation of the infiltration/permeability hazard requires using the electrical conductivity (EC_w) together with the SAR.

Table (1. 3) Sodium hazards of irrigation water based on SAR and EC_w²

Potential for Water Infiltration Problem		
Irrigation water SAR	**Unlikely**	**Likely**
	———EC_w^2 (dS/m)———	
0-3	>0.7	<0.2
3-6	>1.2	<0.4
6-12	>1.9	<0.5.
12-20	>2.9	<1.0
20-40	>5.0	<3.0

Source (Ayers et al. 1994)

Many factors including soil texture, organic matter, cropping system, irrigation system and management affect how sodium in irrigation water affects soils. Soils most likely to show reduced infiltration and crusting from water with elevated SAR (greater than 6) are those containing more than 30% expansive (smectite) clay. Soils containing more than 30% clay include most soils in the clay loam, silty clay loam textural classes and finer and some sandy clay loams. smectite clays are common in areas with agricultural production.

Table (1. 4) Susceptibility ranges for crops to foliar injury from saline sprinkler water (Source (Mass, 1990).

	Na or Cl concentration (mg/L) causing foliar injury			
Na concentration	<46	46-230	231-460	>460
Cl concentration	<175	175-350	351-700	>700
	Apricot	Pepper	Alfalfa	Sugarbeet
	Plum	Potato	Barley	Sunflower
	Tomato	Corn	Sorghum	

1.4.3 pH and alkalinity

According to (T.A. Bauder. et.al 2014) the acidity or basicity of irrigation water is expressed as pH value. The normal pH range for irrigation water is from 6.5 to 8.4. Abnormally low pH's are not common, but may cause accelerated irrigation system corrosion where they occur. High pH's above 8.5 are often caused by high bicarbonate (HCO_3^-) and carbonate (CO_3^{2-}) concentrations, known as alkalinity. High carbonates cause calcium and magnesium ions to form insoluble minerals leaving sodium as the dominant ion in solution. As described in the sodium hazard section, this alkaline water could intensify the impact of high SAR water on sodic soil conditions. Excessive bicarbonate concentrates can also be problematic for drip or micro-spray irrigation systems when calcite or scale builds up causes reduced flow rates through orifices or emitters. In these situations, correction by injecting sulfuric or other acidic materials into the system may be required.

1.4.4 Specific anions (chloride, boron, sulfate and nitrate)

Chloride is a common ion in irrigation waters. Although chloride is essential to plants in very low amounts, it can cause toxicity to sensitive crops at high concentrations (Table 5). Like sodium, high chloride concentrations cause more problems when applied with sprinkler irrigation (Table 6). Leaf burn under sprinkler from both sodium and chloride can be reduced by night time irrigation or application on cool, cloudy days. Drop nozzles and drag hoses are also recommended when applying any saline irrigation water through a sprinkler system to avoid direct contact with leaf surfaces. Chloride tolerance of selected crops. Listing in order of increasing tolerance: (low tolerance) dry bean, onion, carrot, lettuce, pepper, corn, potato, alfalfa, sudangrass, zucchini squash, wheat, sorghum, sugar beet, barley (high tolerance)

Table (1.5) Chloride classification of irrigation water.

Chloride (ppm)	**Effect on Crops**
Below 70	Generally safe for all plants.
70-140	Sensitive plants show injury.
141-350	Moderately tolerant plants show injury.
Above 350	Can cause severe problems.

Source (Mass, 1990)

Boron is another element that is essential in low amounts, but toxic at higher concentrations (Table 6). In fact, toxicity can occur on sensitive crops at concentrations less than 1.0 ppm. Colorado soils and irrigation waters contain enough B that additional B fertilizer is not required in most situations. Because B toxicity can occur at such low concentrations, an irrigation water analysis is advised for ground water before applying additional B to irrigated crops.

Table (1.6) Boron sensitivity of selected plants(mg/L)

Sensitive		**Moderately Sensitive**	**Moderately Tolerant**	**Tolerant**
0.5-0.75	0.76-1.0	1.1-2.0	2.1-4.0	4.1-6.0
Peach	Wheat	Carrot	Lettuce	Alfalfa
Onion	Barley	Potato	Cabbage	Sugar beet
	Sunflower	Cucumber	Corn	Tomato
	Dry Bean		Oats	

Source. (Mass ,1990).

The sulfate ion is a major contributor to salinity in many irrigation water. As with boron, sulfate in irrigation water has fertility benefits, and irrigation water often has enough sulfate for maximum production for most crops. Exceptions are sandy fields with <1 percent organic matter and <10 ppm SO^4-S in irrigation water.

Nitrogen in irrigation water (N) is largely a fertility issue, and nitrate-nitrogen (NO_3-N) can be a significant N source in the South Platte, San Luis Valley, and parts of the Arkansas River basins. The nitrate ion often occurs at higher concentrations than ammonium in irrigation water.

Waters high in N can cause quality problems in crops such as barley and sugar beets and excessive vegetative growth in some vegetables. However, these problems can usually be overcome by good fertilizer and irrigation management. Regardless of the crop, nitrate should be credited toward the fertilizer rate especially when the concentration exceeds 10 ppm NO_3-N (45 ppm NO_3^-).

