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Evaluating and Treating a Drainage Water by Magnetization and Blending Methods for irrigation Uses, Almasab Alam-Iraq as a Case Study

A Thesis

Submitted to the College of Engineering / University of Babylon in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Engineering / Civil Engineering /Water Resources Engineering.

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Dedication

To My Family and My Friends

Kadhim Altaee

2023

Acknowledgment

In the name of ***Allah***, the most compassionate the most merciful, Praise be to ***Allah***. His blessing and peace be upon his Massenger Mohmmad and the people of his home.

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Abstract

This study was conducted on the Almasab Alam drainage located within the Babil governorate sector, which starts from station 360+00 and ends at station 441+00 . This study dealt with the evaluation and treatment of Almasab Alam water. Five stations were selected for collecting samples from them and performing chemical and physical testing on them. Each sample is examined three times in various labs, and the average value was taken. In order to determine if the water is suitable for irrigation and which plants may be cultivated with it, the test results are entered into the software program Irrigation Water Quality Guide **(IWQG V.1)** that was used in this study .For the treatment of this water, two methods were used, the first is to mix this saline water with the water of the rivers in the study area and used it for irrigation. Three proportions were used for mixing. 75% from river water and 25% from Almasab Alam water **(B1),** 50% from river water and 50% from Almasab Alam water **(B2),** and 25% from river water and 75% from Almasab Alam water **(B3).** After that, the chemical and physical properties of the models are examined, and they are entered into the **(IWQG V.1)** to evaluate them, knowing their suitability for irrigation, and determining the type of plant that can be grown for each case, and determining the best mixing ratio.

The second method of treatment is the magnetization method of water by passing it with a magnetic field of different intensities of 1000, 2000, 3000, 5000, and 7000 gausses. The chemical and physical properties of this water are examined after its magnetization. For knowing the effect of magnetization of water on soil and plants, The same soil weight and properties were used to fill all pots. The soil is taken from the study area near stations 360+00 and 441+00. All the pots were placed inside a plastic house to preserve them from rain and other weather conditions. To study the effect of irrigation with magnetized water, Almasab Alam and the river without any other effects such as rain throughout the study period within the seasons 2020-2021 and 2021-2022 are considered. The water used for this study was from Almasb Alam drainage water untreated and treated and river water. The treated water is passed through a magnetic device with five different

intensities (1000, 2000, 3000, 5000, and 7000 G. The onion, bean, maize, and Vicia faba L. are planted in pots. To confirm the accuracy of the findings, three replicates for each pot under the identical irrigation conditions for each plant were made. Three hundred and thirty-six pots were used in this study. Before and after the experiment, the chemical and physical characteristics of the soil are examined.The rate of germination, height, and duration of the flowering of plants are studied. The root length of the onion plant is only measured.

Among the findings of the study are, that Almasab Alam water should be used for irrigation of plants with moderate to the high tolerance of salts. The best mixing ratio is (B1). The magnetized water improves the chemical and physical properties of water and soil, as well as improving the properties of plants in terms of vegetative and root system and production, as well as the early flowering process by an average of 16 days than the usual case. Magnetically treated water in the case of MW3 (3000) G can wash (70%) of the salts in the soil. The state of water passing through a magnetic field of 3000 gausses has been found to be the best percentage for improving the qualities of water, soil, and plants, and is advised for usage in the study region. The magnetization technology is the most effective way to treat the water in the research region.

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Symbol	Description
B	Boron
B1	Mixing ratio one(75% is river water and 25% is Almasab Alam water)
B2	Mixing ratio two (50% is river water and 50% is Almasab Alam water)
B3	Mixing ratio three (25% is river water and 75% is Almasab Alam water)
Ca	Calcium
CaCO3	Calcium carbonate
CW	Control Water (River Water)
Cl	Chlore
CO3	Carbonate
ds/m	Decisiemens per meter
DO	Dissolved Oxygen
EC	Electrical conductivity
ECen	The salinity threshold value for the best yield (ds/m).
ECmax	The maximum salinity value when the crop yield is (0), (ds/m).
ECe	The three years mean value of the salinity in this study
EDTA	Ethylene diamine tetra-acetic acid
ESP	Exchangeable-sodium percentage
FAO	Food Agriculture Organization
G	Gauses
g	gravitational acceleration
h	capillary height of water (cm)
H_2SO_4	Sulphur Acid
HCO_3	Bicarbonate
IWQG V.1	Irrigation Water Quality Guide
K	Potassium

Symbol	Description
LF	Leaching fraction
LR	Leaching requirements
KR	Kelly Ratio
MH	Magnesium hazard
Me/l	Millie-equivalent per liter
Mg	Magnesium
MW	magnetic water
MW1	1000G
MW2	2000G
MW3	3000G
MW4	5000G
MW5	7000G
NMW	no magnetic water (Almasab Alam water)
Na	Sodium
Nacl	Sodium chloride
Naoh	Sodium hydroxide
NO3	Nitrate
% Na	Percent Sodium
pH	potential of hydrogen
PI	Permeability index
PO4	Phosphate
ppm	Part per million
Q_{imax}	the maximum value of q_i in each category
Q_{iamp}	the ampleness of the category
r	Radius capillary tube
SAE	the soil after the experiment
SAR	Sodium adsorption ratio
SBE	The soil before the experiment
SICL	Silty Clay Loam
SW	Salty Water
SO4	Sulfate
SSP	Soluble sodium percentage

Symbol	Description
T.H	Total hardness
TDS	Total dissolved solids
t_1	the flow time of magnetically treated water from top to bottom of the glass ball
t_2	the flow time of distilled water from top to bottom of the glass ball
WCE	water consumption efficiency
WQI	Water Quality Index
X_{ij}	is the parameter marked value
X_{inf}	the minimal value of the category to the parameter
X_{amp}	the ampleness of the category to each parameter
LIST OF ABBREVIATIONS	
σ	coefficient of the strength of surface tension
ρm	the density of magnetically treated water
μ_1	The viscosity of Magnetically Treated
μ_2	The viscosity of Distilled Water
ρ_1	the density of magnetically treated water
ρ_2	the density of distilled water

Chapter 1 *Introduction*

1.1 Introduction

The spread of salinity of irrigation water has become a major environmental constraint that limits the production of plants in most of the dry and semi-arid lands in the world, as water suitable for irrigation is scarce and the salinity of drainage and groundwater increases in most of these cases, which increases the rate of soil salinization in these areas. Unfortunately, this matter threatens agricultural lands in many areas in Iraq, which has a large agricultural activity and suffers from the problem of scarcity of surface water, as the only source for it is drainage and groundwater that is predominantly saline and has characteristics unsuitable for irrigation in many cases. For these cases, it appeared that large areas of land were affected by salinity, which resulted in several negative effects on the growth and production of plants. Chapter one presents general information about Almasab Alam Water with a map of the location, evaluation, and treatment by blending and magnetization of water.

1.2 Magnetized Method for Irrigation Uses

Water that has been subjected to a magnetic field or that has been through magnetic device referred to as magnetize water (MW). According to reports, applying magnetic fields to water can alter some of the water physical and chemical properties such as (surface tension, conductivity, refractive index, melting temperature, viscosity, salt solubility and pH **[Grewal and Maheshwari, 2011].** Decreasing the hydration of salt ions, accelerating coagulation and salt crystallization, increasing the efficiency of added fertilizers, increasing soil nutrient mobility and enhancing extraction and uptake of N, P, K, Fe and Zn by plants improving the microbiological content of soil and making plants more resistant to unfavorable environmental conditions **[Ali kamanoglu and Sen, 2011].**The magnetic fields weaken the intracluster hydrogen connections, splitting the bigger clusters, generating smaller clusters with stronger inter-cluster hydrogen bonds, each made up of six symmetrically arranged molecules, and reorganizing the water molecules into very small clusters. Because of the hexagonal configuration of this small, homogenous cluster, it may easily pass through the openings in the cell membranes of both plants and animals **[Wang et al., 2013].** Additionally, no harmful substances may enter MW structure. That characteristics made MW biocompatible substance for both plant and animal cells. MW may be utilized to improve livestock health, promote seed germination, and increase agricultural productivity **[Hilal et al. 2013]**. The key functions of magnetically treated water in soil are increasing the leaching of additional soluble salts, lowering pH values of soil layers, dissolving slightly soluble salts such as carbonates, phosphates, and sulfates **[Hilal et al., 2013]** Researches have shown that, employing MW for irrigation might increase water production, preserving water supplies for anticipated future universal water crisis. Additionally, MW is successful in preventing and eliminating scale deposits from pipes and other water containing structures **[Ali et al. 2014]..**

The magnetized water helps to break the hydrogen bonds in the salty water, which helps to wash the soil and help the plant to easily absorb water and minerals from the highly saline soils, and accordingly, the usage of magnetically treated water (MW) helps to increase agricultural production quantity and quality and increase the plant's ability to resist diseases. A most importantly, the magnetization of water helps in saving the water used in irrigation and reduces the use of chemical fertilizers, which will positively affect human health and the environment **[Muhammad; 2014].** Also that the use of magnetized irrigation water helps in the speed of germination and early maturity of the crop in addition to raising production and its quality by (20-30%) over the normal conditions of the same plant **[Ali et al. 2014],** and given that studies on magnetized water are new and few in the Arab world in general and especially in Iraq, and there has been a lot of controversy about it among those interested in this field in recent years, so a topic was proposed as a contribution to the study of evaluating the viability of magnetized water for irrigation. Almasab Alam Drainage is a model for this study.

1.3 Blending Method for Irrigation Uses

The un consumed portion of irrigation water that applied to crops is known as drainage water. This kind of water which is intended to be reuse may be mixed or combined with irrigation water residual quantities (e.g. operational losses of both spills and tail ends from irrigation canals, runoff surface from irrigation, water purification plants effluents, and wastewater of domestic and industrial. The upward leakage of groundwater may become part of

The alternatives to drainage water reuse are:

1. Use of drainage water directly for irrigation without dilution.
2. Intermittent usage of drainage or alternating with irrigation water.
3. When drainage and irrigation water are mixed regularly or continuously, the result water is of lower quality than irrigation water but is still safe for the crop being watered.

In arid regions, perennial streams generally located in lowest elevationsof basin. which mean, stream will acts like a water source and basin drain. Colorado River at the west of the United States is proper sample, which is rise high in Rocky Mountains and fed by snow melting. Water of this river originally of extremely high quality. But, as river progresses downstream, it passes through valleys with alluvial in which local groundwater leaks into the channel of the river because of local rainfall. Therefore, the salts that are seeping from the soil will carried to river as it picked up by rainwater, which absolutely reducing the water quality. If this water is used to irrigated a alluvial valleys, then the plants in this valleys will take some of this water and concentrate the salt in the remaining water which will back to the river through the groundwater system. The river water is used by downstream valley as it's only source for water, then the drainage water from the upstream valley is naturally mixed with the undissolved river water and will naturally reused. Even before Colorado River irrigation was developed, riparian vegetation used the river's water and valley groundwater so that any water which flowed into the river along its course was normal drain water. Therefore, drainage water reuse can be considered a phenomenon that occurs in nature with or without human intervention. When water is diverted for industrial, municipal, or agricultural uses, the return flows into the hydrological system quality will be lower than that of diverted water and normal reuse will also occur. To increase the quantity of the total water needed for irrigation, that makes the dilution factor is appropriate to produce an adequate water quality level, its better to mix both drainage and good water. This mixing can be done at the farm level by mixing drainage water with a fresh water or on a regional scale where drainage water is raised from the main drains and discharged into the irrigation canal [**Hamdi and Farraj Ghanem, 2005**]. If the drainage water, needed for any form of reuse, is too saline, then, it should merely be disposed of in an environmentally suitable salt pan. Oceans can receive saline drainage water of any size, while in domestic places and enclosed basins, it sometimes need of the expansion of evaporation lakes specifically created to dispose of drainage water with high saline [**Kadhim, 2013**].

The present study highlights and reviews the potential. Constraints and conditions involved in reusing agricultural Almasab Alam drainage water from the station (360+00) to the station (441+00), and treatment by magnetization and blending with fresh water in the study area for irrigation.

1.4 Almasab Alam Water with a map location

The public estuary is a river with a length of 565 km that extends from northwestern Baghdad and empties into Khor Al-Zubayr in the Arabian Gulf with a design discharge of 220 cumes. Where the land extending from Mosul to Basra is a land of sedimentary plains that decreases as we head south and as the irrigation of agricultural lands continuously produces salt. The middle and south lands are salinized and there is no treatment for that except to drain the excess water with its salts, and this does not happen in the northern regions that do not need taps, because the water flows towards the depressions without human intervention. As for the center and the south, the water remains stagnant over the land and we call that (trench). As a result of evaporation, a salt layer appears on the surface, and over the years the land becomes poorly productive. Studies in the forties of the last century proved the need for trenches to drain the excess water and rid the land of salts and chemical fertilizer products. There is a group of drainages that are flowed into the Almasab Alam and extended from its beginning to its end, as shown in **Table 1.1**. For this purpose, major drainages such as Al-Musayyib and Latifia were accomplished. These main trenches and others start with the field taps and then the branch ones and the main trenches are poured into the main channel, which is the general drainage that collects the water of these trenches and throws it into the Arabian Gulf at Khor Al Zubair. That is, the goal of establishing a public drain to be a channel carrying salt water to the Gulf, and means reviving more than 6 million dunums of agricultural land to increase the yield produced by this land.

Table 1.1: Drainage flow into Almasab Alam

Stations	Drainages	Discharge(CUMES)
528+00	Saqlawiyah	12.70
528+00	Ishaqi	15.60

528+00	Sebea albor	6.30
527+00	Shulaa	0.00
510+00	Abu Ghraib	3.00
504+00	Radwaniyah	6.10
500+00	Almabzal	1.25
485+00	Youssoufia	4.00
471+00	Hor Rajab	4.10
460+00	Latifia 1	1.20
442+00	Latifia 2	1.30
441+00	Al-Musayyib Alshemali	6.40
427+00	Ejblah	2.40
411+00	EKsabh	2.70
398+00	Al-Musayyib Aljanobi	11.90
398+00	AlShehamiea	3.30
354+00	Hillah-Hashimiya	15.00
283+00	Daghra-Huria	17.00
217+00	Al-Garraf Alkabeer	20.00
186+00	Alforat Alsharqi	81.00
172+00	Sharq Alghraf	50.00
124+00	Almaleha	0.00

Al-Maasab Alam project is considered one of the main development projects in Iraq, as its necessary for the transmission of the saline water extracted from reclamation of the land in Iraq's center and southern regions through an interconnected drainage networks, beginning from the total drainage arenas that covered by collected drains and then secondary and main. At the end, the path of Al-Masab Alam responsible for draining the salty water of Arabian Gulf through its sections home. The initial idea of establishing Al-Masab Alam was in the fifties of the past century, when it commissioned an American company to do so by preparing map of the drainage networks between Tigris and Euphrates rivers. It has a direct project in 1973 (first phase) and the work was carried out in stages. On 12/12/2008 was running the project after the completion of the final implementation of the main pumping station south Nasiriya, its coordinates (30˚58'09" N, 46˚20' 38" E) and the discharge capacity of 220 m^3 /Sec **[Aljawei,and Kadhim,2012].** The site of Almasab Alam in IRAQ showed in **Figure 1.1.**

1.5 Evaluating and Treating of Almasab Alam Water by Magnetized and Blending Methods for Irrigation Uses

This research aims to assess the validity of the AlmasabAlam water and treat it using magnetic technology and mixing the Almasab Alam water with the water of the Al-Mashroa River in different ratios. As for the magnetic technique, it is carried out by passing water in different magnetic fields (1000, 2000,3 000, 5000, and 7000 G) used in the study, and the extent of conservatism The water depends on the new properties acquired after its magnetization, by comparing the results of the physical and chemical analyzes obtained for irrigation water before and after it passes through the magnetic field. Then the results of the physical and chemical analyzes are matched with the international classifications adopted in the evaluation of irrigation water, and it has divided this study into two parts:

Figure 1.1 : Map of Almasab Alam [**Kadhim, 2013**]

1.5.1 Evaluating of Almasab Alam water

Samples are taken from Almasab Alam water from five stations, and laboratory tests were performed for these samples for the elements that are included in the evaluation of water and its suitability for irrigation. After the results obtained, they are compared with the international standards FAO for the quality of irrigation water, by using Irrigation Water Quality Guide IWQG

V.1 software and deciding whether this water is suitable for irrigation or not, and what are crops we can grow depending on the results of the tests.

1.5.2 Treatment

Since Almasab Alam water has a high level of salinity and is considered harmful to the soil and plants, it is treated in two ways:

1.5.2.1 Method of magnetizing water

It is one of the modern and effective methods of treating salty water and making it suitable for irrigation, as well as improving the properties of the soil irrigated with this water. Note that this technology is not used in Iraq in this area. Therefore this study will focus on this type of treatment. This method is summarized by passing Almasab Alam water in a magnetic field with different intensities (1000, 2000, 3000, 5000, and 7000 G). Models are taken from the five stations and a model passes from each station with the above magnetic field. The same soil weight and properties were used to fill all pots. The soil is taken from the study area near stations 360+00 and 441+00. Inorder all to study the effect of irrigation with magnetized the pots were placed inside a plastic house to preserve them from rain and other weather conditions. Almasab Alam water, and the river without any other effects such as rain throughout the study period within the seasons 2020-2021 and 2021-2022. To know the effect of magnetized water on plants and soil, it was conducted laboratory experiments with the cultivation of certain crops, and these crops are sensitive to salinity so they cannot withstand Almasab Alam water due to their high salinity in them, and their productivity is very low, and in some crops, it may reach zero percent according to international standards (FAO).

The water used for this study was from Alamasb Alam drainage water untreated and treated. treated water is passing through a magnetic device with five different intensities (1000, 2000, 3000, 5000, and 7000 G). The river water was used as control water in this study.The onion, bean, maize, and *Vicia faba* L. are planted in pots. Three replicates of every pot under same conditions of irrigation for each plant were made to confirm the validity of the results. Number of pots used in this study is 336 pots. The soil properties (chemical and physical) are studied before and after the experiment. The rate of germination, height, and duration of the flowering of plants are studied. The root length of the onion plant is only measured.

The identification of samples are as: Gauses **(G),** magnetic water **(MW)**, nonmagnetic water **(NMW)** of Al-Masab Alam water, control water **(CW)** of river water, **MW1** (1,000 G), **MW2** (2,000G), **MW3** (3,000G), **MW4** (5,000G), and **MW5** (7,000 G). The soil before the experiment is abbreviated, **(SBE)**, and the soil after the experiment, **(SAE).**

1.5.2.2 Method of mixing Almasab Alam water with nearby rivers water

The water of Almasab Alam drainage is mixed with river water in the study region in the following proportions:

75% is river water and 25% is Almasab Alam water, called (**B1)**

50% is river water and 50% is Almasab Alam water, called (**B2)**

25% is river water and 75% is Almasab Alam water, called **(B3)**

All three checks are carried out for the above three ratios, as well as tests for river water and Almasab Alam water are conducted at that site. Five sites are selected for this method. The results of the tests are compared with the international standards for irrigation water, by using **a software for**

Irrigation Water Quality Guide IWQG V.1. Based on the results, the type of crop that is being grown can be known.

1.6 Organization of the thesis

This thesis is organized as follows:

Chapter one is general information about Almasab Alam Water with a map of the location, evaluation, and treatment by blending and magnetization of water. Chapter two includes the literature review of previous research on the subject is showed. Chapter three includes the description of the study area and the experimental works of the study. The experimental results are presented and discussed in chapter four. Chapter five deals with the study of the magnetic water effect on the plants, which are grown during the study period, and the physical and chemical soil properties. In chapter six, conclusions are stated, and recommendations are proposed for conducting further studies.

1.7 Methodology

This study includes:

1. Evaluating Almasab Alam water in the study region and checking their water.
2. Comparing the rivers and Almasab Alam water with the specifications FAO of the irrigation water.
3. Mixing drainage water with river water (in the same region) in different ratios (B1, B 2, and B3).
4. Checking the quality of the water after each mixing ratio and comparing them with the specifications.
5. Testing some types of magnets and selecting a suitable one in the study area.

6. Collecting samples of water from different sites with different dissolved salts.
7. Measuring the water properties before and after magnetization (pH, Do, TDS, EC… etc.) with different magnetic fields (samples are before and after exposure to the magnetic device.
8. Investigating effects of magnetization on water chemical and physical properties.
9. Investigating the magnetization effect on soil chemical and physical properties.
10. Investigating the effect of magnetization on plants germination, height, duration of flower, and root length for onion plant.

1.8 Objectives

1. Determining the different blending percentage qualifications for the use of irrigation water in the study area.
2. Defining the feasibility of what type of plant is grown for each mixing ratio.
3. Investigating and evaluating the effectiveness of the magnetic field on water properties after passing the samples of Almasab Alam water into a magnetic device, then being handled with different magnetic intensities.
4. Testing of the water properties such as pH, EC, TDS, surface tension, and viscosity and DO use of a laboratory instrument. Those properties have a direct impact on crops and changes in water properties may be improved the vegetative and flowering growth.
5. Determining what magnetic field is relevant for the growth type of plant.
6. Determining the effect of magnetic field on chemical and physical soil properties after irrigated with magnetic water.

7. Determining the effect of the magnetic field on the germination, duration, and flower height, and root length of plants.
8. Increasing the amount of irrigation water.
9. Using the marginal water to reduce desertification by planting selected areas.

Chapter 2 Literature Review

2.1 Introduction

It has been understood that salts have an impact on agriculture at least since the beginning of the history of crop production. Mesopotamian farmers utilized one of the richest agricultural land in the world at that time, The Fertile Crescent of Tigris and Euphrates rivers (now Iraq and Turkey), more than 5,000 years ago. The agricultural culture changed from the cultivation of wheat and barley for exclusively salt-tolerant barley, as salt started to build up in the soil as a result of insufficient leaching and drainage of irrigation waters. These rich valleys eventually lost their ability to support life as salt took over, and so the land was abandoned. Just before the time of Christ, the Romans plowed the fields of conquered Carthage and sprinkled salt on the fields in an effort to prevent the Carthaginians from reestablishing themselves. The salted fields remained unproductive for another 24 years, which caused the attempts to recolonize the area to fail. Since ancient times, salts have been recognized as an issue, especially in arid and semiarid regions where there is inadequate rainfall to allow salts to be washed out of the root zone. There are usually some dissolved materials, sometimes known as salts, in irrigation water. These salts include salts that have been dissolved from soil that water has previously passed through as well as dissolved solids that come from the weathering of rocks and soil by water. As salt sources like lime, gypsum, and others dissolve over time, irrigation water becomes variable degrees of salinity. **[Aljawei,and Kadhim,2012].**

2.2 Previous Studies on Magnetized Method for Irrigation Uses

2.2.1 The magnetization of irrigation water

The first magnetic water treatment device was developed by an Australian engineer who specializes in magnets at the beginning of 1990, and therefore this technology has become the focus of researchers' attention compared to other physical and chemical methods for treating water, due to its environmental purity, health safety and ease of use **[Al-Jabouri and Hamza 2012].** This technology is only new to developing countries, as the first patent was registered for treating water magnetically and getting rid of lime scale deposits that form on pipes in Europe in 1890. 1980, with a kind of skepticism, because it did not address convincing explanations for the effect of the magnetic field, unlike today, when these concepts have become scientific facts that can be adopted and defended **[Al-Sumaydi 2012].** A historical overview of the magnetization of water: The use of the magnet goes back a long time, as it was used by the Pharaohs, the Chinese, and the Indians in various fields, and magnetic sciences have developed indicating that the magnetic properties are not limited to certain elements such as iron and manganese, but rather it is a characteristic associated with all solid, liquid, gas and all neighborhoods **[Ziyad et al. 2015]**.

2.2.2 Definition of the Magnetic Field

The magnetic field can be represented by the magnetic lines of force, and the magnetic field line is an imaginary line that represents the path of the hypothetical north poles unit movement as it appears outward from the north pole and entering to the south outside the magnet and entering from south to north. The magnetic field is a directional quantity represented by imaginary lines called magnetic flux lines, which are in the form of closed rings resulting from the exchange of lines for small magnetic fields that are generated from the atoms of the magnet as a result of the spiral or orbital movement of the electron, and number of vertical lines on unit area is defined by the intensity of the magnetic flux and denoted by the letter B and is called every flow line in the global system is a wiper, so units of B called Gauss, as 1 Gauss = 1 Maxwell / cm2 = 1 Weber / m2 = 10^4 Tesla **[Almawsili,2013].**

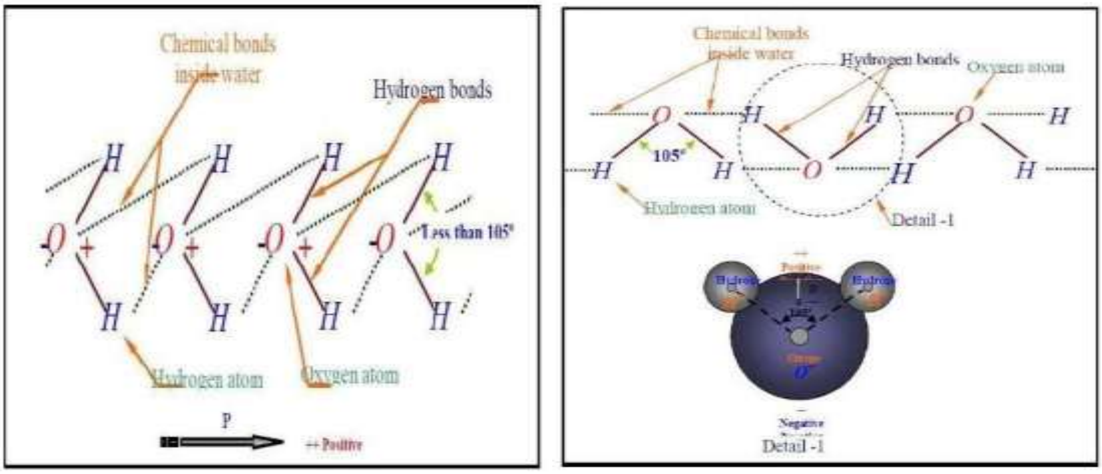
2.2.3 Magnetized water

It is the water that is passed over particular magnetic field, or by insertion the magnet inside or close it for some time, where exposure to influence of that magnetic fields causes many of its properties to change. Several factors control the degree of magnetization of the water, which is the amount intended for magnetization, the force of the magnet used .The duration of the contact between the water and the magnet (magnetization duration). **[Kazem, 2010, and Al-Halfi 2011]** defined magnetized water as exposing the water to magnetic fields that lead to the arrangement of charges in it.**[Al-Jubouri and Hamza, 2012]** mentioned in their definition of magnetically treated water, that water has been exposed to magnetic field, which causes it to acquire magnetic properties that distinguish it from regular water, and that the treatment of water is magnetic using magnetic devices called Magnetron with a certain intensity and for a certain period, as the water is passed through it.

2.2.4 The effect of the magnetization process on water

Figure 2.1.a clarifies water molecules before they are exposed to a magnetic field, while **Figure 2.1.b** explains the arrangement of water molecules after being exposed to a magnetic field. The regularity of water molecules in one direction after passage of water over a magnetic field, to the effect of latter on the angle of bonding of the oxygen atom with the two hydrogen atoms, which changes and becomes less than 103 ° instead of 105 ° (the normal binding angle), and this leads to a decrease in the pool of water

molecules With each other in clusters of 6-7 molecules instead of 10-12 molecules in the natural state, which gives it ability to easily penetrate cell walls and gives better and faster absorption of plants **[Rasool and Younis, 2012],** which is the same interpretation adopted by **[Al-Jabali and Dahl 2012]** and in addition to that, other changes occur to molecules when they pass through a magnetic field, such as increasing the size of the water molecule, which leads to an increase in solubility, a decrease in viscosity and surface tension, and an increase in the surface area, resulting in the ease of crossing water molecules through the cell membrane, and then increasing the nutrients they carry , Moreover, the ability of water to dissolve salts increases, the proportion of dissolved oxygen increases, and the speed of chemical reactions increases, but the magnetized water and the ions it contains lose the effect of magnetization after 24-72 hours. Water is composed of hydrogen and oxygen atoms and a water molecule is very simple, When water molecules are exposed to a magnetic field, the hydrogen bonds between the molecules either change or break down, and this disintegration serves to absorb energy. Hydrogen bonds between water molecules may be double or multi-bonded. It alters crystallization, raises electrolytic susceptibility, and decreases the level of water molecule conjugation. **[Ziyad et al., 2015].**



b **a**

Figure 2.1: Arrangement of Water Molecules

a. Before Magnetization **b.** After Magnetization

2.2.5 The effect of the magnetization process on the physical and chemical properties of water

There are (14) physical and chemical characteristics of water that alter when it is exposed to a magnetic field. These characteristics include electrical conductivity, an increase in the amount of dissolved oxygen, an improvement in the water's capacity to dissolve salts and acids, polymerization, surface tension, a change in the rate of chemical reactions, wetting, plasticity, optical properties, dielectric measurement, and permeability increase (and also what was pointed out) **Rachidi et al. 2016** (Exposing water to a magnetic field causes changes to its physical and chemical properties, some of which last for minutes to several days, and also what is reached) .**Abdulaziz et al. (2017)** who found that applying a magnetic field of 6560 gausses increased the pH value by 12%, while the amount of total dissolved salts TDS decreased by 33%, and a decrease in the concentrations of calcium, sodium, magnesium, potassium, sulfate, Chlorine. They also noted a decrease in viscosity and surface tension by 23% and 18%, and confirmed). **Kazem; 2010** study the passage of water through a magnetic field increases the degree of its interaction towards the basic and improves its physical and chemical properties. **[Al-Halafi stated 2011]** found the physical and chemical properties of water improve upon its magnetization, such as density, boiling point, electrical conductivity, surface tension, and viscosity.

2.2.6 Use of magnetized water for irrigation

The emergence of applications of magnetic techniques in many fields has encouraged researchers in the fields of irrigation to study the effect of using this technology in adapting and treating some of the characteristics of saline groundwater and the possibility of expanding its use in the cultivation of field crops and reducing its negative effects on productivity and soil salinity. The lead-in **[Takachenko 1997 and Ziyad et al. 2015]** opened the door to the use of magnetic technologies as a source of cheap energy in improving and raising the appropriateness of saline water for using it in irrigation and reduce harm of saline groundwater into some areas of the governorate and to adapt some of its properties to expand its use in the fields of irrigation and agriculture, especially after the recent trend of using these technologies. In many fields, water problems are treated as one of the means that do not require much energy when used **[Muzahim et al., 2015].**

2.3 Effect on plants

A number of physiological processes in plants may be affected directly or indirectly by modifications in the physicochemical properties of MTW, according to the research on this issue. MTW delivery to plants hence results in gradual effects on their growth and development. According to numerous writers, plants become more productive and their water and mineral metabolism changes after being the irrigation water exposed the to MF.

[Maheshwari & Grewal, 2009; Mulook Al-Khazan et al., 2011; Abou El-Yazied et al., 2012; Hozayn et al., 2013; Mahmood &Usman, 2014]. discover that saline water (1500 and 3000 ppm NaCl) and recycled water from drainage water treatment facility, used to irrigate celery (Apium graveolens) and bean (Phaseolus vulgaris), buffer the detrimental effects of magnetic treatment. The yield and throughput of plants cultivated with this MTW increased in a controlled greenhouse setting to a level that was almost equal to that of plants irrigated with high-quality potable water and higher than that of plants not treated with magnetic fields.These results are consistent with those of Marei et al. (2014), who utilized saline irrigation water that had been treated with MF and demonstrated a significant improvement in pepper (Capsicum annuum L.) output and water consumption efficiency (WCE). Similar results were obtained by **(Mahmood &Usman, 2014**), who investigated the effects of a magnetic treatment (235 mT; flow 3 L/min) in four types of irrigation water (sewage, saline, irrigation channel, and tap) on the germination of maize (Zea mays) seeds after submerging them in the water for 24 hours. The emergence index, the rate and speed of germination, and the growth of roots and stems were some of the traits that saw significant increases. It was shown that MTW sped up the germination of maize seeds, reducing the time needed to respond to emergencies by 17.90%.

Ferrari et al. (2015) states that lettuce plants' biomass ((based on root length, fresh and dry weight)will rise if the water is treated with a magnetic device if they are given half or a quarter of the water lost to evaporation, offsetting the negative effects of limiting water supply. However, neither the MF dose employed nor the magnetic device characteristics were specified by the authors.

Other authors have found similar patterns of reactions in a number of crops treated with MTW. In the case of jojoba (Simmondsia Chinensis) plants, **[Mulook Al-Khazan et al. 2011]** discovered that MTW irrigation boosted relative water content and WCE in addition to the levels of magnesium, calcium, and phosphorus. This result persisted even in treatments with a lower moisture regime, demonstrating that these plants' ability to handle water is enhanced by magnetic therapy. However, the study omitted mentioning the kind of magnetic therapy used..

Hozayn et al. (2013) also revealed a 19% rise in sugar beet grown WUE using MTW as opposed to water without treatment. For salt, potassium, and amino acids, respectively, it was demonstrated that this process reduced the pollutants' levels in the recovered sugar by 13 percent, 12 percent, and 16 percent. The weight, length of the roots, and total sugars all increased as well. The magnetic doses were not described in depth by these authors, which is unfortunate.

Zúñiga et al. (2016), When two Quantum Biotek devices (3.5 mT - 156 mT) were serially attached to a recirculation system in a greenhouse environment with an exposure length of 30 minutes at a flow of 10 L/min, turmeric (C. longa) was demonstrated to develop noticeably faster . This effect was seen in the length of the main stem, the amount of rhizomes, the quantity of tillers, and the fresh and dry biomass. It's crucial to remember while using MTW that a plant's total mass is mostly made up of water (between 85 and 95 percent), a little amount of paramagnetic and ferromagnetic metals, and barely any non-metals. As a result, it has been claimed that effects on solutes as well as water might cause changes in the metabolism of the plant, including alterations in photosynthesis and water absorption **[Yano et al., 2004].** The presence of MF affects how ions travel through cell membranes, in accordance with the Ion-Cyclotron Resonance Theory **[Galland & Pazur, 2005].** At the very least, the increases in mineral content shown in the subsequent research may be explained by this concept. Based on our personal experience and the research of other authors, we may infer that the magnetic treatment of irrigation water may contribute to the sustainability of water resources by enabling the use of low-quality water as well as more efficient irrigation and WUE in some crops. The most recommended dose for this purpose is between 100 and 200 mT, according to the majority of verified research.

