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Residual Sodium Carbonate in Soil and Irrigation Water in Elsaggai Agricultural Scheme

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

متبقي كربونات الصوديوم في التربة ومياه الري بمشروع السقاي الزراعي

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January 2019

Approval page

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إستهلال

قال تعالى :

(الَّذِي جَعَلَ لَكُمُ الْأَرْضَ فِرَاشًا وَالسَّمَاءَ بِنَاءً وَأَنْزَلَ مِنَ السَّمَاءِ مَاءً فَأَخْرَجَ بِهِ مِنَ الثَّمَرَاتِ رِزْقًا لَكُمْ فَلَا تَجْعَلُوا لِلَّهِ أَنْدَادًا وَأَنْتُمْ تَعْلَمُونَ)

صدق الله العظيم ، البقرة اية (٢٢)

Dedication

To my parents,

husband ,

brothers and sisters

Acknowledgement

Praise to Allah Almighty, the Merciful , for giving me health and patence to complete this work .

My appreciation and thanks to my supervisor

Dr. Omer Adam Mohamed Gibla for his supervision,

Continuous encouragement and valuable advice .

My Thanks are also to all those who, contribute to me in the completion for their more support

Abstract

The aim of this study was to determine the Residual Sodium Carbonate value for evaluating irrigation water quality and soil characteristics in Elsaggai agricultural Scheme at Khartoum North (Sudan). pH value and electrical conductivity were measured for irrigation water samples, (EC) of water sample was between (250-1090) µs/cm. Nile water pH was slightly alkaline (7.20-7.50). Sulfate and nitrate ions concentrations were determined by UV-VIS spectrometry, the concentrations of sulfate were somewhat high in water and soil samples the mean values were (135.5,1320.23 mg/l) respectively, Chloride ions content and total alkalinity were determined titrametrically, for water and soil samples, have been relatively low in water and soil samples the mean value of Cl^- and the concentrations of total alkalinity (2.67, 3.09) mg/l respectively were relatively high (121.09 - 399.69) mg/l in water sample but in soil sample the concentrations were relatively in the same range (121.80-136.10) mg/l. Inductively coupled plasma analysis was carried for investigation of the major elemental contents of irrigation water and soil were found in samples, while for concentration of (Na, Ca, Mg, K and P) the mean value (10.87, 20.44, 10.87, 2.76 and 0.452)mg/l and (48.49, 10.87, 80.03, 122.08, and 229.76), for water and soil sample respectively The obtained concentrations of micronutrients and toxic minerals generally were of low concentration.

The total alkalinity(74.65,399.693)mg/l calcium (56.66.76.15)mg/l and magnesium (26.341,44.83)mg/l concentrations were used to calculate the residual sodium carbonate value(1.44 ,-6.72) in water and soil sample The results show, that, the irrigation water quality and soil characteristics were within the permissible range.

المستخلص

هدفت هذه الدراسة لتقدير قيمة متبقي كربونات الصوديوم لتقييم جودة مياه الري وخصائص التربة لمشروع السقاي الزراعي بالخرطوم بحري (السودان) .تم قياس قيمة الرقم الهيدروجيني والتوصيل الكهربي لعينات مياه الري . وكانت التوصيلية الكهربية لعينة المياه بين (250-1090)µs/سم وكانت درجة الحموضة في مياه النيل قليلة القلوية حيث تتراوح بين (7.20-7.50) وتم استخدام جهاز مطيافية الضوء فوق البنفسجي والمرئي لتقدير تركيز الكبريتات والنترات ، كانت تركيزات الكبريتات مرتفعة إلى حد ما في عينات الماء والتربة وكانت القيم المتوسطة (135.5،132.23 ملجم / لتر) على التوالي والنترات منخفضة نسبيًا في عينات الماء والتربة.تم تقدير الكلوريد والقلوية الكلية بالمعايرات لعينات مياه الري و التربة ، ووجد ان تراكيز الكلوريد منخفض بصورة واضحة في عينات الماء والتربة وكانت القيمة المتوسطة لـ-Cl^- 3.09 ، 2.67) ملجم / لتر على التوالي ، وايضا وجدت تراكيز القلوية الكلية مرتفعة نسبياً (بين 121.09 - 399.69) ملجم / لتر في عينات المياه ولكن في عينات التربة كانت التراكيز متشابهة نسبيا (بين 121.80 - 136.10) ملجم / لتروأستخدم جهاز بلازما الحث المزدوج لاستقصاء المحتوى المعدني الغالب في مياه الري والتربة بينما تم العثور على تركيز (Na، Ca، Mg، K،P) في القيمة المتوسطة (10.87 ، 20.44 ، 10.87 ، 2.76 ، 0.452) ملجم / لتر و (48.49 ، 10.87 ، 80.03 ، 122.08 ، 229.76) ملجم /لتر لكل من عينات الماء والتربة على التوالي وتم ايجاد تراكيز المغذيات الدقيقة والمعادن السامة منخفض بشكل عام

تم استخدام تراكيز القلوية الكلية (74.65 ، 399.69) ملجم / لتر ، الكالسيوم (76.15,56.66) ملجم / لتر والمغنيسيوم (44.8,26.341) ملجم / لتر لحساب قيمة كربونات الصوديوم المتبقية (1.44 ، 6.72-) في الماء والتربة .وقد أظهرت النتائج أن جودة مياه الري وخصائص التربة كانت ضمن المدى المسموح به

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Abbreviate List

Abbreviation	Scientific Term
RSC	Residual Sodium Carbonate
SAR	Sodium Adsorption Ratio
SP	Sodium Percentage
PI	Permeability Index
MC	Magnesium Content
BN	Sample code
JRA	Sample code
HKP	Sample code
PNA	Sample code
PJ	Sample code

CHAPTER ONE

Introduction

Chapter One

Introduction

The Study Area

Elsaggai is located in the northern part of capital Khartoum ,along the Shindic hallenge road ,it an area of plains and valleys, inhabited by number of postural tribes .which depends on agriculture as a source of livelihood ,It includes the agricultural irrigation project with an area of 3000 acres ,It is cultivated by traditional ways and irrigated from the Nile water through pumps, the main crops produced by the project are feed animalFig.1 and some of horticultural crops (green pepper ,tomatoes ,okra, anions Fig.2) but are produced in quantities almost cover the area ,feeder are produced more than other

Average maximum monthly temperatures range from 29.9°C in January to 39.6°C in May with average value of 34.5°C. The minimum average monthly temperatures vary from 13.3°C, in January, to 24.7°C in June with an average value of 20.3° C for the same period.

Rainfall is low normally around 386mm and is unequally distributed. The rainy season normally extends from June/July to September/October. However, the period between the first and last useful rains is limited to 70 to 90 days only

Fig 1.1 .green onion farm at the scheme

Fig 1.2. Part from animal feed farm

Chapter One

1.1-Irrigated agriculture

Irrigated agriculture is of a major importance in many countries all over the world. It is important in terms of food security, public development, and settlement for rural people. As world population growths rapidly, the need for more effective and efficient use of land and water resources is increasing (FAO, 2017). Despite their potential for agricultural growth, there is a remarkable decrease in the performance of several irrigation projects, especially large-scale systems, which are usually perform far below their potential capacity (Alcon et al., 2017; Bos et al., 2005; Dejen, 2015; Murray-Rust and Snellen, 1993). This is mainly due to poor resource management, absence of the planned benefits, and negative health and environmental impacts (Biswas, 1990). This situation has resulted in an increased interventionsto improve irrigation projects performance. Many studies were conducted to investigate the performance assessment and diagnosis in irrigation systemsin worldwide regions of Asia, Africa, Europe, and South America . These studies cover several irrigation projects all over the world in the developed and developing countries e.g. China, India, Spain andSudan (Bouml et al., 2009; Gorantiwar et al., 2005; Molden et al., 1998; Murray-Rust and Snellen, 1993). The purpose of performance assessment is to achieve efficient and effective use of resources by providing relevant feedback to all management at levels (Bos et al., 2005; Small and Svendsen, 1992). Moreover, it helps in obtaining useful information about the corrective actions that may be taken to maximize the benefits of irrigation projects. Performance evaluation could help in verifying the relevant project lessons learned and developing benchmarks to improve planning, implementation, and management of similar projects (Bastiaanssen and Bos, 1999;

Bos, 1997).Performance evaluation assists in improving the efficiency of irrigation systems (PEOPC, 2010). The process of performance evaluation is complicated, since a large number of regular tasks must be performed, both concurrently and sequentially, and these tasks should be coordinated within available resources constraints (Biswas, 1990; Small and Svendsen, 1992). In order to enhance this process, many efforts have been assigned to evaluate the effects of such interventions or to enhance understanding of performance so that, further improvement might be introduced (Alcon et al., 2017; Bos et al., 2005; Small and Svendsen, 1992; Sun et al., 2017). Much has been written, including theories, methodologies, and frameworks related to irrigation performance assessment. It is time to review and evaluate what has been written in order to provide better understanding and enabling practitioners to select and apply suitable evaluation procedures that fit their needs.