1.5Agriculture

Agriculture was and still the development in key the rise of sedentary human civilization, whereby farming of domesticated species created food surpluses that enabled people to live in cities. The study of agriculture is known as agricultural science. The history of agriculture dates back thousands of years; people gathered wild grains at least 105,000 years ago and began to plant them around 11,500 years ago before they became domesticated. Pigs, sheep, and cattle were domesticated over 10,000 years ago. Crops originate from at least 11 regions of the world. Industrial agriculture based on large-scale monoculture has in the past century come to dominate agricultural output, though about 2 billion people worldwide still depend on subsistence agriculture.

1.6Soil

Soil are a mixture of organic matter, minerals, gases, liquids, and microorganisms that together support life. Earth's body of soil is the pedosphere, which has four important functions:

- it is a medium for plant growth
- it is a means of water storage, supply and purification;

- it is a modifier of Earth's atmosphere;
- it is a habitat for organisms; all of which, in turn, modify the soil.

The pedosphere interfaces with the lithosphere, the hydrosphere, the atmosphere, and the biosphere.(Chesworth and Ward,2008). The term pedolith, used commonly to refer to the soil, translates to ground stone. Soil consists of a solid phase of minerals and organic matter well as a porous phase that holds gases and water (Taylor.et.al,1972).Accordingly, soils are often treated as a three-state system of solids, liquids, and gases(McCarthy David,2006).

Soil is a product of the influence of climate, relief organisms, and its parent materials interacting over time.(Gilluly.et.al,1975).

Soil continually undergoes development by way of numerous physical, chemical and biological processes, which include weathering with associated erosion. Given its complexity and strong internal connectedness, it is considered an ecosystem by soil ecologists.(Ponge and Jean,2015)

Most soils have a dry bulk density ranging between 1.1 and 1.6 g/cm^3,while the soil particle density is much higher, in the range of 2.6 to 2.7 g/cm^3(Yu.et al;2015)

Little of the soil of planet Earth is older than the Pleistocene and none is older than the Cenozoic,(Buol.et.al,2011) although fossilized soils are preserved from as far back as the Achaean(Retallack.et al;2011).

Soils are composed of solid particles of various sizes. In decreasing order, these particles are sand, silt and clay. Every soil can be classified according to the relative percentage of sand, silt and clay it contains

Some soil variables of special interest to agricultural soil science are:

1.6.1 Aeration, porosity and drainage

Atmospheric air contains elements such as oxygen, nitrogen, carbon and others. These elements are prerequisites for life on Earth. Particularly, all cells. Root cells require oxygen to function and if conditions become anaerobic they fail to respire and metabolize. Aeration in this context refers to the mechanisms by which air is delivered to the soil. In natural ecosystems soil aeration is chiefly accomplished through the vibrant activity of the biota. Humans commonly aerate the soil by tilling and plowing, yet such practice may cause degradation. Porosity refers to the air-holding capacity of the soil.

In soils of bad drainage, the water delivered through rain or irrigation may pool and stagnate. As a result, prevail anaerobic conditions and plant roots suffocate. Stagnant water also favors plant-attacking water molds. In soils of excess drainage, on the other hand, plants don't get to absorb adequate water and nutrients are washed from the porous medium to end up in groundwater reserves..

1.6.2 Soil fertility

Soil Fertility it is ability of a soil to sustain agricultural plant growth, i.e. to provide plant habitat and result in sustained and consistent yields of high quality. (Tisdale et al; 1985).

The following properties contribute to soil fertility in most situations:

a) Sufficient soil depth for adequate root growth and water retention.
b) Good internal drainage, allowing sufficient aeration for optimal root growth although some plants, such as rice, tolerate water logging.
c) Topsoil with sufficient soil organic matter for healthy soil structure and soil moisture retention.
d) Soil pH in the range 5.5 to 7.0 suitable for most plants but some prefer or tolerate more acid or alkaline conditions.
e) Adequate concentrations of essential plant nutrients in plant-available forms.
f) Presence of a range of microorganisms that support plant growth

1.6.3Soil pH and alkalinity

Root cells act as hydrogen pumps and the surrounding concentration of hydrogen ions affects their ability to absorb nutrients. pH is a measure of this concentration. Each plant species achieves maximum growth in a particular pH range, yet the vast majority of edible plants can grow in soil with pH between 5.0 and 7.5.

Alkaline soils are clay soils with high pH (> 8.5), a poor soil structure and a low infiltration capacity. Often they have a hard calcareous layer at 0.5 to 1 meter depth. Alkali soils owe their unfavorable physicochemical properties mainly to the dominating presence of sodium carbonate, which causes the soil to swell land difficult to clarify. These soils are also referred to as alkaline sodicsoils.(Keller and David, 2010).

1.7 Sodium Adsorption Ratio (SAR)

Is an irrigation water quality parameter used in the management of sodium-affected soils. It is an indicator of the suitability of water for use in agricultural irrigation, as determined from the concentrations of the main alkaline and earth alkaline cations present in the water. It is also a standard diagnostic parameter for the sodicity hazard of a soil, as determined from analysis of pore water extracted from the soil.

Sodium adsorption ratio" (SAR) is a measure of the amount of sodium (Na^+) relative to calcium (Ca^{2+}) and magnesium (Mg^{2+}) in the water extracted from a saturated soil paste. It is the ratio of the Na concentration divided by the square root of one-half of the Ca + Mg concentration (Oster.et al;1980).