The use of the technique of magnetizing irrigation water for agricultural purposes will lead to an improvements in water properties, which will lead to an increase in germination rates, improvement of soil conditions, and an increase in growth, as well as help to increase agricultural production **[Zúñiga et al. (2016)].**

2.3.1 Effect of magnetized water on germination

The germination stage is one of the most important stages in plant life, the success of growth and crop productivity depends on this stage, it is a critical stage in which the plant resists environmental stresses, especially water stress, which plays an important role in accelerating plant growth during the germination stage in dry and semi-arid regions. The magnetized water reduces the effect of water stress and increases the seed activity and germination rate by 6 and 9% respectively. The mechanism responsible for the speed of germination in plants irrigated with magnetized water is not well known yet, but there are some suggested opinions about the occurrence of biochemical changes and a change in the activity of enzymes or because of increased water absorption. Increasing the permeability of the material across the seed coat **[Abdul-Qados, A., Hozayn, M., 2010].** Magnetized irrigation water helps in the speed of germination, and increases the yield, and the quality of production in a time not less than (20-30%) of normal conditions of the same plant **[Rasool and Younis, 2012].** The magnetically treated water contributed to obtaining 100% of the germination of wheat seeds after 6 days and 83% after 9 days for the seeds irrigated with plain water, and after 7 days of watering the wheat with magnetized water, it leads to earlier rooting and an increase in the lengths, number and size of the roots compared to with wheat irrigated with plain water) **[Al-Mawsili 2013].**

2.3.2 The effect of magnetized water on the growth of the Vegetative and root system

The usage of magnetically treated water led to an improvement in the vegetative and root growth characteristics of the gerbera plant, as there was an increase in the average number of leaves, the leaf area, the wet and dry weight of the shoot, the dry weight of the root group, as well as an increase in the percentage of total flowering plants and the number of flowers, that irrigation with magnetized waterworks to wash the soil from salts and increases the abundance of nutrients, which in turn increases plant growth **[Amin and Qasim, 2009, and Khalid M. Elhindi et al, 2020].** The white corn plant responded to the magnetic field and the magnetized water in some characteristics related to vegetative and root growth (germination, length, number of leaves, leaf area, number of roots, wet weight and dry weight) **[Rasool and Younis, 2012].** When using irrigation with magnetized water compared to irrigation with non-magnetized water, we find that the magnetized water excelled in the characteristics of vegetative and root growth (plant height, leaf area, stem weight, dry vegetative weight) **[Muhammad, 2014].** The application of the magnetic field led to significant rise in the rate of plant height, number of branches, number of leaves, number of leaves, fresh and dry weight of the root, fresh and dry weight of the Vegetative **[Al-Jabouri and Hamza, 2016].**

2.3.3 The effect of magnetized water on productivity

Use of magnetically treated water helps to increase agricultural production in terms of quantity and quality, increase the ability of plants to resist diseases, and reduce the use of chemical fertilizers, which will positively affect human health and the environment**,** watering cucumber seeds with water exposed to a magnetic field led to premature growth, increase in length, diameter, number and weight of fruits, and total yield of the plant **[Sumaidi, 2012 , and Muhammad, 2014].**

There are no previous studies in the study area, nor any place other than Almasab Alam, that used water magnetization technology and the extent of its impact on water, soil, and plants. This is the first study that used the method of magnetizing Almasab Alam water in Iraq and studied the effects of magnetization on the chemical and physical water properties and soil. It also dealt with the effect of magnetized water on plants in terms of vegetative growth and productivity when watered with it.

2.4 Previous Studies on Blending Method for Irrigation Uses

Previous studies and field conducted researches indicates that, in suitable soil and water managements, crop grow safely even if irrigates with saline waters.

Rhoades (1977) study the possibility of utilizing agricultural wastewater in western of United States. He evaluated the wastewater from 10 locations into that region of US for irrigation suitability through:

1. predicting the depth-based structures of the soil water that results from a simulated crop root zone for various leaching components.
2. assessing the likelihood of any prospective agricultural challenges caused by the presence of such a soil water structure and related cation exchange composition

Crops have been grown successfully using saline water. Saline water can be applied continuously or it can be applied after better-quality water has been mixed in. During the growing season, sensitivity may change, but regardless of the blending technique, crops react to the weighted mean water salinity. Cotton is an illustration of a crop that is frequently watered with saline water. Cotton still produces nearly as much when irrigated with relatively high salinity water as it does when irrigated with high-quality water. A crop known for its tolerance to salt is cotton. Although more delicate crops can be irrigated with relatively saline water, they will likely yield less than when they are irrigated with water of high quality. By using more saline water, it is frequently possible to achieve yields that are just as high as those produced by the application of non-saline water. Water used for irrigation becomes less effective as salinity rises [Letey, 2007]. The crop that will be grown and the desired relative yield will determine how much the amount is reduced. Functions for crop-water-salinity reflect this relationship.

Other requirements are appropriately salt and boron-tolerant crops **[Maas and Grattan, 1999]** and adequate leaching while avoiding deterioration of soil physical conditions, particularly as a consequence of winter rainfall. Rainfall after the use of saline-sodic irrigation water can lower soil salinity, at the soil surface, to levels that cause crusting, decreased infiltration rates, reduced soil aeration, and poor tilth. The use of amendments such as gypsum can mitigate negative impacts on soil's physical properties. Saline-sodic drainage water is used to irrigate salt-tolerant, perennial grasses **[Oster et al. 1999a].** More recently, **Mitchell et al. (2000)** discovered that irrigation with saline-sodic water reduces the establishment of cotton seedlings. Surprisingly, the addition of cover crops to ameliorate the physical conditions of the soil exacerbated the problem. They thought that most likely mechanism was the formation of “stubble-reinforced” surface crusts following pre-irrigation with 0.4-dS/m irrigation water coupled with rainfall with consequent problems in preparing a seedbed with the required tilth.

Hoffman (2006) has a long history of use in many different applications, including water management and research. However, various salinity response functions have been found to be just as effective in describing the data on crop salt tolerance The use of saline-sodic drainage water for irrigation requires a source when the crop needs it. Drainage water is often available when the crops least need water, that is during cool winter months as evaporative demand is small. Where a continual source of drainage water is not available, storage facilities will be needed, either in soil through controlled drainage techniques or in reservoirs.

Blending comprises mixing of saline drainage with decent quality water and using it for irrigation. Blending does not absolutely increase the practical water supply nor is it always economically feasible **[Grattan & Rhoades 1990]**. Theoretically, the upper limit on the salinity of the drainage water suitable for irrigation is value while, if it used straight without blending, crops could not extract water and grow. **Letey et al. (1985)** developed a model to explain how plants react to irrigation levels when the salinity of the root zone is stable, and used this model to estimate the percentage of saline water that could be mixed with non-saline water to achieve different production potentials.

Blending has been done in the broad view water district since about 1970. This district, located in the northwest corner of Fresno County, California, has an irrigated area of 4000 ha of which 3000 ha are artificially drained. The surface and subsurface drainage water are combined in a single main district drain (5 < EC (dS/m) < 7.5) and blended with canal water (0.5 dS/m). This helps the district to meet the targeted and regulated salt and selenium loads that the district discharges to the San Joaquin River. The crops grown, listed in order of decreasing area are cotton, processing tomatoes, cantaloupe, and seed alfalfa. Between 1990 and 2000 the salinity of the blended water ranged from 0.9 to 1.3 dS/m (Wichelns). As a result of the adoption of improved irrigation water management, the amount of applied water has declined from about 1000 mm in the late 1980s to about 700 mm in late 1990. **[Wichelns et al. 1990]** point out that there may be adverse consequences in terms of crop yields. Average annual cotton yields have declined during this time, but tomato yields have increased, although not as much as the average county-wide yields. Currently, the district is evaluating another option, the direct sequential reuse of drainage water on salt-tolerant forages that are in turn leased to farmers for cattle grazing. The lessons learned from this experience are that the sustainable use of saline water in irrigation could not be reached unless certain measures are carefully considered: the careful selection of farm sites, irrigation methods, controlled use of water, and monitoring of irrigated zone. Such measures and others are under development and continuous evaluation for controlling soil salinization, preserving the environment, and ensuring sustainable and productive agriculture **[Daoud and Halitrim, 1994].**

Egypt is one of the top nations for reusing wastewater for irrigation, where it consumes 88% of the freshwater resources annually for agriculture, which is why there is a national policy encouraging the reuse of wastewater. From 2.6 billion m^3 each year in 1980s to around 5.2 billion m^3 per year in early 2000s, officially reused drainage water grew. year by 2010, and with thanks to the El-Ummum drain project in the western side of the Delta (1 billion cubic meters per year) and the El-Salam Canal Project, the total amount of recycled drainage water in the Nile Delta would reach roughly 8.2 billion cubic meters per (2 billion cubic meters per year). In order to reduce the salinity of the irrigation water to an acceptable level, this drainage water's volume is mixed 1:1 with fresh water (Nile water) and then used for irrigation.

Agriculture productivity, irrigation's role in aquifer recharging, cost savings in wastewater disposal, and the values of fresh irrigation water save are all examples of how drainage water reuse in irrigation benefits the environment. However, as drainage water contains contaminants such salinity, pathogens, trace and heavy metals, minerals, and pesticides, irrigation with this water may be harmful to the ecosystem. Due to irrigation water quality, the use of water of mediocre quality has the potential to result in major issues including soil degradation and decreased crop output. There are also other issues like risks to human health and groundwater quality degradation.

Any decision involving the reuse of drainage water should take both the advantages and the risks into account (costs). Using the mixing ratio to modify quality irrigation water based on financial return can lessen risks. Quality and quantity of irrigation water will fluctuate depending on drainage water to fresh water ratio, which will also have an impact on the effects of the irrigation project. The costs and advantages of the project will fluctuate as the project's affects change. The best decision-making process tries to maximize total national profits, which are profits less cost and cost of environmental damage.

Egypt's reuse of drainage water for agriculture has been designed using a methodology to maximize financial gain. Net Present Value of expenses as well as advantages of wastewater irrigation scheme serves as maximization criterion. For the irrigation project, the model calculates the total amount of mixed irrigation water by using various mixing ratios for fresh water and drainage water. The amount and quality of the water that is available for the proposed irrigation project alter as the mixing ratio is changed. The cost and return on investment of the project are influenced by the quantity and quality of irrigation water. Testing was done to see how sensitive the model was to variations in the demand for and supply of water, as well as economic aspects. This developed model makes the assumption that the amount of fresh water that is now accessible is finite and less than what is needed for irrigation in the project area **[Aljawei,and Kadhim, 2012].**

Agriculture Development in the Algerian Sahara region is affected by severe constraints due to evaporative conditions, low soil fertility, and water salinity. The development of agriculture with the saline water use in the Gassi-Touil region of Algeria was not a successful experience. Putting the area under five years of irrigation with saline water, resulting in severe soil salinization and a nearly 50% yield reduction.

In order to develop salt fields found in Biskard region, southeast of Algeria, wastewater with a reasonably high level of salt concentration (9 dS/m), SAR (15.7), and pH of about 8.0 has been tested. Due to its abundance, which exceeds 3 million m3/year, wastewater is essential supply to irrigate palm plants.The experience showed that drainage water could be successfully used for irrigation when leaching and irrigation through appropriate scheduled, soil additives were added to prevent soil sodicity, and the right palm tree kinds and irrigation technique were chosen. **[Azzouz and Belloum, 1995].** The authors came up to the conclusion that the recovery of the availability of large quantities of wastewater provides the greatest guarantee to increase irrigated area in southern Algeria.

Principal mechanism by which soil salinity can be kept at tolerable levels without causing excessive harm to crops is leaching. So proper drainage and disposal systems, whether natural or built, are crucial. As the quality of the water declines, controlling soil salinity becomes more challenging. More attention must be taken to remove salts from the root zone before they accumulate to a point where they could reduce yields. As an alternative, steps must be taken to grow crops resilient to the anticipated salinity in the root zone. Leaching frequency and volume are influenced by the soil's sensitivity to salinity, climate, and water quality. Water quality, climate, soil and crop susceptibility to salinity, the crop season, and salt buildup in the soil all affect how often and how much leaching occurs.

It is debatably desirable to use more water during each irrigation to leach the soil, which would increase an irrigated area's peak demands, or, on the other hand, to apply less water and use fewer leaching complements when there is more water available, for efficient leaching control. The distribution of salt, which is tied to the growth season, will have a significant impact on this. Leaching occurs when consumption is at its highest, which results in increased salt input into the soil as well as increased water application. Additionally, there is a higher chance of water stagnation and crop suffocation when leaching is permanent. However, in the Mediterranean region and the Middle East where rainfall occurs in the winter, seasonal leaching during a time of low consumptive demand can also benefit from precipitation.

According to research by **Bernstein (1967)** and **Hamdy (2005),** it is preferable for short-season crops to apply the necessary leaching when salt accumulation becomes excessive on occasion rather than during each irrigation activity.

The indirect benefit of using leaching requirement (LR) as extra water at every irrigation operation is the maintenance of higher soil water content for a considerable amount of time after each irrigation process, as opposed to water application without leaching. Under regular irrigations, the impact is greater. Under these circumstances, higher soil moisture and lower soil salinity may both contribute to the favorable crop response to leaching **[Bressler and Hoffman, 1986].**

When saline water is introduced to a field that already has a salinity level lower than the allowed maximum for the crop and salinity build-up takes place, the adoption of LR as extra water at every irrigation is even less desired. A short-season crop may become more salinized as a result of the additional saline water, aggravating the salinity stress. Additionally, the extracted soil solution's EC values can increase as a result. Large unintended errors may occur along with leaching at every stage of the irrigation operation. A little inaccuracy in the estimate of ET may generate a significant error in the planned L.R and, as a result, a leaching practice because LR is typically a tiny portion of irrigation dose.

It has been demonstrated through irrigation testing in Tunisia [Van Iepern, 1996] that leaching during the time of maximum demand can likely be minimized or delayed. Salt balance calculations also imply this. Leaching occurs when consumption is at its highest, which results in greater salt infiltration into the soil as well as increased water application. The benefit of additional leaching water is therefore somewhat offset by this excess salt. The author further explained that there is a higher risk of water stagnation and crop suffocation since chronic leaching requires bigger water applications. On the other hand, in regions like the Mediterranean and the Middle East where it rains during the winter, seasonal leaching during a time of low consumptive usage can also benefit from rainfall.

However, there are still some questions that need to be answered, such whether leaching should be done on a regular basis, at what stage of growth it should be administered, and what leaching fraction is ideal.

Hamdy et al (2005) concluded that leaching should be done according to the salinity tolerance of the growing stage and in the right quantities for optimal utility and improved freshwater conservation (L.F.). In this regard, the salt tolerance of the crops being produced, the salt content of irrigation water, and soil features all have a limit on how much leaching may be prevented. Under the right conditions, improving efficiency or reducing leaching can lead to more effective water use initially, a decrease in the amount of salt that needs to be disposed of, and a significant decrease in the amount of drainage water.

Mohsen Seilsepour et.al (2009) and Yaohu Kang et.al (2010) For crops to be successfully produced, both high-quality irrigation water and effective irrigation management are essential. Even when all other factors and cultural techniques are favorable or ideal, the quality of irrigation water can have an impact on crop yields and the physical characteristics of the soil. Additionally, the quality of the irrigation water varies depending on the crop. Therefore, it is crucial to test the irrigation water before choosing the location and the crops to be produced. It is advised to take more than one sample at various times because the several water sources quality may change dramatically over time or even during specific times (e.g. during dry or wet seasons).Three classifications (physical, chemical, and biological) define factors that affect quality of irrigation water. The chemical characteristics of the irrigation water are covered in this review. The chemical properties of irrigation water include its salt concentration as well as parameters like EC/TDS (Electrical Conductivity/Total Dissolved Solids), SAR (Sodium Adsorption Ratio), alkalinity, and hardness that are resulting from the formation of the salts into the water. The mineral weathering of rocks and minerals is the main natural source of salts in irrigation water. Other secondary sources include seawater infiltration into groundwater aquifers, saline groundwater from rising groundwater, and atmospheric deposition of oceanic salts (salts in precipitation). Chemicals from fertilizers that seep into sources of water, might also affect the quality of irrigation water.

Kadhim and Jaber, 2013 evaluate the mixing of samples of river water and drainage water with samples of agriculturally used water with various ratios to produce water comprising salts proportions were little. These samples (river and drainage from the Dujaili/Wasit Governorate region) . At this study, sodium adsorption ratio (SAR), a labeled standard indicator of water quality, as well as ions (Ca, Na, mg), as well as tests on (EC, PH), were conducted in laboratory of College of Agriculture/University of Wasit. Additionally, compares outcomes with those of the United Nations' Food and Agriculture Organization (FAO) and the U.S. system laboratory salinity (USSL) system (FAO). In this research, authors observed that, proportion mixing(10%drainage + 90%River), (20%drainage + 80%River) is the preferred ratio as well as more EC will increase water salt concentration, while pH amount of that water were in normal limits.

Kadhim, 2013 evaluated whether or not the drainage water from the Alforat Alsharqi drainage was suitable for irrigation. Study subjects included the water from the Euphrates River in Samawa. The physical and chemical characteristics of wastewater and the adjacent river water were also examined. The method used for treating drainage water involves blending it with fresh water from the nearest river in a variety of ratios, starting with B1

(90 percent drainage water and 10 percent river water), followed by B2 (80 percent drainage water and 20 percent river water), and B3 to B9 (10 percent drainage water and 80 percent river water). Over the course of the months of February 2012 to January 2013, water samples were collected each month from four places, one from drainage water and one from a river. The EC, SAR, and pH of these 24 samples were examined physically and chemically. It has been determined that drainage water's Sodium Adsorption Ratio (SAR) is less than 12 and that this value is suitable for irrigation. By blending drainage water with river water, it can use drainage water for irrigation without the usage of any chemical ingredients. When the electrical conductivity (EC) of Alforat Alshrqi drainage water is less than 8000 micro Siemens/cm, it is suitable for irrigating halophytes.

2.5 Previous Studies on Almasab Alam Water

Wali, et al, 2012. determined whether the water in the Jeblla-Sowaira area of the Al-Almasab Alam fall Drain was suitable for irrigation. For this objective, nine testing locations were chosen, and from July 2010 to January 2011, the parameters were continuing to be measured. According to the study's findings, Almasab Alam has a salinity of between 2830 and 4850 mmhos/cm, making it unsuitable for delicate crops. These experiments also demonstrate that the range of sodicity values (3.24–3.66), which indicate the acceptability of water for irrigation purposes on various Soils, has a negligible impact on crop development. The findings show that the testing samples surpass the safe levels for magnesium and chloride. this may result in decreased crop growth and productivity, while the boron is not presented in this study . This study's main finding is about the suitability of water for irrigating non-sensitive crops. Additionally, to prevent soil and water contamination, the agricultural fields in this area need to be well-managed and equipped with an appropriate drainage system and leaching.

Aljawei,and Kadhim, 2012 examined the assessment of irrigation with or without treatment using diluted drainage water from AL Nasiriyah. The technique chosen for the treatment of drainage water is the mixing of salty water from the adjacent river with fresh water. Water samples were taken from six locations each month. Three of them are from drainages water and the other three are from rivers during period from June 2011, to July 2012. These 72 samples were physically and chemically analyzed for EC ,TDS , PH , Ca^{++} , Mg^{++} , Na^{+} , K^{+} , Cl^{-} , SO_4 , NO_3 , Turb. , PO_4 and T.H.

It was concluded that water from stations D1 and D3 can be used directly to irrigate date-palm, barely, Wheat (semi-dwarf), and cotton, and the water from stations D2 can be used directly to irrigate date-palm, lotus tree, Acacia, Eucalyptus and other halophytes.

The blending ratio between drainage water and river showed that for

(a) The blending with different percentages between D1 and C1 showed that R1 is acceptable for irrigating palm, barely Wheat (semi-dwarf), and cotton. R2 is acceptable for Sorghum and Sugar beet irrigation, R3 for Wheat irrigation, R4 for olive irrigation, R5 for Sunflower irrigation, R6 for irrigation Corn and Oats, R7 for rice and Tomato irrigation, R8 water is in the usual range in irrigation water acceptable according to U.S laboratory determination were EC <2530 µs/cm.

(b) The blending between D2 and C2 showed that R1 is acceptable for irrigating palm, R2 for Wheat(semi-dwarf), R3 for Barely irrigation, R4 for Cotton irrigation, R5 for Sugar beet and Sorghum irrigation, R6 for Wheat irrigation, R7 for Soybean and Sunflower irrigation, R8 acceptable for irrigation according to the U.S laboratory determination.

(c) The blending between D3 and C3 showed that R1 is acceptable for irrigating palm, R2 for Cotton irrigation, R3 for Sugar beet irrigation, R4 for Sorghum irrigation, R5 for Wheat irrigation with a reduction factor less than 5% in relative yield, R6 for Olive irrigation, R8 for Soybean irrigation, R9 for Sunflower irrigation.

It is to note that there is no previous study, in the studied area of the present research, on mixing the waters of Almasab Alam with river water.

2.6 Previous Studies on the soil that would be irrigated

Studies have demonstrated the viability of utilizing magnetized seawater for irrigation since it lessens the impact of detrimental ions on plants, enhances the characteristics of the soil, and reduces salinity by washing salts out of the irrigated region. **[Amin and Qasim, 2009].**

2.6.1 Leaching Salts from Soil

As compared to conventional irrigation water, which only removes 30% of the salts from the soil, magnetically treated water can remove between 50% and 80% of them. By accelerating the removal of salts from the root zone and enhancing the soil's beneficial characteristics, it also lessens the harm caused by salinity. According to **[Muzahim et al., 2015],** magnetized water may be utilized to remove and wash salts from soil, restoring matter of soil that has been damaged by use of highly concentrated synthetic fertilizers, capability of magnetized water to eliminate salts outperforms that of ordinary water by a factor of two **,** and one of the biggest issues with agriculture is soil salinity, as buildup of salts in soil pores causes sharp decline the soil's energy and salts concentration in capillaries of plants root causes a decrease in the plant's productivity over the required nutrition amount, which cause wilting and eventually death. Since plant's use magnetic systems, the amount of salts in the water does not diminish because the huge crystals are broken up into smaller ones that may readily travel through soil pores and plant root capillaries. Nevertheless, it is not dangerous because the plant will only consume the portion of this sort of water that it requires for growth, discarding the remainder of the salt crystals and other ineffective components down the drains. Additionally, little salt crystals and their constituent parts will be able to enter soil pores and ground water drains in the lower soil layers more readily. The use of the magnetic method to obtain magnetically treated water has also been demonstrated by some studies. It reduces soil salts and increases water soluble matter in agriculture **[Al-Jubouri and Hamza, 2012].**

2.6.2 Soil fertility

As it was found, irrigation with magnetized water enhances chloride washing speed by 50% to 80% in comparison to regular water's 30% and bicarbonate's 30%. This is due to the magnetic technique's adaptation of the water, which increases its capacity for dissolving and enhances its capacity to effectively remove salts from the soil. The dissolved oxygen level increases by 10%, double the amount of sulfate washing, and the magnetized water enhances the soil surface by lowering surface tension, viscosity, osmotic pressure. Additionally, it try to break up masses of soil around roots and enhances soil's structure and solubility with water. Hence, it promotes root to enter into soil, that will boosts development and productivity of magnetically treated plants. Water's involvement in dissolving salts and minerals makes nutrients in the soil more ready for nutrient uptake, which boosts plant productivity by increasing absorption of essential nutrients. **[Rasool and Younis, 2012]**.

2.6.3 Reducing the surface crust of soil

The crust that forms on top of the soils is frequently considered by high hardness, that manifests the soil's low aeration and other physical qualities unsuitable for development and growth of plant. Recently, the crust that forms on the soil as a result of the physical and chemical changes brought on by magnetic treatment has been managed using water that has undergone magnetic treatment. By altering the ionic state of some compounds and lowering the concentration of others, particularly sodium salts, this technique increases solubility by preventing the sodium ion from attaching to the soil. Because water has undergone magnetic treatment, it has less of a negative impact on the soil's surface crust's hardness and has the potential to mitigate the detrimental effects of sodium salts while also enhancing some soil properties that are important for construction **[Muzahim et al., 2015].**

It is worthy to note that at present there is no similar study to the study presented in this research except only one research presented by **Talib Wali, et al, 2012** which considered the evaluation of Almasab Alam water for a part of the region studied in this research. It is also worth noting that there is no study of curing Almasab Alam water in this area by the magnetization method. This is the first study in this area and there are no other similar studies in all the regions of Almasab Alam. On the other hand, the mixing method is also the first one in this region and there is only one study of the mixing method in Alnassiria province presented by **Aljawei,and Kadhim, 2012**. In the present study, sensitive plants, that do not bear the salinity of Almasab Alam water, are planted and the experiments were performed on them and this does not exist in all other studies.

Chapter 3 Description of the Study Area and the Experimental Work

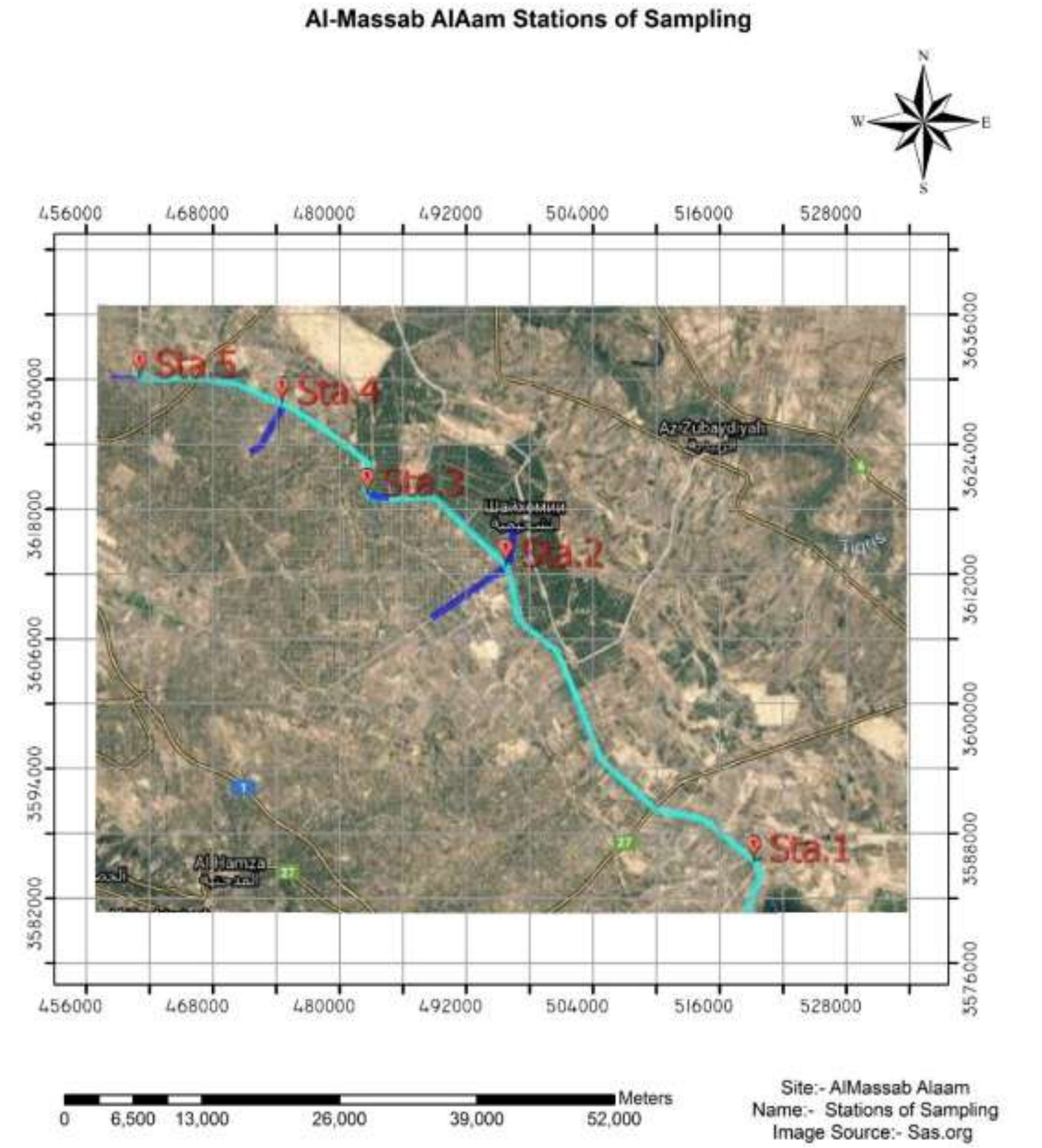
3.1 The Study Area

The area between stations 360+00 (with coordinates (519159, 3563531)) and station 441+00 (with coordinates (461006, 3630087)) represents the site of Almasab Alam in Babylon governorate, IRAQ as displayed in Figure 3.1, which shows the locations of the five stations; from which the samples are taken, which were chosen as intersection points with other drains that flow into Almasab Alam.

Out of the project's overall length of 565 km, Almasab Alam is only around 81 km long passes within the governorate of Babylon. The project's total discharge is 220 m^3/s. The project includes many crucial phases, some of which are located inside the borders of the province of Babylon. These drainages include Almusayyib Alshemali, Ejblah, Eksabah, Almusayyib Aljanobi, and Alshehamiea.

3.2 Climate

The selection of a particular location for the cultivation of a particular crop depends on the climate and other natural factors that have an impact on the production process. The climate has an impact on all the aspects involved in producing agricultural goods, including soil, water resources, factors of life, as well as the activity of agricultural employees and vitality.



WGS_1984_UTM_Zone_38N
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False_Easting: 500000.000000
False_Northing: 0.000000
Central_Meridian: 45.000000
Scale_Factor: 0.999600
Latitude_Of_Origin: 0.000000
Linear Unit: Meter
GCS_WGS_1984
Datum: D_WGS_1984

Pt.	station (Km)	E (m)	N(m)
1	360+000	519159	3563531
2	399+000	459751	3612496
3	416+000	482565	3621310
4	427+000	474365	3627679
5	441+000	461006	3630087

LEGEND
ALmassab AlAam
Drainge

Figure 3.1: The Study Area

3.2.1 The Rain

According to all classifications of climate**,** the governorate of Babylon is located within a dry region and the total annual rainfall does not exceed (127.48) mm. A few amounts of rain falling in the province, to distance from the mainstream of Mediterranean depressions air, and the erosion of part of them before reaching the province since they pass through long distances, as well as the province lower surface, and control (High atmospheric air) above Arabian Peninsula throughout year cold season. stopping Mediterranean from advancing (depressions) into the study area. These rains also have a distinct seasonal pattern, occurring primarily they hit cold season, with very limited rates, nearly negligible in June and September as illustrated in **Table 3.1**.

As shown in **Table 3.1**, the amount of rain falling in the governorate is divided into ten months. The maximum amount of rain is in January (29.17 mm) and then decreases gradually to (0.19 mm) in June. This means that (90.9%) of the total amount of rain falling in the duration of the fall (November-April), in addition to lack of rainfall is volatile. This volatility is due to the occurrence of the province within the desert region such areas are characterized by sudden rainfall and irregular fall. Due to the little quantity of rain, inconsistent distribution of rainy months season, and significant annual changes the governorate's farming is mostly dependent on the process of irrigation.

Table 3.1: Average monthly and annual rainfall (mm) in province of Babylon for period (1970-2010) (**Ministry of Science and Technology**, General Authority (The Anwae) Air, Climate Division, unpublished data)

Month	J	F	M	A	M	J	J	A	S	O	N	D	Sum
Rain quantity	29.17	19.18	20.85	10.52	4.99	0.19	----------	----------	0.83	5.59	14.96	21.2	127.48

3.2.2 Temperature

The temperature affects the power source in most biological processes carried out by plant absorption and metabolism and requirements vary from crop temperatures depending on the type and stages of growth. The temperature in the governorate is a reflection of the fall of the angle of solar radiation and the length of daylight hours, so the upside is characterized by temperature and this is reflected in the annual rate of (25 °C) and rise above this rate during the summer months. The season is up to (47.35 °C). The month of July recorded the highest rate when it amounts to (50 °C) while tending temperatures during the winter season to the moderation between the ranges (11.7 to 3.9 °C) and reaches its lowest rate in January (11.7 °C), which is the colder month in the year. The nature of the temperatures prevailing in the governorate makes it a long growing season that includes almost all months of the year and therefore allows the cultivation of several types of crops.

3.3 The Soil

A natural resource that is crucial to human existence and an essential component of agriculture is soil. It is referred to as a naturally occurring organism that covers the earth's surface in varying degrees of thickness and is made up of a mixture of minerals and organic matter that is decomposing. The plant is stabilized and receives the majority of its requirements for growth when it has the proper water to air exchange ratios. Depending on the conditions that led to the formation of the original organic matter rocks, such as climate, terrain, time, and rights, different regions have different physical and chemical soil characteristics. It affected the way in which agriculture was exploited and how fragile the production of agricultural produce was. The general characteristics of soil in the governorate of Babylon varied greatly in terms of quality due to the surface characteristics, various climate elements, subsequent surface, ground water and vegetation cover characteristics.

These soils are found in the province's southwest and south. In parts of Western, they are gypsum soils, while in the southern parts of Western; they are desert sand and gravel, in general, they are loose soils with active erosion due to the lack of natural vegetation and drought. Results of the analysis revealed that the silt, clay, and sand soils' physical and chemical compositions are (62%), (30%), and (8%), respectively. According to the triangle of soil tissues of FAO 1990, shown in **Figure 3.2**, it is Silty Clay Loam (SiCL).

The virtual density reached (1.87g / cm^3). The average porosity of these soils reached (31%), the permeability is (1.18 x1 0^{-6} cm/sec), the rate of (PH) is (7.85), and the electrical conductivity (EC) is (13.40 µs/ cm). This results are found by testing in Almawal company.

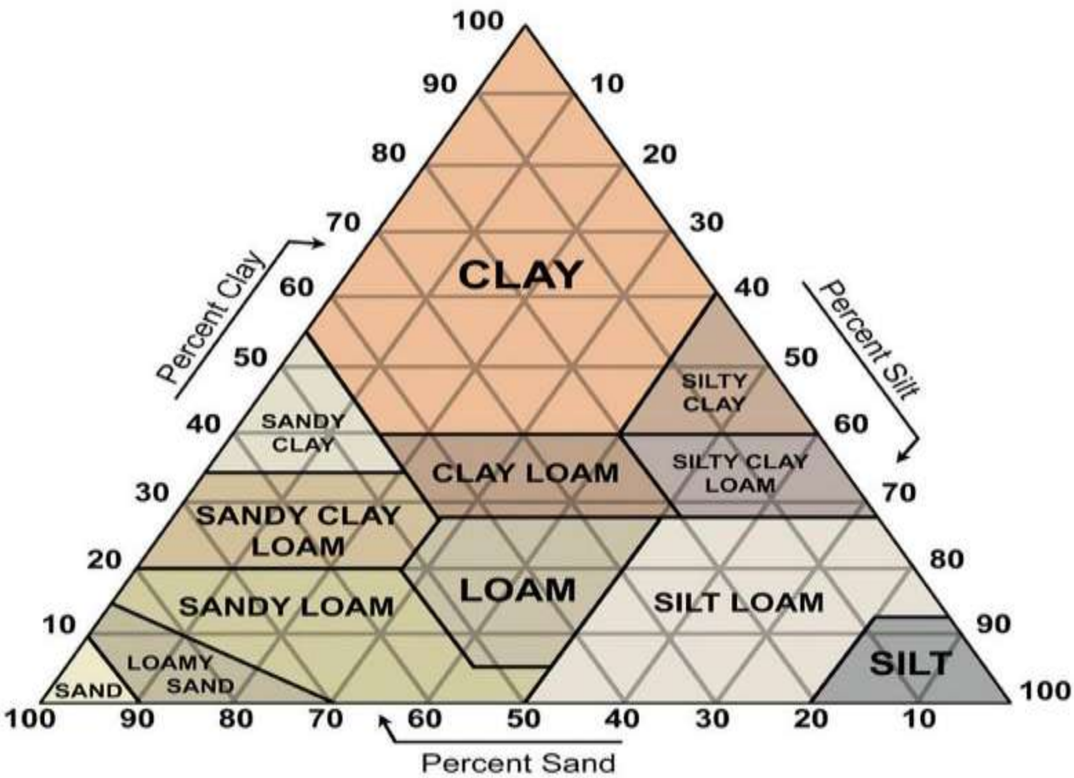

Figure 3.2: Triangle of soil tissues according to FAO 1990

3.4 Experimental Work for Evaluation of Almasab Alam Water Quality

Having a sufficient quantity of usable water is essential for irrigation agriculture. Due to the abundance of good quality water supplies and their accessibility, water quality concerns have frequently been disregarded. Currently, many aspects of this situation are changing. As a result of the extensive use of practically all high-quality resources, new irrigation projects and ongoing ones that need new or additional supplies which depend on less desirable and lower-quality sources. There must be excellent planning to ensure that the quality of water supplied is used to its fullest potential in order to avoid issues while using these low-quality water supplies.