In total, the irrigation performance assessment includes different levels, starting from strategic goals, through operation process, and ending with customer satisfaction with outputs. This can be described as an indicator for resources management of the irrigation schemes. By measuring this indicator, irrigation systems efficiency and sustainability can be observed and monitored through different levels.

1.2- Agriculture in Sudan

Agriculture in Sudan is the principal source of income and livelihood forbetween 60%to 80% of the population, and the engine of growth for other economic sectors such as trade, industry and transport.The expected results of agricultural development should be to create more job opportunities. This would make rural areas more habitable and reduce internal migration to cities, resulting in stable food security status and poverty reduction. Moreover, a sound agricultural base would balance distribution of the benefits of the least developed ones. This does not currently apply to the agriculturesector in Sudan. It has failed to fulfill such objectives.Sudan is endowed with large areas of cultivable land, which are situated between the Blue Nile and the White Nile, and in the region between the Blue Nile and the Atbara River. Other regions with cultivable land are the valleys of the plains, where irrigation is extensively used, and in the narrow Nile valley,this land has different uses, Arable land constitutes approximately one-third of total area of the country, of which 21% is cultivated with fluctuating productivity but the output remains far below the potentialperformance. More than 40% of the total area consists of pasture and forests.Subsistence farming and commercial production for local consumption (FaridaMahgoub, 2018)

1.3- Irrigation Water Quality

The understanding knowledge,of irrigation water quality is critical to the management of water for long-term productivity. Irrigation water quality is related to its effects on soils and crops and its management. High quality crops can be produced only by using high-quality irrigation water keeping other inputs optimal. Irrigation watercharacteristicsthat define its quality vary with source of the water (APHA,2005). There are some differences in water characteristics, based mainly on geology and climate. There may also be great differences in the quality of water available on a local level depending on ,whether, the source is from surface water bodies ,such as, rivers and ponds or from groundwater aquifers, with varying geology, and whether the water has been chemically treated or not (Ayers &Westcot,1994; Nahid et al.,2008). The chemical constituents of irrigation water can affect plant growth directly through toxicity or deficiency, or indirectly by altering nutrients availability to the plants (Ayers and Westcot, 1985; Rowe et al., 1995; Islam and Shamsad,2009).

Analytical procedures for the laboratory determinations of water quality have been written in several publications. Table (1.1) shows the guidelines for interpretations of water quality for irrigation as reported by (Ayers and Westcot ,1985).The chemicals guidelines act as management tools and practical guidelines that have been used successfully in general irrigated agriculture for evaluation of the common constituents in surface water, ground water, drainage water, sewage effluent and waste water. They are the first step in pointing out the quality limitations of water supply.

Table (1.1) also shows the degree of restriction of chemical parameters on the use of irrigation water. A restriction on use,indicates, that there may be a limitation in choice of crop or special management need to maintain full production capability. However, a "restriction on use" does not indicate that, water is not suitable for use.

Irrigation water normally, contains some soluble salts irrespective of its source. The suitability of waters for a specific purpose depends on the types and amounts of the dissolved salts. Some of the dissolved salts or other constituents may be useful for crops. Quality or suitability of waters for irrigation purposes is assessed in terms of the presence of undesirable constituents, and only in limited situations, irrigation water is assessed as a source of plant nutrients. Some dissolved ions, such as NO_3^-, are useful for crops. The primary goal of water analysis is to examine the effect of water on the soil, and ultimately on the plants grown on the soil. Much of the interpretation of the water analysis is based on a prediction of the consequences for soil. Typically,irrigation water quality is assessed based on the salt and salt inducing contents, the presence and abundance of micro and macro nutrients, trace elements, alkalinity, acidity, hardness and the amount of suspended solids(, Ajayi et al., 1990).

Table(1.1).Irrigation guidelines for water quality

Potential Irrigation Problem				Unit s	Degree of Restriction on Use		
					None	Slight to Moderate	Severe
Salinity							
	EC			dS/m	< 0.7	0.7 – 3.0	> 3.0
	(or)						
	TDS		=	mg/l	< 450	450 – 2000	> 2000
SAR	= 0 – 3	EC	=		> 0.7	0.7 – 0.2	< 0.2
	= 3 – 6		=		> 1.2	1.2 – 0.3	< 0.3
	= 6 – 12		=		> 1.9	1.9 – 0.5	< 0.5
	= 12 – 20		=		> 2.9	2.9 – 1.3	< 1.3
	= 20 – 40		=		> 5.0	5.0 – 2.9	< 2.9
Specific Ion Toxicity							
	Sodium (Na)						
	surface irrigation			SAR	< 3	3 – 9	> 9
	sprinkler irrigation			me/l	< 3	< 3	

	Chloride (Cl)				
	surface irrigation	meq/l	< 4	4 – 10	> 10
	sprinkler irrigation	meq/l	< 3	< 3	
	Boron (B)	meq/l	< 0.7	0.7 – 3.0	> 30
	Nitrogen (NO3 - N)	meq/l	< 5	<5 – 30	> 30
	Ph		Normal Range 6.5 – 8.4		

Source :(Ayers&Westcot ,1985)

Another factor is the effect of carbonates and bicarbonates on the alkalinity status of the soil. High alkalinity indicates ,that, water will tend to increase the pH of the soil or growing media, possibly to a point that is detrimental to plant growth. Low alkalinity could also be a problem in some situations. This is because many fertilizers are acid-forming and by time could, make the soil too acid for some plants. Another aspect of alkalinity is its potential effect on sodium. Soil irrigated with alkaline water may, upon drying, cause excess of available sodium. Among the components of water alkalinity, bicarbonates are normally the most significant concern. Bicarbonates become of increasing concern as the pH of water increases from a pH of 7.4 to 9.3. Bicarbonates also can be found in water of lower pH. Carbonates become a significant factor as the water pH increases beyond 8.0 and are a dominant factor when the pH exceeds about to 10.3 (Maurya, 1982). Chloride Cl^- is one of the anions measured in irrigation water, for the potential of the water for phytotoxicity. Nitrate (NO_3^-) is also important anion assessed for irrigation water quality. The normal ranking for nitrate nitrogen is a maximum of 10mg/l. Although it may be seen as nitrogen in whatever form, may be desirable for plants' growth. The risk associated with excess nitrogen, especially the nitrate form, which is not adsorbed at exchange sites, is the tendency for it to be leached into underground water or being washed away via drainage water to sundry water bodies ,where, it can cause eutrophication (Adamu .G.K ,2012).

1.4- Factors affecting for water quality

Soil scientists use the following categories to describe irrigation water effects on crop production and soil quality(T.A. Bauder, et al.,2011)

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

Another potential irrigation water quality impairment, that may, affect suitability for cropping systems is the microbial pathogens.

Salt-affected soils, develop from a wide range of factors including: soil type, field slope and drainage, irrigation system type and management, fertilizer and manuring practices, and other soil and water management practices. In Colorado (U.S), perhaps the most critical factor in predicting, managing, and reducing salt-affected soils, is the quality of irrigation water being used. Besides affecting crop yield and soil physical conditions, irrigation water quality can affect fertility needs, irrigation system performance and longevity, and how water can be applied. Therefore, knowledge of irrigation water quality is critical to understand, what management changes are necessary for long-term productivity(T.A.Bauder et al.,2011)

1.4.1- Salinity Hazards

The most influential water quality guideline on crop productivity is the water salinity, which is measured as electrical conductivity (EC). The primary effect of high EC water on crop productivity is the inability of the plant to compete with ions in the soil solution for water known as (physiological drought) R.M. Waskom (2011) The higher EC value, the less water is available to plants, even though the soil appear wet, because plants can only transpire "pure" water, plant usable water in the soil solution even though the soil appear wet, because plants can only transpire "pure" water.

Table (1.2)Guidelines for salinity hazard based on electrical conductivity (EC)

Electrical conductivity (dS/m)	Limitations for use
$\leq$ 0.75	Non
0.76 – 1.5	Some
1.5 - 3.00	Moderate
$\geq$ 3.00	Severe

Source: T. A.Bauder,et al (2011)

in the soil solution decreases dramatically as EC increases. So that yield reductions from irrigating water with high (EC)valuevaries substantially(T .A.Bauder et al ,2011).

1.4.2- Sodium Hazards

Although plant growth is primarily limited by salinity level of 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 calcium and magnesium contents. This condition, which termed as (sodicity), results from excessive soil accumulation of sodium. Sodic water is not the same as saline water, because Sodicity causes swelling and dispersion of soil clays, surface crusting and pore plugging. This degraded soil structure, obstructs infiltration and may increases runoff. Sodicity causes a decrease in the downward movement of water into and through the soil, so that 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 Sodium Adsorption Ratio (SAR). Sodium Adsorption Ratio defines sodicity in terms of the relative concentration of sodium (Na^{+}) compared to the sum of calcium (Ca^{2+}) and magnesium (Mg^{2+}) ions in a sample. Sodium Adsorption Ratio(SAR) assesses the potential for infiltration problems due to sodium imbalance in irrigation water (T.A.Bauder et al.,2011).