Sodium adsorption ratio (SAR) allows assessing the state of flocculation or of dispersion of clay aggregates in a soil. Sodium and potassium ions facilitate the dispersion of clay particles while calcium and magnesium promote their flocculation. The behavior of clay aggregates influences the soil structure and affects the permeability of the soil that’s directly depends in the water infiltration rate. It is important to accurately know the nature and the concentrations of cations at which the flocculation occur critical flocculation concentration.

The (SAR) parameter is also used to determine the stability of colloids in suspension in water. Although (SAR) is only one factor in determining the suitability of water for irrigation, in general, the higher the sodium adsorption ratio, the less suitable the water is for irrigation. Irrigation using water with high sodium adsorption ratio may require soil amendments to prevent long-term damage to the soil (Dwaf,1996).

If irrigation water with a high (SAR) is applied to a soil for years, the sodium in the water can displace the calcium and magnesium in the soil. This will cause a decrease in the ability of the soil to form stable aggregates and a loss of soil structure and tilth. This will also lead to a decrease in infiltration and permeability of the soil to water, leading to problems with crop production. Sandy soils will have fewer problems, but fine-textured soils will have severe problems if SAR is greater than 9. When (SAR) is less than 3, there will not be a problem (Reeve.et al, 1954).

The concept of (SAR) addresses only the effects of sodium on the stability of soil aggregates. However, high K and Mg concentrations have also negative effects on soil permeability. The effect of potassium can be similarly treated by means of the potassium adsorption ratio (PAR)To take into account simultaneously all major cations present in water, (Sposito Garrison,2008).

Anew irrigation water quality parameter was defined: the cation ratio of structural stability a generalization of SAR.(Smith.et.al,2016).

1.8Quality assessment of groundwater and agricultural soil in Hail region, Saudi Arabia

Amaal.et.al,(2017)assessed the quality of groundwater and agricultural soil in Hail region. The abundance of main cations in ground water was generally in the order $K^+ < Mg^{2+} < Na^+ < Ca^{2+}$, while the order of the anions was $Cl^- > SO_4^{2-} > HCO_3^-$. With respect to TDS, Cl^-, SO_4^{2-}, Na^+, Ca^{2+} concentrations, more than 33% of groundwater samples exceeded the allowable levels cited for drinking water, while about 43% of water samples contained Pb levels higher than the drinking water guidelines.

Assessment of groundwater's quality for irrigation was achieved using several indices as sodium adsorption ratio, Na% and residual sodium carbonate.

Among these, the majority of index results implied that about 97% of the groundwater samples fall within the excellent category. The total metal concentrations in soil samples were ordered as follows: Cd < Pb ≈ Ni ≈ Cu < Cr < Zn < Mn < Fe. According to soil quality guidelines, there is a slight risk from Ni and Zn and a considerable risk from Cd. The geo accumulation, single pollution, Nemerow pollution indices showed that the Cd pollution intensity was significant for agricultural soils.

Table (1.7) Hail Groundwater quality classifications based on RSC, Na% and SAR values.

The measured parameter	**Categories**	**Ranges**	**Percent of samples (present study)**
SAR	Excellent	0–10	96.6% (58 sample)
	Good	10–18	3.3% (2 sample)
	Doubtful	18–26	Nil
	Unsuitable	>26	Nil
Na%	Excellent	<20%	15% (9 samples)
	Good	20–40%	28.3% (17 sample)
	Permissible	40–60%	51.7% (31 sample)
	Doubtful	60–80%	3.3% (2 sample)
	Unsuitable	>80%	Nil
RSC	Good (safe)	<1.25	100%
	Marginal	1.25–2.5	Nil
	Unsuitable	>2.5	Nil

Source (Amaal.et al,2017)

1.9Soil sodium and potassium adsorption ratio along a Mediterranean–arid transect

P.Sarah,(2004) studied the Changes in the relationship between soil soluble ions and rainfall on hills lopes at seven research sites that represent four climatic regions: Mediterranean, semi-arid, mildly arid and arid. At each site, soil samples were taken in several seasons and the ratio between the Na^+ plus K^+ content and the Ca^{2+} plus Mg^{2+} content sodium and potassium adsorption ratio was determined. In general, SPAR increased with increasing aridity except for the most arid site in which the soil contains a gypsum layer. The relationship between SPAR and rainfall was non-linear. A biotic threshold, characterized by a sharp change in the SPAR, was found around the 200 mm isohyets sites that receive less than 200 mm annual rainfall showed significantly higher SPAR than those that receive more than 200 mm, where SPAR was very low.

1.10Salinity and sodium hazards of three streams of different agricultural land use systems in Ile-Ife, Nigeria

O. Ogunfowokan.et.al, (2013) studied three streams (Amuta, Agbogbo and Abagbooro) for salinity and sodium hazards and suitability of the water for irrigational purpose. The three streams are located within areas of three different agricultural practices and land uses. Water samples from the streams were collected twice a month for 1 year. Irrigation water quality parameters assessed included pH, electrical conductivity (EC), sodium adsorption ratio (SAR), percentage sodium, permeability index and potential salinity. Water samples were analyzed using standard chemical procedures. Results of the irrigation water quality parameters studied showed that water samples from the three streams do not exhibit toxicity problem in relation to salinity and sodium hazard. Although the data obtained for the three catchment areas for pH, EC and SAR were closely related, least concentrations of these irrigation water indices were obtained for Abagbooro stream where there is secondary forest; highest concentrations were found in Agbogbo stream and moderate values were obtained for water from Amuta stream where subsistent and mechanized farming are practiced, respectively.