3.4.1 Water sampling and analysis

The data records of water quality, from October 2020 to September 2021, were used in this study. The samples of water were collected monthly from five stations in Almasab Alam drainage. Twelve water quality parameters are tested and used in the analyzing of water quality. Every case is repeated three times, and then the average is taken. To verify the results of laboratory tests, the same tests were carried out in other laboratories and found that the results were close. The (12) parameters of water quality used to confirm IWQG V.1 program are shown in **Table 3.2**.

Also, IWQG V.1 software is developed then used to case study region in middle of Iraq for evaluating surface water quality for irrigation demand (Almasab Alam drainage). This new irrigation guide is being proposed for development. The FAO 29 guideline for irrigation water quality's recommendations were used to adapt the existing IWQI of Meireles et al. (2010) and modify the parameters use to satisfy crop irrigation water quality standards **[Ayers and Westcot, 1994].**

Table 3.2: FAO 29 guidelines (Ayers and Westcot, 1994)

Parameter	FAO 29 guidelines
Ca^{+2} (mg/l)	0–20 (meq/l)
Mg^{+2} (mg/l)	0–5 (meq/l)
Na^{+} (mg/l)	0–40 (meq/l)
K^{+} (mg/l)	0-2 (meq/l)
Cl^{-} (mg/l)	0–30 (meq/l)
SO_4^{-2} (mg/l)	0–20 (meq/l)
CO_3 (mg/l)	0-0.10 (meq/l)
HCO_3 (mg/l)	0–1 (meq/l)
NO_3 (mg/l)	0–10 (meq/l)
EC (ds/m)	0–3 (ds/m)
pH	6.0–8.5
SAR (meq/l)	0-15 (meq/l)

3.4.2 The specification of the IWQG V.1 software

Irrigation water quality evaluation software IWQG V.1 was developed using guidelines from the United Nations Food and Agriculture Organization (FAO), which are presented in Table 3.3, and the irrigation water quality index (IWQI), which was created by **Meireles et al (2010)**.

In 2010, a measure of irrigation water quality reflecting the effects of water toxicity, sodicity, soil salinity, and other dangers on sensitive crops was developed by Meireles et al. Two phases were taken in the development of this IWQI: in the first phase, the characteristics that affect water quality such as electrical conductivity (EC), bicarbonate (HCO_3^-), chloride (Cl^-), sodium (Na^+), and sodium adsorption ratio (SAR) are determined by using statistical approach (principal component analysis).

Table 3.3: The specifications of the irrigation water quality **(Ayers and Westcot, 1994)**

Potential irrigation problem	The degree of restriction on use		
	None	Slight to moderate	Sever
Salinity			
EC at 25 ^{0}C (dS/m) or	<0.7	0.7-3.0	>3.0
TDS (mg/l)	<450	450-2000	>2000
Infiltration (Sodicity)			
SAR = 0-3 and 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
SAR	<3	3-9	>9
Chloride (Cl)	(meq/l) <4	4-10	>10
Boron (B)	(meq/l) <0.7	0.7-3.0	>3.0
No_3	(meq/l) <5	5-30	>30
Hco_3	(meq/l) <1.5	1.5-8.5	>8.5
pH	Normal range 6.5-8.4		

In the second phase, each ith parameter's quality sub-index (Qi) and unit weight (Wi) are defined. Ayers and Westcot (1994)'s criteria mentioned in Table 3.4 were used to define the values of (Wi) in accordance with the parameter values in their study area. The values of Wi were standardize so that their total was 1. According to the limits of tolerance indicated in Table 3.4 and information from samples that were gathered from study region, the values of Qi were computed using Eq. 3.1.

Table 3.4: Calculation of W_i and Q_i for IWQI parameters, all in (meq/l) and EC in (µs/ cm) (Meireles et al. (2010))

Q_i	EC (µs/cm))	SAR	Na^+ (meq/l)	Cl^-	HCO_3^-
0-35	EC<200 or EC≥3000	SAR<2 or SAR≥12	Na^+<2 or Na^+≥9	Cl^-<1 or Cl^-≥10	HCO_3^{--}<1 or HCO_3^{--}≥8.5
35-60	1500≤EC<3000	6≤SAR<12	6≤ Na^+<9	7≤ Cl^-<10	4.5≤HCO_3^-<8.5
60-85	750≤EC<1500	3≤SAR<6	3≤ Na^+<6	4≤ Cl^-<7	1.5≤HCO_3^-<4.5
85-100	200≤EC<750	2≤SAR<3	2≤ Na^+<3	1≤ Cl^-<4	1≤ HCO_3^-<1.5
W_i	0.211	0.189	0.204	0.194	0.202

$$Q = (X_{ij} - X_{inf}) x\, Q_{iamp}/Q_{imax} \qquad 3.1$$

Where;

Q_{imax} : Maximum value of q_i for every category

X_{ij} : Parameter marked value

X_{inf} : Minimal value of category to parameter

Q_{iamp} : Ampleness of category

X_{amp} : Ampleness of category for every parameter

IWQI is dimensionless, with four categories in range (0 – 100) calculated by:

$$IWQI = \sum_{i=1}^{N} Q_i\, x\, W_i \qquad 3.2$$

Figure 3.3 Demonstrate IWQG V.1 **software** main window , while **Figure 3.4** shows the window for entering the data.

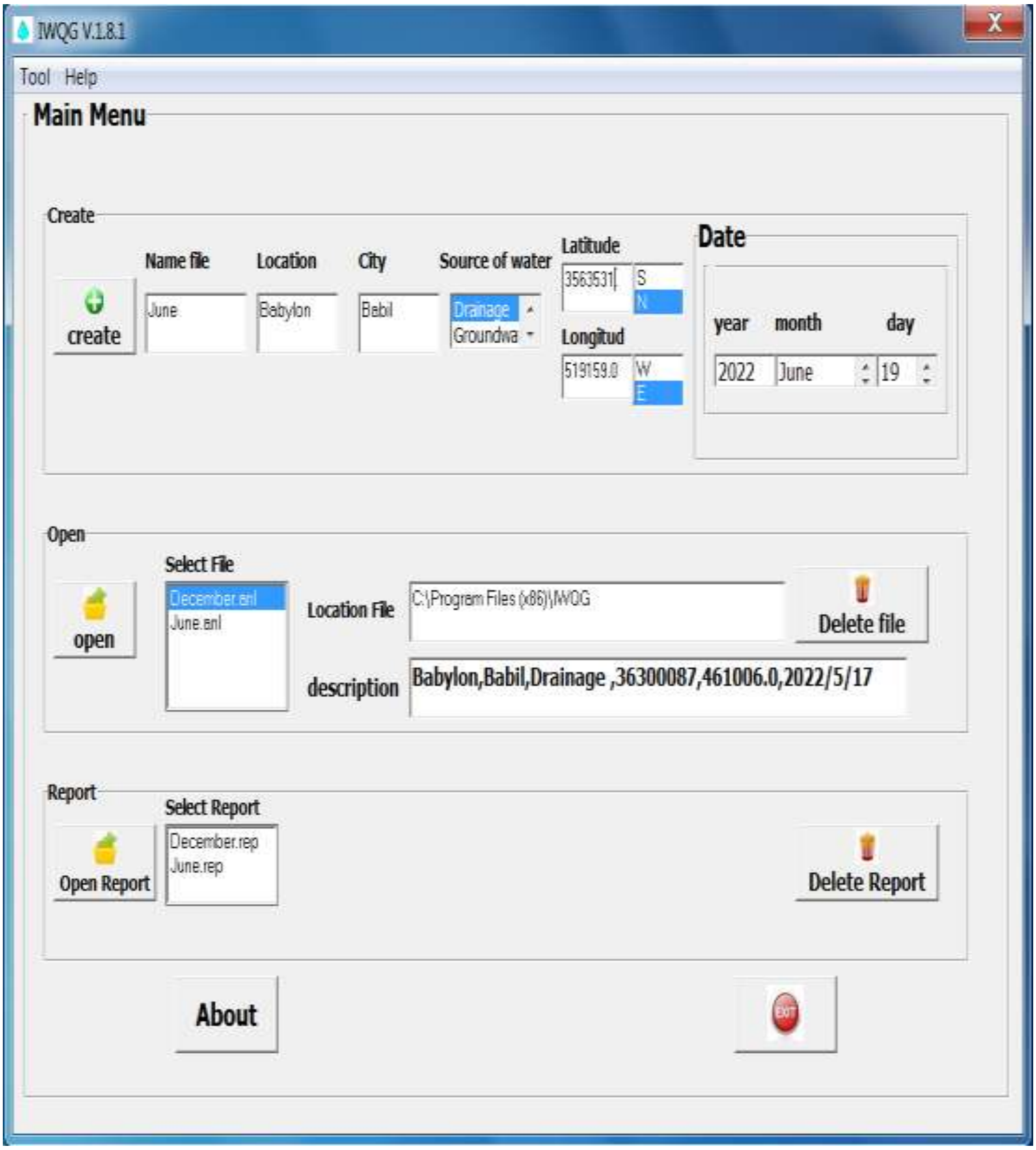

Fig.3.3: IWQG V.1 software main window

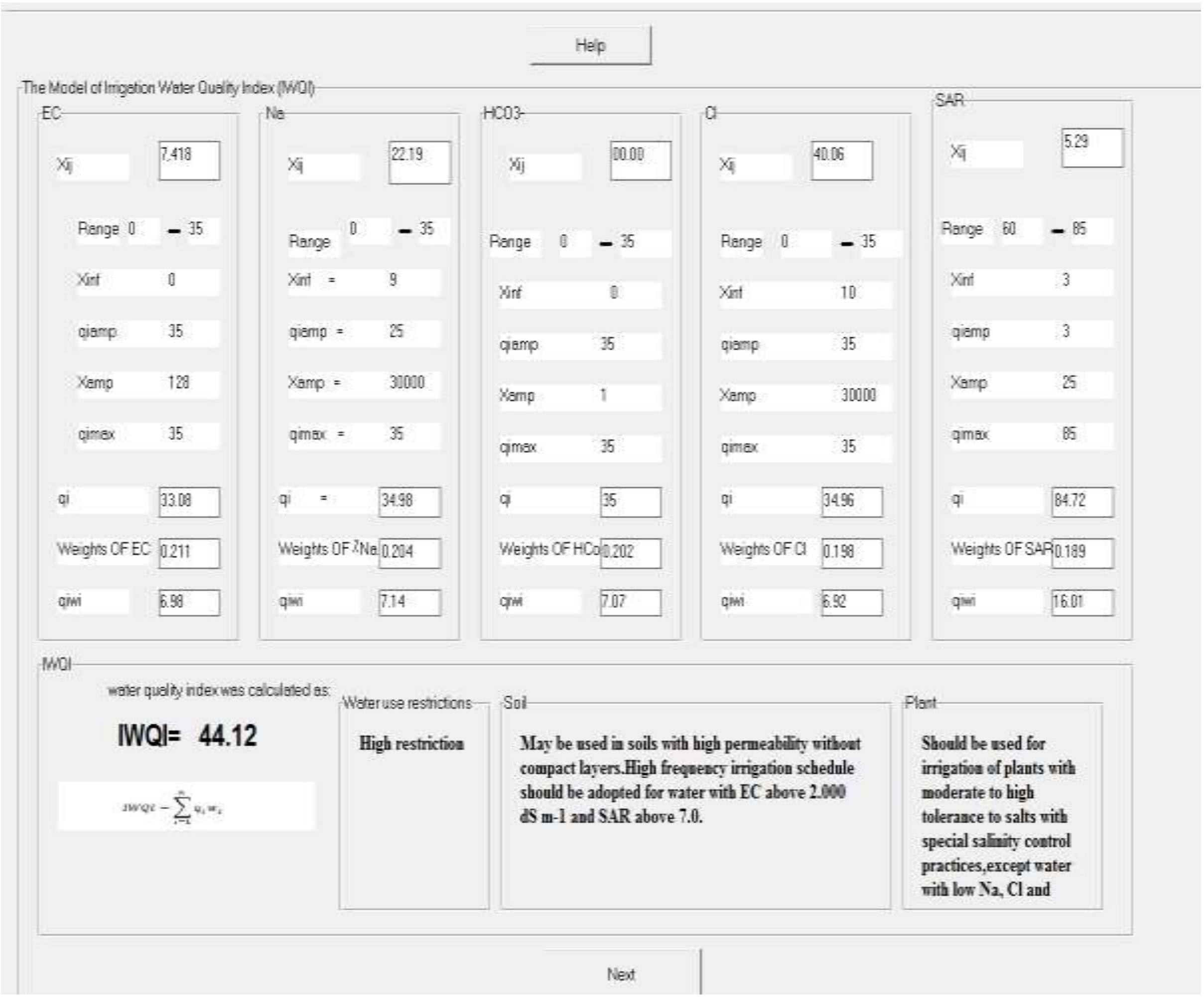

Fig. 3.4: Window for entering the data

3.5 Experimental Work using Magnetized Method for Almasab Alam Water

It is one of the modern and effective methods of treating salty water and making it suitable for irrigation, as well as improving the properties of the soil and vegetative growth of plants irrigated with this water and affecting the chemical and physical properties of water.

It is to note that this technology is not used in Iraq in this area, and the present study focuses on this type of treatment. This method is summarized by passing Almasab Alam water in a magnetic field with different intensities (1000, 2000, 3000, 5000, and 7000) Gausses. Samples are taken from five stations and passed in the aforementioned magnetic field. Each test repeated three times, then the average is taken.

3.6 Magnetize Water Device

Al-Nahrain University improved an equipment for the magnetization of water with (5) intensities: (1000, 2000, 3000, 5000, and 7000) G and that is why these intensities are used in the present study. These devices are constructed from plastic tube with 16 mm diameter and surrounded by constant magnetic strength required for each device. **Figure 3.5** shows the experimental setup.

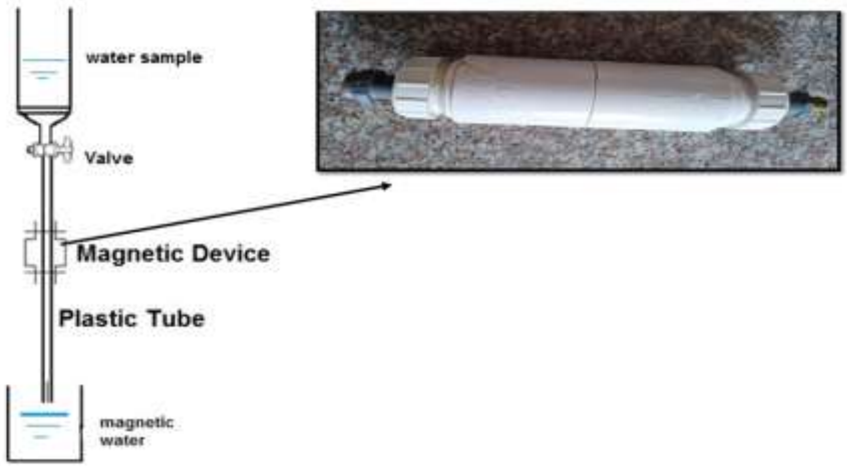

Figure 3.5: Experimental setup schematic diagram

The experimental setup packed from outside through additional plastic tube. For all testing, the water's set speed through the system is constant. The following tests are performed on the water's chemical and physical characteristics after the samples have been passed through the magnetizing device at all intensities:

3.7 Chemical and Physical Properties of Water

3.7.1 Chemical properties of water

3.7.1.1 pH

The value of pH is the negative logarithm of hydrogen ion concentration measured in mole/liter. If this value to any site at any time is the result of the overlapping of several factors, the most important of the water temperature and the rate of consumption or production of CO_2 or representation of photosynthesis respiration and decomposition of organic materials as well as alkaline and acidic water.

Different organisms each other vary widely in terms of their need for specific concentrations of hydrogen ions in water. The value of the PH range for the natural water is (5 to 9). The majority of freshwater is (5.5 to 5.8). The normal range of pH for irrigation water is (6.5 - 8.5). The water in Iraq is characterized by the alkaline, where pH could reach more than (8) in some cases. If the pH of irrigation water outside typical range, this may lead to nutritional imbalance or may comprise toxic ion **[Karkush et al 2019].**

3.7.1.2 Electrical Conductivity (EC)

Electrical conductivity represents the ability of one cubic centimeter of water to deliver electricity. It is measured at room temperature (25 °C) because the value is unaffected by temperature and the concentration of ions in water. It is measured in units of µs/ cm.

Most of the acids and alkaline and inorganic salts dissolved in water are good conductors of electricity, while the salts and acids are organic materials and are poor conductors of electricity because they are low in water ionization. The ions in the water move the electric charge, the direct relationship between the number of dissolved salts in the water and the value of connectivity and because of this relationship can be used as a measure of conductivity approximation of the salts dissolved in water.

3.7.1.3 Total Dissolved Solids (TDS)

Total dissolved solids are defined as all the solids dissolved in water, whether ionized or not ionized, and do not include suspended solids or slimy. Sometimes known as salinity, dissolved salts in the water and made positive ions and negative ions. The familiar cation is calcium ions (Ca^{+2}), magnesium ions (Mg^{+2}), and sodium ions (Na^{+1}), while the more familiar negative ions are chloride ions (Cl^{-1}), sulfate ions (SO_4^{-2}), and bicarbonates ions (HCO_3^{-1}). The ratios of these ions vary according to the sources of water.

There are also other ions in water sources, like potassium ions (K^{+1}), carbonate ions (Co^{-2}), and nitrate (No_3^{-1}), but the concentration is relatively low. Total dissolved solids are directly related to salinity, as it represents an indication of the salts dissolved in water and which have the ability of electrical conductivity **[Karkush et al 2019].**

3.7.1.4 Turbidity

Turbidity is the scattering of visible light by water turbidity. Additionally, it functions as a general indicator of water quality. It could be brought on by algae growing, clays very small colloids, or dissolved organic matter such as humic acids from soil organic material. Solids that are carried by the water or suspended in it may potentially be the reason. Thus, it is a good method of determining the quality of the water. Something may be impacting the water quality if the turbidity varies between readings. Units named FTU or NTU are used to measure turbidity.

3.7.1.5 Chloride ion

Chloride ion is one of important negative ions in natural waters and earns taste salty water if linked with the sodium ion component of sodium chloride (table salt). Chloride salts are characterized by high susceptibility to soluble in water. Another ion that is frequently present in waters used for irrigation is chloride. Even though, the necessity of chloride for crops at low quantities, but, at greater level it can be harmful to sensitive crops. Burns or tissue deaths of leaf are the first signs of its harmful effects. Typically, plant damage starts at leaf tips then spreads outward along edges as the severity grows. Initial leaf drop or defoliation occurs frequently (Ayers & Westcot, 1985). In general, waters with chloride readings under 140 mg/l are regarded as high grade irrigation waters.

3.7.1.6 Calcium and Magnesium ions

Ionics calcium and magnesium are the main cause of most of the hardness in the water despite the presence of other metallic elements such as iron, manganese, zinc, and others. There are small quantities of dissolved calcium in the magnesium, to its tendency to deposition of large quantities. The calcium cations are necessary for the growth of plants and animals and are the most present in the water.

3.7.1.7 Sulphate ion (SO_4^{-2})

Sulfates are one of the substances that cause permanent hardness in water, especially when their presence is in the form of calcium sulfate or magnesium within the causing substances of the salinity; it is also an important factor in determining the validity of water for irrigation. Some crops are sensitive to exceptionally high sulfate concentrations in irrigation water, however this sensitivity is likely related to the fact that high sulfate concentrations tend to prevent plants from absorbing calcium. On the other hand, a relative increase in sodium and potassium absorption is linked to this decrease in calcium absorption.

3.7.1.8 Phosphate ion

One of the crucial components required for the growth of plants and animals is phosphorus (P). Water undergoes complex phosphorus reactions. Phosphorus is typically found in phosphate molecules in nature (PO). Three different types of phosphates are exists: metaphosphate (or polyphosphate), orthophosphate (inorganic phosphorus), and phosphate that is bound to an organic substance. There are various chemical configurations of phosphorus in each molecule. Inorganic phosphate is phosphorus that does not have an organic component. Plants need phosphorous found in inorganic forms, whereas, animals can use organic or inorganic phosphate **[Karkush M. O. et al 2019].**

3.7.1.9 Nitrate ion

The intervention of nitrogen compounds in the water from multiple sources, including natural sources of geological processes and the death of plants, decomposition of animals, and rainwater which carries with it these compounds from the air. Also, their sources are industrial and agricultural activities, private waste industry, chemical fertilizers, and water drainage of agricultural land involving the use of compounds of nitrogen fertilizer. Nitrogen is a nutrient for plants that promotes crop growth. The typical sources of nitrogen are the naturally occurring soil or additional fertilizers, but nitrogen in irrigation water has a similar effect to nitrogen put to the soil as a fertilizer, and too much nitrogen will have the same negative effects as too much fertilizer.

The growth of some widely produced crops may be overstimulated, maturity may be delayed, or the quality may suffer if extreme amount is available or applied. For Nitrogen concentrations greater than 5 mg/l, sensitive crops may get an impact. Prior to nitrogen exceeding 30 mg/l, the majority of other crops are largely unaffected **[Ayers and Westcot 1994].**

3.7.1.10 Sodium-ion

The majority of natural fluids include sodium (Na+) salts since they are all extremely soluble. High salt levels in irrigation water can affect the plant and the soil. Poor physical characteristics for plant growth and water infiltration are present in soil that has a significant amount of salt and a clay percentage. Na may poison many plants when it is present in large amounts. The irrigation system is not affected by sodium. Domestic water sources are frequently sodium-softened to prevent the growth of scale.

Although sodium toxicity is more difficult to diagnose than chloride toxicity, there have been documented cases of the former due to relatively high intake of sodium.

Concentrations of water (high Na or SAR), leaf burn, dead tissue, and scorch are typical poisoning symptoms, as opposed to chloride toxicity symptoms, which often appear first at extreme leaf tip. Long periods of time (a few days or even weeks) are often essential before the buildup reache harmful levels. The symptoms originally appear on older leaves, which start at the edges and eventually spread throughout the leaf migrating inside between the veins into the leaf's center as the severity increases. Only a few examples of sensitive crops are beans, citrus, nuts, deciduous fruits, and nuts (Ayers and Westcot 1994).

Alkali soils are those that have carbonate as the major anion and have high sodium content; saline soils have chloride or sulfate as the primary anion. The importance of salt in classifying river water for irrigation was highlighted because sodium reacts with soil and causes particle blockage, which lowers permeability. One measure used to determine if water is suitable for irrigation is the percent sodium in the water.**[Nagaraju et al. 2017].** Eq. 3.3 can be used to calculate Na %:

$$NA\ \% = (Na^{+}+K^{+})/(Ca^{++}+Mg^{++}+Na^{+}+K^{+}) *100 \qquad 3.3$$

Where,

Na^{+}, K^{+}, Ca^{++} and Mg^{++} measured in meq/l.

3.7.1.11 Potassium ion

The most important sources of potassium in the aquatic environment are the stripping of Feldspar metal and Biotite. The concentration of potassium is less than (0.1) than the concentration of sodium in natural waters. That is the presence of potassium in minerals that are resistant to weathering processes is contrary to the sodium. The natural concentration of potassium in the irrigation water is between (2-0) mg/ l, while the concentration in water drainage is (30) mg/ l. Therefore, the use of water drainage in agriculture as a source of potassium helps in providing the potassium chloride salt that is used by farmers to increase the concentration of potassium in the soil, as they contain high levels of potassium**.[Al-Gawthari, Hayawi 2006]**

3.7.1.12 Sodium Adsorption Ratio (SAR)

With a high sodium level in the irrigation water, a soil permeability issue develops. Due to the high solubility of its salts, sodium has the highest concentration of any cation in saline water. Positively charged, it is drawn to soil particles that are negatively charged, taking the place of the calcium and magnesium cations that are more prevalent. By dispersing the soil aggregates and weakening its structure as a result of the sodium ions' replacement of the calcium ions, the soil becomes impermeable to both air and water. Increases in soil pH over 8.5 and a decrease in the availability of some micronutrients, such as iron and phosphorus, may result from an increase in exchangeable salt content. To overcome sodium problems, the amount of (Ca + Mg) must be greater than the amount of sodium. This relation is referred to as sodium adsorption ratio SAR which van be calculated through the following relation:

$$SAR = \frac{Na^{+}}{\sqrt{(Ca^{2+} + Mg^{2+})/2}} \qquad 3.4$$

where the concentrations of sodium, calcium, and magnesium are expressed in milli equivalents per liter (meq/ l) **[Abbas 2012].**

3.7.2 Physical properties of water

3.7.2.1 The boiling point of water

Two tubes that are blocked at one end are used to calculate the boiling point of water. The first was a standard capillary tube with dimensions of (100mm) in length and (1mm) in diameter, like those used to calculate the melting point of substances. The second has a 5 mm diameter and a 90 mm length. The wide tube is filled with 0.25 to 0.5 ml of liquid, capillary tube inserted inside liquid (water may be magnetized or may not) hence, sealed end facing up and wide tube attached to thermometer's leg using a rubber ring **[M.C. Amiri, A.A. Dadkhah 2006].**

Figure 3.6., illustrates that thermometer with accessories are covered, Solids melting point is measured by using a water bath as the bath gradually heated, the air bubbles will gradually escape out of the capillary tube end submerged into liquid as the liquid reaches its boiling point, air bubbles can be notice swiftly and continuously, liquid boiling point is measured in degrees.

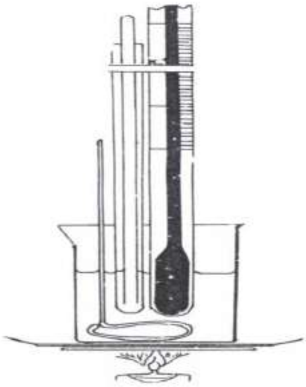

Figure 3.6: the device used to determine the boiling points.

3.7.2.2 Solubility

Solubility of (SW and MW) can be estimated through taken A tiny quantity of water, and (1g) of table salt is dissolved in (100ml) of water samples both before and after it has been magnetized. The two are placed in a device after it has been left for an hour. The transparency ratio is determined by EXAO equipment.

3.7.2.3 The density of water

By using of density flask at laboratory temperature (25 ^{0}C), the densities of magnetic and non-magnetized water are calculated. Its weighed empty then with water. Differences represent water mass. The density is calculated as (gm/cm^3) by dividing the mass of the water, by its volume.

3.7.2.4 Evaporation

To find evaporation duration of (SW and MW) before and after magnetizing, providing same temperature for all samples, vessel is used for heating. Amount of water is estimated at (10ml) in every sample.

3.7.2.5 The surface tension of water

The capillary tension flask is filled with water to measure the value of the surface tension of the magnetically handled water. After that, a capillary tube of known diameter is inserted into the water and the water begins to rise within the tube until it ends. **Figure 3.7** shows the surface tension and viscosity measuring devices **[Mousa,2002**, **Al-Tikrity, 2014]** The relationship that follows is:

$$\sigma = \tfrac{1}{2}\, h \times \rho m \times g \times r \qquad 3.5$$

where

σ = coefficient of strength of surface tension (dyne / cm)

h = capillary height of water (cm)

ρm = density of water (g/cm^3)

g = gravitational acceleration (cm/s^2)

r = Radius capillary tube (cm)

3.7.2.6 Viscosity of water

The test is carried out through the following steps:

1- The viscometer, as shown in **Figure 3.7,** is cleaned with acetone well and then dried.

2. About (50 ml) of magnetically treated water is placed in the viscometer accurately.

3. Withdrawing water carefully through the upper tube of the device until the water surface becomes above the glass ball of the viscometer.

4. Allowing the water to flow to the top of the neck of the glass ball, and then holding it down by placing the index finger on the leather straw nozzle.

5. Preparing the stopwatch and starting to calculate the time (t) taken by the flow of water between the upper and lower neck of the glass ball. To calculate the viscosity of the magnetically treated water, the viscosity of the distilled water is calculated, which is often known, which is about 0.983 G/(cm·s), at a temperature of 33 degrees Celsius, and then the viscosity of the magnetically treated water is calculated by equation 3.6**.[Al-Talib A. and Al-Sinjary Z. A].**

Figure 3.7: The surface tension and viscosity measuring devices

$$\mu_1 = \frac{\rho_1 \ x \ t_1 \ x \ \mu_2}{\rho_2 \ x \ t_2} \qquad 3.6$$

μ_1 = Viscosity of Magnetically Treated (gm/(cm·s))

μ_2 = Viscosity of Distilled Water (gm/(cm·s))

t_1 = flow time of magnetically treated water from top to bottom of the glass ball (sec).

t_2 = flow time of distilled water from top to bottom of the glass ball (sec).

ρ_1 = density of magnetically treated water (gm/cm^3).

ρ_2 = density of distilled water (gm/cm^3).

3.8 Experimental Work using Blending Method for Almasab Alam Water

To investigate field testing for recycling saline drainage water, blending techniques have been proposed. The "Blending Strategy" and the "Cyclic Strategy" are two types of these techniques. These strategies require a substantial supply of year-round, saline drainage water as well as high-quality, clean water. In order to create irrigation water that is acceptable for the chosen crop's salt tolerance, saline water and good quality water must be blended together. After that, irrigation uses this water. The other strategy was developed and examined by **Rhoades et al (1989)**. Only selected crops and only at specific times of their growth season are employed with saline drainage water. The cyclic strategy's goal is to reduce soil salinity (also known as salt stress) when growing crops that are sensitive to salt or during sensitive growth phases. The idea of increasing the current water supply by blending good quality water and saline drainage water is frequently put forth. However, blending does not always result in an increase in the supply of potable water, nor is it always an economically viable option **[Grattan S.R. & Oster J.D. 2002].**

Excessively frequently, growers are forced to mix water that is too salty for the crop they are trying to grow. The maximum salinity at which saline drainage water is blendable exists. The salinity of saline water component of blend cannot be higher than a number, where if it used directly without blending, crops would be unable to extract water and grow. This is because the aim of blending is to enhance the overall supply of water available to the crop. Blending will reduce the amount of potable water available if the salinity of the saline component is greater than this threshold. Therefore, the salinity upper limit is determines by the maximum salinity that a crop can tolerate while still allowing for transpiration and growth. If drainage water is unable to provide at least 20–25% of the entire irrigation water demand, blending is not an acceptable option. A cyclic technique allows the soil salinity profile to change rather than remain in a stable condition, allowing crops having lower tolerances to be included in cycle. The strategy of cyclic maintains an average soil salinity that is lower than under mixing method, specifically in top portion of profile, which is crucial of plant emergence and establishment **[Grattan S.R. & Oster J.D. 2002].**

3.8.1 Water sampling, mixing, and analysis

The samples were taken from October 2020 to September 2021. Water samples were monthly collected from five stations in Almasab Alam drainage as shown in **Figure 3.1** and mixed with river water in the study area. Testing of 12 water quality parameters is used for water quality analysis. Every case is repeated three times then average is taken. The 12 parameters of water quality were utilized in IWQG V.1 program validation.

The mixing ratios of the study are as follows:

1. 75% river water is mixed with 25% Almasab Alam water, called (B1)

2. 50% river water is mixed with 50% Almasab Alam water, called (B2)

3. 25% river water is mixed with 75% Almasab Alam water, called (B3)

The results of the tests are compared with the international standards for irrigation water by using IWQG V.1 software. Based on the results, the type of crop that is being grown can be known.

3.9 Effect of magnetizing on soil and Plants

The same soil weight and properties were used to fill all pots. The soil is taken from the study area near stations 360+00 and 441+00. All the pots were placed inside a plastic house to preserve them from rain and other weather conditions. To study the effect of irrigation with magnetized water, Almasab Alam water and the river water without any other effects such as rain throughout the study period within the seasons 2020-2021 and 2021-2022 are considered.

The water used for this study was the river water and untreated and treated water from Alamasb Alam drainage. The treated water is passing through a magnetic device with five different intensities: 1000, 2000, 3000, 5000, and 7000 G. The onion, bean, maize, and Vicia faba L. are planted in pots. Three replicates of each case under the same condition of irrigation for each plant were made to ensure the validity of the results. The number of pots used in this study is 336 pots. The chemical and physical properties of the soil are studied before and after the experiment. The chemical properties of soil EC, pH, Ca, NO_3, PO_4, K, Na, Mg, Cl, and SO_4, and the physical properties like porosity, bulk density, and permeability were examined before the beginning and after the end of the season of plants to determine the effect of magnetized water (MW) on the soil properties. The effect of magnetization on plants in terms of germination rate, height, and duration of the flowering of plants has been studied. The root length of the onion plant is only measured.

Chapter 4 *Results and Discussion*

4.1 Introduction

This chapter deals with the evaluation of the validity of Almasab Alam water for irrigation for the study area using the **IWQG V.1** programe. Two methods are investigated. The first is the method of mixing with river water in different proportions and the evaluation by using the **IWQG V.1** programe. The second method is by using magnetic water technology with different intensities and studying the magnetization effect on water physical and chemical properties.

Figure 4.1 shows the electrical conductivity (EC) of Almasab Alam water for all study stations for a full agricultural year (2020-2021) and the permissible electrical conductivity for irrigation according to the FAO. It is found that Almasab Alam water in the study area for all stations and throughout the year has a value higher than the permissible value. The classification of Almasab Alam water is medium to highly saline water. **Figure 4.1** also shows that the amount of electrical conductivity or salts increases towards the south; from station 441 + 00 towards station 360 + 00.

Because of the large number of results, only two months' results are considered to discuss and evaluate the results of this study. The other results are mentioned in **Appendix A.**

The salinity EC in Almasab Alam water is used in determining the selected two months. The first month in which salinity EC is higher than the rest of all the months is June 2021 at station 360+00. The second month in which the salinity EC of the water is lower than the rest of all the months is

December 2020 at station 441+00. For other months and for all stations, the salinity value is confined between the highest and lowest values in June and December.

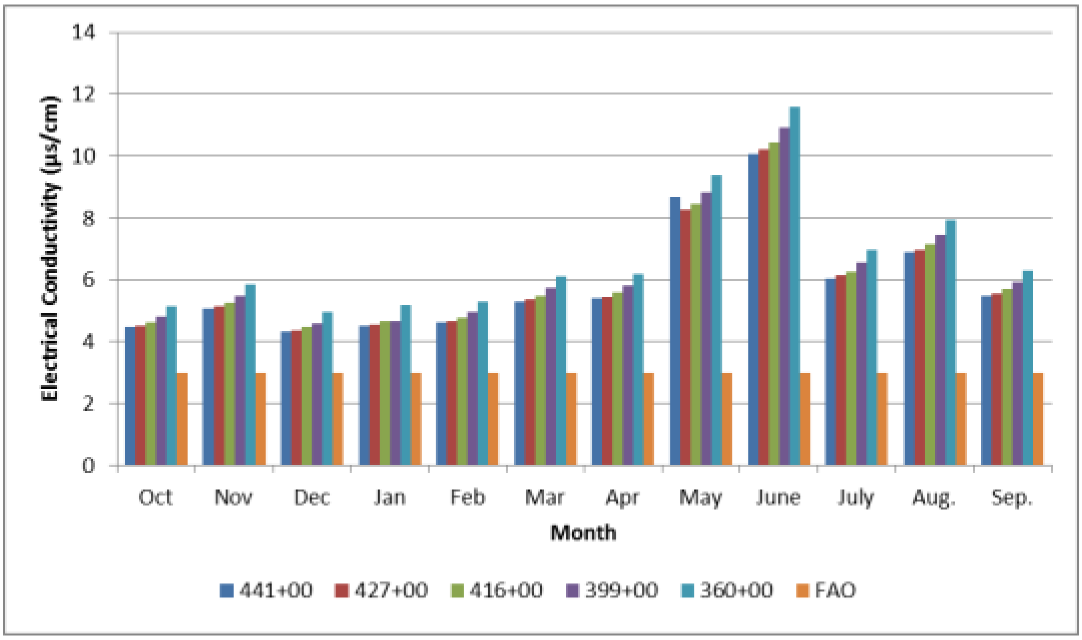

Figure 4.1: The Electrical Conductivity for all stations of Almasab Alam

4.2 Water sampling and analysis

Water quality data records from October 2020 to September 2021, which represent the agricultural year in Iraq, were utilized. These samples collected monthly from Almasab Alam drainage including 12 water quality parameters and used for the water quality analysis. Each test is repeated three times, then average is considered. To verify the results of laboratory tests, the same tests were carried out in other laboratories and found that the results were close. The parameters of water quality used for validating IWQG V.1 programe are shown in **Table 4.1**.