Table (1.3)Classification of sodium hazard based on SAR values.

SAR values of water	Sodium hazard	Comments
1-9	Low	Use on sodium sensitive crops must be cautioned
10-17	Medium	Amendments ,such as, gypsum and leaching needed.
18-25	High	Generally unsuitable for continuous use
>26	Very high	Generally unsuitable for use.

Source : J.G.Davis et al (2011)

The SAR is mathematically written as :

$$SAR = \frac{(Na\ meq/L)}{\sqrt{(Ca^{++} meq/L)+(Mg^{++} meq\ /l)}}$$

Where meq/L = mg/L divided by atomic weight of ion divided by ionic charge (Na^+ = 23.0), Ca and Mg are the concentrations of these ions in milliequivalents per liter (meq/L). Concentrations of these ions in water samples may be expressed in (mg/L). To convert Na, Ca, and Mg from mg/L to meq/L, the concentration we divided by 22.9, 20 and 12.15 respectively.

1.5.3- pH and Alkalinity

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. pHvalues above 8.5 are often caused by high bicarbonate (HCO_3^-) and carbonate (CO_3^{-2}) concentrations, known as Total alkalinity. High carbonates cause calcium and magnesium ions to form insoluble compounds leaving sodium as dominant ion in solution. Alkaline water could intensify, the impact of high (SAR) water on sodic soil conditions. Excessive bicarbonate concentration can be problematic for drip or micro-spray irrigation systems when calcite or scale buildup causes reduced flow rates through orifices or emitters. In these situations, correction by injecting sulfuric or other acidic materials to the system may be required(R.M. Waskom, et al.,2011).

1.4.4- Effects of anions content in irrigation water

The normal and safe limit for chloride ions in irrigation water should not exceed 30 mg/l. If the chloride contamination in the leaves exceeds the tolerance of the crop, injury symptoms develop such as leaf burn or drying leaf tissue (FAO, 1976). These symptoms occur when leaves accumulate from 0.3 to 1.0 percent chloride .Although chloride is an essential mineral to plants in very low amounts, it can cause toxicity to sensitive crops at high concentrations. Like sodium, high chloride concentrations cause more problems when applied with sprinkler irrigation (Mass,1990).

Table(1.4): show the effect of chlorides on plants and its classification in irrigation water. 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 saline irrigation water through a sprinkler system to avoid direct contact with leaf surfaces. (Mass, 1990).,(Ehsan et al., 2010) reported reduced growth of faba bean at high concentrations of Cl^- than that of Na^+. They observed that increasing concentrations of NaCl in soil increased the concentrations of Cl^-more than that of Na^+ probably due to Na^+ ions interaction with bicarbonates. Similar results had been reported by Hajrasulha(1980).In another experiment with tomato plants, Sara et al.,(2007) reported great inhibition of tomato plant growth at high concentration of chlorides

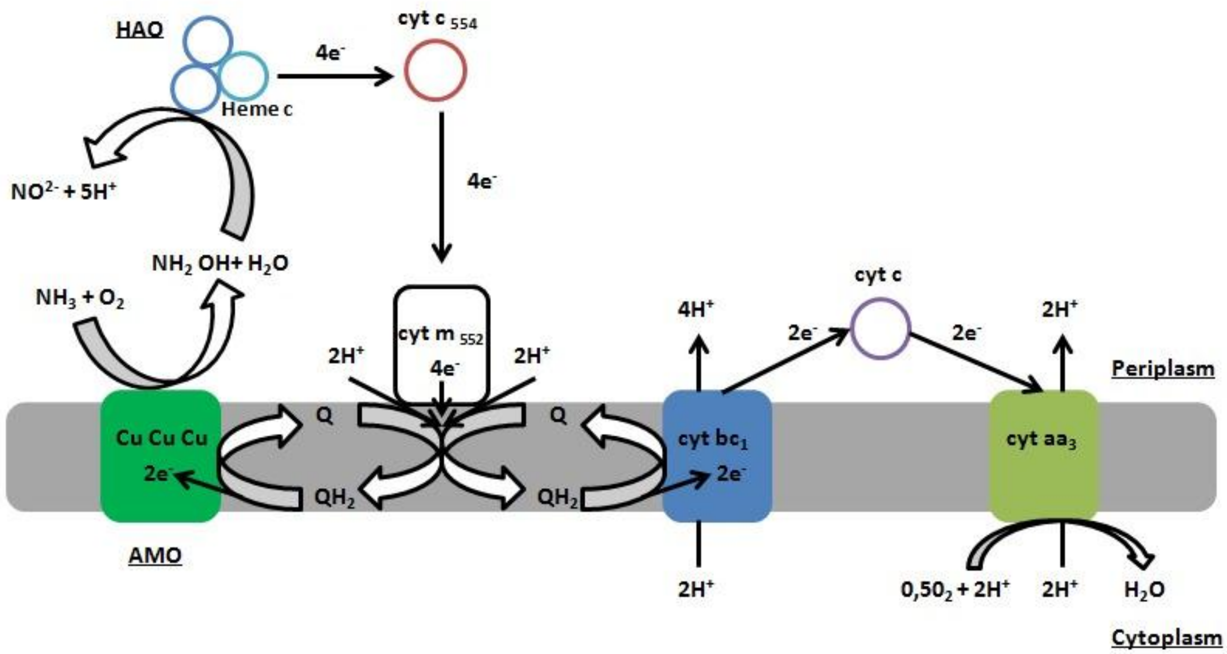
Table(1.4) Chloride classification of irrigation water**.**

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

Source: (Mass,1990)

1.5 -Effects of water quality on crop production

Irrigation water whether, of good quality or not, can have effects on plant growth, for example poor irrigation water quality with excess salt can damage plants in various ways, but the most common problems are caused by salts effecting osmotic relationship between the root and the soil moisture (Malash et al.,2005).Water with high amount of salts can hinder the conversion of ammonium salts to nitrate by nitrifying microorganisms in soil when used for irrigation shown below.



Most of tomato plants are more sensitive to salt during seed germination, seedling growth and when flowering or fruiting. The seed and seedling stages are vulnerable ,not only, because the plant structures are immature and delicate, but also because tiny roots system draw moisture and nutrients from the soil surface where salts tend to concentrate(Breckle, 1995).A severe reduction in water infiltration rate due to water quality is usually related to either, very low water salinity or to a high sodium adsorption ratio (SAR). In either case, the calcium content of the water may be at a relatively low concentration. If the calcium in the soil-water taken up by the crop is less than 2 meq/l, there is a strong probability that the crop yield will be reduced due to a calcium deficiency (Rhoades, 1982). Salinity is a measure of the total amount of salt in water. When the salt levels are too high, a salinity hazard may exist. Salts in soil and/or water can reduce water availability to the crop to such extent that, yield can be affected. Electrical conductivity and /or total dissolved solids (TDS) tests are two means of measuring salinity. Electrical conductivity is a useful and reliable index for the measurement of water salinity or

(TDS) in water. Electrical conductivity in water is due to ionization of dissolved inorganic solids. The total amount of (TDS) should be used together with (SAR). (TDS) levels below 700 mg/L and SAR below 4 are considered safe; (TDS) levels between 700 and 1,750 mg/L and (SAR) levels between 4 and 9 are considered slightly safe, while levels above these are considered hazardous to any crop. The properties of soil, the ground water and the landscape interact with the salinity of the irrigation water to either increase or decrease the salinity hazard.

1.6- Effects of irrigating water sources on crops

According to Biernbaum (1994), both irrigation water quality and proper irrigation management are critical to successful crop production. In addition, the quality of the irrigation water may affect both crop yields and soil physical conditions, even if all other conditions and cultural practices are favorable or optimal. Different crops, require different irrigation water qualities, therefore, testing the irrigation water prior to selecting ten the site and the crops to be grown is critical (Shahinasi and Kashuta,2008). The quality of some water sources may change, significantly, with time or during certain periods, such as, in dry or rainy seasons (Islam et al.,2009). So it is recommended to have more than one sample taken, in different time periods. Growth of plants is frequently limited by imbalances in electrical conductivity (EC), alkalinity, sodium (Na^+), and boron (B). High (EC) levels inhibit the germination of seeds, the rooting of cuttings, and root growth of some established crops. Alkalinity directly influences the pH of the root medium, as alkalinity in irrigation water increases, so does root medium pH. High levels of (Na^+) can antagonize the uptake of potassium (K^+), calcium (Ca^{+2}),and magnesium (Mg^{2+}). Leaf necrosis occurs when high levels of boron are present in irrigation water. Other potential irrigation water contaminants that may affect suitability for agricultural use include heavy metals and microbial contaminants (Bauder et al., 2007).