Table (1.8) General classification of irrigation water based upon SAR values.

SAR	**Category**	**Precaution and management suggestions**	**Range in Amutaa**	**Range in Agbogboa**	**Range in Abagbooroa**
0–10	**1 (low Na water)**	**Little danger**	**1.32–8.28**	**1.41–9.07**	**1.04–8.46**
10–18	**2 (medium Na water)**	**Problems on fine texture soils and sodium sensitive plants, especially under low-leaching conditions. Soils should have good permeability**	–	–	–
18–24	**3 (high Na water)**	**Problems on most soils. Good salt tolerant plants are required along with special management such as the use of gypsum**	–	–	–
24	**4 (very high Na water)**	**Unsatisfactory except with high salinity (>2.0 dS/m), high calcium levels and the use of gypsum**	–	–	–

Source (O. Ogunfowokan.et al ,2013).

1.11 Salinity and sodicity hazard in water flow processes in the soil.

F. Burger and A. Č Elková, (2003) studied the distribution of salinity characteristics (electrical conductivity and sodium adsorption ratio) of groundwater, and based on the results, the reported the evaluation of the salinity and sodicity hazards in the fluctuation processes of shallow mineralized groundwater, if such groundwater is used for irrigation.

The study included the soil-water environment in the south-east of the Danube Lowlands for the period 1991 to1994. The measured data and data taken from archives were processed in the form of graphical attachments (appendixes, supplements, graphical documentation) – maps, by means of the kriging inter polation method. Groundwater in the area in question is classified as highly mineralized with a high hazard of salinisation of the subsurface soil environment. The average annual values of the electrical conductivity of groundwater ranged from 600 to 2100 μS/cm in the examined period.

The sodium adsorption ratio values were found to be1.7 to 22.0 and indicate low, medium to high sodium salinisation of the environment due to groundwater. The distribution of electrical conductivity and sodium adsorption ratio on the regional scale can serve as a reference basis for the evaluation of changes in the groundwater salinity after 1994

The objectives of the study area:

1. To measure Sodium Adsorption Ratio(SAR) for irrigation water and agricultural soil in Seleit Agricultural Scheme
2.
3. To measure the macro minerals contents in irrigation water and agricultural soil of the Scheme.
4. To determine the concentrations of some toxic minerals in irrigation water and agricultural soil in the Scheme.
5. To measure the concentrations of anions (chloride, nitrate and sulfate) in irrigation water and agricultural soil, because these ions are responsible for soil and irrigation water salinity.

Chapter Two

Materials and Method

Chapter two

2. Materials and Method

2.1 Materials

2.1.1 Collection of samples

Thirty Soil samples were collected from ten different farms, cultivated with various types of crops. Three samples were obtained from each farm at the begging, the medial and the end of the farm. 5 grams from each three samples of each crop area were weighed and mixed to obtain ten composite soil samples for each farm. Table (2.1) showed the type of the crops cultivated in each farm.

Ten irrigation water samples were collected from 10 pumps which are used as main sources of irrigation for each farm

Table (2.1) Type of crops in each farm in the study area.

Composite soil sample(No)	**Type of crop**
S1	Animal feed
S2	Beans
S3	Orange
S4	Animal feed
S5	Lemon
S6	plum
S7	Grapefruit
S8	Tomatoes
S9	Bressem
S10	Hot pepper

2.1.2 Chemicals

- Nitric acid (69%) Loba Chemie PVT-LTD,Mumbai-India
- Hydro fluoric acid (40%). Mumbai-India. Product No.4150
- Hydrochloric acid (35-38%).Mumbai-India. Product No.38507
- Diphenylcarbzone indicator (99-95%). Hopkin&Williams Ltd.
- Mercury nitrate .98%.Hopkin &Williams Ltd.Caweell-Heath –Essex -England
- Phenol(99-95%)CarloerbaReactifs –SDS ,CE :200-467-2
- Sulfuric acid (95-98%). Mumbai-India. Product No.9853
- Ammonia solution(25-28%). LobaChemie PVT-LTD,Mumbai-India
- Barium chromate 98%.Hopkin &Williams Ltd.Caweell-Heath –Essex -England

2.1.3 Instruments:-

- Inductively coupled plasma(ICP-OES725ES)(Vista-MPX-CCD)
- Microwave(Multi wave PRO)
- (UV-VIS)Spectrophotometer Model-(HACH)2000DR
- Sensitive balance(GH252)UK

2.2 Methods of analysis

2.2.1 Preparation of water samples

1ml of conc. nitric acid (69%) was added to 10ml of each water samples.The solution was filtered withashless filter paper. The clean filtered was then used for Inductively coupled plasma(ICP) analysisto measuring the mineral content in each water sample.