Table 4.1: Test results of the study area

Parameter	Stat.441+00 Dec. 2020	Stat.360+00 June 2021	FAO 29 guidelines
EC (µs/cm)	4.33	11.6	0–20
TDS ppm)	2771	7418	0–5
Cl (ppm)	530	1420	0–40
So4 (ppm)	998	2016	0-2
Na^{+} (ppm)	332	510	0–30
K (ppm)	9.0	10.50	0–20
Mg^{+2} (ppm)	160	300	0-0.10
Ca^{+2}(ppm)	250	210	0–1
No3 ppm)	1.18	2.81	0–10
Po4 (ppm)	0.30	0.13	0–3
PH	7.90	8.10	6.0–8.5
Do (ppm)	12	7	0-15

The analysis results cleared that, the validity of Almasab Alam drainage water for irrigation and its conformism with FAO 29 guideline standards [**Ayers and Westcot, 1994**].

4.3 Results and discussions

In this part, the results obtained from the evaluation program for the general estuary water during the study period 2020-2021 are discussed.

The main value of IWQG was determined by using programe, result was (44.42 and 44.12) for minimum and maximum months respectively indicating high restriction, with an error of ion balance (-61.67%) is not acceptable for December and (-17.23%) for June is not acceptable. This means that the Almasab Alam water quality suitable to irrigate soil with high permeability without compacted layers. Since soil in land irrigated by drainage clay loam (heavy texture), hence, sodality of soil problem could happen which will affect the growth of plants that are sensitive to salt [**Kiremit and Arslan, 2016; Ewaid, 2018].**

Report of irrigation water quality valuation for December and June, respectively, is shown in **Tables (4.2 & 4.3**). It was obtained by using the IWQG V.1 program and explains impact of salinity on crop production as well as the percentage reduction of expected yield when using Almasab Alam drainage water. The IWQG V.1 advises accepting anticipated decline rates or taking steps for solving the issue.

Tables 4.2: The IWQG V.1 salinity assessment report about the validity of Almasab Alam water to irrigate some important crops.

ECen: Salinity threshold value for the best yield (ds/m).

ECmax: The maximum salinity value when the crop yield is (0), (ds/m).

ECe: The three years mean value of the salinity in this study (4.33 ds/m).

Water Quality Index (WQI)	44.42	High restriction
% Error of Ion Balance	-61.67	Error not acceptable

Crop	ECen	ECmax	ECe	Expected yield %
Barley	5.3	19	4.33	100.00
Cotton	5.1	18	4.33	100.00
Sugar beet	4.7	16	4.33	100.00
Date palms	2.7	21.0	4.33	91.10
Wheat	4.0	13.0	4.33	97.66
Maize	1.1	6.7	4.33	42.34
Potato	1.1	6.7	4.33	61.24
Bean	0.7	4.2	4.33	0.00

Crop	ECen	ECmax	ECe	Expected yield %
Onions	0.8	5.0	4.33	15.99
Rice	2.0	7.6	4.33	58.39
Citrus (Orange)	1.1	5.3	4.33	23.09
Groundnut	2.1	4.4	4.33	3.04
Carrots	0.7	5.4	4.33	22.79
Apricot	1.1	3.8	4.33	0.00
Tomato	1.7	8.4	4.33	60.76
Lettuce	0.9	6.0	4.33	32.77
Broccoli	1.9	9.1	4.33	66.27
Grapes	1.0	7.9	4.33	51.75
Alfalfa	1.3	10.0	4.33	65.19
Sugarcane	1.1	12.0	4.33	70.38
Clover, Barseem	1.0	13.0	4.33	72.26
Sorghum	4.5	8.7	4.33	100.00
Soybean	3.3	6.7	4.33	69.71
Cowpea	3.3	8.8	4.33	81.27
Spinach	1.3	10	4.33	65.19
Beet, red	2.7	10	4.33	77.69

Table 4.3: The IWQG V.1 salinity assessment report about the validity of Almasab Alam water to irrigate some important crops.

ECen: Salinity threshold value for the best yield (ds/m).

ECmax: The maximum salinity value when the crop yield is (0), (ds/m).

ECe: The three years mean value of the salinity in this study (11.60 ds/m).

Water Quality Index (WQI)	44.12	High restriction
% Error of Ion Balance	-17.23	Error not acceptable

Crop	ECen	ECmax	ECe	Expected yield %
Barley	5.3	19	11.60	71.42
Cotton	5.1	18	11.60	67.89
Sugar beet	4.7	16	11.60	59.56
Date palms	2.7	21.0	11.60	64.13
Wheat	4.0	13.0	11.60	62.58
Maize	1.1	6.7	11.60	0.00
Potato	1.1	6.7	11.60	1.96
Bean	0.7	4.2	11.60	0.00
Onions	0.8	5.0	11.60	0.00
Rice	2.0	7.6	11.60	0.00
Citrus (Orange)	1.1	5.3	11.60	0.00
Groundnut	2.1	4.4	11.60	0.00
Carrots	0.7	5.4	11.60	0.00
Apricot	1.1	3.8	11.60	0.00
Tomato	1.7	8.4	11.60	0.00
Lettuce	0.9	6.0	11.60	0.00
Broccoli	1.9	9.1	11.60	0.00
Grapes	1.0	7.9	11.60	0.00
Alfalfa	1.3	10.0	11.60	8.42
Sugarcane	1.1	12.0	11.60	25.08
Clover, Barseem	1.0	13.0	11.60	31.11
Sorghum	4.5	8.7	11.60	0.00
Soybean	3.3	6.7	11.60	0.00
Cowpea	3.3	8.8	11.60	0.00
Spinach	1.3	10	11.60	8.42
Beet, red	2.7	10	11.60	10.06

Tables 4.4 and **4.5** show the irrigation water quality indicators values for December and June respectively obtained by IWQG V.1 program with some descriptions and advices:

The value of EC was (4.33 and 11.60) µs/cm for December and June respectively, indicating the moderately saline condition of drainage water for December and the high saline condition of drainage water for June. For moderately and high salinity hazards, plants may be negatively impacted and need to be chosen for their salt tolerance, cautious irrigation, adequate drainage, and leakage of soil. [**He et al., 2015**].

Sodium percentage (Na%) is (36.36% and 40.06%) for December and June respectively **Tables 4.4** and **4.5** showed good condition for December and June. The soil structure may be negatively impacted by high sodium levels in irrigation water, which will hinder plant growth. The formula below can be used to compute the (Na%) [**Ghadiri et al., 2004**]:

$$Na\ \% = \frac{(Na^{+} + K^{+})\ x100}{Ca^{+2} + Mg^{+2} + Na^{+} + K^{+}} \qquad 4.1$$

Concentration of chlorides (Cl^{-}) is (15.80 and 40.06 meq/l) for December and June respectively and there is a severe problem as shown in **Tables 4.4** and **4.5**, but in case of excesses chlorides,it will accumulate on leaves, burning the leaves. Planting a crop that is less susceptible to damage from high chloride irrigation water can help, also drip irrigation can be used to avoid foliar contact. **[Butcher et al., 2016].**

According to IWQG V.1 outcomes, sodium adsorption ratio SAR value was (4.03 and 529 meq/l), for December and June respectively, indicating that sodium risk of Almasab Alam drainage water was low as shown in **Tables 4.4** and **4.5**.

Table 4.4: The calculated values of irrigation water quality indicators for month of December and their interpretation as delivered from IWQG in this work are proposed for the month of December 2020.

Indicators of Water Quality for Irrigation	Value	Result
Electrical conductivity (EC): (Primary drainage water and groundwater)	4.3296875	moderately saline
The sodium percentage (Na %):	36.38	Good
Chioride	15.80	Sever problem
Sodium adsorption ratio (SAR)	4.03	Sodium hazard of water is Low
Adj. Sodium Adsorption Ratio (SAR.adj)	4.82	
Total Hardness mg/L	1,283.98	Very hard
"Very Hard ground." Organic matter dissolution in soil ("slick spots") and dispersion of clay leads to a poor soil structure. The topsoil hardens. Water penetrates and permeates soil extremely slowly..		
Magnesium hazard (MH)	51.35	suitable for irrigation purposes
The Permeability Index (PI)	36.02	suitable
Kelley Index (KI)	0.56	suitable
Soluble sodium percentage (SSP)	36.38	Good

Table 4.5: The evaluated values for the June month's irrigation water quality indicators and their explanation provided by the IWQG and suggested of present work for June 2021.

Indicators of Water Quality for Irrigation	Value	Result
Electrical conductivity (EC): (Secondary drainage water and groundwater)	11.6025	high saline
The sodium percentage (Na %):	38.97	Good

Chloride (Cl-):	40.06	Sever problem
Sodium adsorption ratio (SAR)	5.29	Sodium hazard in water Low
Adj. Sodium Adsorption Ratio (SAR.adj)	6.32	
Salinity potential (PS)	60.85	safely use only in coarse-textured soils
Total Hardness mg/L	1,760.77	Very hard
"Very Hard ground." Dissolution of organic matters in soil ("slick spots") and Poor soil structure is caused by the dispersion of clays. Soil surface sealing. Into and through the soil, water travels very slowly.		
Magnesium hazard (MH)	70.20	suitable for irrigation purposes
The Permeability Index (PI)	38.69	suitable
Kelley Index (KI)	0.63	suitable
Soluble sodium percentage (SSP)	38.97	Good

From the results of **Tables 4.4** and **4.5**, it is clear that Almasab Alam water is suitable to irrigate plants that have moderate to high salts tolerance utilizing special mechanisms to regulate salinity, except for the water that has low values for Na, Cl, and HCO3. SAR is described as the Ca^{+2}, Mg^{+2} , and Na^{+} relative concentrations which indicate the concentrations influence of two cations on the accumulation of sodium in soil; therefore, SAR is more preferable technique for defining that effect than (Na %).The high amount of Na^{+} or low amount of Ca^{+2} the root zone water quantity will reduced [**Kiremit and Arslan, 2016].**

Bortolini et al. (2018) ascribed a decrease in yield brought on by high levels of Na and Cl ions in tissues of plant to causes like:

(a) Decrease expansion in leaf's surface.

(b) Accumulating of Na inside leaves and lowering photosynthetic.
(c) Competition with the ions K^+, Ca^{+2}, and Mg^{+2} for uptake
(d) The phase of reproductive beginning too late.

Total hardness (TH) values were 1283.98 and 1760.77 mg/l, for December and June respectively. The programe classified the drainage water from Almasab Alam as very hard. This hardness of water leads to dissolution of the organic matter in soil (slick spots), clays dispersion leads to poor structure of soil, and water moves inside and through soil very slowly. **[Butcher et al., 2016].**

In present study, the magnesium hazard (MH), and permeability index (PI) values are suitable for irrigation purposes as shown in **Tables 4.4** and **4.5.** This finding implies that, depending on the type of soil and water concentration of (Na+, Ca+2, Mg+2, and HCO3-), Almasab Alam water is harmful for soil permeability, which affected due to irrigation for long terms.

The Kelly Ratio (KR) values of Almasab Alam drainage water are (0.56 and 0.63) meq/l as shown in **Tables 4.4** and **4.5**. This specifies that water appropriate and falls within limit of <1.0. The increment of Na^+ concentration leads to dispersion in soil and replaces Ca^{+2} which has an essential part in nutrition of plant. The KR can be determined using: **[He et al., 2015]:**

$$KR = \frac{Na^+}{(Ca^{+2} + Mg^{+2})} \qquad 4.2$$

In addition to the results of the IWQG V.1 programe's calculation of irrigation water quality indicators and its interpretation, section (Issue and Management) of programe provides guidance and solutions for dealing with potential issues brought on by the investigated wateras as illustrated in **Tables 4.6** and **4.7**.

Table 4.6: The issue and management section for December month provides IWQG recommendations and solutions for addressing and managing the majority of irrigating water issues for December 2020.

Issue & Management
In soils with good permeability and with no compact layers, a high restriction may be applied. Water with EC greater than 2 dS/m and SAR more than 7 must use a high-frequency irrigation schedule. Except for water with low Na, Cl, and HCO_3 values, it is utilized for irrigation of plants with special salinity management techniques that have a moderate to high tolerance to salts.
Electrical conductivity (EC): High hazard. generally unsuitable for irrigation, with the exception of particularly salt-tolerant plants where great drainage, regular leaching, and intense management, as well as solutions for regulating irrigation water so as to prevent dilution and also remove salts, are present.
The sodium percentage (Na %): significant sodium risk in some fine-textured soils.
Sodium adsorption ratio (SAR): Use of SAR on crops like avocados that are sensitive to sodium must be avoided.
Total Hardness: At levels exceeding 150 mg/L, total hardness causes equipment clogging and foliar staining issues. Pipelines, irrigation systems, and farm equipment may experience an increased sodium effect as a result of water softening treatment. Calcium salts could create white lime encrustation (calcium carbonate). Those buildups eventually damage hot water pipes and obstruct irrigation equipment. Heating elements that have deposits on them overheat and burn off. As a result, it is advised against using metal components in irrigation systems.

Treatment: Softening water is the process of lowering hardness. Water can be softened through ion exchange, water-softening chemicals, desalination techniques like reverse osmosis, lime utilize, adjustments pH, and temperature management.

The Permeability Index (PI): Growth Responsible (range at which affected) Crop (Beans) stunted growing at low values of ESP even if the soil physical characteristics were good.

Kelley Index (KI): Growth Responsible (range at which affected) Crop (Deciduous fruits, Nuts, Citrus, Avocado) Under Field Conditions from Sodium toxicity symptoms low ESP values.

Soluble sodium percentage (SSP): Growth Responsible (range at which affected) Crop (Beans) stunted growing at low values of ESP even if the soil physical characteristics were good.

Table 4.7: The IWQG offers recommendations and solutions in the issue and management paragraph for June month to address and manage the majority of irrigation water problems for June 2021.

Issue & Management

In soils without compact layers and with good permeability, high restriction may be applied. For waters having EC more than 2 dS/m and SAR greater than 7, a program with high-frequency irrigation must be used. Except for water with low Na, Cl, and HCO3 concentrations, it is used to irrigate plants having moderate to high tolerance to salts using particular salinity management techniques.

Electrical conductivity (EC): High hazard. Generally undesirable for irrigation, with the exception of exceptionally salt tolerant plants, in which, there is great drainage, regular leaching, and intense management, methods for controlling irrigation water so as to avoid dilution, and remove salts from water used for irrigation.

The sodium percentage (Na %): considerable sodium risk in confident fine-textured soils .

Sodium adsorption ratio (SAR): Use of SAR on crops like avocados that are sensitive to sodium must be avoided.

Total Hardness: equipment clogging and problems of foliar staining at levels beyond 150 mg/L. The use of water softening for treatment could increase the impact of sodium on pipelines, irrigation systems, and agricultural equipment. Calcium salts can create a white lime encrustation (calcium carbonate). These buildups eventually damage hot water pipes and obstruct irrigation equipment. As a result of deposits, heating elements overheat and burn out .Therefore, its recommended not to use metal parts in irrigation systems.

Treatment: Softening water is the process of lowering hardness. Water can be softened through ion exchange, water-softening chemicals, desalination techniques like reverse osmosis, lime utilize, pH adjustments, and temperature management.

The Permeability Index (PI): Growth Responsible (range at which affected) Crop (Beans) stunted growing at low values of ESP even if the soil physical characteristics were good.

Kelley Index (KI): Growth Responsible (range at which affected) Crop (Deciduous fruits, Nuts, Citrus, Avocado) Under Field Conditions from Sodium toxicity symptoms low ESP values.

Soluble sodium percentage (SSP): Growth Responsible (range at which affected) Crop (Beans) stunted growing at small values of ESP even if the soil physical properties were good.

4.4 Blending Results

In this part, the results obtained from the evaluation program for the Almasab Alam water during the study period 2020-2021 are discussed.

For analyzing the results of blending Almasab Alam's water, river water tests, and their suitability for irrigation, two months were chosen for the evaluation. The rest of the results are placed in Appendix B. In The first, the EC has the lowest value and in the second the EC has the highest value. The first month in which the Electrical conductivity (EC) value is lowest, is December and it is equal to 4.33 (µs/cm) at station 441+00. The second month in which the Electrical conductivity (EC) value is heights, is June and it is equal to 11.60 (µs/cm) at station 360+00. For the rest of the study months, its values are confined between the values of these two months. The results of the evaluation of blending treatments are as follows:

4.4.1 Month: December 2020 at Station 441+00

Table 4.8 shows the results of blending treatment for December month 2020 at station 441+00.

Table 4.8: the results of blending treatments

Water Type	River	Almasab	B1	B2	B3
EC(µs/cm)	0.94	4.33	1.73	2.51	3.55
TDS ppm)	618	2771	1108	1607	2270
Cl (ppm)	60	530	159	265	413
SO_4 (ppm)	262	998	630	898	958
Na^+ (ppm)	122	332	166	232	269
K (ppm)	7.7	9.0	7.8	8.2	8.8
Mg^{+2} (ppm)	45	160	93	98	112
Ca^{+2} (ppm)	155	250	118	148	206
NO_3 (ppm)	0.98	1.18	1	1.14	1.16
PO_4 (ppm)	0.65	0.30	0.56	0.39	0.33
pH	7.6	7.90	7.68	7.75	7.88
DO(ppm)	15.20	12	14.80	14	13

4.4.1.1 Blending ratio with 25%

The program's calculation of the IWQG's primary value produced a score of (57.31) for the month of December, suggesting moderate restraint, with an unacceptable ion balance inaccuracy of (9.05 percent). This indicates that the water quality in Almasab Alam is suitable for irrigating soil with a good permeability and no compacted layers. Since the drainage-irrigated land's soil is silty clay loam (heavy texture), soil sodality difficulties may arise which have an impact on the growth of plants sensitive to salts [**Kiremit and Arslan, 2016; Ewaid, 2018**].

Table 4.9 demonstrates a report for irrigation water quality evaluation obtained by using IWQG V.1 program, explains salinity impact on crop production, and displays the percentage of estimated decrease of yield if blending treatments were used. This information was obtained as a result of the application of IWQG V.1 program, which also, advises accepting the anticipated reduction rates or taking steps to solve the issue.

Table 4.9: IWQG V.1 salinity valuation report of the validity of Almasab Alam water to irrigate some significant crops.

ECen: Salinity threshold value for the best yield (ds/m).

ECmax: The maximum salinity value when the crop yield is (0), (ds/m).

ECe: The three years mean value of the salinity in this study (1.73 ds/m).

Water Quality Index (WQI)	57.31	High restriction
% Error of Ion Balance	9.05	Error not acceptable

Crop	ECen	ECmax	ECe	Expected yield %
Barley	5.3	19	1.73	100.00
Cotton	5.1	18	1.73	100.00
Sugar beet	4.7	16	1.73	100.00
Date palms	2.7	21.0	1.73	100.00
Wheat	4.0	13.0	1.73	100.00
Maize	1.1	6.7	1.73	88.75
Potato	1.1	6.7	1.73	92.44
Bean	0.7	4.2	1.73	70.57
Onions	0.8	5.0	1.73	77.87
Rice	2.0	7.6	1.73	100.00
Citrus (Orange)	1.1	5.3	1.73	85.00
Groundnut	2.1	4.4	1.73	100.00
Carrots	0.7	5.4	1.73	78.09
Apricot	1.1	3.8	1.73	76.67
Tomato	1.7	8.4	1.73	99.55
Lettuce	0.9	6.0	1.73	83.73
Broccoli	1.9	9.1	1.73	100.00
Grapes	1.0	7.9	1.73	89.42
Alfalfa	1.3	10.0	1.73	95.06
Sugarcane	1.1	12.0	1.73	94.22
Clover, Barseem	1.0	13.0	1.73	93.92
Sorghum	4.5	8.7	1.73	100.00
Soybean	3.3	6.7	1.73	100.00
Cowpea	3.3	8.8	1.73	100.00
Spinach	1.3	10	1.73	95.06
Beet, red	2.7	10	1.73	100.00

Table 4.10 demonstrates the results of the IWQG V.1 programe's calculation of irrigation water quality indicators for December month along with the following justifications and suggestions:

The EC value was (1.73) µs/cm specifying slightly saline condition of drainage water. If there is moderately and high salinity hazards, plants might be adversely affected and need utilizing of plants that are salt-tolerant, good drainage, soil leaching, and careful irrigation [**He et al., 2015**].

Sodium percentage (Na %) is (35.40%) and exhibited good condition. Increased sodium levels in irrigating water might negatively affect soil structure and hinder growing of plants.

As shown in **Table 4.10**, the mean concentration of chlorides (Cl^-) was (4.49 meq/l), without any problem. However, if the concentration were to rise, chloride would deposit on the leaves and cause a foliar burn. By choosing a less sensitive crop or using drip irrigation to avoid foliar contact, damage from irrigation water with high chloride levels can be minimized (Butcher et al., 2016). Based on the program, sodium adsorption ratio (SAR) result is (2.77 meq/l), which shows that, sodium risk of Almasab Alam drainage water little.

Table 4.10. The IWQG's analysis of the measured values for irrigation water quality indicators for the month of December is reported in this study.

Indicators of Water Quality for Irrigation	Value	Result
Electrical conductivity (EC):	1.73125	slightly saline (Irrigation water)
The sodium percentage (Na %):	35.40	Good
Sodium adsorption ratio (SAR)	2.77	Sodium hazard of water is Low
Adj. Sodium Adsorption Ratio (SAR.adj)	3.31	
Salinity potential (PS)	10.99	safely used in

		medium and coarse
Total Hardness mg/L	677.81	Very hard
"Very Hard ground." Organic matter dissolution of soil ("slick spots") and dispersion of clays results in poor soil structure. Soil surface seals. Water moves very slowly into and through the soil.		
Magnesium hazard (MH)	56.50	suitable for irrigation purposes
The Permeability Index (PI)	34.78	suitable
Kelley Index (KI)	0.53	suitable
Soluble sodium percentage (SSP)	35.40	Good

From the results shown in **Table 4.10**, it concludes that the Almasab Alam must be used to irrigate plants with moderate to high salts tolerance utilizing adequate salinity control technique, except for water having low amount values of Na, Cl, and HCO_3.

The concentrations effect of two cations' on accumulation of sodium in soil indicated by the Ca^{+2}, Mg^{+2}, and Na^{+}; relative concentrations, as a result, SAR is more accurate technique for defining this effect than (Na%). Water content in the root zone is decreased by high levels of Na+ or low Ca+2. **[Kiremit and Arslan, 2016].**

Bortolini et al. (2018) ascribed decreases of yield due to high sodium concentration and plant tissues chloride ions to the following:

(a) Decrease in the leaf's surface expansion.
(b) Na accumulating in leaves and lowering photosynthetic.
(c) Competition for uptake with the ions K^{+}, Ca^{+2}, and Mg^{+2}.
(d) Beginning of the reproductive phase too late.

Value of total hardness (TH) is 677.81 mg/l. According to programe, drainage water from Almasab Alam is very hard, which results in soil organic matter dissolution (slick spots) and clays dispersion, which leads to poor structure of soil and very slow water movement into and through out soil (Butcher et al., 2016). Based on results shown in Table 4.10, the magnesium hazard (MH) and permeability index (PI) values are suitable for irrigation. This outcome implies that the water from Almasab Alam is harmful to soil permeability which is affected by irrigation for long-term and depends upon the soil type and water content (Na+, Ca+2, Mg+2, and HCO3). The drainage water from Almasab Alam has a Kelly Ratio (KR) value of (0.56) meq/l. This shows that, water appropriate and within range of < 1.0. Higher concentration of Na^{+} increases soil dispersion and substitutes Ca^{+2}, which is an essential component of plant nutrition.

In addition to the results of the IWQG V.1 programe's calculation of indicators of irrigating water quality with its interpretation, its provides guidance and solutions for handling any issues caused by the water under examination as illustrated in section (Issue and Management) of program, which summarized in**Table 4.11**.

Table 4.11: The paragraph of (issue and management) for December month presents guidance and solusions provided by IWQG to manage and solve irrigation water problems for December 2020.

Issue & Management
For moderate salt leaching, moderate restriction may be utilized in soils with values ranging from moderate to high permeability. It is possible to grown plants with a mediocre tolerance to salt. Electrical conductivity (EC): Medium hazard. Salinity may adversely affect plants. It requires the choice plants that are salt-tolerant, careful irrigation, good drainage, and leaching. Options for controlling irrigation water management to avoid dilution and remove salt from irrigation water.

The sodium percentage (Na %): considerable sodium risk in certain fine-textured soils .

Sodium adsorption ratio (SAR): SAR use on sodium-sensitive crops like avocados need to be avoided.

Total Hardness: At concentrations exceeding 150 mg/L, apparatus clogging and foliar staining issues arise. An increase in sodium may follow water softening treatment. Impact on irrigation, farm machinery, and pipelines. A white encrustation of lime can be created by calcium salts (calcium carbonate). Over time, these deposits cause hot water systems to malfunction and obstruct irrigation equipment. On heating elements, deposits cause overheating and eventual burnout. Hence, it is advised using metal components in irrigation systems must be avoided.
Treatment: Softening water is the process of lowering hardness. Water can be softened through ion exchange, water-softening chemicals, desalination techniques like reverse osmosis, lime use, pH adjustments, and temperature management.

Permeability Index (PI): Growth Responsible (range at which affected) Crop (Beans) stunted growing at low values of ESP even if the soil physical characteristics were good.

Kelley Index (KI): Growth Responsible (range at which affected) Crop (Deciduous fruits, Nuts, Citrus, Avocado) Under Field Conditions from Sodium toxicity symptoms low ESP values.

Soluble sodium percentage (SSP): Growth Responsible (range at which affected) Crop (Beans) stunted growing at low values of ESP even if the soil physical characteristics were good.

4.4.1.2 The blending ratio of 50%

In this section, the results obtained from the evaluation program for the general estuary water during the study period 2020-2021 are discussed

The main value of IWQG which was calculated using the program was (48.68) for December month indicating High Restriction, with the error of ion balance (-0.48%) not acceptable. That means Almasab Alam water quality is appropriate for irrigating soils with high permeability without compacted layers. Since soil in irrigated land by drainage is clay loam (heavy texture) hence, problem of sodality of soil can happen and affects the growth of plants that are salt-sensitive [**Kiremit and Arslan, 2016; Ewaid, 2018**].

Table 4.12 displays the evaluation of the irrigation water quality report that was obtained through the use of the IWQG V.1 program, elaborating on the impact of salinity on crop production and displaying the percentage of anticipated yield reduction when utilizing blending treatments. The IWQG V.1 advises either accepting the anticipated decline rates or acting to solve this issue.

Table 4.12: The IWQG V.1 salinity assessment report about the validity of Almasab Alam water to irrigate some important crops

ECen: Salinity threshold value for the best yield (dS/m).

ECmax: The maximum salinity value when the crop yield is (0), (dS/m).

ECe: The three years mean value of the salinity in this study (2.51 dS/m).

Water Quality Index (WQI)	48.68	High restriction
% Error of Ion Balance	-0.48	Error is acceptable

Crop	ECen	ECmax	ECe	Expected yield %
Barley	5.3	19	2.51	100.00
Cotton	5.1	18	2.51	100.00
Sugar beet	4.7	16	2.51	100.00
Date palms	2.7	21.0	2.51	100.00
Wheat	4.0	13.0	2.51	100.00
Maize	1.1	6.7	2.51	74.83
Potato	1.1	6.7	2.51	83.08
Bean	0.7	4.2	2.51	48.29
Onions	0.8	5.0	2.51	59.30
Rice	2.0	7.6	2.51	90.89
Citrus (Orange)	1.1	5.3	2.51	66.43
Groundnut	2.1	4.4	2.51	82.17
Carrots	0.7	5.4	2.51	61.50
Apricot	1.1	3.8	2.51	47.79
Tomato	1.7	8.4	2.51	87.91
Lettuce	0.9	6.0	2.51	68.44
Broccoli	1.9	9.1	2.51	91.53
Grapes	1.0	7.9	2.51	78.12
Alfalfa	1.3	10.0	2.51	86.10
Sugarcane	1.1	12.0	2.51	87.07
Clover, Barseem	1.0	13.0	2.51	87.42
Sorghum	4.5	8.7	2.51	100.00
Soybean	3.3	6.7	2.51	100.00
Cowpea	3.3	8.8	2.51	100.00
Spinach	1.3	10	2.51	86.10
Beet, red	2.7	10	2.51	100.00

Table 4.13 displays the indicators of irrigation water quality values for December calculated by application of IWQG V.1 programe with recommendations and descriptions as in following sections:

EC value is (2.51) µs/cm signifying moderately saline condition of drainage water. formoderately and high salinity risks, plants might be Affected negatively, which requires the selection of plants that can tolerate both salinity, good drainage, soil leaching, and careful irrigation [**He et al., 2015**].

Sodium percentage (Na %) is (40%) and indicated respectable condition. Additional amounts of sodium in irrigation water can badly influence structure of soil, making growing of plant difficult. Mean chloride (Cl^-) concentration is (7.48 meq/l) which indicate an increasing problem as shown in **Table 4.13**. while, if there is excesses of Chloride then it will deposit on the plant leaves resulting in foliar burn. this kind of damages can be overcome or at least minimized through planting crops which are less sensetive to Chloride or use drip irrigation technique **[Butcher et al., 2016].** According to programe, SAR is (3.63 meq/l), signifying that sodium danger of Almasab Alam drainage water low.

Table 4.13. The calculated values of irrigation water quality indicators for month of December, along with the IWQG's interpretation of those values, are reported in this work.

Indicators of Water Quality for Irrigation	Value	Result
Electrical conductivity (EC):	2.5109375	moderately saline (Primary drainage water and groundwater)
The sodium percentage (Na %):	40.00	Good
Chloride (Cl^-):	7.48	increasing problem
Sodium adsorption ratio (SAR)	3.63	Sodium danger of water Low
Adj. Sodium Adsorption Ratio (SAR.adj)	4.34	
Salinity potential (PS)	16.74	safely use only with

		coarse-textured soils
Total Hardness mg/L	773.40	Very hard
"Very Hard ground." Dissolution of soil organic matter ("slick spots") and clays dispersion leads to poor structure of soil. Soil surface seals. Water moves very slowly into and through the soil.		
Magnesium hazard (MH)	52.17	suitable for irrigation purposes
The Permeability Index (PI)	39.51	suitable
Kelley Index (KI)	0.65	suitable
Soluble sodium percentage (SSP)	40.00	Good

From the results shown in **Table 4.13**, it concludes that the Almasab Alam should be used to irrigate plants having moderate to high tolerance to salts with special practices to control salinity, except for water with low values of Na, Cl, and HCO_3.

The SAR measures the effect of the qualified concentrations of Ca^{+2}, Mg^{+2}, and Na^{+} on sodium buildup in soil, making it more accurate approach of assessing this effect than (Na%). Water content in the root zone is decreased if the concentration of Na^{+} is high or the concentration of Ca^{+2} is low **[Kiremit and Arslan, 2016].**

Bortolini et al. (2018) ascribed the causes for the decreased in yield caused by the high levels of Na and Cl ions in the plant tissues to:

(a) Decrease in the leaf's surface expansion.
(b) Na accumulating in leaves and lowering photosynthetic.
(c) Competition for uptake with the ions K^{+}, Ca^{+2}, and Mg^{+2}.
(d) Beginning of the reproductive phase too late.

The value of total hardness (TH) is 773.40 mg/l. The programe categorized Almasab Alam drainage water very hard, Hard water dissolves soil organic matter (slippery spots), clay dispersal weakens soil structure, and water moves so slow in and through soil [**Butcher et al., 2016**], (**Table 4.13**). In present study, the magnesium hazard (MH), and permeability index (PI) values are suitable for irrigation purposes as shown in **Table 4.13**. This result advises that Almasab Alam water is harmful to soil permeability and is affected by irrigation for long periods, depending upon soil quality and water content of (Na^+, Ca^{+2}, Mg^{+2}, HCO_3^-). The value of Kelly Ratio (KR) of Almasab Alam drainage water is (0.56) meq/l. This shows that water is appropriate and is within the range of <1.0. The increment of Na^+ concentration leads to dispersion of soil and replacing of Ca+2, which has energetic role in nutrition of plant.

In addition to calculating and interpreting the values of quality indicators for irrigation water, the program IWQG V.1 also provides solutions and tips to address problems which might caused by water samples under test as indicated in section (Issue and Management) as illustrated in **Table 4.14.**

Table 4.14. Paragraph of issue and management for December month highlights the solutions and proposals offered by program IWQG to manage and solve f the problems associated with irrigation water for December 2020.

Issue & Management
In soils without compact layers and with good permeability, high restriction may be applied. For water with EC above 2 dS/m and SAR above 7, a high-frequency irrigation program should be used. Except for water with low Na, Cl, and HCO3 concentrations, it is used for irrigation of plants with a moderate to high tolerance to salts using particular salinity management techniques.

Electrical conductivity (EC): High risk is generally unacceptable and undesirable in irrigation water, except in cases where plants with a high tolerance for salinity are grown due to excellent drainage, intensive management, frequent filtration, and multiple irrigation water management options in order to avoid dilution, and salt removal in water that is used for irrigation purposes

The sodium percentage (Na %): Noticeable sodium danger in certain fine-textured soils .

Chloride (Cl^-): Relative sensitivity of crop for the advancement of injury from salt spray water, almond, apricot, citrus, peaches, grapes, peppers, and potatoes. "Change the sprinkler irrigation method to another method."

Sodium adsorption ratio (SAR): Use of SAR on sodium-sensitive crops like avocados should be cautioned.

Total Hardness: Equipment clogging and problems of foliar staining occurring at levels above 150 mg/L. Any treatment utilizing water softening might lead to an increment in effect of sodium on pipelines, Irrigation, and farm equipment calcium salts can form white incrustation of lime (calcium carbonate). Those deposits finally block irrigation tools and affects hot water systems. Heating elements deposits leads to overheat and burn them out .Therefore, its recommended not to use metal parts in irrigation systems.

Treatment: Softening water is the process of lowering hardness. Water can be softened through ion exchange, water-softening chemicals, desalination techniques like reverse osmosis, lime use, pH adjustments, and temperature management.

Permeability Index (PI): Growth Responsible (range at which affected) Crop (Beans) stunted growing at low values of ESP even if the soil physical characteristics were good.