1.7- Effects of water quality on soil properties

High pHvalues above 8.5 are often caused by high bicarbonate (HCO_3^-) and carbonate (CO_3^{-2}) concentrations, known as alkalinity. According to Mass,(1990), alkaline water can intensify sodic soil conditions. While (EC) is an assessment of all soluble salts in a sample, sodium hazard is defined separately because of sodium's specific detrimental effects on soil physical properties. Sodium Adsorption Ratio (SAR) index quantifies the proportion of sodium (Na^+) to calcium (Ca^{2+}) and magnesium (Mg^{2+}) ions in a sample. Calcium will flocculate (hold together), while sodium disperses (pushes apart) soil particles. This dispersed soil will readily crust and have water infiltration and permeability problems.

Table(1.5) Classification of sodium hazard of water based on SAR values.

SAR values	Sodium hazard of water	Comments
1-9	Low	Use on sodium sensitive crops must be cautioned.
10-17	Medium	Amendments (such as gypsum) and leaching needed.
18-25	High	Generally unsuitable for continuous use
≥26	Very High	Generally unsuitable for use.

Source :Bauder, T A et al ,(2011)

1.8- Physical and chemical properties of soils

According to Jackson (1973), determined the soil acidity, pH values and electrical conductivity (EC) were measured in (1:1) water extract (1 soil : 1water) using a pH- Meter and electrical conductivity-Meter. The soil texture was determined using USDA textural triangle.

According to previous studies, the following parameters were measured using the methods below :

1.6.1-cation exchange capacity was estimated by taking 5 grams of soil and adding 33 ml sodium acetate 1N, then sample was shacked for 10 minutes and then centrifuged for 15 minutes. and run centrifuge the mixture. Then liquid extract was poured out and sample is re-washed with 33 ml of Isopropyl Alcohol to remove excess sodium. Then same steps are used to wash sample with 33 ml of Ammonium Citrate replacing Sodium citrates. The wash out is collected to reach 99 ml then 1 ml of distilled water is added to reach 100 ml of extract. Then the extract was analyzed with Flam photometer.

1.6.2- Organic matter was estimated using the determination of cations and Anions of soil: saturated paste extract is utilized according to the method of Richards (1954) to estimate the cations and anions in soil extracts. Sodium and potassium were measured using the Flam photometer. Calcium and magnesium were analyzed according to Richards (1954) using titration with EDTA solution and indicator EBT-MUREXIDE. Chloride (Cl^-) was analyzed by titration with silver nitrate. Phosphate (PO_4^{-3}) was measured in saturated soil extract using color absorption at 882 mm using spectrophotometer. Carbonate and bicarbonate were measured using titration with sulfuric acid (H_2SO_4). Sulfate (SO_4^{-2}) was analyzed in saturated soil extract by precipitation with barium sulfate in the presence of barium chloride then light absorption was measured using Spectrophotometer at wave length 420 nm.

1.9.3- Heavy metals Concentration McGrath and Cunliffe (1984) method was used to estimate the heavy metals. 1 gm grinded soil sample was taken from each sample in digestion tube and 20 ml of acids mix (HCL: HNO3) by (1:3) and set for 24 hours. After cooling, the sample is filtered using WhatmanNo.542 paper. The filtered solution is completed to 100 ml with diluted HNO3 (1.5%). Then samples were measured using atomic absorption spectrophotometer

1.9- Characterization of elements in water

In a study of irrigation water quality analysis was carried by Jackson(1973) the Standard Methods for examination of water. Sodium and potassium ions (Na^+ ،K^{+})were measured in water using a flame photometer, Calcium and magnesium ions have been estimated by titration with EDTA solution in the presence of the two indicators Eriochrome Black T and Murexide. Phosphate (PO_4^{-3}) was measured using spectrophotometer and light absorption at wavelength 882 nm. Carbonate and bicarbonate were analyzed using water titration with hydrochloric acid in the presence of the two indicators phenolphthalein and methyl orange. Chloride ion (Cl^-) was measured by titration with solution of silver nitrate a until pinkish yellow color is reached. Sulfate ion (SO_4^{-2}) was measured in water by precipitation in presence of barium chloride and then was measured by spectrophotometer at wavelength of 420 nm. Concentration of Heavy Metals in Water samples: Water samples were preserved by adding concentrated nitric acid (HNO_3) and then filtered with Whitman paper and the samples were measured by Atomic Absorption Spectrophotometer according to the Standard Method for Examination water and waste water

1.10-Residual Sodium Carbonate (RSC)

The influence of bicarbonate and carbonate on the suitability of water for irrigation purpose is empirically assessed based on the assumption that all Ca^{2+} and Mg^{2+} precipitate as carbonate. Based on this, the concept of residual sodium carbonate (RSC) for the assessment of high carbonate water is used. Water with high (RSC) have high pH, and land irrigated with such water becomes infertile owing to deposition of sodium carbonate; as known from black color of the soil. (RSC) values more than 2.5mol/l are considered as unsuitable for irrigation (Landon, 1991). Adamu G.K (2012).attempted to examine the quality of water used in the Watari irrigation project with a view to ascertaining its suitability.The residual sodium carbonate index of irrigation water or soil water was used to indicate the alkalinity hazard for soil. The (RSC) index is used to find the suitability of water for irrigation in clay soils which have a high cation exchange capacity.

When dissolved sodium in comparison with dissolved calcium and magnesium is high in water, clay soil swells or undergoes dispersion which drastically reduces its infiltration capacity, Residual Sodium Carbonate (RSC) is calculated to determine the hazardous effects of carbonate and bicarbonate on the quality of water used for irrigation activities. The Residual Sodium Carbonate (RSC) is changing their quality of water through the precipitation of alkali earth elements calciumand magnesium thereby increase the percentage of sodium (Eaton, 1950). The water-soluble excess carbonate is combined with alkaline earth ions to form the$NaHCO_3$. The relationship between carbonates and alkali earth's concentrations can be explained by (RSC) for irrigation quality of water. Here, all the concentrations are expressed in meq/l. The suitability of residual sodium carbonate (RSC) value for irrigation is 1.25 meq/l. The higher value of (RSC) may lead to poor quality of soil for irrigation. The value of residual sodium carbonate RSC ranges from -12.29 to 2.51.

In a study conducted by Nigerian scientists of irrigation water quality was assessed based on salt contents and salt inducing parameters, abundance of nutrients, trace elements, alkalinity, acidity, hardness and the amount of suspended solids. The physiochemical properties of Watari irrigation water were assessed and the findings indicated mean pH of water ranged from 7.10 to 7.50, while the EC values across the sectors ranged from 50 to 60μS/m for cations. Sodium ranged from (15.00 to 20.07)mg/l ,calcium ranged from(5.41 to 16.22)mg/l , magnesium ranged from(3.29 to 6.57)mg/l and potassium ranged from(14.83 to 15.00) mg/l. Sodium Adsorption Ratio was ranged from (6.87 to 10.17), while the(TDS) values were ranged from (31.00 to 36.00) mg/l. The carbonates concentration was ranged from (4.00 to 12.00)mg/l while the bicarbonate content ranged from (22.00 to55.00)mg/l. Chloride and nitrate were within (9.87 to31.58)mg/land(1.00 to1.65)mg/l, respectively. Residual Sodium Carbonate (RSC) was ranged from(8.00 to 30.69) meq/l.

There was no detectable ammonia(NH_4^+) in the irrigation water. It was recommended that, adequate drainage with emphasis on surface drainage should be provided to reduce the risk of salinity whereas salt and sodium build up should be monitored regularly(Adamu G.K,2013) .

The normal safe ranking for the above results of carbonate (CO_3^{-2}) and bicarbonates (HCO_3^-) were 1.00 and 10.00 mol/l respectively (Landon, 1991). By this criteria therefore, the irrigation water in the sectors assessed could be described as being at severe risk with regards to carbonates and bicarbonates. High carbonate and bicarbonate in water essentially increases sodium hazard of the water to a level greater than that indicated by Sodium Adsorption Ratio (SAR).

Table(1.6) Irrigation Water Quality Parameters for the Watari Irrigation Scheme

Sample Name	CO_3^{-2}(mol/l)	HCO_3^-(mol/l)	Cl^- (mol/l)	NO_3^- (mg/l)	RSC (mol/l)
Dam	6.67	36.67	9.87	1.00	3.69
Sector 1	6.67	41.67	16.45	1.65	3.44
Sector 2	4.00	20.00	8.88	0.90	1.30
Sector 3	12.00	15.00	14.80	1.50	0.80
Sector 4	8.00	55.00	14.81	1.80	4.13
Sector 5	6.00	40.00	12.83	1.30	2.86
Sector 8	8.00	25.00	31.58	3.16	1.40

Source:Adamu G.K,(2013)

High $CO_3^{-2}$and HCO_3^-tend to precipitate calcium carbonate ($CaCO_3$) and magnesium carbonate ($MgCO_3$), when the soil solution concentrates during soil drying. If the concentrations of calcium and magnesium in soil solution are reduced relative to sodium, the(SAR) of soil solution tends to increase. Another effect of carbonates and bicarbonates is on alkalinity status of the soil. High alkalinity indicates, that, water will tend to increase the pH of the soil or growing media, possibly to a point that, is detrimental to plant growth. Low alkalinity could also be a problem in some situations, because many fertilizers are acid-forming, and could over time, make the soil too acid for some plants. Another aspect of alkalinity is its potential effect on sodium. Soil irrigated with alkaline water may, upon drying, cause an excess of available sodium. Several potential sodium problems as highlighted above could therefore result. Among the components of water alkalinity, bicarbonates are normally the most significant concern. as the water pH increases from(7.4 to 9.3) However, bicarbonates can be found in water of lower pH. Carbonates become a significant factor as the water pH increases beyond 8.0 and are a dominant factor when the pH exceeds.