2.2.2Preparation of soil samples

3ml of Hydro fluoric acid(40%) , 2ml of Hydrochloric acid (37%) and 6ml of Nitric acid(69%) were added to 0.5g of each soil sample. The sample mixture was objected in microwave then the solution was transferred into 50ml volumetric flask and the volume was completed to the mark .Inductively coupled plasma instrument was used for measuring the mineral content in each soil sample

2.2.3 Determination of Chloride in soil and water samples

1ml of nitric acid and 0.2ml of indicator were added to 50 ml of water and dissolved soil samples in 250ml conical flask the color was changed from blue to yellow. The solution was titrated against Mercury nitrate and endpoint to the constant volume was recorded and calculated concentration of chloride

2.2.4 Determination of Nitrate in soil and water samples

25ml of water and dissolved soil sample was placed in water path after the evaporation process was completed, the sample was extracted and dissolved by disolfonic acid (Sulfuric acid was dissolved in Phenol). then 10ml of water was added and transferred the solution to test tube 50ml then 3ml of ammonia was added and the volume was completed to the market The solution was read in 410nm wave length by Spectrophotometer (UV-VIS).

2.2.5 Determination of Sulfate in soil and water samples

1ml of hydrochloric acid was added to 50ml of water and dissolved soil sample in 150ml conical flask then the solution was heated and boiled to 5min. 2.5ml of barium chromate was added to solution and boiled again for 5min when thevolume of solution became 25ml ammonia1:1 was added and then the solution was transferred to color comparison tube 50ml and added water to solution and shake uniformly. The solution was filtered and read in440nm wave length by Spectrophotometer (UV-VIS).

Chapter Three

Results and Discussions

Chapter Three

3. Results and Discussions

3.1 Macro minerals content of water samples

Macro minerals in water samples showed different concentrations of potassium, phosphor and magnesium which were relatively medium in all samples. Silicon have high concentrations in sample (1) but in other samples the concentrations ranging between (4.50-23.86). Sodium in water samples have low concentrations but Calcium concentrations were relatively high. Table (3.1).

Table (3.1) Macro minerals content of water samples (ppm)

Element	1	2	3	4	5	6	7	8	9	10	Average
P	0.5005	0.004732	0.1825	0.1593	0.1772	0.1434	0.1308	0.1822	0.1343	0.3697	0.1984
Na	0.5985	0.5512	0.4238	0.3118	0.3298	0.6611	1.428	0.5042	1.535	2.357	0.87
K	8.425	4.842	3.22	3.069	3.622	2.558	2.703	3.467	2.679	3.48	3.80
Mg	31.95	13.55	8.256	7.720	8.596	8.349	8.646	8.458	8.657	11.95	11.61
Si	131.2	15.49	7.779	7.382	7.356	4.509	6.702	7.892	6.785	23.86	21.89
Ca	115.9	53.72	31.75	31.35	37.72	35.83	31.25	34.03	31.15	35.5	43.82

3 .2 Micro minerals content in water samples

Irrigation water content of micro minerals was found to be very low in all samples. Cobalt, chromium, copper, molybdenum, lithium and nickel have same concentrations in all the analyzed water samples, which were very low. Their concentrations were at the least detection limits. Manganese, titanium, and zinc showed different concentrations, but they were also very low. (Iron) have different concentrations in etch samples and it high concentrations in sample (No.1) as (59.250ppm). Iron concentrations may be lower than that expected in any water samples. Most of these minerals have no importance in irrigation water and their low availability may be considered as an advantage from quality point sight of view. This type of irrigation therefore may be described as safe and good quality. So the agricultural products may not contain any risky levels of these elements. Table (3.2)

Table (3.2) Micro minerals content in water samples(ppm)

Element	1	2	3	4	5	6	7	8	9	10	Average
Ni	0.0000674	0.0000674	0.0000674	0.0000674	0.0000674	0.0000674	0.0000674	0.0000674	0.0000674	0.0000674	0.0000674
Co	0.000198	0.000198	0.000198	0.000198	0.000198	0.000198	0.000198	0.000198	0.000198	0.000198	0.000198
Mo	0.000277	0.000277	0.000277	0.000277	0.000277	0.000277	0.000277	0.000277	0.000277	0.000277	0.000277
Cu	0.000298	0.000298	.000298	0.000298	0.000298	0.000298	0.000298	0.000298	0.000298	0.000298	0.000298
Cr	0.000583	0.000583	0.000583	0.000583	0.000583	0.000583	0.000583	0.000583	0.000583	0.000583	0.000583
Li	0.001279	0.001279	0.001279	0.001279	0.001279	0.001279	0.001279	0.001279	0.001279	0.001279	0.00127
Zn	0.0213	0.000112	0.000112	0.000112	0.000112	0.0068	0.0027	0.0038	0.0026	0.0035	0.0041
Se	0.004993	0.004993	0.004993	0.004993	0.004993	0.004993	0.004993	0.004993	0.004993	0.004993	0.004993
Ti	0.2259	0.000147	0.0015	0.0012	0.0048	0.001	0.0012	0.0070	0.0013	0.0453	0.028
Mn	0.4776	0.000075	0.000075	0.000075	0.000075	0.000075	0.000075	0.0111	0.000075	0.1791	0.066
Fe	59.250	0.000763	0.1031	0.0510	0.7934	0.005	0.0317	1.168	0.0459	10.3	7.17

3.3. Toxic elements in water samples

The toxic or hazardous mineral content of Seleit irrigation water samples may be described as very low especially beryllium, barium, cadmium, lead, antimony and tin. Aluminum showed different concentrations in analyzed samples, but these concentrations were all below the expected hazardous levels. Aluminum as one of the most available element in earth crust is expected to show high concentrations in surface water. Arsenic was at the lowest detection limit concentrations expect in only one sample showed high concentrations but other samples same concentrations. Beryllium and Cadmium have the lowest concentrations in all samples. These results may indicate that the irrigation water used in Seleit scheme are very good quality and very safe for irrigation and can be even safe for human consumption and general uses. Table (3.3).