Kelley Index (KI): Growth Responsible (range at which affected) Crop (Deciduous fruits, Nuts, Citrus, Avocado) Under Field Conditions from Sodium toxicity symptoms low ESP values.

Soluble sodium percentage (SSP): Growth Responsible (range at which affected) Crop (Beans) stunted growing at low values of ESP even if the soil physical characteristics were good.

4.4.1.3 The blending ratio of 75%

When the IWQG main value was calculated by the programe, the resul score was (44.46) for December month indicating High Restriction, with the error of ion balance (0.05%) acceptable. That means Almasab Alam water quality suitable for irrigation of soil with high permeability without compacted layers. As the soil in land irrigated by drainage is clay loam (heavy texture), then problem of soil sodality may happen and affects growing of plants which are salt-sensitive [**Kiremit and Arslan, 2016; Ewaid, 2018**].

Table 4.15 displays evaluation for the irrigation water quality report that was achieved through use of the IWQG V.1 program and explains how salinity affects crop production while also displaying the percentage of anticipated yield reduction when using blending treatments. The IWQG V.1 suggests that you either accept anticipated reduction rates or take an action so as to solve this topic.

Table 4.15: IWQG V.1 report of salinity evaluation regarding viability of using water from Almasab Alam to irrigate some significant crops.

ECen: Threshold value of Salinity of best yield (dS/m).

ECmax: Maximum value of salinity as crop yield (0), (dS/m).

ECe: Three year salinity mean value in this work (3.55 dS/m).

Water Quality Index (WQI)	44.46	High restriction
% Error of Ion Balance	0.05	Error is acceptable

Crop	ECen	ECmax	ECe	Expected yield %
Barley	5.30	19	3.55	100.00
Cotton	5.10	18	3.55	100.00
Sugar beet	4.70	16	3.55	100.00
Date palms	2.70	21.0	3.55	95.36
Wheat	4.00	13.0	3.55	100.00
Maize	1.10	6.7	3.55	56.27
Potato	1.10	6.7	3.55	70.60
Bean	0.7	4.2	3.55	18.58
Onions	0.8	5.0	3.55	34.55
Rice	2.0	7.6	3.55	72.32
Citrus (Orange)	1.1	5.3	3.55	41.67
Groundnut	2.1	4.4	3.55	36.95
Carrots	0.7	5.4	3.55	39.38
Apricot	1.1	3.8	3.55	9.28
Tomato	1.7	8.4	3.55	72.40
Lettuce	0.9	6.0	3.55	48.06
Broccoli	1.9	9.1	3.55	77.10
Grapes	1.0	7.9	3.55	63.05

Crop	ECen	ECmax	ECe	Expected yield %
Alfalfa	1.3	10.0	3.55	74.15
Sugarcane	1.1	12.0	3.55	77.53
Clover, Barseem	1.0	13.0	3.55	78.76
Sorghum	4.5	8.7	3.55	100.00
Soybean	3.3	6.7	3.55	92.65
Cowpea	3.3	8.8	3.55	95.46
Spinach	1.3	10	3.55	74.15
Beet, red	2.7	10	3.55	88.36

Table 4.16 displays the indicators of irrigation water quality values for December calculated by application of IWQG V.1 programe with recommendations and descriptions as in following sections:

EC value is (3.55) µs/cm signifying moderately saline condition of drainage water. For moderately and high salinity risks, plants might be Affected negatively, which requires the selection of plants that can tolerate salinity, good drainage, soil leaching, and careful irrigation [**He et al., 2015**].

The sodium (Na%) content is (37.96%), which indicated good conditions. Increased salt levels in irrigation water may negatively affect structure of soil and make plant growing hard. As demonstrated in Table 4.16, there is a growing difficulty with the mean chlorides (Cl) concentration of (11.65 meq/l), but if there are excesses of chloride then it will deposit on the plant leaves resulting in foliar burn. This kind of damages can be overcome or at least minimized through planting crops which are less sensetive to Chloride or use drip irrigation technique **[Butcher et al., 2016].** According to the program, SAR is (3.75 meq/l), signifying that sodium danger of Almasab Alam drainage water low.

Table 4.16: The calculated values of irrigation water quality indicators for month of December, along with the IWQG's interpretation of those values, are reported in this work.

Indicators of Water Quality for Irrigation	Value	Result
Electrical conductivity (EC):	3.546875	moderately saline (Primary drainage water and groundwater)
The sodium percentage (Na %):	37.96	Good
Chloride (Cl^-):	11.65	Sever problem
Sodium adsorption ratio (SAR)	3.75	Sodium hazard of water is Low
Adj. Sodium Adsorption Ratio (SAR.adj)	4.48	
Salinity potential (PS)	21.53	safely used only in coarse-textured soils
Total Hardness mg/L	976.10	Very hard
"Very Hard ground." Soil organic matter dissolution ("slick spots") and clays dispersion resulting in poor structure of soil. Soil surface seals. Water moves so slowly in and through of the soil.		
Magnesium hazard (MH)	47.28	suitable for irrigation purposes
The Permeability Index (PI)	37.50	suitable
Kelley Index (KI)	0.60	suitable
Soluble sodium percentage (SSP)	37.96	Good

From the results shown in **Table 4.16**, it concludes that Almasab Alam must be used irrigate plants having moderate to high tolerance to salts with special practices to control salinity, except for water has low values of Na, Cl, and HCO_3.

The SAR measures the effect of Ca^{+2}, Mg^{+2}, and Na^{+} relative concentrations on sodium buildup in soil, making it more accurate approach for assessing the effect than (Na%). Water content in the root zone is decreased by high Na^{+} or low Ca^{+2} concentrations **[Kiremit and Arslan, 2016].**

Bortolini et al. (2018) ascribed the causes for the decreased in yield caused by the high levels of Na and Cl ions in the plant tissues to:

(e) Decrease in the leaf's surface expansion.
(f) Na accumulating in leaves and lowering photosynthetic.
(g) Competition for uptake with the ions K^{+}, Ca^{+2}, and Mg^{+2}.
(h) Beginning of the reproductive phase too late.

Total hardness (TH): There were 976.10 mg/l of total hardness. According to the programe, the drainage water from Almasab Alam is classified as being very hard. According to **Butcher et al. (2016),** hard water causes the soil's organic matter to dissolve, creating slick spots, and clays that have been dispersed cause the soil to have a poor structure. It also causes water to move through the soil very slowly.

According to **Table 4.16** of the current study, the magnesium hazard (MH) and permeability index (PI) values are suitable for irrigation. According to this finding, Almasab Alam water may be harmful to soil permeability, which affected by irrigation for long time and depends on type of soil and water content of (Na^{+}, Ca^{+2}, Mg^{+2}, and HCO_3^{-}). The drainage water from Almasab Alam has a Kelly Ratio (KR) value of (0.6) meq/l. This shows that the water is suitable and within the range of (< 1.0). The increment in concentration of Na^{+} leads to soil dispersion and displaces Ca^{+2}, which is crucial for plant nutrition.

In addition to the results of the IWQG V.1 programe's calculation of the values of quality indicators for irrigation water and its interpretation, It provides guidance and solutions for dealing with potential issues that the investigated water may bring about (Issue and Management) section **(Table 4.17).**

Table 4.17: Paragraph of issue and management for December month highlights the solutions and proposals offered by program IWQG to manage and solve the problems associated with irrigation water for December 2020.

Issue & Management
For soils having high permeability and no compact layers, there is high restriction may be used. Water with EC more than 2 dS/m and SAR greater than 7 used to irrigate plants that have a moderate to high tolerance to salts should adopt a high-frequency irrigation schedule through special salinity control techniques, except foe cases of water with low Na, Cl, and HCO3 values. Electrical conductivity (EC): High danger is generally unwanted for irrigation, except in cases where plants with a high tolerance for salinity are grown due to excellent drainage excellent drainage, intensive management, frequent leaching, and multiple irrigation water management options in order to avoid dilution, and salt removal in water that is used for irrigation purposes The sodium percentage (Na %): Noticeable sodium danger in certain fine-textured soils . Sodium adsorption ratio (SAR): Use of SAR on sodium-sensitive crops like avocados should be cautioned. Total Hardness: At concentrations above 150 mg/L, equipment clogging and foliar staining issues arise. Increased sodium effects on pipelines, irrigation systems, and agricultural equipment may result from water softening treatment. Calcium salts can create white lime incrustation (calcium carbonate). Over time, these deposits cause hot water systems to malfunction

and obstruct irrigation equipment. On heating elements, deposits cause overheating and eventual burnout. It is advised against using metal components in irrigation systems as a result.

Treatment: Softening water is the process of lowering hardness. Water can be softened through ion exchange, water-softening chemicals, desalination techniques like reverse osmosis, lime use, pH adjustments, and temperature management.

Permeability Index (PI): Growth Responsible (range at which affected) Crop (Beans) stunted growing at low values of ESP even if the soil physical characteristics were good.

Kelley Index (KI): Growth Responsible (range at which affected) Crop (Deciduous fruits, Nuts, Citrus, Avocado) Under Field Conditions from Sodium toxicity symptoms low ESP values.

Soluble sodium percentage (SSP): Growth Responsible (range at which affected) Crop (Beans) stunted growing at low values of ESP even if the soil physical characteristics were good.

4.4.2 Month: June 2021 at Station 360+00

The results of June 2021 are shown in **Appendix B.**

From the results of blending for all stations, the best mixing ratio found is B1. The salinity becomes less than 3 for a duration of seven months, from December 2020 to May 2021, so the water becomes suitable for irrigation according to the FAO. From May 2021 to the end of the study the salinity becomes medium to high water. The other ratios are B2 and B3. The salinity becomes more than 3 at all stations through the study duration, then the salinity of the water is medium to high. The water is unsuitable for irrigation according to FAO.

4.5 Effect of Magnetization on Water Properties

For analyzing the results of magnetization of Almasab Alam's water test and their suitability for irrigation, two months were chosen for the evaluation: December 2020 at station 441+00 and June 2021 at station 360+00. The rest of the results are placed in Appendix C.

4.5.1 Impact of magnetic field on Chemical Properties of saltwater of Almasab Alam .

The results of magnetic field impact on chemical characteristics of saltwater are shown in **Tables 4.18, and 4.19**.

Table **4.18**: The average water salinity features of the study (taken from Almasab Alam drainage before and after the magnetization) for December 2020.

Water Type	Almasab	1000G	2000G	3000G	5000G	7000G
EC (µs/cm)	4.33	4.33	4.34	4.35	4.37	4.41
TDS (ppm)	2771	2774	2780	2782	2801	2825
Cl (ppm)	487.2	487.2	475.02	429.78	442.83	484.59
So4 (ppm)	1748	1750	1761	1789	1794	1801
Na^+ (ppm)	329.73	329.73	332.34	335.82	338.43	342.78
K (ppm)	8.00	8.00	8.04	8.70	8.05	8.06
Mg^{+2} (ppm)	156.6	156.6	161.82	177.48	180.96	184.44
Ca^{+2} (ppm)	226	226	234	258	261	267
No3 (ppm)	1.15	1.16	1.35	1.65	1.17	1.23
Po4 (ppm)	0.26	0.26	0.30	0.65	0.37	0.44

Water Type	Almasab	1000G	2000G	3000G	5000G	7000G
PH	6.96	6.96	7.02	7.13	7.22	7.26
Do (ppm)	9.13	9.14	9.57	10.43	9.77	10.02

Table 4.19: The average water salinity features of the study (taken from Almasab Alam drainage before and after the magnetization) for June 2021.

Water Tybe	Almasab	1000G	2000G	3000G	5000G	7000G
EC(µs/cm)	11.6	11.61	11.63	11.65	11.73	11.84
TDS ppm)	7418	7427	7440	7448	7500	7566
Cl (ppm)	1420	1417	1385	1253	1291	1413
So4 (ppm)	2016	2018	2030	2056	2068	2076
Na^{+} (ppm)	510	511	514	520	522	524
K (ppm)	10.50	10.50	10.56	11.20	10.60	10.75
Mg^{+2} (ppm)	300	302	311	340	347	353
Ca^{+2} (ppm)	210	211	217	240	243	248
No3 (ppm)	2.81	2.83	3.29	3.98	2.84	2.99
Po4 (ppm)	0.13	0.13	0.15	0.32	0.20	0.22
PH	8.10	8.11	8.17	8.31	8.41	8.46
Do (ppm)	7.00	7.00	7.34	8.10	7.50	7.68

The impacts of magnetizing on the chemical characteristics of Almasab Alam drainage water are as follows:

4.5.1.1 Impacts of Magnetization on pH

When the pH of water is equal to 7 at 25 degrees centigrade and the concentrations of ions OH and H^{+} are equal, the water is termed neutral. The weakening of hydrogen bonds between water molecules causes it to become more volatile because of magnetic processing. The pH of water may be altered by the magnetic process [**A. Andrianov, E. Orlov,2018 and Karkush**

M. O.and et al.,2019]. The production of calcite nuclei because of the release of H^+ ions causes an increase in pH. Figure 4.2 shows the results of the pH testing for months with maximum EC (June 2021) and month with minimum EC (December 2020) on Almasab Alam drainage water.

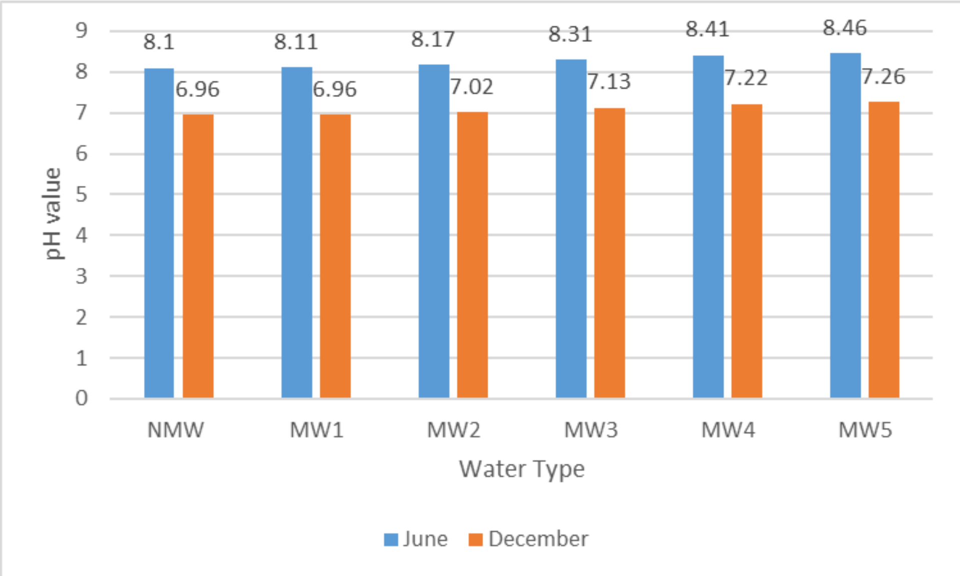

Figure 4.2: pH values for max and min EC under a magnetic field of different intensities.

Table 4.20 shows the percentage of pH difference between all cases of magnetized water and Almasab Alam non-magnetized water (NMW) for June 2021 and December 2020.

Table 4.20: The difference ratio for PH values of different intensities with NMW.

Water Type	Difference ratio with NMW %	
	June	December
MW1	+0.12	0
MW2	+0.86	+0.86
MW3	+2.59	+2.58
MW4	+3.83	+3.74
MW5	+4.44	+4.32

From **Table 4.20**, the pH magnitudes of water sample results are increased when the intensity of magnetic is increased. Depending on the findings, the pH magnitude rises as the magnetic field strength rises, indicating H^+ ion absorption and an increase in the amount of OH^- ions in the water specimen. Previous research has backed up these results [**A. Elaoud et al,2016, and F. Alimi, 2008].**

4.5.1.2 Impacts of Magnetization on Electrical Conductivity (EC)

Electrical Conductivity represents the material's ability to conduct electric current. The magnitudes of EC content with different magnetic field intensities for months with maximum EC (June 2021) and months with minimum EC (December 2020) on the Almasab Alam drainage water are shown in **Figure 4.3.**

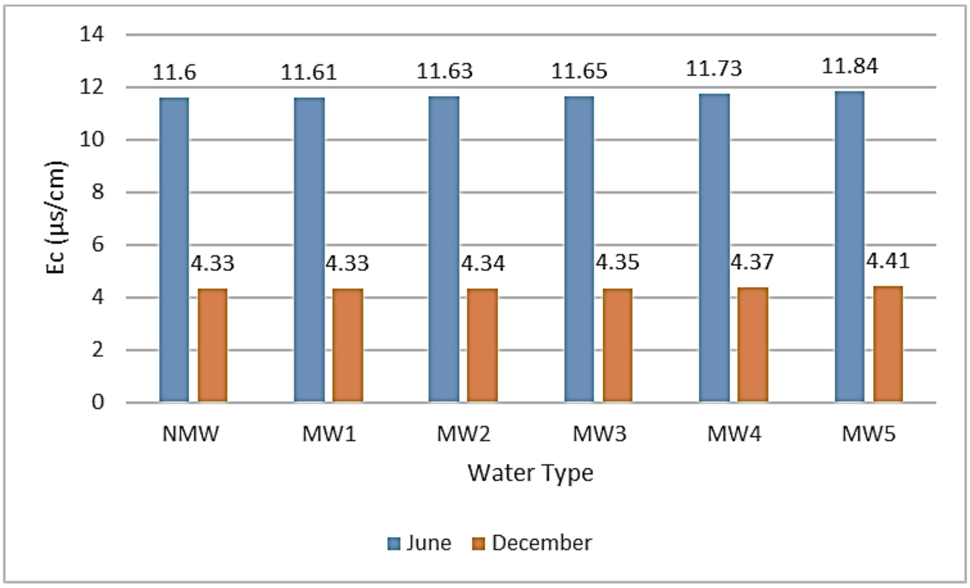

Figure 4.3: The magnitude of EC under a magnetic field of different intensities.

Table 4.21 shows the percentage of EC difference between all cases of magnetized water and Almasab Alam non-magnetized water (NMW) for June 2021 and December 2020.

Table 4.21: The difference ratio for EC values of different intensities with NMW.

Water Type	Difference ratio with NMW %	
	June	December
MW1	+0.09	0
MW2	+0.17	+0.23
MW3	+0.43	+0.46
MW4	+1.12	+0.92
MW5	+2.07	+1.85

From **Table 4.21**, the EC magnitude of water sample results is increased when the intensity of magnetic is increased. This increase is due to an increase of TDS in samples after magnetization. These findings were confirmed by [**Karkush M. O. et al.,2019**].

4.5.1.3 Impacts of Magnetization on Total Dissolved Solids (TDS)

TDS is a measurement of the molecular, micro granular, or ionized suspended organic and inorganic compounds present in a liquid. Sulfates, lead, iron, chlorides, bicarbonates, sodium, potassium, magnesium, and EC are all examples of TDS. Weathering of rocks and erosion of the earth's surface are major sources of dissolved solids in water. Because many minerals are soluble in water, large concentrations will build over time as a result of the cyclical process of precipitation and evaporation. Because it spends more time in touch with the underlying rocks and sediments, drainage water typically has a greater TDS concentration than surface water. **Figure 4.4** shows the TDS content magnitudes for various magnetic field strengths for months with maximum EC (June 2021) and months with minimum EC (December 2020) on Almasab Alam drainage water.

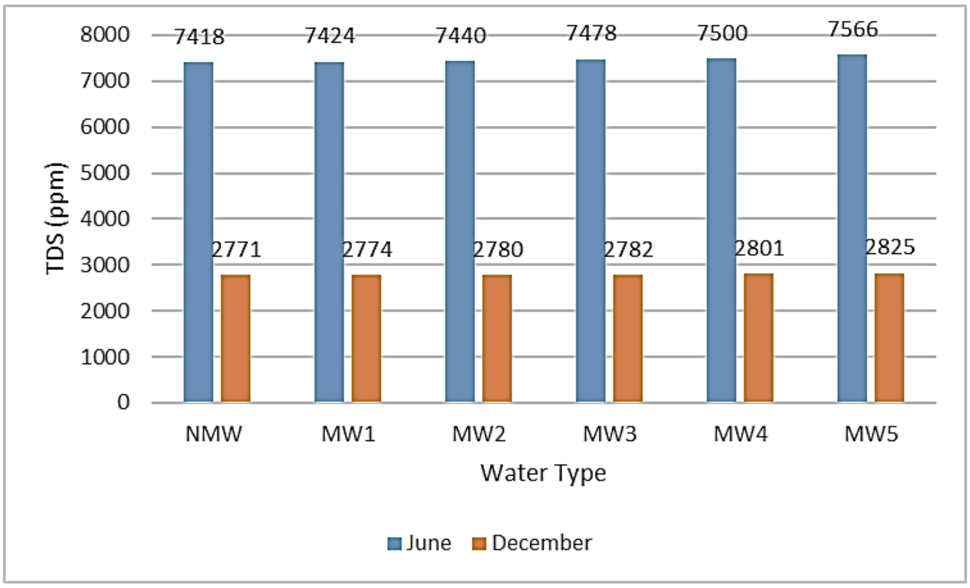

Figure 4.4: The magnitude of TDS under a magnetic field of different intensities**.**

Table 4.22 shows the percentage of TDS difference between all cases of magnetized water and Almasab Alam non-magnetized water (NMW) for June 2021 and December 2020.

Table 4.22: The difference ratio for TDS values of different intensities with NMW.

Water Type	Difference ratio with NMW %	
	June	December
MW1	+0.12	+0.09
MW2	+0.30	+0.31
MW3	+0.40	+0.40
MW4	+1.11	+1.10
MW5	+1.99	+1.97

From this Table, the magnitude of TDS content is increased with increasing magnetic field intensity. These findings were confirmed by [**Karkush M. O. et al.,2018**].

4.5.1.4 Impacts of Magnetization on alkaline minerals

When alkaline metals are dissolved in water with a pH higher than 7.0, they become basic. In general, when water is not magnetized, it produces more carbonate which speeds up the formation of calcite. The production of calcites and the bicarbonates' precipitation are both inhibited by the magnetic field, while the precipitation of Mg, K, and Na is increased. Alkaline metals tend to increase when the magnetic field strength rises. Because the inversion protons spin in the diamagnetic field of salts, the magnetic field promotes quicker proton transfer from hydrogen carbonate to water. **Figure 4.5** depicts the change in alkaline concentration as a function of magnetic field intensity.

Figure 4.5 illustrates how various magnetic field strengths affect the concentration of alkaline minerals such as K, Ca, Mg, and Na. With increasing magnetic field strength, the Ca, Mg, and Na concentrations in water rose substantially. After the water has been magnetized, the potassium remains unaffected. Previous research has backed up these results [**F. Alimi, 2008**].

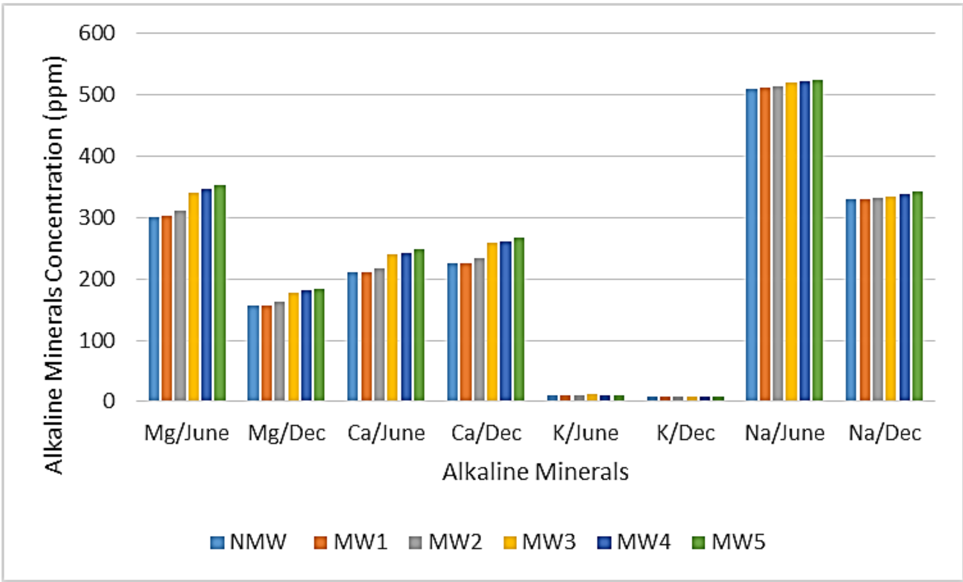

Figure 4.5: The magnitude of Mg, Na, Ca, and K under a magnetic field of different intensities.

4.5.1.5 Impacts of Magnetization on Chloride

When the Cl element acquires an electron or when a molecule like a hydrogen chloride is dissolved in water or other polar solvents, the chloride (Cl) anion is produced. Chloride salts are highly water-soluble, the results of chloride (Cl^-) for the magnitudes for various magnetic field strengths for months with maximum EC (June 2021) and months with minimum EC (December 2020) on Almasab Alam drainage water. Samples before and after magnetization of Almasab Alam water are shown in **Figure 4.6**.

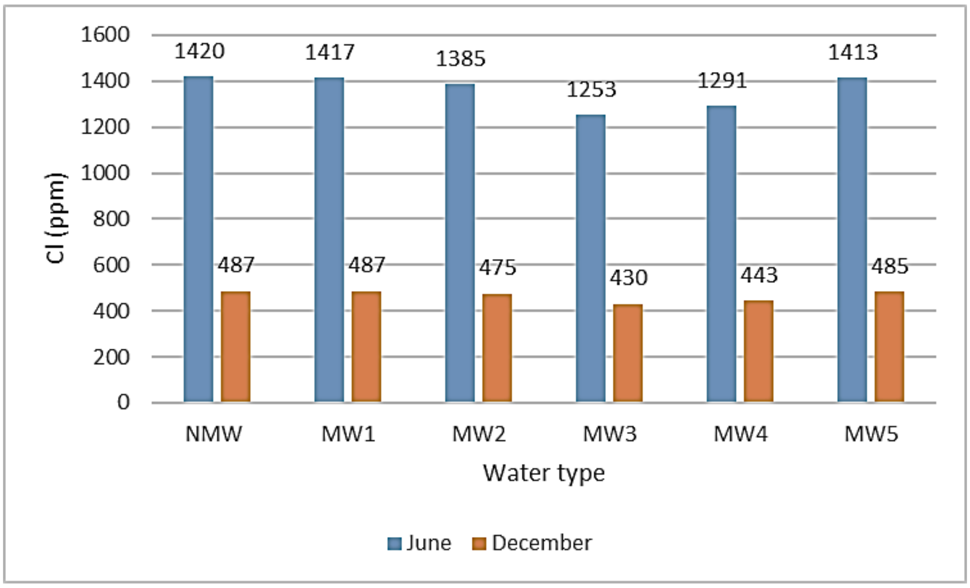

Figure 4.6: The magnitude of chloride under a magnetic field of different intensities

The percentage of Cl difference between all cases of magnetized water and Almasab Alam non-magnetized water (NMW) for June 2021 and December 2020 are shown in **Table 4.23**.

Table 4.23: The difference ratio for Cl values of different intensities with NMW.

Water Type	Difference ratio with NMW %	
	June	December
MW1	-0.21	0
MW2	-2.46	-2.50
MW3	-11.76	-11.79
MW4	-9.08	-9.10
MW5	-0.49	-0.54

The results show that the magnitude of different ratios of chloride is minimum at MW1, which is -0.21% and 0 % for June and December respectively. The maximum difference ratio occurred at MW3, which is -11.76% and -11.79% for June and December respectively. The maximum decrease of the ratio occurred when the saltwater of Almasab Alam passed through a 3000-gauss magnetic field.

4.5.1.6 Impacts of Magnetization on Sulfate

The results of SO_4 testing for months with maximum EC (June 2021) and months with minimum EC (December 2020), before and after magnetization of Almasab Alam water are shown in **Figure 4.7.**

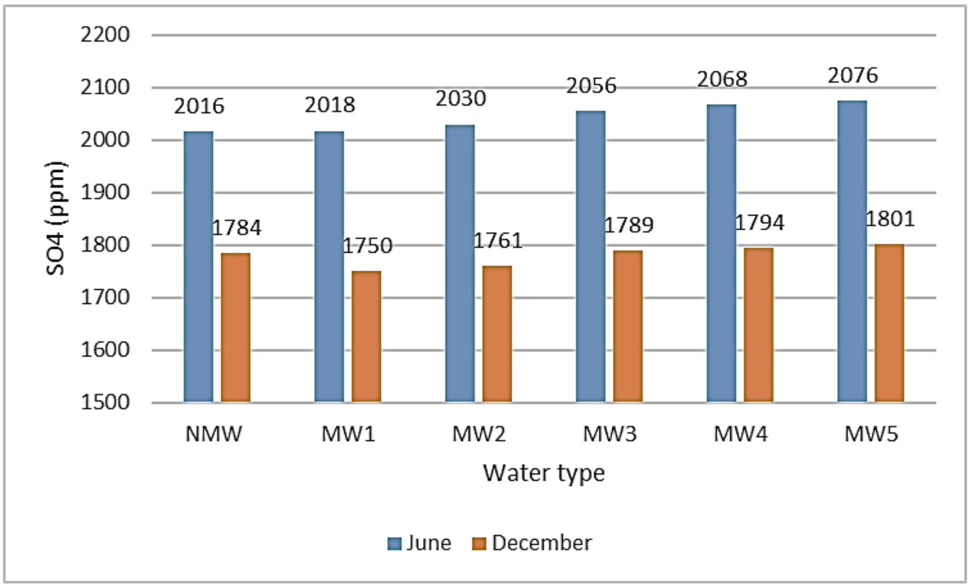

Figure 4.7: The magnitude of SO_4 under a magnetic field of different intensities.

Table 4.24 shows the percentage of SO_4 difference between all cases of magnetized water and Almasab Alam non-magnetized water (NMW) for June 2021 and December 2020.

Table 4.24: The difference ratio for SO_4 values of different intensities with NMW.

Water Type	Difference ratio with NMW %	
	June	December
MW1	+0.10	+0.10
MW2	+0.69	+0.70
MW3	+1.98	+2.34
MW4	+2.58	+2.59
MW5	+2.98	+2.99

From this **Table**, the magnitude of DO content is increased with increasing magnetic field intensity. These findings were confirmed by [**Karkush et al.,2018, and Alimi, 2008**].

4.5.1.7 Impacts of Magnetization on Dissolved Oxygen (DO)

The results of total hardness (DO) for months with maximum EC (June 2021) and months with minimum EC (December 2020) on Almasab Alam drainage water before and after magnetization are shown in **Figure 4.8.**

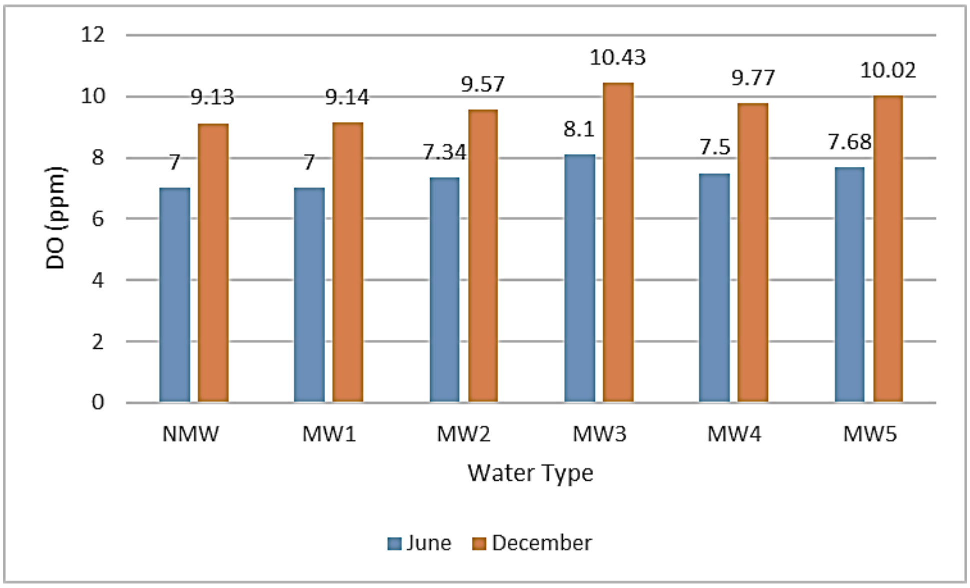

Figure 4.8: The magnitude of DO under a magnetic field of different intensities

The percentage of DO difference between all cases of magnetized water and Almasab Alam non-magnetized water (NMW) for June 2021 and December 2020 are shown in **Table 4.25**.

Table 4.25: The difference ratio for DO values of different intensities with NMW.

Water Type	Difference ratio with NMW %	
	June	December
MW1	0	+0.11
MW2	+4.86	+4.82
MW3	+15.71	+14.24
MW4	+7.14	+7.01
MW5	+9.71	+9.75

The results show that the magnitude of different ratios of chloride is minimum at MW1, which is 0% and 0.11% for June and December respectively. The maximum difference ratio occurred at MW3, which is 15.71% and 14.24% for June and December respectively. The maximum ratio increased (15.71%) and 14.24% occurs when the saltwater of Almasab Alam passes through a 3000 G magnetic field in June and December respectively. This percentage will improve the irrigation water and positively affect the respiration and growth of the root system. In addition, this feature can be used by the owners of fish lakes to get rid of the problem of fish deaths due to the lack of dissolved oxygen. These findings were confirmed by previous studies [**E. Esmaeilnezhad et al 2017, and F. Alimi 2008**].

4.5.1.8 Impacts of Magnetization on Phosphate (PO_4) and Nitrate (NO_3)

The results of Phosphate and Nitrate for the samples before and after magnetization of Almasab Alam water are shown in **Figure 4.9**. The results show that the magnitude of PO_4 and NO_3 for NMW and MW1 are equal, which means that they are not affected by the magnetic field strength of 1000 G. But for the other samples MW2, MW3, MW4, and MW5, the magnitudes of Po4 and No3 are increased when passing through magnetic intensities of 2000, 3000, 5000, and 7000 G.

The maximum ratio increased by 166.67% for PO_4 and 42.30% for NO_3 occurred when the saltwater of Almasab Alam passed through a 3000 G magnetic field. This percentage will improve the irrigation water and positively affects the plants' growth because of the increase in phosphate and nitrate, which is an important fertilizer for plants.

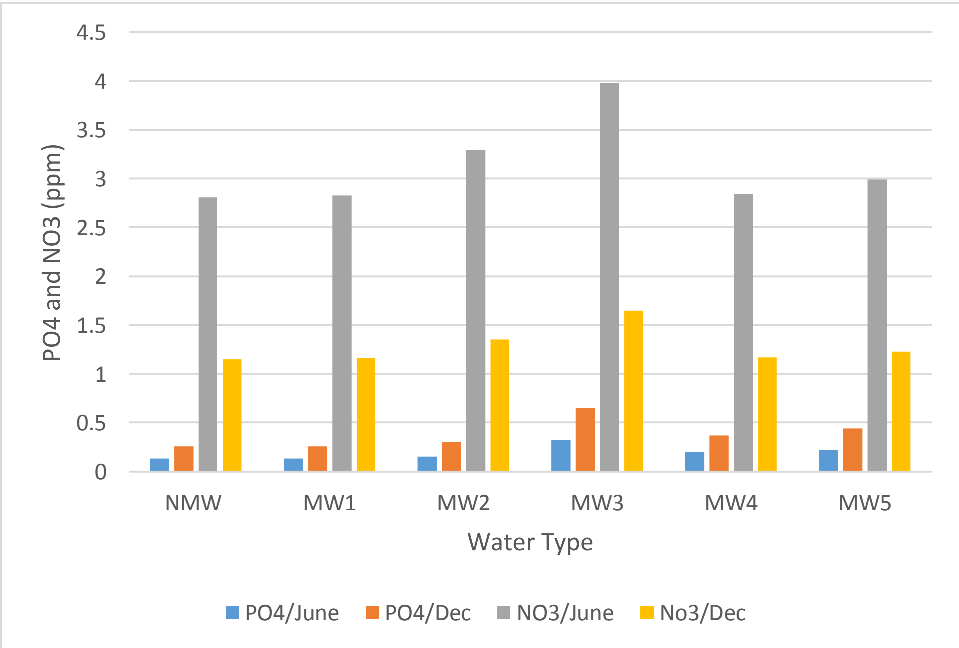

Figure 4.9: The magnitude of PO_4 and NO_3 under a magnetic field of different intensities

The percentage of PO_4 and NO_3 difference between all cases of magnetized water and Almasab Alam non-magnetized water (NMW) for June 2021 and December 2020 are shown in **Table 4.26**.