In a study Performed by DhirendraMoh, et al (2009) water quality of river Ganga in Haridwar district was analyze for irrigation purpose. Water samples were collected from 5 sampling stations. Have samples were collected for three seasons, Winter (November-February), summer (March to June) and rainy (July to October). Water quality variables were measured in the river over a period of two years (Nov.2006 to Oct. 2 008). The samples were analyzed for electrical conductivity (EC), total dissolved salts (TDS), magnesium content (MC), sodium percent (SP), sodium adsorption ratio (SAR), residual sodium carbonate (RSC) and permeability index (PI). The study of all these characteristics indicates that, river water in rainy season is not suitable for irrigation purpose because, of high values of total dissolved salts, (EC) and (SP).

Grab sampling was generally applied during the sampling. Water samples were analyzed by. MC, SP, SAR, RSC and PI were calculated as follows:

1.11.1-Magnesium Content

magnesium content of water is considered as one of the most important qualitative criteria in determining quality of water for irrigation. Magnesium content is calculated by the following formula.

Mg content=[Mg^{2+}/ (Mg^{2+}+ Ca^{2+})] 100 (Concentrations are in meq/l)

1.11.2- Sodium percentage (Na%)

Na% = [(Na^{+} + K^{+})/ (Ca^{2+}+ Mg^{2+}+ Na^{+} + K^{+})] 100

(Concentrations are in meq/l)

1.11.3 - Sodium absorption ration(SAR)

is an important parameter to determine the suitability of irrigation water and is calculated by the following formula:

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

1.11.4-Residual sodium carbonate (RSC)

The concept of residual sodium carbonate (RSC) is employed for evaluating high carbonate waters and is calculated by the formula :

$$RSC = (CO3^{2-} + HCO3^{-}) - (Ca^{2+} + Mg^{2+})$$

(Concentrations are in meq/l)

Table(1.7) Irrigation water characteristics in winter season

Parameter	BN	JRA	HKP	PNA	PJ
EC	128.52	110.28	97.86	95.89	100.06
TDS	42.58	49.50	47.50	58.65	50.37
MC	29.412	31.800	35.976	30.246	26.018
PS	23.566	24.036	23.654	28.409	33.163
SAR	0.571	0.629	0.593	0.754	0.871
RSC	0.474	-0.601	-0.804	-0.304	-0.160
PI	115.513	74.361	66.607	91.017	101.644

Source :Dhirendra Mohan, et al (2009)

Table (1.8) Irrigation water characteristics in summer season

Parameter	BN	JRA	HKP	PNA	PJ
EC	125.58	147.67	139.25	142.27	138.25
TDS	217.95	246.20	226.18	234.46	246.15
MC	29.817	33.074	37.703	34.700	32.064
PS	23.566	24.036	23.654	28.409	33.163
SAR	0.396 0	0.458	0.486	0.534	0.588
RSC	0.147	0.168	0.353	0.027	0.236
PI	89.838	86.130	78.555	98.859	116.566

Source :Dhirendra Mohan, et al (2009)

The concentration of bicarbonate and carbonate also influences the suitability of water for irrigation purpose. One of the empirical approaches is based on the assumption that all Ca^{2+} and Mg^{2+} precipitate as carbonate. Considering this hypothesis, residual sodium carbonate (RSC) for the assessment of high carbonate waters. The water with high RSC has high pH and land irrigated with such water becomes infertile owing to deposition of sodium carbonate; as known from black color of the soil. According to U.S. Salinity Laboratory, an R.S.C. value less than 1.25 meq/lit is safe for irrigation. A value between 1.25 and 2.5 meq/lit is of marginal quality and value more than 2.5meq/lit is unsuitable for irrigation. In the present study R.S.C. values are below 1.25 meq/lit at all sampling stations. So water of Ganga river can be considered safe for irrigation purpose as mentioned according to above considerations(DhirendraMoh, et al ,2009).

In a research conducted by Arun Prasad et al; (2001) the effect of residual sodium carbonate (RSC) in irrigation water on soil sodication and yield and cation composition of palmarosa and lemon grass were studied in the open bottom reinforced concrete cemented cylindrical barrels embedded in the field and filled with study loam soils .the results indicated that the increasing (RSC) in irrigation water significantly increased the PH, electrical conductivity (EC) and (SAR) of the soil and hence ,considerably decreased the herb and oil yield of both the palmarosa and lemon grass. The reduction in total herb yield was 14.5,18.3,28.8and 32.0% in palmarosa and 38.6,46.0,57.7 and 62.6% in the lemon grass over control at 4.0,8.0,12.0 and 16.0meq/l of (RSC) decreased the oil yield by 13.0,22.4 and 22.9% over control at 8,12 and 16 meq/l Residual Sodium Carbonate respectively .The total oil yield of lemon grass was decreased by 27.0, 39.4 ,47.7 and 50.8% over control at 4,8,12 and 16 meq/l respectively .The concentration of Na increased significantly and K and Ca^{2+}decreased with increase in RSC of irrigation water in vegetative tissues of both species.

Table 1.9 :Effect of residual sodium carbonate in irrigation water on the yield of lemongrass

Level of RSC (meq/l)	Herb Yield (kg/barrel)			Oil Yield (mg/ barrel)		
	F. Year	Sc. Year	Total	F. Year	Sc. Year	Total
2.00	0.31	1.32	1.63	1.72	6.94	8.66
4.00	0.31	0.69	1.00	2.00	4.32	6.32
8.00	0.31	0.57	0.88	1.90	3.55	5.45
12.00	0.30	0.39	0.69	1.77	2.76	4.53
16.00	0.23	0.38	0.61	1.65	2.61	4.26

A .Prasad et al (2001)

Lemon grass accumulates significantly greater amount of Na in shoot tissues as compared to palmarosa and it fails to survive at high (RSC) after 21 month of trans planting.The result suggest that palmarosa is more tolerant to irrigation water sodicity than the lemon grass.

Carbonates (CO_3^{2-}) and bicarbonates (HCO_3^-) guideline values are 1.00 and 10.00 mol/l respectively (Landon,1991).considering this criteria, irrigation water in the study area assessed could be described as being at severe risk with regards to carbonates and bicarbonates. High (CO_3^{2-})and (HCO_3^-)tend to precipitate calcium carbonate ($CaCO_3$) and magnesium carbonate ($MgCO_3$), thereby increasing sodium hazard in the soil relative to Ca^{2+} and Mg^{2+}, and consequently the SAR.

High levels of bicarbonates can be directly toxic to some plant species. Bicarbonate levels above 3.3m mol/l will cause lime to be deposited on soils and even on foliage especially when irrigated with overhead sprinklers.

In a study carried at Watari River irrigation project, located on the slopes of Watari River valley in Bagwai local government of Kano state for assessing soil properties and quality of irrigation water, a total of 32 representative soil samples were randomly collected from eight sectors. Seven water samples were also collected from the sectors and the dam. The samples were treated and analyzed for physical, chemical and fertility related indices. The quality of irrigation water is assessed based on the salt and salt inducing contents, the presence and abundance of micro and macro nutrients, trace elements, alkalinity, acidity, hardness and the amount of suspended solids. The results were grouped into general quality parameters which included salinity, salt inducing cations, anions and pollutants. The findings indicated that the pH was ranged from 7.10 to 7.50, while the (EC) values across the sectors ranged from 50 to 60µS/m. The metal cations in the water ranged from 15.00 to 20.07; 5.41 to 16.22; 3.29 to 6.57; 14.83 to 15.00 mol/l for Na, Ca, Mg and K respectively. The SAR ranged from 6.87 to 10.17, while the range of (TDS) values was from 31.00 to 36.00mg/l. The mean carbonates concentration detected in irrigation water was from 4.00 to 12.00cmol/l, while the mean bicarbonate content ranged from 22.00 to 55.00 mol/l. The ranges for chloride and nitrate were 9.87 to 31.58 and 1.00 to 1.65mg/kg respectively. The residual sodium carbonate (RSC) ranged from 8.00 to 30.69.There was no detectable NH_4^+ in the irrigation water. The results have shown that alleight sectors had sand dominated texture. The mean pH in the soil ranged from 5.50 to 5.95. The (EC) ranged between 0.49 to 1.30 mol/kg, the Cl^- ranged between 0.29 to 1.07mol/kg and (SAR) ranged between 0.13to 0.72. The mean soil organic carbon across the sectors ranged between 0.62 to 1.49%. The total nitrogen ranged between 0.0043 to 0.084% while NH_4^+ and NO_3^- Forms of nitrogen ranged between 0.0043 to 0.0065mol/kg and 0.0025 to 0.0065mg/kg respectively. The EC ranged between 9.04 to 12.68 mol/kg. The exchangeable bases ranged from 3.13 to 4.25; 1.06to1.73 and 1.28 to 2.08mol/kg for Ca, Mg and K respectively. The boron content in the soil across the sectors ranged between 4.09 to 6.34mg/kg. It was recommended that adequate drainage with emphasis on surface drainage should be provided and salt and sodium build up should be monitored regularly.