Table (3.3). Toxic elements in water samples (ppm)

Element	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**Average**
Be	**0.000030**	**0.000030**	**0.000030**	**0.000030**	**0.000030**	**0.000030**	**0.000030**	**0.000030**	**0.000030**	**0.000030**	**0.000030**
Cd	**0.000198**	**0.000198**	**0.000198**	**0.000198**	**0.000198**	**0.000198**	**0.000198**	**0.000198**	**0.000198**	**0.000198**	**0.000198**
As	**0.002547**	**0.002547**	**0.002547**	**0.002547**	**0.002547**	**0.002547**	**0.002547**	**0.002547**	**0.002547**	**0.002547**	**0.002547**
Pb	**0.004727**	**0.004727**	**0.004727**	**0.004727**	**0.004727**	**0.004727**	**0.004727**	**0.004727**	**0.004727**	**0.004727**	**0.004727**
Sb	**0.006078**	**0.006079**	**0.006080**	**0.006081**	**0.006082**	**0.0053**	**0.0049**	**0.0049**	**0.0044**	**0.0051**	**0.0055**
V	**0.0299**	**0.000099**	**0.0061**	**0.0056**	**0.005**	**0.0067**	**0.0054**	**0.0073**	**0.0055**	**0.00141**	**0.0073**
Sn	**0.009724**	**0.009724**	**0.009724**	**0.009724**	**0.009724**	**0.0062**	**0.0057**	**0.0053**	**0.0055**	**0.0061**	**0.0077**
Ba	**0.1052**	**0.00057**	**0.0063**	**0.0055**	**0.0138**	**0.0122**	**0.0071**	**0.0146**	**0.007**	**0.023**	**0.0195**
Sr	**0.1399**	**0.0628**	**0.0486**	**0.0475**	**0.0631**	**0.0558**	**0.0167**	**0.0411**	**0.0172**	**0.0286**	**0.052**
Al	**12.95**	**0.0336**	**0.0683**	**0.0307**	**0.1966**	**0.0208**	**0.0337**	**0.271**	**0.0393**	**1.801**	**1.54**

3.4 Macro minerals in soil samples

Macro minerals calcium, magnesium, sodium, potassium and phosphor showed high concentrations their availability in agricultural soil is a high essentially. Potassium and phosphor sometimes added to agricultural soil as fertilizers, to satisfy plant requirement for growth. Magnesium is very important according to it^{s} basic rate as chlorophyll constituent.

The results obtained by this study showed that agricultural soil in Seleit scheme were very rich with five macro minerals. Calcium showed the highest concentrations followed by magnesium and this may be an indication of clayey formation of the soil. Potassium was the third element available cation in composite soil samples. Sodium and phosphorous concentrations were found to be generally high and may be quite enough to supply the different cultivated plant with their requirements Table (3.4).

Table (3.4) Macro minerals in soil samples (ppm)

Element	1	2	3	4	5	6	7	8	9	10	Average
P	355.9	507.6	523.8	350.4	391.8	560.0	1190	285.3	294.1	328.3	478.72
Na	1189	1905	1511	1234	1678	2593	3474	2272	981.6	975.60	1781.32
K	2151	2516	2670	1740	2264	2887	3116	2210	734.4	1549	2183.74
Mg	7425	7645	6 518	5016	8366	8754	7022	7764	2316	4702	6552.8
Ca	15668	17876	15939	12962	18567	25009	16550	21979	6673	8776	15999.9

3.5Micro minerals in soil samples

Micro minerals concentrations in the analyzed composite soil samples may be categorized as high, relatively high and low concentrations. Iron showed significantly high concentration in soil samples followed by titanium and manganese. nickel, copper, cobalt and zinc showed relatively high concentrations, which may be suitable to satisfy the plant requirements. Chromium showed significantly different concentrations in the different samples. But surprisingly lithium showed unexpected concentrations in all samples with almost similar values. Selenium and molybdenum as real trace elements showed low concentrations in all samples. Table (3.5) .