Table 4.26: The difference ratio for PO_4 and NO_3 values of different intensities with NMW.

Water Type	Difference ratio with NMW %		Difference ratio with NMW %	
	PO_4/June	PO_4/DEC.	NO_3/June	NO_3/DEC.
MW1	0	0	+0.71	+0.87
MW2	+15.38	+15.38	+17.08	+17.39
MW3	+146.15	+150	+41.64	+43.48
MW4	+53.85	+42.31	+1.07	+1.74
MW5	+69.23	+69.23	+6.41	+6.96

From **Table 4.26**, the results show that the magnitude of the different ratios of PO_4 is a minimum at MW1, which is 0 % for June and December. The maximum difference ratio occurred at MW3, which is 146.15% and 150% for June and December respectively. The minimum ratio increase of NO_3 is 0.71 % and 0.87 % occurred at MW1 for June and December respectively. The maximum increase of NO_3 is 41.46% and 43.48% occurred at MW3 for June and December respectively. The maximum ratio increase of PO_4 and NO_3 occurred when the saltwater of Almasab Alam passed through a 3000 G magnetic field. This percentage will improve the irrigation water and positively affect the plants' growth because of the increase in phosphate and nitrate, which is an important fertilizers for plants. These findings were confirmed by previous studies [**E. Esmaeilnezhad et al 2017, and F. Alimi 2008**].

4.5.2 Effect of Magnetization of Almasab Alam Salty Water Physical Properties

Following are some physical changes caused by magnetizing saline irrigation water.

4.5.2.1 Boiling point

The influence of magnetizing saline irrigation water for study site on average degree of boiling point of irrigation water is depicted in Table 4.27 and Figure 4.10. Overall, the results indicated a highly substantial difference between the boiling points of regular non-magnetized water and water that has been magnetized. When water magnetized with 3000G in proportion to its amount of 1.52 percent, the rate decreased the most. The concept of magnetized water is based on passing water through a magnetic field inside the magnetizing apparatus, which will cause the water to be impacted by the magnetic flux and cause the internal particles to be arranged as electrical charges. That is, it operates on magnetization of water, or, to put it another way, as a function of electron motion and the covalent bond's completion of the electronic shell. Water now has a zero electromagnetic moment as a result of acquiring the magnetic property. Additionally, if its exposed to external magnetic field, it develop magnetic moment that is connected to nature of the magnetic property, which is a reduction in internal magnetic induction, leading to inductor magnetization. As seawater is magnetized, the magnetic moment causes it to gain energy [**M.C. Amiri, A.A. Dadkhah 2006].** This increases in water molecules movement and salt ions, that are already there, can disengage water molecules bound and salt ions. So it need less energy to evaporate if compared to normal water which requires energy to disengage and another energy to evaporate. Hence, the boiling point of ordinary water must be greater than of magnetized water.

After being magnetized, water has a lower boiling point because the higher energy the water ions receive from the magnetization helps to disentangle them from one another and increases the rate of evaporation. As a result, the water evaporates more quickly and in a shorter amount of time than salty water, necessitating a lower boiling point than saltwater.

Table 4.27: Magnetic field effect on saltwater boiling point.

Water Type	Boiling point (C°)	The difference with NMW %
NMW	98.5	-------
MW1	98.2	- 0.03
MW2	97.6	-0.09
MW3	97.0	- 1.52
MW4	98.0	- 0.05
MW5	97.5	- 1.01

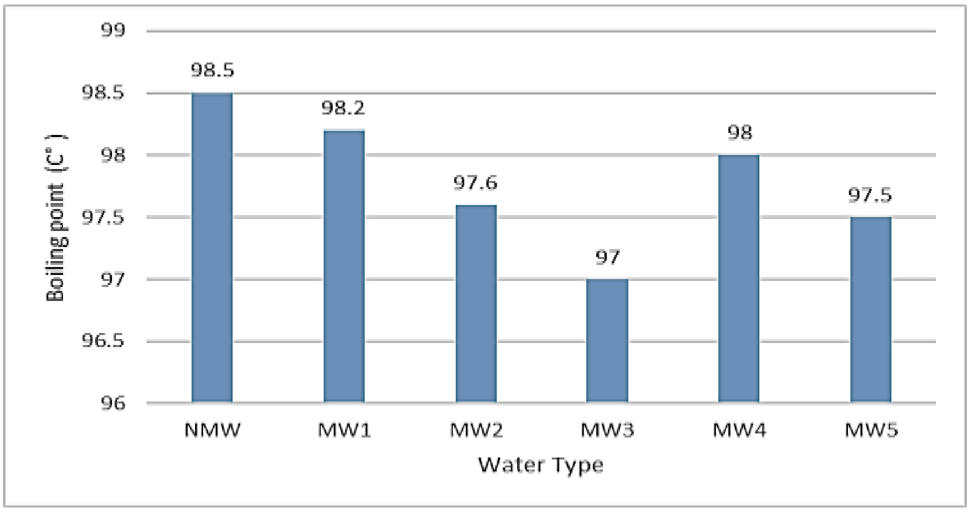

Figure 4.10: : Magnetic field effect on saltwater boiling point

4.5.2.2 Degree of Solubility

Result of **[Table 4.28 and Figure 4.11]** displayed transparency percentage of water before and after magnetization, which show that amount of transparency of magnetized water greater than of non magnetized water, indicating that, magnetized water solubility greater than of non magnetized water. Maximum rate of transparency is reached as water was magnetized by 3000G, which exceeded the rate of non magnetized water by 14%.

Table 4.28: Magnetic field effect on saltwater transparency percentage.

Water Type	Transparency percentage %	The difference with NMW %
NMW	66	---
MW1	68	+3.03
MW2	74	+12.12
MW3	80	+21.21
MW4	72	+9.09
MW5	75	+13.64

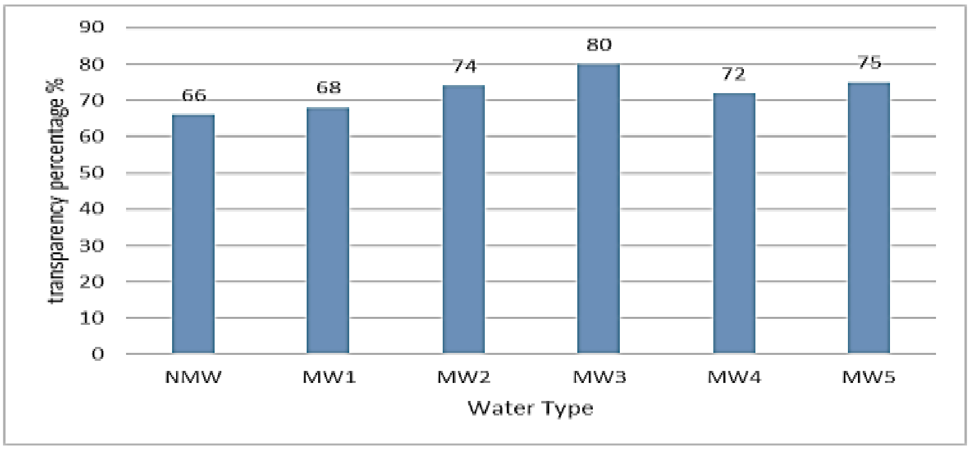

Figure 4.11: Magnetic field effect on saltwater transparency percentage**.**

Due to the fact that water is a polar liquid, magnetized water has a higher solubility than regular non-magnetized water. In other words, the electric charges of the water molecules are positive in one section and negative in another, yet the net electric charge was negative. Or, because water is dipole, the magnetic or electric field can alter by rotating the molecule to get high voltage, either positive or negative, depending on whether an external magnetic field is utilized on south (positive) or north pole (negative). Thus, water becomes more soluble and has reduced surface tension due to the favorable influence field that extends to the South Pole [**Cai R, Yang H, He J, et al. 2009**].

4.5.2.3 Evaporation

Results of the evaporation duration are presented in **Table 4.29** and **Figure 4.12.** According to **Table 4.29** following magnetization, the water sample's evaporation time decreases. The greatest evaporation duration time reduction obtained as the water was magnetized with 30000 G for, which resulted in a 4.86 % drop in evaporation rate. Based on the findings, it can be said that the evaporation duration and boiling point have an inverse relation.

Table 4.29: Magnetic field effects on saltwater duration of evaporation.

Water Type	Duration of Evaporation (min.)	The difference with NMW%
NMW	4.853	---
MW1	4.822	- 1.56
MW2	4.809	- 3.07
MW3	4.617	-4.86
MW4	4.821	- 1.70
MW5	4.800	- 4.20

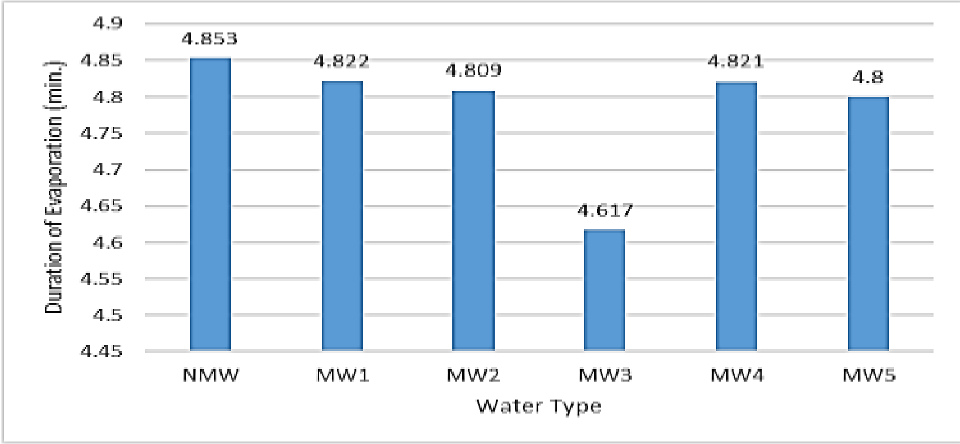

Figure 4.12: Magnetic field effects on saltwater duration of evaporation.

4.5.2.4 Water Density

Table 4.30 and **Figure 4.13** illustrates impact of magnetization on average water density at location for saline irrigation water. The findings indicated that the density value is lower than it was before to magnetization. When the water was magnetized with 3000 G, the rate of decrease in evaporation time was at its highest, and the quantity to its amount was 0.13%. This outcome is in line with what **[Gallon 2004]** found, which physical and kinetic properties of water are improved and reduced as a result of magnetization.

Table 4.30: Magnetic field effects on saltwater density.

Water Type	Water Density (**gm/cm³**)	The difference with NMW%
NMW	1.03000	------
MW1	1.0298	- 0.019
MW2	1.0291	- 0.087
MW3	1.0287	- 0.130
MW4	1.0293	- 0.068
MW5	1.0289	- 0. 11

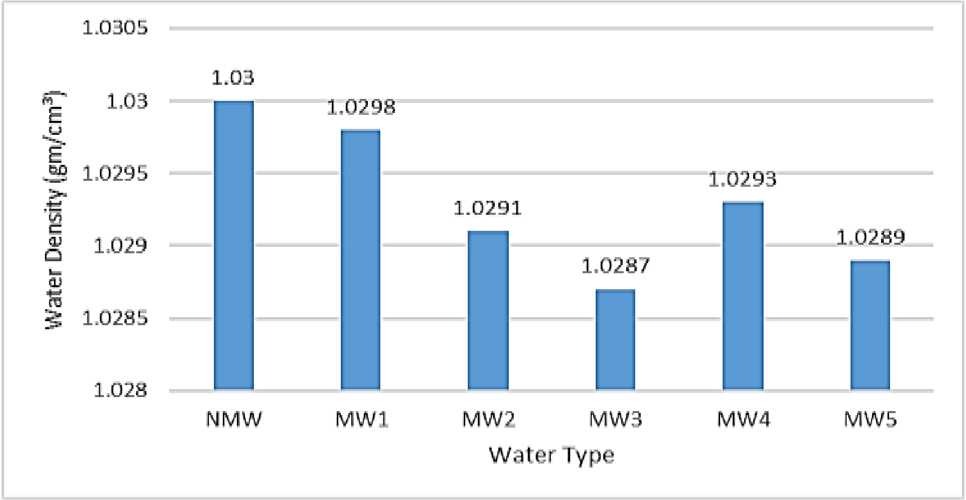

Figure 4.13: Magnetic field effects on saltwater density**.**

Water molecules bind to each other through hydrogen bonds, which can be double, multiple, or even numbering in the tens. According to **Pang XF and Deng (2008),** as water molecules exposed to magnetic field, the hydrogen bonds amongst these molecules will either change or disintegrate. This disintegration affects energy absorption, lowers level of water part union, and raises the sensitivity to electrolysis.

4.5.2.5 Discussion of Results

According to the experimental findings, magnetic fields (MF) have altered the boiling point, density, length of evaporation (amount of evaporation), and degree of solubility of seawater. Findings on evaporation are in line with findings of others indicating, following MF treatment, the amount of salty water that evaporates rises **[Kadhim N. and Ahmed H. 2018, and Toledo EJL et al, 2008].** It is important to note that the test conditions in this study are from room temperature to boiling point temperature, which is different from the test settings in room research, and rise degree is more visible in this study. This may be described by the fact that, when the temperature increases, evaporation accelerates .Additionally, this study investigates how MF affects the length of time that salt water evaporates and its boiling point, and it has been found that both the specific heat and boiling point have decreased. This is significant finding can open up new possibilities for altering the two characteristics of water and applying them to appropriate industries to reduce consumption of energy. According to finding of this work, as seawater travels through MF, solubility increases and density lowers. Due to water's capacity to dissolve salts in soil, an increase of irrigation water solubility improves the soil's characteristics. Additionally, MW3 achieves the best outcome in every experiment, which shows that at an MF strength of 3000 G, the magnetization effect is at its strongest. It must be noted that magnetization effect does not become stronger with increasing MF, and other researchers **[Amiri MC, Dadkhah AA. 2006, and Wang Y et al. 2013]** have also reported this conclusion. Additionally, research has been done to determine how MF affects the characteristics of pure water or highly filtered water. The changes resemble those in saltwater in general, including increased evaporation, decreased surface tension, and increased conductivity **[Holysz L et al 2007, Pang XF, Deng B. 2008].** Therefore, it may be concluded that influence of dissolved solids and ions on the magnetic effect is extremely minimal, and the amount of this influence should be researched in the future. However, the basic idea behind MF treatment is still unclear. The concept that hydrogen bonds between water molecules are likely impacted by MF was put up by several authors in an effort to comprehend it **[Pang XF, Deng B.2008, Zacharia and Rardef, 1981].** However, the research does not explicitly state how this impact works.

4.5.2.6 Results of water surface tension

The energy needed to increase a liquid's surface area as a result of intermolecular forces is known as surface tension.Since those intermolecular forces differ depending upon liquid nature, each solution exhibits differing surface tension properties. Whenever anyone fills a glass of water too far will notice afterward that the level of the water in the glass is higher than the height of the glass. Also may have noticed that the water that spilled has formed into pools that rise off the counter. Two of these phenomena are due to surface tension. The surface tension of water is affected by many factors such as temperature, oxidation, and chemicals. One of the elements that affects the value of surface tension is the magnetic field. The current study examines how the surface tension values of the water in Almasb Alam are affected by five different magnetic field intensities with EC = 5.26 µS/cm was studied as shown in **Table 4.31** and plotted in **Figure 4.14**.

Figure 4.14 shows that the amount of surface tension of Almasab Alam water decreases from its pre-magnetizing value when it passes through the magnetic field with different intensities (1000, 2000, 3000, 5000, and 7000 G) and begins to gradually decrease and continue until magnetization with the severity of 3000 G. Then it begins to rise gradually until its value is 39.61 dyne/cm at its magnetization by 7000 G is close to the surface tension of Almasab Alam water before magnetization (45.62 dynes/cm) and decreased by 13.17%. The results show that the largest decrease in the amount of surface tension is 28.19%, which occurred when passing water through a magnetic field of 3000 G. As for the slightest decrease in surface tension, it occurred when it was magnetized in a field of strength of 1000 G and by 1.70% from the value of the surface tension of Almasab Alam water before magnetization.

This decrease in the amount of surface tension leads in turn to converting water from hard to soft water, so that the irrigated plants can benefit from it so that their roots can easily absorb it due to the lack of tightness of the bonds that connect the water molecules and their transformation into a smaller form and this is due to the ionic exchange that takes place in the water when it passes through a magnetic field. This decrease in the results of the surface tension value is compatible with the results of [**Mousa, 2002**, and **Al-Tikrity, 2014**]. The hydrogen bonds in the water molecule are less than 105 degrees because of the magnetic field's reduction.

Table 4.31: Magnetic field effects on water surface tension.

Water Type	Surface tension (dyne/cm)	The difference with Almasab Alam water %
NMW	45.62	-------
MW1	44.85	- 1.70
MW2	37.20	-18.46
MW3	32.76	- 28.19
MW4	38.66	- 15.37
MW5	39.61	- 13.17

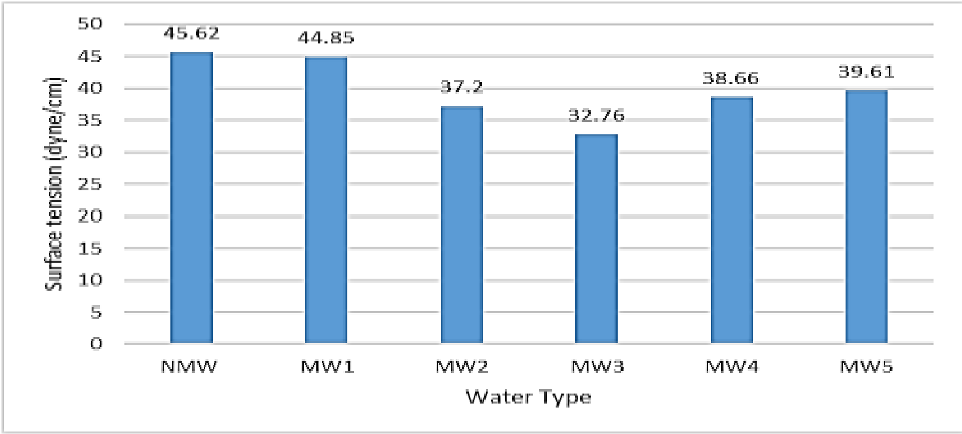

Figure 4.14: Magnetic field effects on water surface tension**.**

4.5.2.7 Results of water viscosity

A fluid's resistance to gradual deformation by tensile or shear stress is measured by its viscosity. It is equivalent to the colloquial term "thickness" for liquids; for instance, honey has a higher viscosity than water. The fluid's viscosity is a characteristic that prevents the relative motion between its two moving surfaces from occurring. Viscosity can be defined as the friction that occurs between fluid molecules. The fluid's constituent particles typically travel more swiftly towards the tube's axis and more slowly toward its walls when the fluid is driven through a tube; therefore some stresses (e.g. pressure difference between tube two ends) is crucial to reduce the resistance between particle layers to keep the fluid moving. In present work, the results indicates a decrease in water viscosity after exposure the magnetic field. The decrease might occur because magnetic field makes hydrogen bonds of water molecule less than 105 degrees.

Figure 4.15 and **Table 4.32** show that the viscosity of Almasab Alam water decreases from its value before magnetization when it passes the magnetic field with different strengths (1000, 2000, 3000, 5000, and 7000 G) and begins to gradually decrease and continue to the magnetization strongly 3000 G. Then it starts to rise gradually until its value is 1.002 Bois close to the viscosity The Almasab Alam water was before magnetization (1.1580 Boas), with a decrease of 4.99%. The results show that the highest value of the decrease in the amount of viscosity is 12.90%, and it occurred when passing the water with a magnetic field of 3000 G. As for the lowest decrease in viscosity, it occurred when it was magnetized in a field of 1000 G, and by 1.81% of the value of the surface tension of Almasab Alam water before magnetization. The low viscosity of water is a very important factor to use in the irrigation process. Plants can easily absorb this water through their roots. This is due to the lack of strength of the bonds between the water molecules and their transformation into a smaller form. This is due to the ionic change that takes place in the water when it passes through a magnetic field.

This results in a decrease in the value of the water viscosity compatible with the results of [**Al-Talib and Al-Singari, 2009**] and is not compatible with the results of **[Al-Tikrity, 2014]** who said that the magnetic field leads to an increase in the viscosity value.

Table 4.32: Magnetic field effect on water viscosity.

Water Type	viscosity gm/(cm·s)	The difference with Almasab Alam water %
NMW	1.1580	-------
MW1	1.1370	- 1.81
MW2	1.0776	- 6.94
MW3	1.0086	- 12.90
MW4	1.0963	- 5.33
MW5	1.1002	- 4.99

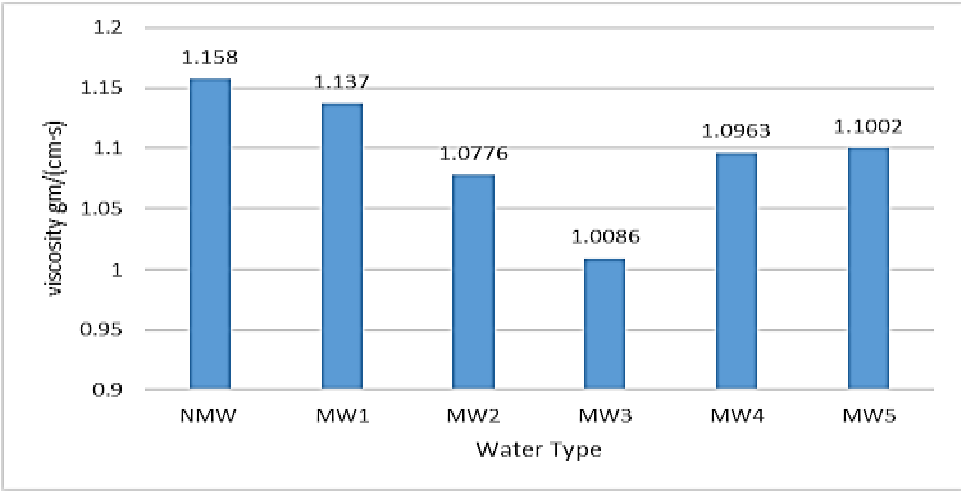

Figure 4.15: Magnetic field effect on water viscosity**.**

From the results of surface tension and viscosity, it has been proven that there is a direct relationship between the surface tension and viscosity of Almasab Alam water when it is exposed to a magnetic field of different intensities.

Chapter 5

Effect of Magnetization Water on Plants and Soil

5.1 Introduction

This chapter deals with the study of the effect of magnetic water in all its states on the plants that were grown during the study period (onions, beans, Vicia faba L, and maize), in terms of germination percentage, plant height, flowering period, as well as the length of the roots of onion plants. It also deals with the study of the effect of magnetized water on the soil in terms of its physical and chemical properties after planting season end. These results are compared with the properties of soil before conducting experiments on it.

5.2 Procedure of Experiments

The same soil weight and properties were used to fill all pots. The soil is taken from the study area near stations 360+00 and 441+00. All the pots were placed inside a plastic house to preserve them from rain and other weather conditions. To study the effect of irrigation with magnetized water, Almasab Alam water and the river water without any other effects such as rain throughout the study period within the seasons 2020-2021 and 2021-2022 are considered. The water used for this study was from Alamasb Alam drainage water untreated and treated and river water. The treated water is passing through a magnetic device with five different intensities (1000, 2000, 3000, 5000, and 7000 G. The onion, bean, maize, and Vicia faba L. are planted in pots. Three replicates of each pot under the same condition of irrigation for each plant were made to ensure the validity of the results. The number of pots used in this study is 336 pots. The soil properties (chemical and physical) are studied before and after the experiment. The rate of germination, height, and duration of the flowering of plants are studied. The root length of the onion plant is only measured.

5.3 Effects on plants

The use of the technique of magnetizing irrigation water for agricultural purposes will lead to improvements in water and soil properties, and this will lead to an increase in germination rates, improvement of soil conditions, and an increase in growth, as well as help to increase agricultural production **[Muhammad; 2012]** improvement in the vegetative and root growth characteristics of the plant, as there was an increase in the root length and group, as well as an increase in the percentage of total flowering plants and the number of flowers **[Al-Mawsili 2013]**. The plants grown in this study are as follows:

5.3.1 Onion Plants

5.3.1.1 Effect of magnetized water on germination

The germination stage is one of the most important stages in plant life, the success of growth and crop productivity depends on this stage. It is a critical stage in which the plant resists environmental stresses, especially water stress, which plays an important role in accelerating plant growth during the germination stage in dry and semi-arid regions. Experiment results of onion seed germination rate for seasons 2020-2021 and 2021-2022 with application of diverse levels of magnetized saline water in contrast to non-magnetized saline water after 15 days after planting are shown in **Figure 5.1.**

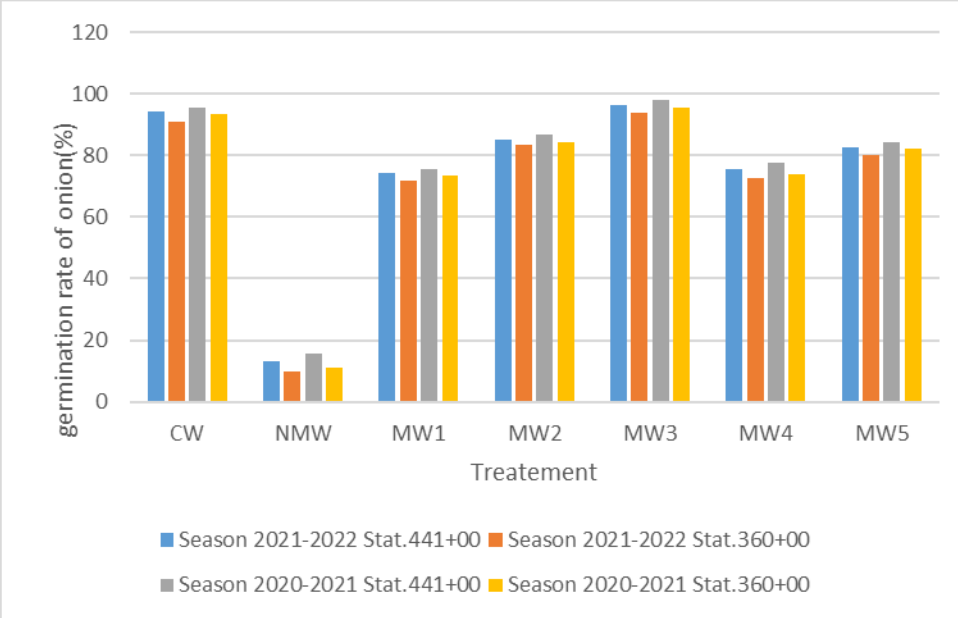

Figure 5.1: The percentage of germination of onion plant after 15 days after planting.

It was noticed that the germination of seeds that irrigated with magnetized water started earlier than that iorrigated with non-magnetized water by end for all treatments.The outcomes showed that magnetic water (MW) treatments increased the total germination rate as compared with no magnetized Almasab Alam water (NMW) for two seasons.

The results obtained from this study indicate that the highest germination rate obtained as the seeds irrigated with magnetized water of 3000 gausses (MW3) is 95.55% and 97.78% for the stations 360+00 and 441+00, respectively, for agricultural season 2020-2021. The results for the same stations, but for agriculture season 2021-2022 are 93.70% and 96.45%, respectively. The lowest germination rate happen as the seeds irrigated with magnetized water of 1000 gausses (MW1) is 73.33% and 75.55% for the stations 360+00 and 441+00, respectively, for the agricultural season 2020-2021. The results for the same stations, but for agriculture season 2021-2022 are 71.70% and 74.45%, respectively. The percentage of germination in the case of irrigation with the Almasab Alam non-magnetized water (NMW) was very low compared to all other cases, which are 11.11% and 15.53% for the stations 360 + 00 and 441 + 00, respectively, for the agricultural season 2021-2020, and 10%, 13% for the stations 360+00 and 441+00 respectively for the agricultural season 2021-2022. The percentage of germination if irrigated using river water (CW) is 93.33% and 95.53% for the stations 360+00 and 441+00 respectively for the agricultural season 2020-2021. The results for the same stations, but for agriculture season 2021-2022 are 91% and 94.11%, respectively.

5.3.1.2 Effect of magnetized water on Plant height

The results of **Figure 5.2** clarify magnetization of saline irrigation water effects of sites on height of onion plant. Results showed a highly significant difference between the rates of treatments irrigated with magnetized water (MW) compared to the rate of nonmagnetic water (NMW) in the length of the plant.

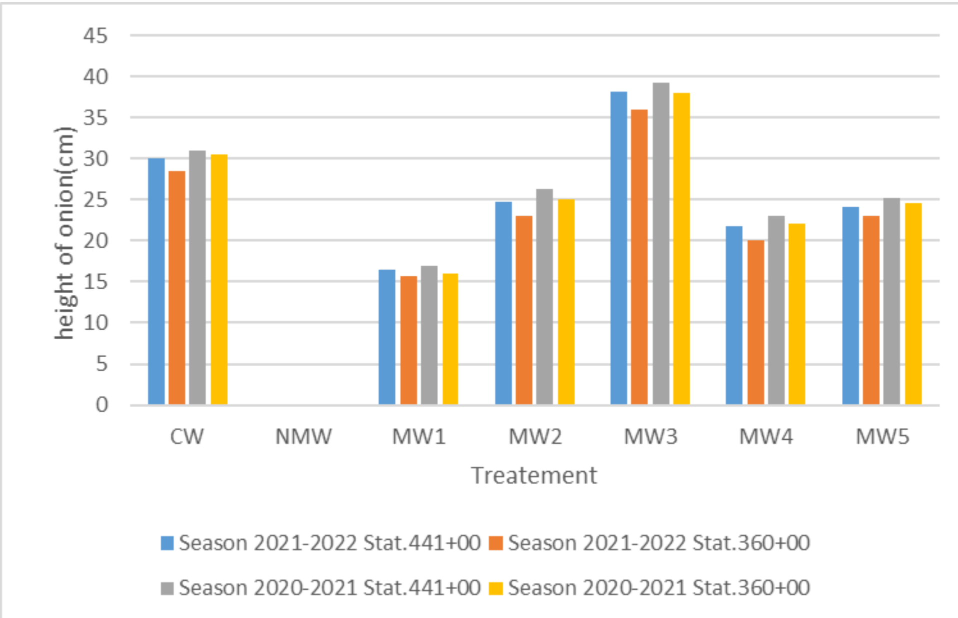

Figure 5.2: The height of the onion plant (cm) after 60 days.

From the results shown in **Figure 5.2,** it was observed that the height of the onion plant is higher for all treatments with magnetized water (MW) as compared to no magnetized Almasab Alam water (NMW) for two seasons. **Figure 5.3** shows the Photo of the onion plant after 60 days.

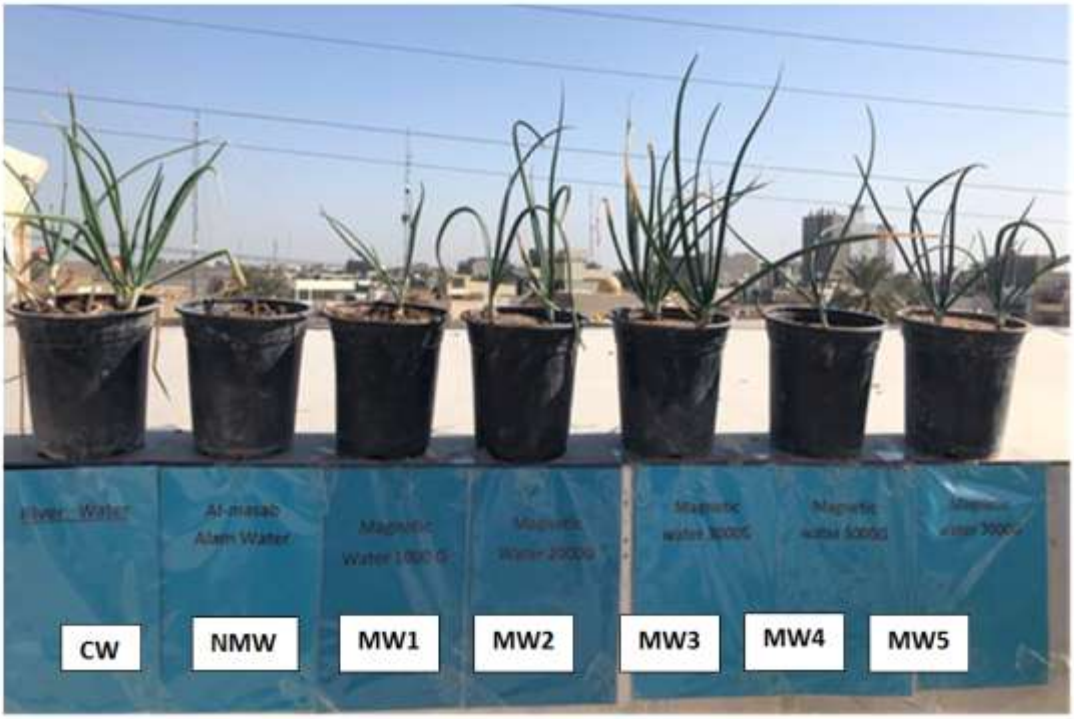

Figure 5.3: Onion plant height with different irrigation case

The results obtained from this study indicate that the maximum height that happened if irrigated using magnetized water with 3000 gausses (MW3) is 38.03 and 39.30 cm for the stations 360+00 and 441+00, respectively, for the agricultural season 2020-2021. The results for the same stations, but for agriculture season 2021-2022 are 36 and 38.10 cm, respectively. The lowest height occurred if irrigated using magnetized water with 1000 gausses (MW1) is 16.05 and 17 cm for the stations 360+00 and 441+00, respectively, for the agricultural season 2020-2021. The results for the same stations, but for agriculture season 2021-2022, are 15.75 and 16.50 cm, respectively. The zero height of the onion plant, in the case of irrigation with the Almasab Alam non-magnetized water (NMW), is for all cases of irrigation. The height of the plant if irrigated using river water (CW) was 30.50cm and 31cm for the stations 360+00 and 441+00 respectively for the agricultural season 2020-2021 and 28.55cm and 30cm for the stations 360+00 441+00 for the agricultural season 2021- 2022.

5.3.1.3 Effect of magnetized water on the duration of flowering

Figures (5-4) display results of magnetization effect for Almasab Alam irrigation water of sites on duration flowering of the onion plant. The results showed a highly significant difference between the duration of flowering of onion plants when irrigated with magnetized water (MW) compared to duration of flowering of nonmagnetic water (NMW).