In a research conducted in Nigeria was found that much of the interpretation of results of water analysis is based on a prediction of the consequences on the soil. Typically, the quality of irrigation water is assessed based on the salt contents and salt inducing parameters, abundance of nutrients, trace elements, alkalinity, acidity, hardness and the amount of suspended solids. The physiochemical properties of the Watari irrigation water were assessed and the Findings indicated that the mean pH of water ranged from 7.10 to 7.50, while the EC values across the sectors ranged from 50 to 60µS/m. Metal cations in the water ranged from 15.00 to 20.07; 5.41 to 16.22; 3.29 to 6.57; 14.83 to15.00cmol/l for Na, Ca, Mg and K respectively. The SAR ranged from 6.87 to 10.17, while the range of TDS values was from 31.00 to 36.00mg/l. The mean carbonates concentration detected in the irrigation water was from 4.00 to 12.00cmol/l, while the mean bicarbonate content ranged from 22.00 to 55.00cmol/l. Chloride and nitrate were within 9.87 to 31.58 and 1.00 to 1.65mg/kg, respectively. Residual sodium carbonate (RSC) ranged from 8.00 to 30.69.There was no detectable NH_4^+in the irrigation water. It was recommended that adequate drainage with emphasis on surface drainage should be provided to reduce the risk of salinity whereas salt and sodium build up should be monitored regularly (Adamu G.K, 2012)

The Residual sodium carbonatehascalculatedusingas equation 2:

$$RSC=(CO_3^- + HCO_3^-)-(Ca^{2+} + Mg^{+2}) \longrightarrow (2)$$

It is another alternative measure of the sodium content in relation with Mg and Ca. This value may appear in some water quality reports although it is not frequently used.

If the RSC < 1.25 the water is considered safe

If the RSC> 2.5 the water is not appropriate for irrigation. Residual sodium carbonate (RSC) exists in irrigation water when the carbonate (CO_3^{-2}) plus bicarbonate (HCO_3^-) content exceeds the calcium (Ca^{+2}) plus magnesium (Mg^{+2}) content of water.

CHAPTER TWO

Materials and Methods

Chapter Two

Materials and Methods

2.1- Collection of Samples

Thirteen soil samples were collected from ten different farms, cultivated with various types of crops. Three samples were obtained from each farm at the begging, in the middle and the end of the farm. 5 grams from each sample were weighed and mixed to obtain ten composite soil samples of each farm. Table (2.1) showed the types of the crops cultivated in each farms.

And (10) 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

Sample area (farm)	Type of crop
1	Guava
2	Lemon
3	Green onion
4	Animal feed
5	Lemon
6	Plum
7	Mango
8	Animal Feed
9	Alfalfa
10	Animal Feed

2.2- Chemicals

acid (69%) LobaChemie 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%). Hop kin&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

2.3 –Instruments

- Microwave(Multi wave PRO)
- Inductively coupled plasma(ICP-OES725ES)(Vista-MPX-CCD)
- Spectrophotometer Model (HACH)DR5000
- Sensitive balance(GH252)UK

2.4 -Methods of Analysis

2.4.1- Preparation of water samples

1ml of conc. nitric acid (69%) was added to 10ml of each water samples. The solution was filtered through filter paper. The clean filtrate was used for (ICP) analysis to measure the mineral content in each water sample

2.4.2-Preparation 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 placed in microwave then the solution was transferred to 50ml volumetric flask and volume completed to the mark in volumetric flask

Inductively coupled plasma instrument was used for measuring the mineral content in each soil sample.

2.4.3- Determination of chloride in water samples

50 ml of water sample was taken by a cylinder in 250 ml conical flask ,0.20 ml of phenyl dicarbazone indicator was added.few drops of nitric acid (1M) were added, then 0.6 ml of nitric acid also added to the solution to change the color from blue to yellow. The solution was titrated against Mercury (II) nitrate until the endpoint.

2.4.4 - Determination of nitrate in water samples

25ml of each water sample was heated on a water path. After the evaporation process was completed, the sample was extracted and dissolved by disolfonic acid**,** then 10ml of water was added and the solution wastransferred to test tube 50ml then 3ml of ammonia conc was added and the volume completed to the market, The solution was read into the spectrophotometer(UV-VIS). in wave length 440 nm by 1cm cell then concentration was calculated.

2.4.5- Determination of sulfate in water samples

1ml of hydrochloric acid was added to 50ml of each water sample in 150ml conical flask. Then the solution was heated and boiled until the volume was decreases to the half, 2.5ml of barium chromate was added to the solution and boiled again for 5min. When the volume of solution became 25ml ammonia(1:1) was added and then the solution was transferred to test tube 50ml and completed the volume to the mark by distillated water.

The solution was filtered and Absorption was read in410nm wave length by (UV-VIS)Spectrophotometer.

2.4.6-Determination of chloride in soil samples:-

50 ml ofdissolved soil sample was taken by a cylinder in 250 ml conical flask ,0.20 ml of phenyl dicarbazone indicator was added.few drops of nitric acid (1M) were added, then 0.6 ml of nitric acid also added to the solution to change the color from blue to yellow. The solution was titrated against Mercury (II) nitrate until the endpoint.

2.4.7- Determination of nitrate in soil samples

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2.4.8- Determination of sulfate in soil samples

1ml of hydrochloric acid was added to 50ml of each soil sample in 150ml conical flask. Then the solution was heated and boiled until the volume was decreases to the half, 2.5ml of barium chromate was added to the solution and boiled again for 5min. When the volume of solution became 25ml ammonia(1:1) was added and then the solution was transferred to test tube 50ml and completed the volume to the mark by distillated water.

The solution was filtered and Absorption was read in410nm wave length by (UV-VIS) Spectrophotometer.

CHAPTER THREE

Results and Discussion

CHAPTER THREE

Results and Discussion

3.1-EC and pH values for water samples

Electrical conductivity for the analyzed irrigation water samples were found to be in the suitable range .Electrical conductivity as an important parameter for assessing irrigation water quality is a good indication of salinity hazard.

The guideline range of irrigation water electrical conductivity is from 20 to 300 µs/cm (Maurya ,1976) .According to this samples in this situation wit in the permissible range .Sample (No 5&10) showed high (EC) values (table 3.1) .The pH values were ranged from 7.20 to 7.50 as the lowest in (sample No1) and the highest value (sample No 5) pH values for normal irrigation water should be between 6.00 and 7.00 all analyzed samples showed pH values relatively high and sample No 5and 10 showed the highest values (table 3.1). Singh et al ;(1996) and Danko (1997) considered pH values above 7.00 to be of increasing salinity hazard.

Table (3.1) Electrical conductivity and pH values of water samples

Sample No	EC µs /cm	pH
Sample 1	250.00	7.20
Sample 2	263.00	7.48
Sample 3	248.00	7.37
Sample 4	255.00	7.25
Sample 5	689.00	7.50
Sample 6	270.00	7.33
Sample 7	281.00	7.26
Sample 8	269.00	7.38
Sample 9	263.00	7.44
Sample 10	1090.00	7.45
mean	387.80	7.37

The pH is logarithmic, meaning that, a change of 1.0 unit is a ten-fold change in either acidity or basicity. Therefore, changes of even less than 1.0 unit may be significant. This characteristic of the water has a significant influence on other characteristics or reactions in the soil and water, as well as the way plants perform. The concentration of total salt content in irrigation waters is estimated in terms of EC and it may be the most important parameter for assessing the suitability of irrigation waters (Maurya, 1976). Generally, the ranges considered for irrigation water suitability are 20 to 300µS/cm being normal, which is increasingly severe with respect to salinity hazards according to this we find that sample 5 and sample 10 have high EC vales there fore increase the salinity hazard. Most of the analyzed samples were god for irrigation purpose ,but samples (5 and 10) may be suitable only for salt to be out types of crops.