Table (3.5) Microminerals in soil samples (ppm)

Element	1	2	3	4	5	6	7	8	9	10	Average
Mo	**0.000277**	**0.000277**	**0.000277**	**0.000277**	**0.000277**	**0.000277**	**0.000277**	**0.000277**	**0.000277**	**0.000277**	**0.000277**
Se	**0.5993**	**0.004993**	**0.0400**	**0.4593**	**0.2000**	**0.004993**	**0.004993**	**0.004993**	**0.004993**	**0.004993**	**0.132**
Li	**13.72**	**13.81**	**11.55**	**12.2**	**14.58**	**13.96**	**12.19**	**12.70**	**9.378**	**11.29**	**12.53**
Co	**23.53**	**19.79**	**21.59**	**19.11**	**21.70**	**26.915**	**30.881**	**18.770**	**21.976**	**17.459**	**22.17**
Cu	**27.85**	**25.14**	**23.09**	**21.35**	**26.65**	**31.070**	**33.34**	**24.02**	**23.12**	**21.21**	**25.68**
Cr	**0.000583**	**11.9**	**0.7995**	**66.09**	**21.00**	**35.79**	**5.797**	**20.17**	**73.99**	**81.70**	**31.72**
Zn	**44.27**	**42.81**	**42.75**	**34.05**	**39.99**	**54.35**	**63.76**	**34.98**	**36.29**	**39.19**	**43.24**
Ni	**70.74**	**67.28**	**62.22**	**65.22**	**68.83**	**66.47**	**65.54**	**61.24**	**66.87**	**60.73**	**65.51**
Mn	**605.2**	**369.3**	**722.3**	**376.1**	**462.2**	**616.0**	**627.1**	**421.0**	**481.6**	**421.4**	**510.22**
Ti	**5177**	**4598**	**4450**	**4025**	**4730**	**6120**	**6257**	**4296**	**4344**	**4182**	**4817.9**
Fe	**29163**	**25483**	**23864**	**21224**	**27972**	**35011**	**38695**	**28073**	**39990**	**22211**	**29168.6**

3.6 Toxic elements in soil samples

Toxic minerals showed generally low concentrations in the composite soil samples. The highest concentrations were presented by aluminum, But high aluminum content of soil may be considered as normal because it's normal high availability in earth crust. Barium and Strontium concentrations may be at risky levels, if they farm considerable concentrations in the final cultivated crops. Boron concentrations may be considered fair, since the element is important for plants at cation level. Vanadium showed relatively high concentration in all samples. Such concentrations may not be expected in soil for vanadium as a trace element. Elements which are normally classified as toxic exhibit very low availability in all the analyzed soil samples. these are normally beryllium cadmium arsenic, lead, tin and Antimony. Table (3.6)

Table (3.6) Toxic elements in soil samples (ppm)

Element	1	2	3	4	5	6	7	8	9	10	Average
Cd	0.000198	0.000198	0.000198	0.000198	0.000198	0.000198	0.000198	0.000198	0.000198	0.000198	0.000198
Pb	0.004727	0.004727	0.004727	0.004727	0.004727	0.004727	0.004727	0.004727	0.004727	0.004727	0.004727
Sb	0.006078	0.2399	0.006078	0.006078	0.006078	0.5199	1.439	0.006078	1.760	0.799	0.4788
Sn	0.009724	0.009724	0.009724	0.009724	0.009724	8.278	0.009724	0.009724	0.009724	0.009724	0.836
Be	0.9988	0.9194	0.7795	0.8387	1.020	1.08	1.039	0.859	0.900	0.819	0.925
As	0.002547	7.036	13.19	3.794	10.4	0.002547	2.978	7.728	20.08	16.2	8.14
B	11.27	13.67	10.51	17.17	11.560	22.2	23.45	26.56	15.76	9.65	16.18
Sr	85.88	117.7	89.47	76.84	105.6	123.7	107.6	107.4	38.21	53.18	90.55
V	145.4	122.6	111.2	111.9	130	159.4	147.0	123.8	137.9	100.6	128.98
Ba	171.2	142.4	160.0	106.0	1419.0	149.0	145.6	126.9	67.79	99.18	258.7
AI	36322	32886	27649	22750	33619	33419	26730	29938	14287	20901	27850.1

3.7SAR values of water samples

In Table (3.7) Sodium adsorption ratios were calculated for ten irrigation water samples. The lowest value was shown by samples (W5 and W1) as (0.0685) and (0.0696) respectively. The highest value shown by samples (W9 and W10) as (0.342 and0.483) respectively and the average of SAR for the ten water samples were found to be (0.161ppm). Sodium adsorption ratios value were found to be less than the recommended guideline value which is (<3) (Reeve.et al; 1954).

Table (3.7) SAR values of water samples (ppm)

Sample No	**Element concentrations(ppm)**			**SAR values**
	Na	**Ca**	**Mg**	
W1	**0.5985**	**115.9**	**31.95**	**0.0696**
W2	**0.5512**	**53.72**	**13.55**	**0.095**
W3	**0.4238**	**31.75**	**8.256**	**0.094**
W4	**0.3118**	**31.35**	**7.720**	**0.070**
W5	**0.3298**	**37.72**	**8.596**	**0.0685**
W6	**0.6611**	**35.83**	**8.349**	**0.140**
W7	**1.428**	**31.25**	**8.646**	**0.147**
W8	**0.5042**	**34.035**	**8.458**	**0.109**
W9	**1.535**	**31.15**	**8.657**	**0.342**
W10	**2.357**	**35.5**	**11.95**	**0.483**
Average	**6.0751**	**43.82**	**11.612**	**0.161**

3.8 SAR values of soil samples

When compared to irrigation water of Seleit schemethe soil samples showed significantly high sodium adsorption ratio, ranging from 10.11as the lowest value in sample (S9) to (32.00) as the highest value in sample (S7), with average value (16.21). The crop grown in sample (S9) was (Bressem) and that in sample (S7) was(Grapefruit).