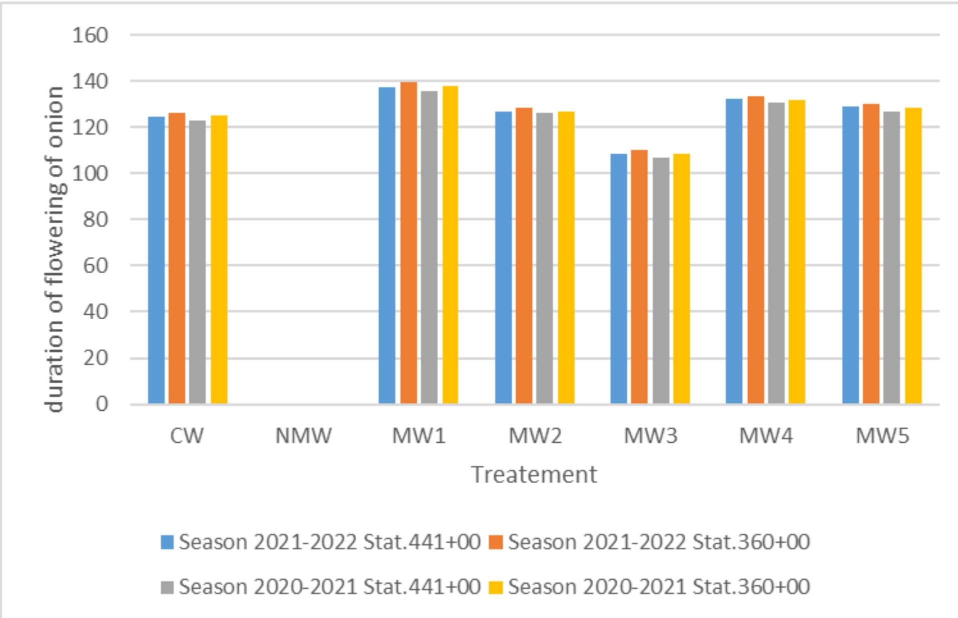

Figure 5.4: The duration of flowering of onion plant in days after planting.

Figure 5.4 shows the duration of flowering for all treatments of magnetized water (MW) is less than the duration for no magnetized Almasab Alam water (NMW) for two seasons.

The results obtained from this study indicate that the minimum time for flowering that happened as the irrigation is done by using of magnetized water of 3000 gausses (MW3) is 108.67 and 107 days for the stations 360+00 and 441+00, respectively, for the agricultural season 2020-2021. The results for the same stations, but for agriculture season 2021-2022 are 110 and 108.67 days, respectively. The Maximum time for flowering occurred if irrigated using magnetized water with 1000 gausses (MW1) is 138 and 135.67 days for the stations 360+00 and 441+00, respectively, for the agricultural season 2020-2021. The results for the same stations, but for agriculture season 2021-2022 are 139.67 and 137 days, respectively.

if the irrigation was by using non-magnetized Almasab Alam water for all stations and two seasons, there is no duration for flowering, because the plant does not continue to grow for a long time in this case, due to the high salts present in it, which the onion plant cannot tolerate, being one of the plants sensitive to salinity. The duration for flowering if the irrigation was by using river water (CW) was 125 and 123 days for the stations 360+00 and 441+00 respectively for the agricultural season 2020-2021 and 126.12 and 124.64 days for the stations 360+00 and 441+00 for the agricultural season 2021- 2022.

5.3.1.4 Magnetized water effect on length of root

The use of magnetically treated water led to an improvement in the vegetative and root growth characteristics of the onion plant, as there was an increase in the root group, **[Muzahem et al 2015]**, that irrigation with magnetized waterworks washes the soil from salts and increases the abundance of nutrients, which in turn increases plant growth **[Amin and Qasim, 2009]** when using irrigation with magnetized water in compared to irrigation with non-magnetized water, we find that magnetized water excelled in the characteristics of vegetative and root growth (plant height, leaf area, stem weight, dry vegetative weight) **[Muhammad, 2014].**

The results of **Figure 5.5** display magnetization effect of saline irrigation water of sites on onion plant root length. The results showed a highly significant difference between the rates of treatments irrigated with magnetized water (MW) compared to rate of nonmagnetic water (NMW) in the length of the plant.

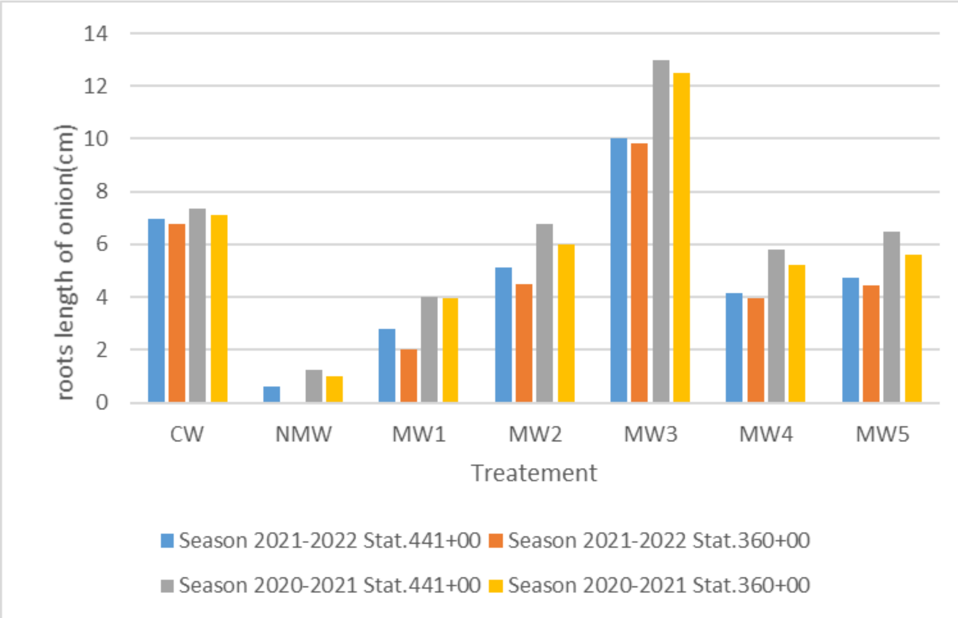

Figure 5.5: The root length of the onion plant in cm after 7 days

The results obtained from this study indicate that the maximum length of onion roots that happened as irrigated using magnetized water of 3000 gausses (MW3) is 12.50 and 13cm for the stations 360+00 and 441+00, respectively, for the agricultural season 2020-2021. The results for the same stations, but for agriculture season 2021-2022 are 9.85 and 10 cm, respectively. The minimum length occurred if the irrigation was by magnetized water with 1000 gausses (MW1) is 3.95 and 4 cm for the stations 360+00 and 441+00, respectively, for the agricultural season 2020-2021. The results for the same stations, but for agriculture season 2021-2022 are 2 and 2.78 cm, respectively. The root length in the case of irrigation with the Almasab Alam non-magnetized water (NMW) was very low compared to all other cases, which are 1, 1.25cm for the stations 360 + 00 and 441 + 00, respectively, for the agricultural season 2020-2021. The results for the same stations, but for agriculture season 2021-2022 are 0 and 0.62 cm, respectively. The length of the root if the irrigation was by river water (CW) with 7.10, 7.35cm for stations 360+00 and 441+00 respectively for the agricultural season 2020-2021 and 6.75, 6.95cm for the stations 360+00 and 441+00 respectively for the agricultural season 2021- 2022. **Figure 5.6** shows the root length.

By evaluating the results, it was found that the longer roots were obtained if using magnetized water with a 3000 gausses of strength for the stations 360+00 and 441+00 for the two agricultural seasons. Magnetized water improves the physical and chemical properties of soil in terms of porosity and permeability and also reduces the hardening of surface crust of soil, which leads to an increment in activity and improvement of plant in root system. Also, chemical elements that nourish the plant increase, which leads to an increase in the growth of the roots.

These results are consistent with many recent studies conducted on many plant species, especially the ones that are affected by salinity, and among them are what he found **[Muzahim et al.; 2015, Raad and Hind; 2012 & Al-Jabouri and Hamza, 2012].** Which explained the rapid growth of the root system by increasing the absorption of magnetized water by the plant As a result of the decrease in surface tension, viscosity, and density, as well as its fairness to small groups of water molecules linked together as a result of breaking some hydrogen bonds, which facilitates their penetration of cell membranes It is absorbed by the seed cells and increases the efficiency of transporting nutrients from the soil solution, which leads to further improvement in the growth and development of plants.

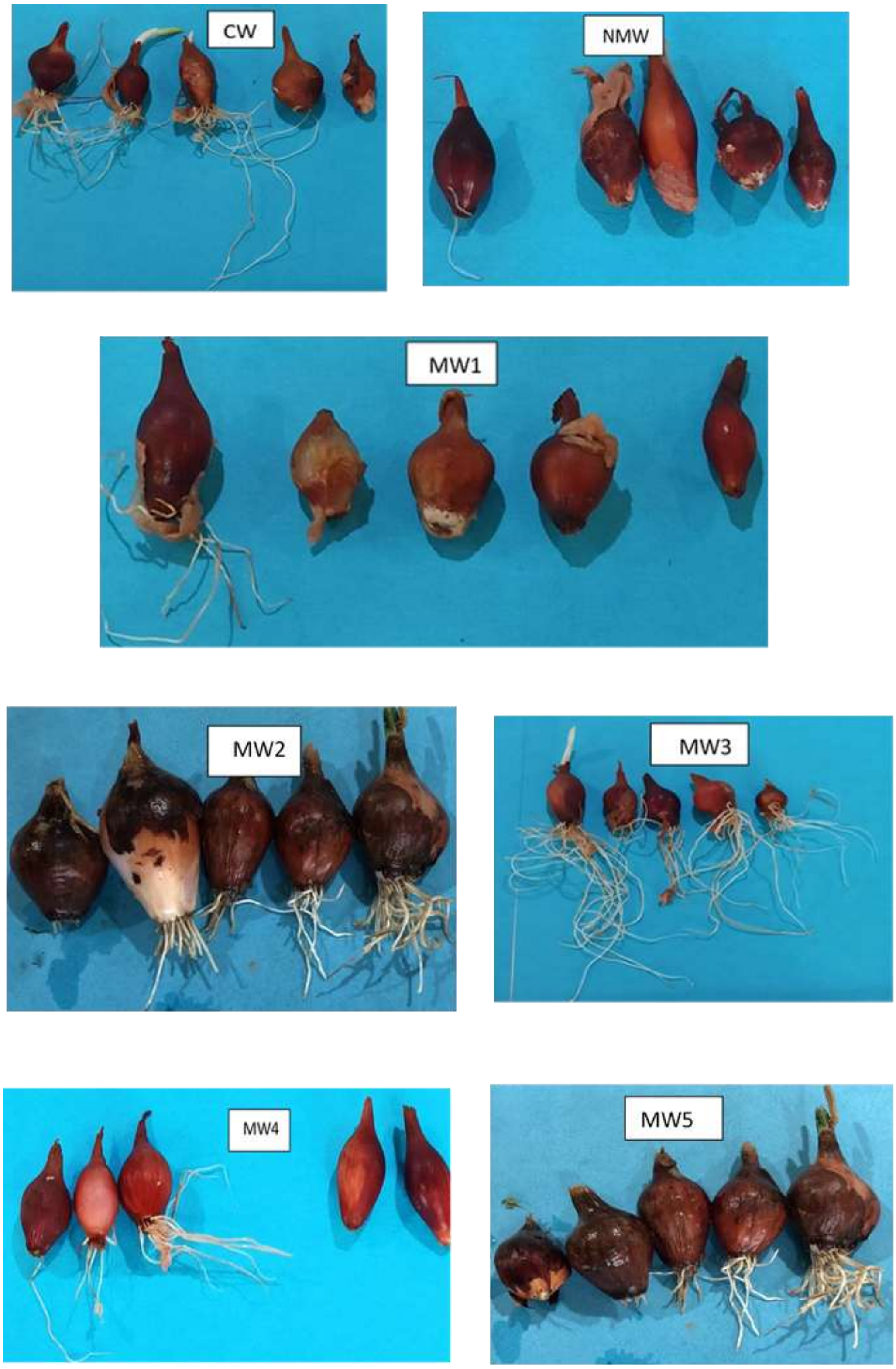

Figure 5.6: Photo of root length after 7 days

5. 3.2 Bean

5.3.2.1 Effect of magnetized water on germination

The germination stage is one of the most important stages in plant life, the success of growth and crop productivity depends on this stage. It is a critical stage in which the plant resists environmental stresses, especially water stress, which plays an important role in accelerating plant growth during the germination stage in dry and semi-arid regions. Experiment results of bean seed germination rate for seasons 2020-2021 and 2021-2022 with application of different levels of magnetized saline water in contrast to non-magnetized saline water after 15 days after planting are shown in **Figure 5.7.**

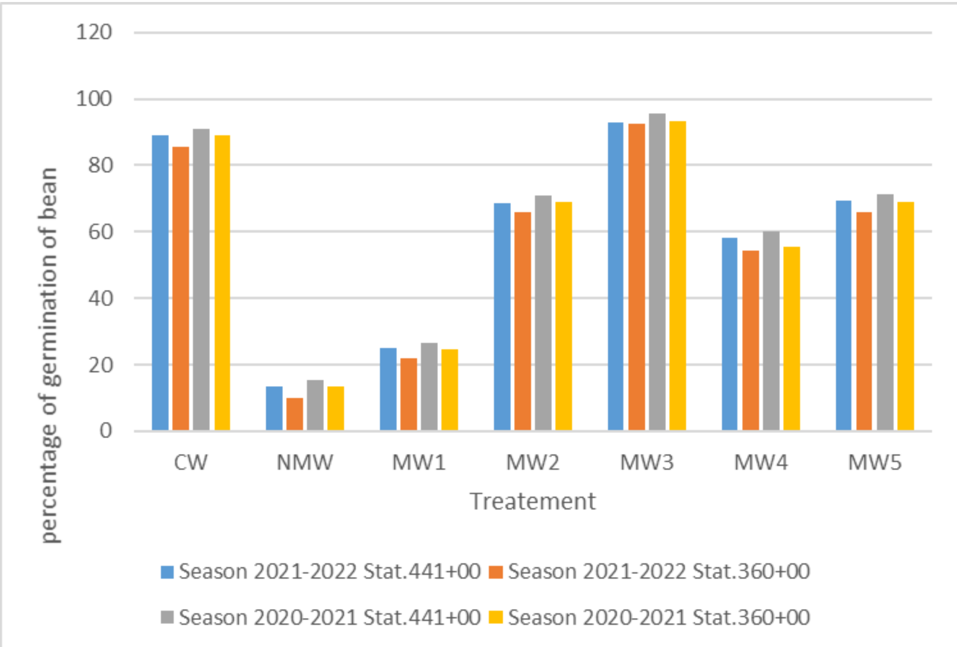

Figure 5.7: The percentage of germination of bean plant after 15 days after planting.

It was observed from the results that, the germination of seeds irrigated with magnetized water started earlier than that of non-magnetized water by one to two days for all cases. Results also proves that, overall rate of germination for irrigation using magnetized water (MW) was higher than that with no magnetized Almasab Alam water (NMW) for all treatments and for two seasons.

The results obtained from this study indicate that the highest germination rate for bean plants occurred if irrigation was by using magnetized water with 3000 gausses (MW3) is 93.33% and 95.53% for the stations 360+00 and 441+00, respectively, for the agricultural season 2020-2021. The results for the same stations, but for agriculture season 2021-2022 are 92.33% and 93%, respectively. The lowest germination rate occurred if irrigation was by using magnetized water with 1000 gausses (MW1) is 24.45% and 26.63% for the stations 360+00 and 441+00, respectively, for the agricultural season 2020-2021. The results for the same stations, but for agriculture season 2021-2022 are 21.88% and 25%, respectively. The percentage of germination in the case of irrigation with the Almasab Alam non-magnetized water (NMW) was very low compared to all other cases, which are 13.33% and 15.53% for the stations 360 + 00 and 441 + 00, respectively, for the agricultural season 2021-2020, and 10%, 13.45% for the stations 360+00 and 441+00 respectively for the agricultural season 2021-2022. The percentage of germination if irrigation was by using river water (CW) with 88.88% and 91.07% for the stations 360+00 and 441+00 respectively for the agricultural season 2020-2021. The results for the same stations, but for agriculture season 2021-2022 are 85.45% and 88.89%, respectively.

5.3.2.2 Effect of magnetized water on Plant height

The results of **Figure 5.8** show the magnetization effect of saline irrigation water of sites on bean plant height. Results showed a highly significant difference between the rates of treatments irrigated with magnetized water (MW) compared to rate of nonmagnetic water (NMW) in the length of the plant.

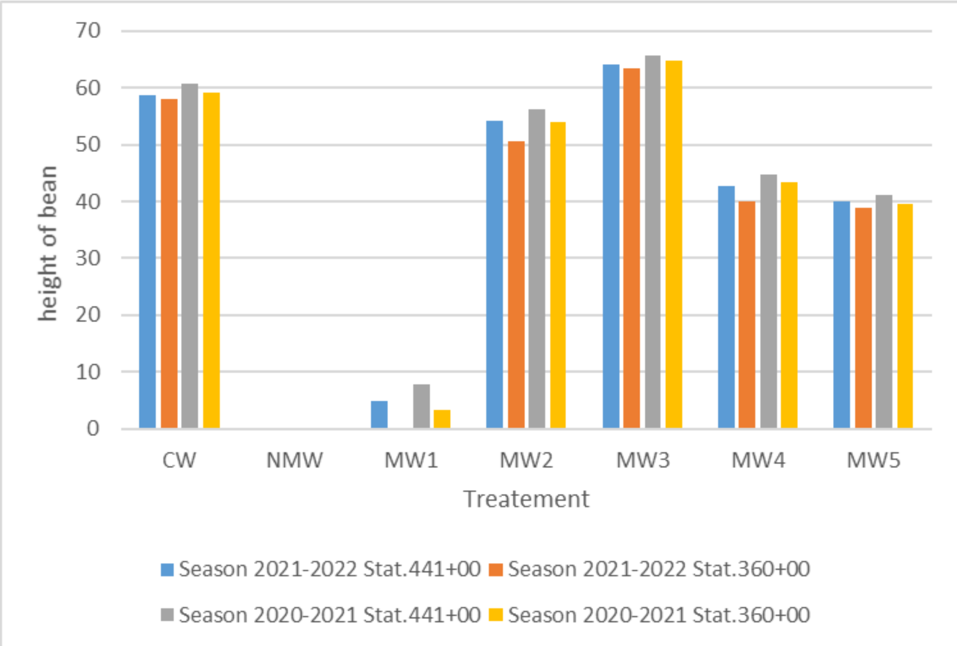

Figure 5.8: The height of bean plant (cm) after 60 days.

From the results shown in **Figure 5.8,** it was observed that the height of the bean plant was higher in all treatments with magnetized water (MW) as compared with non magnetized Almasab Alam water (NMW) for two seasons. **Figure 5.9** shows the Photo of the bean plant after 15 days.

Figure 5.9: Bean plant height with different irrigation case

The results obtained from this study indicate that the maximum height that occurred if irrigation was by using magnetized water with 3000 gausses (MW3) is 64.67 and 65.76 cm for the stations 360+00 and 441+00, respectively, for the agricultural season 2020-2021. The results for the same stations, but for agriculture season 2021-2022 are 63.45 and 64 cm, respectively. The minimum height occurred if irrigation was by using magnetized water with 1000 gausses (MW1) is 3.33 and 7.92 cm for the stations 360+00 and 441+00, respectively, for the agricultural season 2020-2021. The results for the same stations, but for agriculture season 2021-2022 are 0 cm and 4.85cm, respectively. The zero height of the bean plant, in the case of irrigation with the Almasab Alam non-magnetized water (NMW), is for all cases of irrigation. The height of the plant if irrigation was by using river water (CW) was 59.03 and 60.63cm for the stations 360+00 and 441+00 respectively, for the agricultural season 2020-2021, and 58, 58.76 cm for the stations 360+00 441+00 for the agricultural season 2021- 2022. The zero height of the bean plan, if irrigation was by using Almasab Alamnon-magnetized water (NMW), is for all cases of irrigation. The height of the plant if irrigation was by using river water (CW) is 59.03cm and 60.63cm for the stations 360+00 and 441+00 respectively for the agricultural season 2020-2021 The results for the same stations, but for agriculture season 2021-2022 are 58 and 58.76cm, respectively.

5.3.2.3 Effect of magnetized water on the duration of flowering

Figure 5.10 shows the results of the magnetization effect of Almasab Alam irrigation water of the sites for duration of flowering of bean plant. The results showed a highly significant difference between the duration of flowering of bean plants when irrigated with magnetized water (MW) compared to the duration of flowering of nonmagnetic water (NMW).

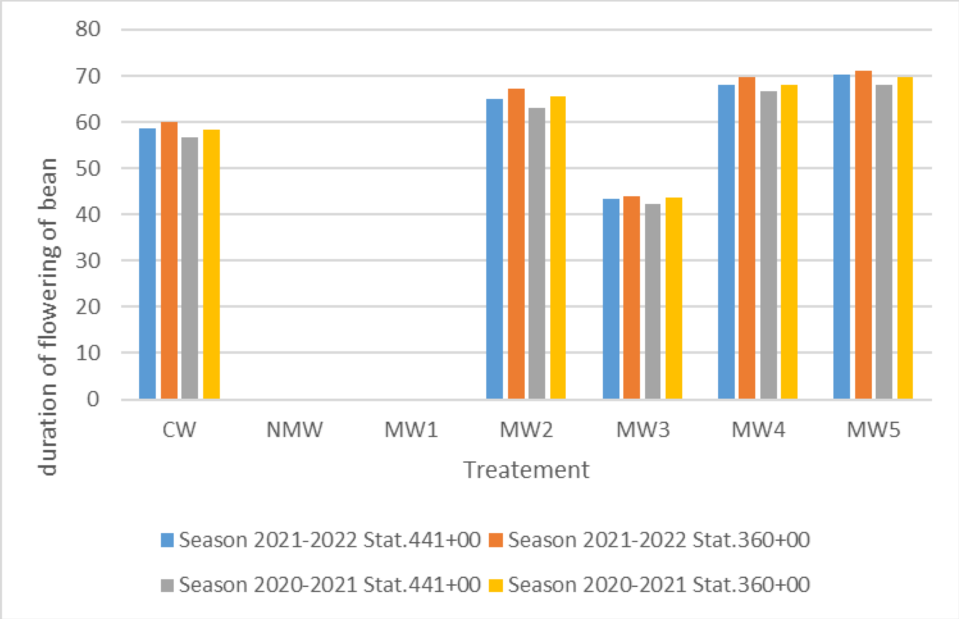

Figure 5.10: The duration of flowering of bean plants in days after planting.

Figure 5.10 shows the duration of flowering for all treatments of magnetized water (MW) is less than the duration for no magnetized Almasab Alam water (NMW) for two seasons.

The results obtained from this study indicate that the minimum time for flowering that occurred if irrigation was by using magnetized water with 3000 gausses (MW3) is 44 and 42days for the stations 360+00 and 441+00, respectively, for the agricultural season 2020-2021. The results for the same stations, but for agriculture season 2021-2021 are 44 and 43days, respectively. When irrigation was by using magnetized water with 1000 gauss (MW1) and non-magnetized Almasab Alam water (NMW) for all stations and two seasons, there is no duration for flowering, because the plant does not continue to grow for a long time in this case, due to the high salts present in it, which the bean plant cannot tolerate, being one of the plants sensitive to salinity. The duration for flowering if irrigation was by using river water (CW) is 58and 57 days for the stations 360+00 and 441+00 respectively for the agricultural season 2020-2021 and 60 and 59 days for the stations 360+00 and 441+00 respectively for the agricultural season 2021- 2022.

By evaluating the results, it was found that the minimum time for flowering was obtained if the strength of magnetized water was 3000 gausses for the stations 360+00 and 441+00 for the two agricultural seasons. The average minimum duration time of flowering is 16 days less than the duration time of flowering in river water (control).

5.3.3 Vicia faba L.

5.3.3.1 Effect of magnetized water on germination

The germination stage is one of the most important stages in plant life, the success of growth and crop productivity depends on this stage. It is a critical stage in which the plant resists environmental stresses, especially water stress, which plays an important role in accelerating plant growth during the germination stage in dry and semi-arid regions. Experiment results of Vicia faba L seed germination rate for seasons 2020-2021 and 2021-2022 for diverse levels of both magnetized and non-magnetized saline water after 15 days after planting are shown in **Figure 5.11.**

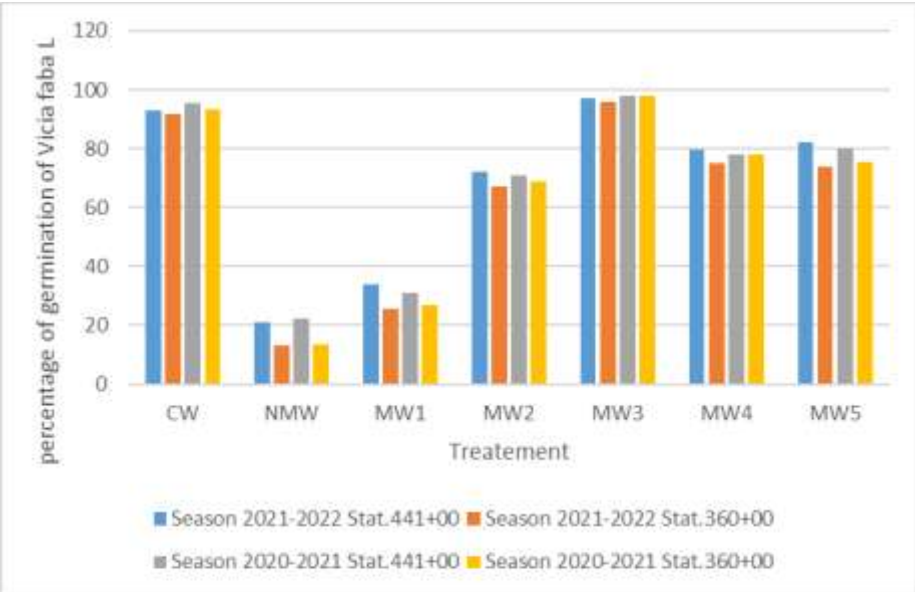

Figure 5.11: The percentage of germination of Vicia faba L plant after 15 days after planting.

From the results of (Fig. 5.11) It can be conclude that, the germination of seeds irrigated with magnetized water start earler than that irrigated with non-magnetized by one to two days in all cases. Additionally, results revealed that overall rate of germination for treatments with magnetized water (MW) higher than with no magnetized Almasab Alam water (NMW) for two seasons.

The results obtained from this study indicate that the highest germination rate for Vicia faba L. happened when irrigated using magnetized water with 3000 gausses (MW3) is 97.78%, and 97.77% for the stations 360+00 and 441+00, respectively, for the agricultural season 2020-2021. The results for the same stations, but for agriculture season 2021-2022 are 95.89%, and 97%, respectively. The lowest germination rate happened when irrigated using magnetized water with 1000 gausses (MW1) is 26.66%, and 31.09% for the stations 360+00 and 441+00, respectively, for the agricultural season 2020-2021. The results for the same stations, but for agriculture season 2021-2022 are 25.66%, and 33.70%, respectively. The percentage of germination in the case of irrigation with the Almasab Alam non-magnetized water (NMW) was very low compared to all other cases, which are 13.33%, and 22.22% for the stations 360 + 00 and 441 + 00, respectively, for the agricultural season 2021-2020, and 13%, 21% for the stations 360+00 and 441+00 respectively for the agricultural season 2021-2022. The percentage of germination as irrigated with river water (CW) was 93.30%, and 95.35% for the stations 360+00 and 441+00 respectively for the agricultural season 2020-2021. The results for the same stations, but for agriculture season 2021-2022 are 91.55%, and 93%, respectively.

5.3.3.2 Effect of magnetized water on Plant height

The results of **Figure 5.12** display magnetization effect on saline irrigation water of sites on height of Vicia faba L plant. The results showed a highly significant difference between the rates of treatments irrigated with magnetized water (MW) in comparison to rate of nonmagnetic water (NMW) in the length of the plant.

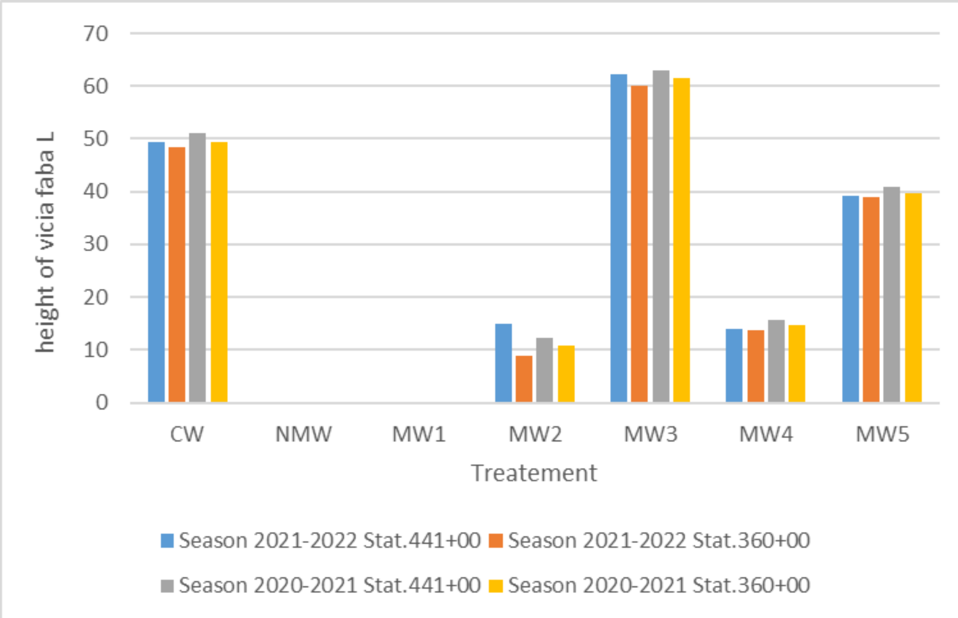

Figure 5.12: The height of Vicia faba L plant (cm) after 60 days.

From the results shown in **Figure 5.12,** it was observed that the height of the Vicia faba L plant was higher in all treatments with magnetized water (MW) in comparison with no magnetized Almasab Alam water(NMW) for two seasons.

The results obtained from this study indicate that the maximum height that obtained if irrigation by magnetized water with 3000 gausses (MW3) is 61.57, and 63 cm for the stations 360+00 and 441+00, respectively, for the agricultural season 2020-2021. The results for the same stations, but for agriculture season 2021-2022 are 60.10, and 62.17 cm, respectively. The zero height of the Vicia faba L plant, when irrigation with magnetized water of 1000 gauss (MW1) and irrigation with the Almasab Alam non-magnetized water (NMW), is for all cases of irrigation. The height of the plant if the irrigation was with river water (CW) is 411.60, 51cm for the stations 360+00 and 441+00 respectively, for the agricultural season 2020-2021, and 48.50, 49.50 cm for the stations 360+00 441+00 for the agricultural season 2021-2022.

5.3.3.3 Effect of magnetized water on the duration of flowering

Figure 5.13 shows the results of magnetization effect on Almasab Alam irrigation water of sites on duration of flowering of the Vicia faba L plant. The findings exhibited greatly significant difference between duration of flowering of Vicia faba L plant when irrigated with magnetized water (MW) as compared to duration of flowering of nonmagnetic water (NMW).

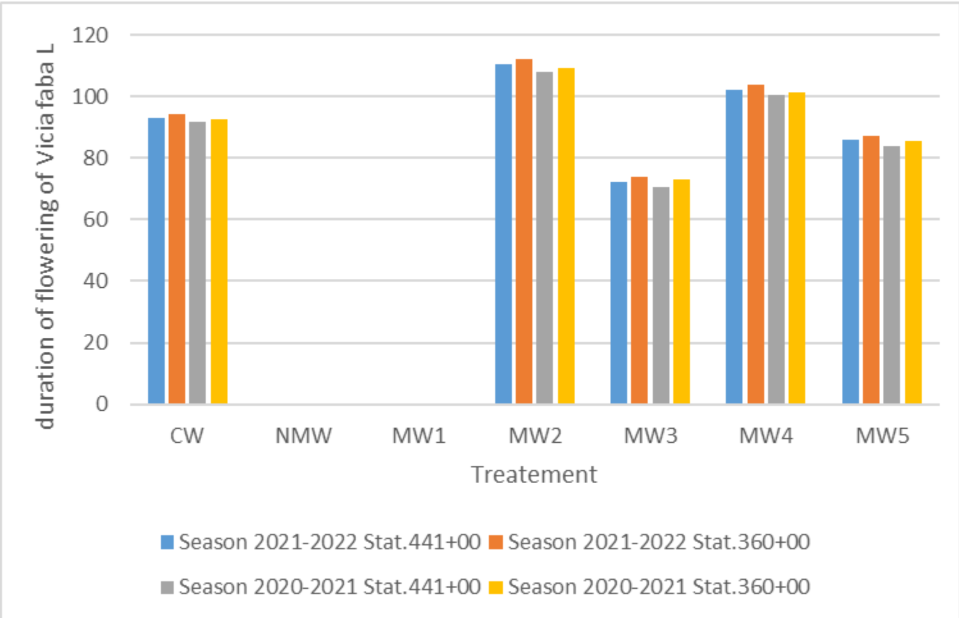

Figure 5.13: The duration of flowering of Vicia faba L plant in days after planting.

Figure 5.13 shows the duration of flowering for all treatments of magnetized water (MW) is less than the duration for no magnetized Almasab Alam water (NMW) for two seasons.

The results obtained from this study indicate that the minimum time for flowering that happened if irrigation was by magnetized water with 3000 gausses (MW3) is 73 and 70.67 days for the stations 360+00 and 441+00, respectively, for the agricultural season 2020-2021. The results for the same stations, but for agriculture season 2021-2021 are 74 and 72 days, respectively.

The Maximum time for flowering occurred if irrigation was by magnetized water with 1000 gausses (MW1) is 138 and 135.67 days for the stations 360+00 and 441+00, respectively, for the agricultural season 2020-2021. The results for the same stations, but for agriculture season 2021-2021 are 139.67 and 137 days, respectively.

When irrigation was by magnetized water with 1000 gauss (MW1) and with non-magnetized Almasab Alam water for all stations and two seasons, there is no duration for flowering, because the plant does not continue to grow for a long time in this case, due to the high salts present in it, which the Vicia faba L plant cannot tolerate, being one of the plants sensitive to salinity. The duration for irrigation by river water (CW) was 92.67, 91.67 days for the stations 360+00 and 441+00 respectively for the agricultural season 2020-2021 and 94.33, 93 days for the stations 360+00 and 441+00 for the agricultural season 2021- 2022.