3.2- Anions and total alkalinity contents of water samples

Table (3.2) Sulfate, chlorides, nitrates and total alkalinity in water Samples (ppm)

Sample Name	Total Alkalinity	Sulfate mg/l	Chloride mg/l	Nitrate mg/l
Sample 1	130.104	136.00	3.10	2.30
Sample 2	144.115	142.00	2.20	1.70
Sample 3	121.097	143.00	2.60	1.10
Sample 4	136.109	152.00	2.60	2.10
Sample 5	434.99	129.00	5.40	1.90
Sample 6	131.45	143.00	3.20	1.80
Sample 7	145.67	137.00	1.70	2.60
Sample 8	132.987	128.00	1.90	1.30
Sample 9	140.289	122.00	2.20	1.90
Sample 10	399.693	123.00	1.80	2.40
Mean	191.65	135.50	2.67	1.91

Table (3.2) Shows the concentrations of the main anions that are normally cause natural water salinity .Nitrate content of the ten samples was significantly low ,as one of the main anions required by all plants sample (No.5) showed the lowest nitrate content (1.1) and the highest concentration was shown y sample (No.7) .Chlorides showed low concentrations in all samples , ranging from (1.7ppm) in sample (No 7) to (5.40ppm) in sample (No 5) . Chloride content of natural water is normally higher than this .It may be concluded that nitrate and chloride ions have no contribution in the salinity of irrigation water samples.

Sulfate and total alkalinity of the ten samples were found to almost of similar ranges. Samples (No 3,4and 6) showed the highest sulfate concentrations. Total alkalinity values were relatively high in sample (No 5) as (434ppm) and sample (No 10) as (399.693ppm). As a result salinity of irrigation water of Elsaggai scheme may be due sulfate and total alkalinity content. The relatively high total alkalinity values in samples (No 5and 10) may be responsible of the high pH values in these two samples (Table 3.1)

3.3-Macronutrients concentrations in water samples

Table (3.3)Macronutrients concentrations in water samples(ppm)

Sample No	Ca	Na	Mg	K	P
Sample 1	10.827	8.727	3.439	2.023	0.432
Sample 2	11.011	8.45	3.546	2.134	0.236
Sample 3	10.212	7.989	3.262	1.995	0.187
Sample 4	11.131	9.136	3.553	2.165	0.321
Sample 5	61.151	20.655	27.574	4.013	0.843
Sample 6	10.756	7.653	3.441	2.063	0.294
Sample 7	11.011	8.876	3.521	3.011	0.378
Sample 8	10.564	9.121	3.521	3.215	0.412
Sample 9	11.112	8.431	3.432	2.891	0.501
Sample 10	56.661	19.687	26.341	4.055	0.911
Mean	20.444	10.873	8.163	2.757	0.452

Table3.3. Shows that the concentrations of the main macronutrient ions .Sodium content of ten samples within the international guidelines (0-40ppm) but sample (No 5 and 10) showed high concentration than other this may be due to increase the carbonate and bicarbonate in the same sample. Magnesium and calcium

showed normal range except sample 5and 10 and the result of this nutrient showed that the concentration of Ca^{+2} is increase compare with sodium and magnesium this shows percentage of calcium carbonate precipitate is higher than other,potassium and phosphor showed different concentration in different water samples which were relatively medium. Zinc and cobalt were found to be very low in all water samples. Table (3.3).

3.4-Micronutrientsconcentrations in water samples

Table (3.4) Micronutrients concentrations in water samples (ppm)

Sample Number	Ni	V	Fe	Cu	Zn	Co
Sample 1	0.074	0.057	0.090	0.039	0.00321	0.000121
Sample 2	0.078	0.058	0.056	0.039	0.00251	0.000631
Sample 3	0.076	0.054	0.035	0.039	0.00956	0.000131
Sample 4	0.073	0.055	0.039	0.039	0.00181	0.000123
Sample 5	0.08	0.052	0.045	0.041	0.00271	0.000161
Sample 6	0.076	0.053	0.07	0.038	0.00739	0.000172
Sample 7	0.073	0.051	0.034	0.038	0.00581	0.000134
Sample 8	0.074	0.054	0.036	0.039	0.00211	0.000166
Sample 9	0.071	0.056	0.041	0.038	0.00639	0.000122
Sample 10	0.081	0.057	0.039	0.040	0.00518	0.00135
Mean	0.0756	0.0547	0.0485	0.039	0.00467	0.000311

Table(3.4) Showed the micronutrients concentrations in water samples as the main ions that are normally found in natural water .Iron ,copper and nickel ions contentsof the ten water samples were significantly low. Micronutrients in all forms of irrigation water are assessed because they have the tendency to get into

Nile waters via runoff coming through agricultural fields in which agrochemicals and fertilizers are applied, because they form constituents of many of such chemicals. Monitoring trace elements in irrigation water is as important as monitoring salinity status because of their potential to build up in soil and be absorbed by plants thereby being introduced into food chain. When such happens, they constitute further risks to human and livestock in terms of health and wellbeing.(Adamu,2012).Iron ion is doesn't poisonous to plants in well-ventilated soils but its effect occurs in acidic soil. Copper concentrations from (0.1-1.0) mg/l is toxic to many plants and less affected in alkaline soils the results of the ions analysis for water samples showed that the copper ions within the range from (0.038 – 0.041ppm) this range is best to use in irrigation, according to the water quality criteria nickel is toxic to many plants at concentrations from (0.1-.05ppm) and decrease toxicity in alkaline soils but the results of analysis for water samples showed that the range between (0.071 – 0.081ppm)f this is safe range. Zinc, vanadium and cobalt were found to be very low in all water samples.

3.5-Toxic minerals in water samples

Table 3.5 shows toxic or hazardous minerals content of water samples may be described as very low .Aluminum showed different concentration in analyzed samples ,the range of results from (0.048-0.139)ppm these concentration were all below the expect hazardous level .sample (No 4 and 5) showed high concentration but other samples were converged in values. Aluminum ion high concentration can cause handicap in plant germination and when it has a negative effect on the growth of plant cells Arsenic, lead, cadmium and strontium have the lowest concentration in allsamples. These results may indicate that the irrigation water used in Elsaggai scheme are very good quality and very safe. Table (3.5) showed the result below:

Table (3.5) Toxic minerals concentrations in water samples (ppm)

Sample No	As	Pb	Al	Sr	Cd
Sample 1	0.274	0.099	0.097	0.0631	0.000121
Sample 2	0.281	0.108	0.068	0.0172	0.000121
Sample 3	0.262	0.102	0.048	0.0431	0.00121
Sample 4	0.295	0.118	0.139	0.0721	0.000121
Sample 5	0.282	0.121	0.102	0.0972	0.000121
Sample 6	0.275	0.116	0.056	0.0558	0.000121
Sample 7	0.273	0.103	0.064	0.0141	0.000121
Sample 8	0.282	0.106	0.073	0.0521	0.000121
Sample 9	0.267	0.104	0.058	0.0472	0.000121
Sample 10	0.291	0.118	0.099	0.0112	0.000121
Mean	0.278	0.110	0.0804	0.0473	0.00023

3.6-Residual Sodium Carbonate in Irrigation Water

Table (3.6) Residual Sodium Carbonate in Irrigation Water

Sample Number	Mg	Ca	Total Alkalinity	RSC
Sample 1	3.439	10.827	130.104	1.31
Sample 2	3.546	11.011	144.115	1.52
Sample 3	3.262	10.212	121.097	1.20
Sample 4	3.553	11.131	136.109	1.38
Sample 5	27.574	61.151	434.99	1.78
Sample 6	3.441	10.756	131.45	1.33
Sample 7	3.521	11.011	145.67	1.54
Sample 8	3.521	10.564	132.987	1.36
Sample 9	3.432	11.112	140.289	1.46
Sample 10	26.341	56.661	399.693	1.52
mean				1.44

Table 3.6 showed that residua sodium carbonate values for the analyzed water samples were found to be of different range. concentratons were ranged from 1.20meq/lin sample(No 3) to 1.78meq/l in sample (No 7), salinity hazard can be described according to these values. The water soluble excess carbonate may combine with alkaline earth's ions to form $NaHCO_3$. The suitability of residual sodium carbonate value for irrigation is 2.5 meq/l. This mean that, all samples above this value are relatively hazardous and may lead to poor quality of soil. According to that, most of the analyzed samples were good for irrigation purpose.

3.7-Anions and total alkalinity content in soil samples

Table(3.7) Sulfates ,chlorides , nitrates and total alkalinity of soil samples

Sample Number	Sulfate mg/l	Total Alkalinity	Chloride mg/l	Nitrate mg/l
Sample 1	131.30	74.23	2.30	2.10
Sample 2	127.90	76.92	6.30	3.20
Sample 3	122.80	81.36	3.00	2.10
Sample 4	133.20	72.35	1.90	1.90
Sample 5	140.60	76.34	2.10	2.40
Sample 6	123.60	77.36	3.30	1.60
Sample 7	136.10	74.12	2.40	1.70
Sample 8	121.80	80.94	3.10	2.30
Sample 9	135.20	74.65	2.40	1.50
Sample 10	129.80	73.66	4.10	1.70
Mean	130.23	76.19	3.09	2.05

Table (3.7) showed that Soil samples content of anions nitrate and chloride were found to be very low in all samples but sulfate had relatively high concentrations in the ten soil samples. The concentrations of sulfate ion were ranging from (121.80 ppm) to (140.60 ppm) these values were higher than nitrate and chloride. Total alkalinity of the ten samples were almost in the normal range. Chloride and nitrate showed very low concentration. It indicating that, these ions have no contribution in the salinity of soil samples. As a result salinity of Elsaggai Scheme may be due to sulfate ions ,also it may be affected by total alkalinity, but less than that of sulfate ions (Table 3.6).