The result obtained indicated that the soil samples in study area are rich in calcium and magnesium whereas sodium concentrations are relatively low. There is no accepted guideline value of sodium adsorption ratio (SAR) for agricultural soil (Table 3.8)

Table (3.8) SAR values of soil samples(ppm).

Samples No	**Element concentrations(ppm)**			**SAR values**
	Na	**Ca**	**Mg**	
S1	**1189**	**15668**	**7425**	**11.06**
S2	**1905**	**17876**	**7645**	**16.86**
S3	**1511**	**15939**	**6518**	**14.26**
S4	**1234**	**12962**	**5016**	**13.01**
S5	**1678**	**18567**	**8366**	**14.40**
S6	**2593**	**25009**	**8754**	**19.96**
S7	**3474**	**16550**	**7022**	**32.00**
S8	**2272**	**21979**	**7764**	**18.63**
S9	**981.6**	**6673**	**2316**	**10.11**
S10	**975.60**	**8776**	**4702**	**11.8**
Average	**1693.51**	**15210.06**	**6129.62**	**16.21**

(3.9) Concentrations of anions (CI^-, NO_3^- and SO_4^{-2}) in water samples

The concentrations of (CI^{--}, NO_3 and SO_4^-2) ions in irrigation water samples were generally low Table (3-9), sulfate ions concentrations were higher than that of chlorides and nitrates. there for the irrigation water salinity may be described as low. On the other hand, this type of water may be classified as sulfates water. Concentrations of chloride in water it falls in permissible range (below 70) it safe for all plant (Mass,1990).

Concentration of nitrate in water fall permissible range below (<10) (T.A. Bauder.et al; 2014) except sample W9 (12.20) was high may be to fertilizer, they effected in soil and plant. As for the Concentrations of sulfates in water samples it did not exceed the permissible limits and thus did not pose a danger to soil and plant (T.A. Bauder. et.al 2014).

Table (3.9) Concentrations of anions (CI^-, $NO_3^-$and SO_4^{-2}) in water samples

Sample No	CI^{--}	NO_3	SO_4^{-2}
W1	2.80	10.00	13.13
W2	2.80	2.70	13.82
W3	3.40	2.80	12.65
W4	2.00	4.90	25.32
W5	2.60	7.50	23.15
W6	2.20	7.50	21.24
W7	8.70	6.20	22.26
W8	2.50	2.70	10.48
W9	9.10	12.20	8.96
W10	10.60	9.20	11.06
Average	4.67	6.57	14.2

3.10 Concentrations of anions (CI^{--}, NO_3^- and SO_4^{-2}) in soil samples

The analyzed soil samples showed relatively low Chlorides and Nitrates concentrations, with limited exception in sample (S3). Sulfate concentrations were different from sample to another ranging from (9.93ppm) to (66.49ppm). it be look to soil, sulfate concentrations compared to that of Calcium and Magnesium it may indicate that the soil composition is dominated by calcium and magnesium (Table (3.4). Sulfate taking in consideration that ($MgSO_4$) is more soluble than ($CaSO_4$).

At the same time the higher (Ca^{+2}) availability may indicate high gypsum formation of the area. Normally soils with high sodicity and (SAR) are treated with gypsum so the soil in study area may describe as good soil.

Table (3.10). Concentrations of anions (CI$^-$, NO_3^- and SO_4^{-2}) in soil samples

Sample No	**CI^{--}**	**NO_3**	**SO_4^{-2}**
S1	**4.70**	**2.84**	**14.93**
S2	**2.30**	**0.24**	**9.93**
S3	**8.90**	**16.68**	**66.49**
S4	**1.50**	**0.12**	**41.64**
S5	**2.30**	**0.31**	**33.61**
S6	**3.10**	**0.42**	**43.63**
S7	**2.10**	**2.11**	**63.34**
S8	**4.43**	**0.32**	**36.42**
S9	**1.90**	**0.43**	**54.61**
S10	**2.90**	**0.51**	**61.39**
Average	**3.41**	**2.39**	**42.5**

Conclusion

- Depending on the obtained result the irrigation water of Seleit Agricultural Scheme may be classified as good from quality criteria sight of view.
- The anionic contents of the irrigation water as chloride nitrate and sulfate were relatively low when compared to concentrations of calcium and magnesium cations. This may indicate that the irrigation water samples are mainly bicarbonate water, since calcium and magnesium bicarbonate are readily soluble salts.
- The significantly high concentrations of calcium and magnesium in the analyzed soil samples, as well as, the relatively high sulfate concentrations, may be taken as, geochemical indication to suggest, that, the agricultural soil of AlSeleit scheme are dominated by gypsum, calcite, magnicite dolomite or magnesium sulfate.
- Sodium adsorption ratios for soil samples were found to be different from field to another and this may affect the growth of some types of crops.

Recommendations

- Further studies may be needed to determine the effect of sodium adsorption ratios (SAR) on the quality and quantity of crops production
- Geochemical investigations may be required to give clear information about salinity, alkalinity and sodicity of the agricultural soil throughout AlSeleit scheme area.
- Sodium Adsorption Ratio determination should be considered as an essential parameter for determining irrigation water and agricultural soil quality.
- Treatment of soil affected by increasing of sodium adsorption ratio by adding gypsum as ($CaSO_{4.}$) may be needed.

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