Most ofnitrogen in soil is bound to organic compounds that make up the soil organic matter, and must be mineralized to the ammonium or nitrate form before it can be taken up by most plants. The total nitrogen content depends largely on the soil organic matter content, which in turn depends on the climate, vegetation, topography, age and soil management. Soil nitrogen typically decreases by 0.2 to 0.3% for every temperature increase by 10 °C. Usually, grassland soils contain more soil nitrogen than forest soils. Cultivation decreases soil nitrogen by exposing soil organic matter to decomposition by microorganisms, and soils under no-tillage maintain more soil nitrogen than tilled soils.

Nitrogen is a moving element in the plant, itis found to be in the soil in two forms:

The mineral form as ammonium NH_4^+ or nitrate NO_3^- which is the good part of absorption. .i

The organic form ,the plant cannot benefit the organic form until after the analysis and transformation into the metal form. .ii

The most important functions of nitrogen in the plant are:-

It enter in building protein materials. (a

Enter the installation of chlorophyll. (b

In the installation of the most components of flowers and fruits. (c

Controls the plant's ability to absorb phosphorus and potash (d

According to the results obtained the concentrations of nitrate were very low. Nitrogen ratio is increased in the soil by adding urea, according to the type of plant grown.

3.8-Macronutrients concentrations in soil samples

Table (3.8)Macronutrients concentrations in soil samples (ppm)

Sample No	P	K	Ca	Mg	Na
Sample 1	213.09	121.87	88.162	51.433	8.727
Sample 2	306.33	115.92	76.692	44.031	8.45
Sample 3	189.23	109.98	77.487	49.396	7.989
Sample 4	231.98	113.66	78.578	46.764	9.136
Sample 5	199.11	134.61	82.413	51.29	20.655
Sample 6	314.75	125.21	76.984	46.987	7.653
Sample 7	179.49	114.89	77.183	47.234	8.876
Sample 8	221.48	140.66	79.942	50.876	9.121
Sample 9	178.79	119.01	76.153	44.83	8.431
Sample 10	263.37	124.94	86.673	52.123	19.687
Mean	229.76	122.08	80.027	48.496	10.873

Table (3.8)Showed macronutrients concentrations in soil samples. Calcium, magnesium, sodium, potassium, and phosphor values of the most analyzed composite soil sample were relatively high. Sodium and phosphor contents were found to be in normal range and may be quite enough to supply the different cultivated plants with their requirements. Potassium and phosphor added to agricultural soil to increase the fecundity of soil for growth. Calcium is more available on the soil colloids than potassium. Magnesium was relatively low, it was important as chlorophyll component.

3.9-Micronutrients concentrations in soil samples

Table (3.9)Micronutrient concentrations in soil samples (ppm)

Sample No	Fe	Zn	Co	V	Ni	Cu
Sample 1	273.309	53.661	22.124	0.816	0.414	0.203
Sample 2	228.045	52.901	19.651	0.702	0.344	0.143
Sample 3	260.18	50.614	26.732	0.737	0.411	0.186
Sample 4	239.584	47.510	20.936	0.658	0.381	0.168
Sample 5	267.162	51.935	23.610	0.74	0.427	0.196
Sample 6	266.365	49.041	22.531	0.713	0.352	0.199
Sample 7	259.932	55.109	26.015	0.734	0.393	0.169
Sample 8	270.946	50.631	21.952	0.781	0.401	0.176
Sample 9	271.236	59.066	28.612	0.807	0.321	0.165
Sample 10	269.312	46.076	18.461	0.766	0.421	0.21
Mean	260.607	51.654	23.062	0.745	0.387	0.182

The concentration of copper in the soil samples ranged between (0.14 ppm) in sample 2 and (0.21 ppm) in sample 10, this range is very low. The lower concentration of copper in soil is due to low movement in soils with pH value close to neutral. Also the content of soil organic matter, soil texture and the proportion of clay affect the availability of the copper in the soil (Omer Asad ,2015). Iron is the fourth most abundant element found in soil though it is largely present in forms that cannot be taken up by plants. Iron, in small amounts, is essential for healthy plant growth. It is important for the development and function of chlorophyll and a range of enzymes and proteins. It also plays a role in respiration, nitrogen fixation, energy transfer and metabolism. As with other nutrients, plants can have too much iron but this primarily affects the uptake of other nutrients rather than producing direct toxicity symptom. Iron concentration of ten samples were almost similar ranging from (228.045 ppm) in sample (No 2) to (273.309 ppm) in sample (No1) this considered normal range. Nickel and vanadium content were clearly low. Cobalt and zinc showed relatively high concentration which may be suitable to satisfy the plant requirement (Table 3.8).

3.10-Toxic minerals concentrations in soil samples

Table (3.10) Toxic minerals concentrations in soil Samples (ppm)

Sample No	Al	Sr	As	Pb	Cd
Sample 1	273.989	10.871	1.268	0.676	0.0984
Sample 2	239.695	11.254	1.133	0.605	0.0654
Sample 3	285.113	9.957	1.253	0.72	0.029
Sample 4	274.439	10.663	1.257	0.685	0.0984
Sample 5	295.039	11.209	1.283	0.733	0.0298
Sample 6	241.872	13.016	1.163	0.651	0.0607
Sample 7	272.874	12.084	1.197	0.636	0.0529
Sample 8	280.165	11.193	1.201	0.643	0.0718
Sample 9	245.512	10.995	1.123	0.654	0.0639
Sample 10	278.653	13.055	1.271	0.726	0.0766
Mean	268.735	11.429	1.2149	0.673	0.0647

Toxic minerals in composite soil samples for Elsaggai Scheme were found to be in the suitable range but aluminum ions Showed high concentration in all the samples. This may be considered as normal because its high availability in earth crust. Strontium and vanadium concentration were relatively low, minerals which are normally classified as toxic exhibit low availability in all analyzed soil samples .these are cadmium and lead. Arsenic concentration was found to be relatively high ,this may increase the toxicity and its effect on crops. Arsenic combines with other minerals to form organic and inorganic compounds. Inorganic arsenic compound are thought to be more toxic than organic arsenic compounds (Nriaga, J.O.,1994).

3.11-Residual sodium carbonate in soil samples

Table (3.11) Residual sodium carbonate in soil samples (meq/l)

Sample No	Ca	Mg	Total Alkalinity	RSC
Sample 1	88.162	51.433	74.23	-7.89
Sample 2	76.692	44.031	76.92	-6.66
Sample 3	77.487	49.396	81.36	-7.10
Sample 4	78.578	46.764	72.35	-7.03
Sample 5	82.413	51.29	76.34	-7.56
Sample 6	76.984	46.987	77.36	-6.91
Sample 7	77.183	47.234	74.12	-6.98
Sample 8	79.942	50.876	80.94	-7.34
Sample 9	76.153	44.83	74.65	-6.72
Sample 10	86.673	52.123	73.66	-7.86
mean				-7.21

Residual sodium carbonate for the analyzed soil samples were found to be in the lowest range .RSC values as, an important parameter for assessing agricultural soil quality is a good indication of salinity hazard. The permissible range of (RSC) values of soil samples maximum (2.5 meq /l). According to that ten samples in this situation in the safe range. As a result soil of agricultural growth of Elsaggai scheme is suitable for crops growth(Table3.11)

Conclusion

The obtained results showed that :-

• That the chemical properties of irrigation water samples analysis both from river Nile sources did not differ significantly in most of measured values.

•The measured values were generally within the limits acceptable for irrigation and crop production.

•Sulfate and total alkalinity values were found to be relatively high compared with chloride and nitrate ions concentrations, indicating that irrigation water of Elsaggai scheme is mainly sulfate and bicarbonate water.

•The obtained residual sodium carbonate values were found to be within the acceptable range and Elsaggai irrigation water may be described as good quality water for irrigation use .

• High (CO_3^{2-})and (HCO_3^-)tend to precipitate calcium carbonate ($CaCO_3$) and magnesium carbonate ($MgCO_3$), thereby increasing sodium hazard in the soil relative to Ca^{2+} and Mg^{2+}, and consequently the SAR.

• The significantly low concentration of nitrate and phosphor in the analyzed soil samples indication that the agricultural soil of Elsaggai scheme its low fertility.

• Residual sodium carbonate (RSC) ranged from 8.00 to 30.69.There was no detectable NH_4^+in the irrigation water

Recommendations

•Further studies may be needed to cover more areas of sampling and greater number of samples

• The effect of irrigation water on plant growth and crop production may also need to be further studied

• Residual Sodium Carbonate determination should be considered as an essential parameter for determining irrigation water and agricultural soil quality.

•More research to be carried out especially in the farmers fields as away of educating farmers on the good practices of horticultural crops production.

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