5.3. 4 Maize

5.3.4.1 Effect of magnetized water on germination

The germination stage is one of the most important stages in plant life, the success of growth and crop productivity depends on this stage. It is a critical stage in which the plant resists environmental stresses, especially water stress, which plays an important role in accelerating plant growth during the germination stage in dry and semi-arid regions. Experiment results of maize seed germination rate for seasons 2020-2021 and 2021-2022 with the utilization of many levels of both magnetized and non-magnetized saline water after 15 days after planting are shown in **Figure 5.14.**

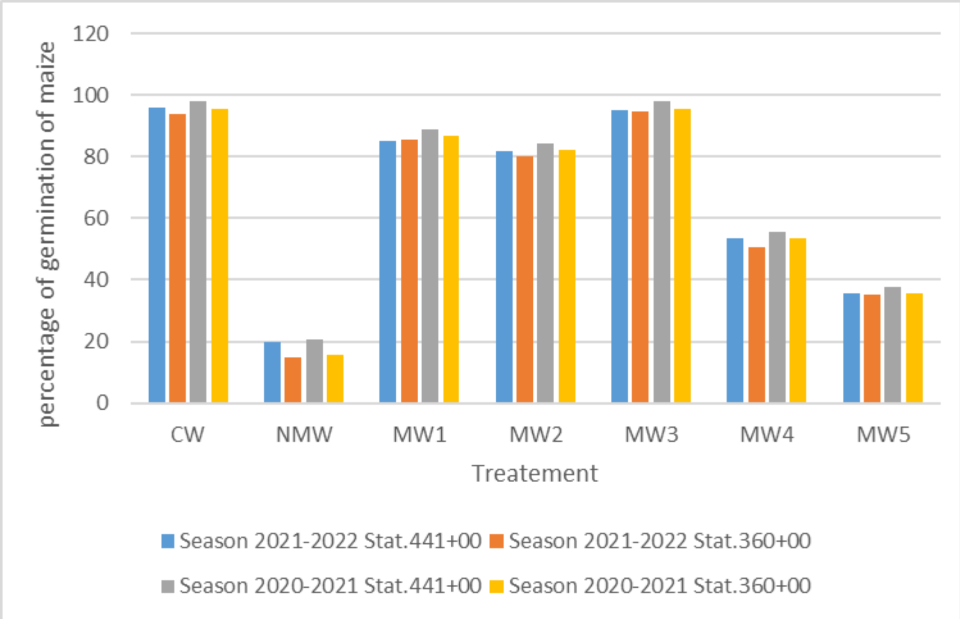

Figure 5.14: The percentage of germination of maize plant after 15 days after planting.

Results of (Fig. 5.14) cleared that, seed germination irrigated by earlier magnetized water start earlier than that irrigated with non-magnetized water by one to two days for all cases. Results also revealed that overall rate of germination of magnetized water (MW) was higher as compared th that of non magnetized Almasab Alam water (NMW) for all treatments and for two seasons.

The results obtained from this study indicate that the highest germination rate for maize plants occurred if irrigation was using magnetized water with 3000 gausses (MW3) is 95.56% and 97.98% for the stations 360+00 and 441+00, respectively, for the agricultural season 2020-2021. The results for the same stations, but for agriculture season 2021-2022 are 94.67% and 95 %, respectively. The lowest germination rate happened when irrigation was using magnetized water with 1000 gausses (MW1) is 86.67% and 88.88% for the stations 360+00 and 441+00, respectively, for the agricultural season 2020-2021. The results for the same stations, but for agriculture season 2021-2022 are 85.55% and 85%, respectively. The percentage of germination in the case of irrigation with the Almasab Alam non-magnetized water (NMW) was very low compared to all other cases, which are 15.55% and 20.50% for the stations 360 + 00 and 441 + 00, respectively, for the agricultural season 2021-2020, and 14.80%, 20% for the stations 360+00 and 441+00 respectively for the agricultural season 2021-2022. The percentage of germination when irrigation using river water (CW) is 95.55% and 97.78% for the stations 360+00 and 441+00 respectively for the agricultural season 2020-2021. The results for the same stations, but for agriculture season 2021-2022 are 94% and 96%, respectively.

5.3.4.2 Effect of magnetized water on Maize height

The results of **Figure 5.15** demonstrate magnetization effect on saline irrigation water of sites on height of maize plant. Results showed a highly significant difference between the rates of treatments irrigated with magnetized water (MW) compared to the rate of nonmagnetic water (NMW) in the length of the plant.

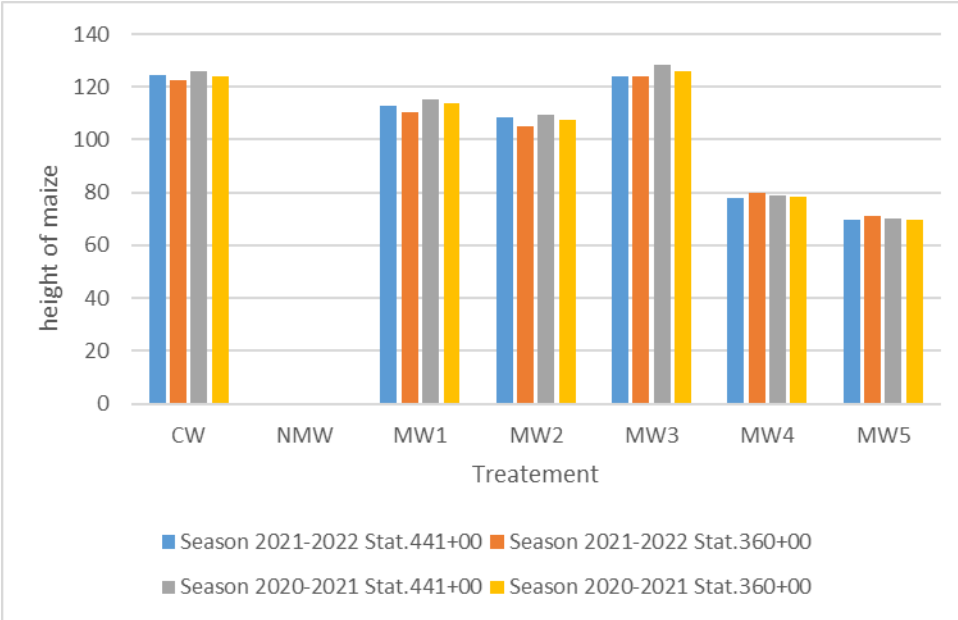

Figure 5.15: The height of maize plant (cm) after 60 days

From the results shown in **Figure 5.15**, it was observed that the height of the maize plant was higher in all treatments using magnetized water (MW) in as compared to that using non magnetized Almasab Alam water (NMW) for two seasons. **Figure 5.16** shows the Photo of the maize plant after 10 days.

Figure 5.16: Maize plant height with different irrigation case

The results obtained from this study indicate that the maximum height that happened if irrigation by magnetized water with 3000 gausses (MW3) is 124 and 126.17 cm for the stations 360+00 and 441+00, respectively, for the agricultural season 2020-2021. The results for the same stations, but for agriculture season 2021-2022 are 124.20 and 123.80 cm, respectively. The minimum height occurred when irrigation using magnetized water with 5000 gausses (MW5) is 69.62 and 70.35cm for the stations 360+00 and 441+00, respectively, for the agricultural season 2020-2021. The results for the same stations, but for agriculture season 2021-2022 are 71.20 and 69.50cm, respectively. The zero height of the maize plant, when irrigation using Almasab Alamnon-magnetized water (NMW), is for all cases of irrigation. The height of the plant if irrigated by river water (CW) was 59.03 and 60.63cm for the stations 360+00 and 441+00 respectively, for the agricultural season 2020-2021, and 58, 58.76cm for the stations 360+00 441+00 for the agricultural season 2021- 2022. The zero height of the bean plant, in the case of irrigation with the Almasab Alam non-magnetized water (NMW), is for all cases of irrigation. The height of the plant in case of irrigation using river water (CW) was 124 and 126.17cm for the stations 360+00 and 441+00 respectively for the agricultural season 2020-2021 The results for the same stations, but for agriculture season 2021-2022 are 122.75, and 124.60 cm, respectively.

5.3.4.3 Effect of magnetized water on the duration of flowering

Figure 5.17 shows the results of the influence of magnetization of Almasab Alam irrigation water of sites on flowering duration of the maize plant. The results showed a highly significant difference between the duration of flowering of maize plants when irrigated with magnetized water (MW) compared to the duration of flowering of nonmagnetic water (NMW).

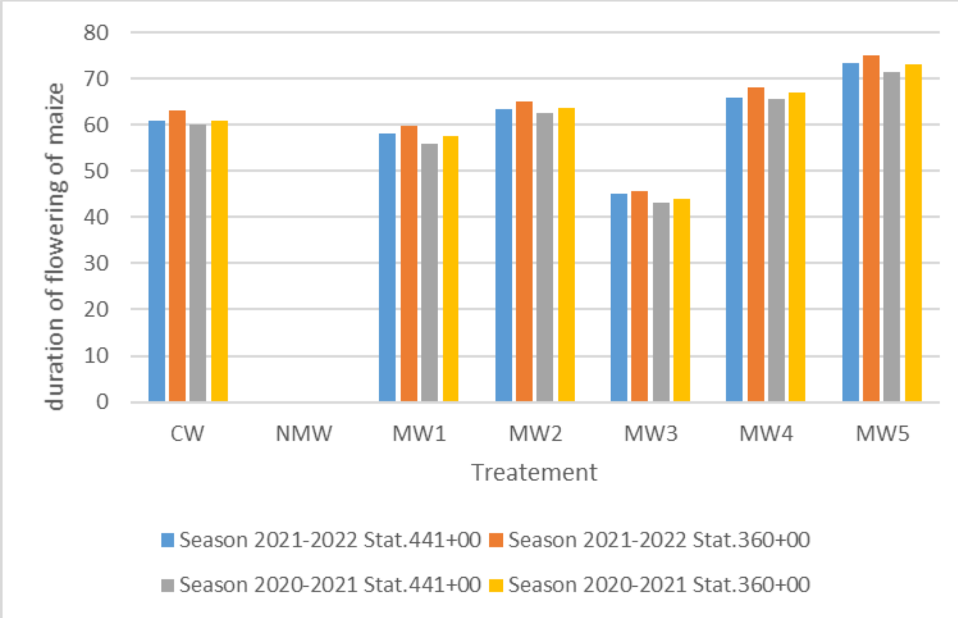

Figure 5.17: The duration of flowering of maize plant in days after planting.

Figure 5.17 shows the duration of flowering for all treatments of magnetized water (MW) is less than the duration for no magnetized Almasab Alam water(NMW) for two seasons.

The results obtained from this study indicate that the minimum time for flowering that happened in case of irrigation by magnetized water with 3000 gausses (MW3) is 44 and 43 days for the stations 360+00 and 441+00, respectively, for the agricultural season 2020-2021. The results for the same stations, but for agriculture season 2021-2021 are 45.50 and 45 days, respectively. The Maximum time for flowering occurred if irrigation was by magnetized water with 7000 gausses (MW5) is 73 and 71.33 days for the stations 360+00 and 441+00, respectively, for the agricultural season 2020-2021. The results for the same stations, but for agriculture season 2021-2021 are 75 and 73.33 days, respectively. If irrigation was by non-magnetized Almasab Alam water for all stations and two seasons, there is no duration for flowering, because the plant does not continue to grow for a long time in this case, due to the high salts present in it, which the maize plant cannot tolerate, being one of the plants sensitive to salinity. The duration for flowering when irrigation using river water (CW) is 61, 60 days for the stations 360+00 and 441+00 respectively for the agricultural season 2020-2021, and 63, 61 days for the stations 360+00 and 441+00 respectively for the agricultural season 2021- 2022.

5.3.5 Discussion of the results

5.3.5.1 Germination

By evaluating the results, it was found that the best germination condition was obtained if using magnetized water with strength 3000 gausses for the stations 360+00 and 441+00 for the two agricultural seasons.

The findings are consistent with the germination observed by **Al-Mawsili (2013) and Mahmood & Usman (2014),** which indicated a favorable impact of magnetization on seeds germination and emergence in soil. The magnetic treatment's impact on amount and pace of water absorption in onion seed as opposed to non-magnetized water may be the cause of the greater germination rate. Changes in ionic concentration and osmotic pressure brought on by a magnetic field control how much water enters seeds. The increased water content is mostly to blame for these beneficial effects of magnetic therapy, but other potential causes include changes in plant systematic biochemical levels and their potential consequences at the cellular level. There is evidence that the polarization of dipoles and the activation of ions in living cells are both influenced by external electric and magnetic fields **[Raad and Hind 2012].**

The activation of hormones and enzymes involved in the germination process and nutrient mobilization may be attributed to irrigation with water that has undergone magnetic treatment. The mobilization and transfer of nutrients to the embryonic axis are likely improved as a result, which increases the rate of germination and speed of emergence of onion seedlings.

5.3.5.2 Height

By evaluating the results, it was found that the maximum height of onion was obtained is using magnetized water with 3000 gausses strength for the stations 360+00 and 441+00 for the two agricultural seasons. The results of the second agricultural season confirmed their agreement with the results of the first season, and this gives strength to the validity of the results obtained through experiments. The results indicate that the percentage of germination if irrigated by magnetized water with 3000 gausses strength exceeded that of irrigation with river water (CW).

This is because the magnetization of water increases the levels of enzymes and maintains the hormonal balance, which leads to an increase in transpiration rates, growth, expansion, division, and elongation of cells, which is positively reflected in the length of the plant, as the breaking of the hydrogen bonds of water as a result of magnetization facilitates From the process of water absorption by root cells, as well as becoming a good carrier of nutrients, increases the availability of nutrients in the soil and works to dissolve minerals and salts, and this was confirmed by **Nada Elloumi et al (2018)** on the one hand. On the other hand, the concentration of oxygen increases in the magnetized water, which has an important role in increasing plant growth by dissolving minerals containing nutrients, and this was confirmed by **Makhmoudov (1998), and Khattab et al (2000)** who indicated that irrigation of plants with magnetized water increases plant growth, and this is what **Al-Gawthry (2006)** obtained when using magnetized water to increase the height of plants. In addition, magnetization effects change the physical and chemical properties of water leading to an improvement in its kinetic properties. **Gallon (2004)** indicated that these changes lead to an increase in the soil's ability to get rid of salts and to better absorption of nutrients before the plant as a result of the ease of movement of the magnetic water into the plant cells and the transmission of the electromotive force from the water to the plant, which has proven its ability to stimulate plant growth. Also, the lack of surface tension on the surface of the magnetized water led to its penetration into the cell walls and this leads to the rapid division of cells increasing vegetative growth in general, including plant height. This result agrees with what was found by **Kazim and Mehsin (1980b), and Balibrea et al. (1999).**

5.3.5.3 Duration of Flowering

By evaluating the results, it was found that the minimum time for flowering was obtained as using magnetized water with of 3000 gausses strength for the stations 360+00 and 441+00 for the two agricultural seasons. The average minimum duration time of flowering is 16 days less than the duration time of flowering in river water (control). Early flowering leads to early production of the plant, this in turn leads to a reduction in the duration of plant care in terms of the amount of water and fertilizer used for it, and thus the economic return increases in this case. Early flowering is an important factor in providing a suitable time to prepare the field for the following season. The reason for early flowering is due to the improvement of the chemical and physical properties of water and soil, mentioned previously in the water and soil paragraphs, in terms of nutrients, increased permeability, and porosity, and less hardening of surface crust of soil, as well as the early germination of plants when irrigated with magnetized water **[Khalid M. Elhindi et al, 2020 & Abdul-Qados and Hozayn, 2010].**

Through the results of the current study, which was conducted for two agricultural seasons, it was found that the results of the second season are almost identical to the results of the first season, and this gives strength to the results of the study. Among these important results is that the condition of irrigation with magnetized water with an intensity of 3000 gausses is the best for all the plants on which the study was conducted in terms of the percentage of germination, height, and duration of flowering for these plants, as well as the length of the roots for onion plants. Note that these plants are sensitive to salinity and could not grow when irrigated with untreated Almasab Alam water (NMW), but it has excellent growth when irrigated with magnetic water (MW) from Almasab Alam and in some cases, it has outperformed the irrigation with irrigated river water (CW). It was recommended to use magnetic water with 3000 Gauss (MW3) as a condition in the study area. The reason for this is that the chemical and physical properties of water, such as the degree of solubility, the nutrients for plants (nitrate) Potassium phosphorous), dissolved oxygen, surface tension, and viscosity are the best in this case. The other reason is that the chemical and physical properties of soil such as plant nutrients (phosphorous potassium nitrate) and dissolved oxygen as well as the porosity, permeability, and surface crust of the soil are the best in the case of 3000 gausses. It concludes from this study that we were able to obtain suitable water for irrigation from unsuitable water by using magnetic water technology. This leads to an increase in water suitable for irrigation, an increase in the area of cultivated land, and a decrease in desertification and drought in Iraq, especially in the central and southern regions, due to the lack of rain over these years. It is possible to benefit from the water of the drainage and groundwater in this country.

5.4 Effect on Soil

5.4.1 Effects of magnetized saltwater irrigation on chemical properties of soil

As compared to conventional irrigation water, which only removes 30% of soil salts, the magnetically treated water can eliminate up to 50–80% of them. By accelerating the washing of salts and clearing root zone of their harmfulness, it also enhances characteristics of soil and lowers harmfulness of its salinity **[Muzahem et al, 2015].** Salts are extracted from the soil and washed with magnetized water. Because magnetized water has double the capacity to dissolve salts than regular water does, it replenishes soil matter that has been degraded by the application of highly concentrated synthetic fertilizers **[Kazem, R. Jawad, 2010].** One of the biggest issues in agriculture is salinity of soil, which results from the buildup of salts in the soil pores, which severely reduces the energy of the soil and concentration of salts in capillaries of plant roots. This decreases the plant's yield relative to its nutritional requirements, which causes wilting and eventually plant death.

To ascertain the impact of magnetized water (MW) on the chemical characteristics of the study area's soil, the soil's chemical properties were tested prior to the experiment's start and after the winter onion plants' agricultural season had ended. Silty clay loam is the distinctive feature of this soil. **Table 5.1** displays the soil's chemical composition prior to the start of the experiment (SBE).

Table 5.1: Chemical properties of soil before experiments start

Chemical Properties (ppm)	EC	pH	Ca	NO_3	PO_4	K	Na	Mg	Cl	SO_4%
SBE	13.40	7.85	280	30.10	0.31	10.80	317	199	765	1.23

Table 5.2 displays results of tests for chemical properties of soil of study area after experiments (SAE) and after end of planting season.

Table 5.2: Chemical properties of soil after experiments end

Type of water	Chemical Properties (**ppm**)									
	EC	pH	Ca	NO_3	PO_4	K	Na	Mg	Cl	SO_4%
CW	8.61	7.76	194	21	0.12	5.38	172	135	532	0.86
NMW	15.30	7.90	341	32.35	0.33	11.20	375	238	995	1.54
MW1	12.30	7.84	276	29.75	0.30	10.80	294	193	760	1.21

MW2	5.20	7.42	178	8.12	0.15	2.85	98	122	316	0.70
MW3	4.01	7.25	157	4.81	0.05	1.62	76	102	272	0.59
MW4	9.30	7.60	221	17.47	0.19	6.75	191	152	532	0.93
MW5	4.41	7.38	172	5.20	0.08	1.78	91	112	305	0.65

Table 5.3 shows the percentages of the difference in the values of the chemical elements in the soil of study area after end of experiment from their values before the experiment.

Table 5.3: The difference ratio of the chemical properties of soil (SAE) with SBE (%)

	Different Chemical Properties (%)				
Water Type	EC	pH	Ca	NO3	PO4
CW	-35.75	-1.15	-30.71	-30.23	-61.29
NMW	+14.18	+0.64	+21.79	+4.15	+6.45
MW1	-8	-0.12	-1.40	-1.16	-3.23
MW2	-61.20	-5.48	-36.43	-73	-51.61
MW3	-70	-7.64	-43.93	-84	-83.87
MW4	-30.60	-3.18	-21.07	-41.96	-38.71
MW5	-67	-5.99	-38.57	-82.72	-74.19
	Different Chemical Properties (%)				
Water Type	K	Na	Mg	Cl	SO_4
CW	-50.19	-45.74	-30.46	-30.46	-30.10
NMW	+3.70	+18.30	+19.60	+30	+25.20
MW1	0	-7.26	-3	-0.65	-1.63
MW2	-73.61	-69.10	-38.69	-58.69	-43.10
MW3	-85	-76.03	-48.74	-64.44	-52
MW4	-37.50	-39.75	-23.62	-30.46	-24.39

	Different Chemical Properties (%)				
Water Type	EC	pH	Ca	NO3	PO4
MW5	-83.52	-71.29	-43.72	-60.13	-47.15

5.4.2 The dissolving of soil salts

Through the results in **Table 5.2,** it is found that the effect of magnetized water in all its states leads to a decrease in the value of the Electrical conductivity (EC) of its amount for the soil of study area before start of experiments. Different rates for all cases are shown in **Table 5.3.**

Table 5.3 shows that the percentage of decrease in Electrical conductivity of soil after end of growing season for onion plants, which were planted in these experiments, ranged from the lowest value of 8% in the case of MW1 to the highest value of 70% in the case of MW3. The Electrical conductivity decreases by 35.75% for the soil when irrigation by river water CW. Its value increases by 14.18% when irrigated with non-magnetized NMW downstream water. The reason for this increase is the increase in the concentration of salts in the soil, which causes the plant to not be able to absorb them. The reason for the low electrical conductivity of soil for study area if irrigated by magnetized water is that this water increases the availability of nutrients in soil, so it is easily absorbed by the plant and thus leads to an increase in the growth of plants as a result of its absorption of these elements. This was confirmed by **Maheshwari and Grewal (2009), and Hilal et al. (2012).** The best case found is that of magnetized water with a strength of 3000 gausses. In this case, it was found that the amount of the remaining elements of salts and other ions was less than in all other cases. This indicates that the consumption of these elements by the plant is the highest possible and thus will lead to an increase in its growth and productivity. It is also found that this case has surpassed that of river water CW.

5.4.3 pH of Soil

Table 5.2 indicates the results of the pH interaction values for the soil of the study area for all cases. **Table 5.3** shows the decrease and rise of the reaction values for the soil from their value before the start of the experiments. The results indicate that magnetized water in all its states leads to a decrease in the value of the soil interaction at the end of the agricultural season with different percentages. The lowest percentage, which is 0.12%, was achieved in the case of MW1 and the highest percentage of the decrease occurred in the case of MW3, which is 7.64%. The percentage decrease in river water CW is 1.15%. The value of the interaction of the soil in the case of NMW increases by 0.64% over its value before the beginning of the experiment. The reason for this is the neutral salts that cause a decrease in the soil pH towards the neutral direction As for the results obtained, they agree with the results of**, Diaa F. Hassan et al., (2016),** who indicated a decrease in the interaction of soil with an increase in its salinity.

5.4.4 Soluble Content of Ca, Na, Mg, Cl, and SO_4 in the Soil

Table 5.2 shows the values of positive and negative ions for the soil of study area after end of experiment. **Table 5.3** shows the difference between these elements from their values before the experiments started. From the results, it was found that the magnetized water in all its states leads to a decrease in the amounts of these elements in different proportions. The highest percentage of decrease was discovered in the case of MW3. This case outperformed all cases, including the case of CW. The lowest value of decrease occurred in the case of MW1, but in the case of NMW, it increased. Evaluating these elements is according to increase in the concentration of salts in soil and inability of the plant to benefit from them. The reason for the decrease in the concentrations of positive and negative ions in the soil irrigated with magnetized water is that this water increases availability of nutrients in soil, so it is easier to be absorbed by the plant **[Maheshwari and Grewal, 2009; Hilal et al., 2012].**

5.4.5 Plant Nutrients: PO_4, NO_3, and K

Through the results in **Table 5.3,** it can be noticed that the values of the three elements (NO_3, PO_4, and K) decreased in the soil after the end of the experiment. That is, the end of the agricultural season for onion plant growth in that soil and all cases of magnetized water at a rate ranging between (3.23, 1.16, 0) % in the case of MW1 and (83.87, 84, 85) % in the case of MW3 for the elements NO_3, PO_4, and K, respectively. When irrigated with non-magnetized general downstream water (NMW), the values of these elements raise by 6.45, 4.15, and 3.70%, respectively, for the elements NO_3, PO_4, and K. It decreases by (30.23, 61.29, and 50.19%) for the elements NO_3, PO_4, and K, respectively, when irrigated with river water (CW). The highest decrease of these three important elements that nourish the plant was found if irrigated using magnetized water with 3000 gausses of intensity. The reason is due to the consumption of these elements by the cultivated plants which indicates that the plant, in this case, is the best in terms of vegetation and production.

The reason for using magnetic devices is not the chemical change of the salts in MTW but the magnetic water's ability to affect directly the chemical and physical properties of the soil and its indirect effect on the plant's uptake of available nutrients **[Maheshwari & Grewal, 2009, and Abou Eiyazied et al., 2012].** The main properties of MTW are the reduction of water molecules and the storage of water within the water. When that water passes through the soil, it leads to positive changes in the chemical and physical properties, i.e., reduces the soil EC and pH, improves the soil permeability, fastens water movement to dissolve soil salts, and enhances the assimilation of nutrients which become available to plant uptake **[Maheshwari & Grewal, 2009].**

5.5 Effect of Magnetization of Saline Irrigation Water of Almasab Alam on Some Physical Properties of Soil

Crust that forms on the soil's surface is typically distinguished by excessive hardness, which is reflected in the soil's poor aeration and several physical qualities that are unsuitable for plant growth and development. Recently, these crusts can be controlled through the using water that are magnetically treated due to in soils physical and chemical properties as a result of magnetic treatment. By altering some substances' ionic states and lowering the concentrations of others, particularly sodium salts, it increases solubility and prevents sodium ions from adhering to soil. The magnetically treated water, which lessens hardness of surface crust and lessens detrimental effect on increasing hardness of soil's surface crust. Additionally, it can improve several soil properties relevant to building and eliminate the detrimental effects of sodium salts **[Hassan DF et al, 2016].**

The soil's physical characteristics were evaluated before the experiment started as indicated in **Table 5.4.,** and after plants agricultural season end. To ascertain the impact of magnetized water (MW) on the soil's physical characteristics, e.g. (bulk density, porosity, and permeability) of soil in study area.

Table 5.4: Physical properties of soil before beginning of experiment

Physical property	**Bulk Density (gm/cm^3)**	**Porosity (%)**	**Permeability (cm/sec)**
SBE	1.87	31	1.18×10^{-6}

Table 5.5 illustrates the outcomes of tests conducted on some significant physical characteristics of the study area's soil, including its bulk density, porosity, and permeability, both before experiments start (SBE) and following end of onion-planting season.

Table 5.5: Physical properties of soil before and after experiments

Physical properties	Bulk density (gm/cm^3)	Porosity (%)	Permeability (cm/sec)
SBE	1.87	31	1.18×10^{-6}
NMW	1.98	28	1.0×10^{-6}
CW	1.70	45	2.98×10^{-4}
MW1	1.82	32	1.20×10^{-6}
MW2	1.67	46	3.80×10^{-4}
MW3	1.36	51	7.70×10^{-4}
MW4	1.78	40	4.30×10^{-5}
MW5	1.50	48	5.12×10^{-4}

5.5.1 Bulk Density

According to findings in **Table 5.5**, the soil bulk density dropped if it was irrigated using river water, and in every instance when it was done with magnetized saline water from Almasab Alam . While, as the research area's soil was irrigated using saline Almasab Alam water without magnetization, the bulk density of the soil increased. In **Table 5.6** and **Figure 5.18,** the percentages of decreasing and increasing soil bulk density are displayed.

Table 5.6: Percentage of decrease and increase in amount of soil bulk density.

Soil case	Bulk density (gm/cm³)	The difference with bulk density for SBE (%)
SBE	1.87	---
NMW	1.98	+5.90
CW	1.70	-9.10
MW1	1.82	-2.70
MW2	1.67	-10.70
MW3	1.36	-27.30
MW4	1.78	-4.80
MW5	1.50	-19.80

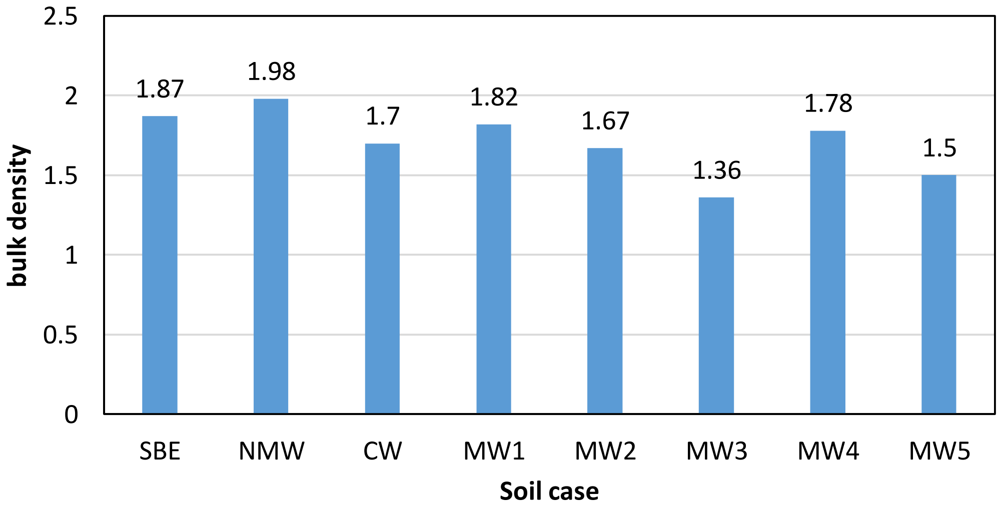

Figure 5.18: Bulk density for the soil.

Drop of bulk density varied between (2.70 and 27.30) %. Irrigation with magnetized water with strength of 3,000 g results in highest percentage of decline (27.30 %), whereas, in case of magnetized water with a strength of 1,000 g results in lowest value of reduction in bulk density of soil (mw3). Percentage decline for irrigation using river water (CW) is 9.10 %. When the soil is irrigated with salinized, non magnetized Almasab Alam water (NMW) (5.90 %), bulk density of soil rises due to increase in salt content in soil, which also causes the soil's porosity to drop and its surface crust to become harder. This finding is agree with refs **[AL-Ani S et al 2021, and Al-Wali RSS, 2005].**

5.5.2 Porosity

According to the findings in **Table 5.7,** irrigation by river water and irrigation using magnetized saline water from Almasab Alam both increase soil's porosity. When study area's soil irrigated using saline Almasab Alam water without magnetization, its porosity value drops. **Table 5.7** and **Figure 5.19** illustrate the percentages of soil porosity growth and decrease.

Table 5.7: Percentage of increase and decrease in amount of soil porosity.

Soil case	Porosity (%)	The difference with Porosity for SBE (%)
SBE	31	---
NMW	28	-9.60
CW	45	+45.16
MW1	32	+3.23
MW2	46	+48.39
MW3	51	+64.52
MW4	40	+29.03
MW5	48	+54.48

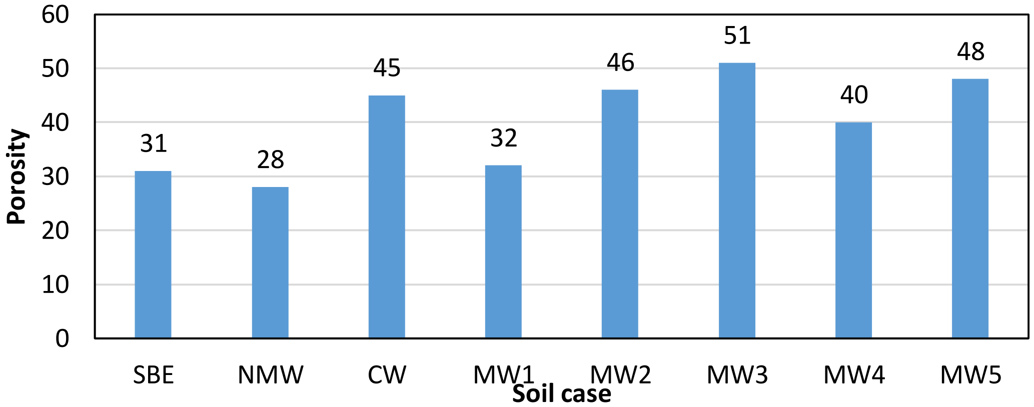

Figure 5.19: The porosity of the soil

The increment varied between (3.23 - 64.52) %. The increase in soil porosity that resulted from irrigation with 1,000 g of magnetized water (MW1) had the lowest value (3.23 %), whereas the rise that resulted from 3,000 g strength of magnetized water (mw3) had the highest percentage of increases (64.52%). The increase is 45.16% when using river water for irrigation (CW). The soil's porosity decreases as irrigated with saline, non-magnetized Almasab Alam water (NMW) (9.60 percent) due to increase in soil salts, which in turn causes a drop in porosity and an increase in hardening of soil's surface crust. This brings us back to significance of magnetized water in improving the physical properties of soil, as previously mentioned and as mentioned in [Al-Wali RSS, 2005] and as shown in **Table 5.6.**

By washing salts from root area, magnetism also aids in reducing the salinity impacts near the root area. The soil became more porous as a result of increased plant activity, root system penetration, and improvement. The bulk density of the soil decreased as its volume increased, which in turn caused its porosity to rise. These findings are observed when comparing the planting season's finish to the beginning. These findings are in line with findings from in **[Karkush MO, Ali SD, 2019],** which showed that increasing soil porosity increases soil structure improvement and increases penetration and spread of root system **[Hassan DF et al, 2016, Karkush MO, Ali SD, 2019].**

5.5.3 Permeability

According to the findings in **Table 5.8,** irrigation using river water and irrigation using magnetized Almasab Alam saline water both increase soil's permeability. While, as the study area's soil is irrigated using saline Almasab Alam water without magnetization, its porosity value fell. **Table 5.8** and **Figure 5.20** display the percentage increases and decreases in the soil's permeability.

Table 5.8: Percentage of increase and decrease in amount of soil permeability.

Soil case	Porosity (%)	The difference with Permeability for SBE (%)
SBE	1.18×10^{-6}	---
NMW	1.0×10^{-6}	-15.25
CW	2.98×10^{-4}	+251.54
MW1	1.20×10^{-6}	+16.95
MW2	3.80×10^{-4}	+321
MW3	7.70×10^{-4}	+651.54
MW4	4.30×10^{-5}	+35.44
MW5	5.12×10^{-4}	+432.89

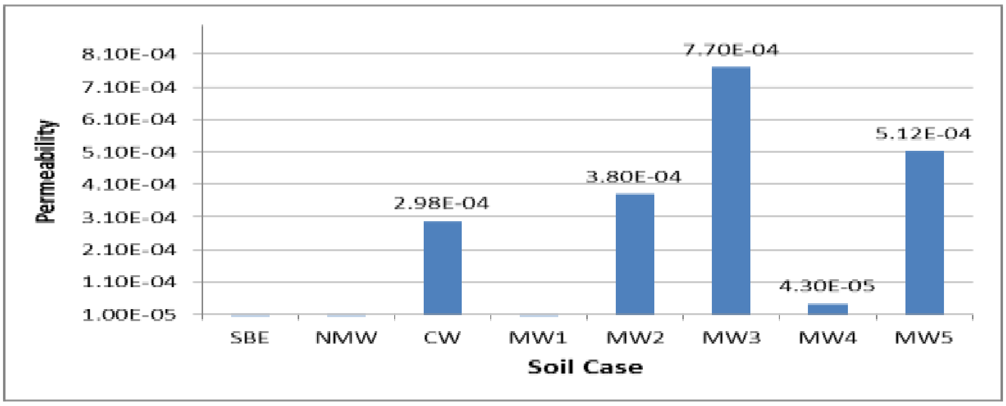

Figure 5.20: Permeability of soil.

Range of the permeability increase was (16.95 - 651.54)%. The permeability of the soil increases by the least amount (16.95 %) when magnetic water of 1,000 g (MW1) is used for irrigation, and by the most amount (651.54%) when magnetized water with 3,000 g is used for irrigation (mw3). Increase is 251.54 percent while using river water for irrigation (CW). Due to the increase in salt content and high bulk density of the non-magnetized Almasab Alam water (15.25%), permeability of soil decreases when it is irrigated. This brings up the importance of magnetized water of enhancing soil physical characteristics, which was discussed previously and detailed by **[Gallon PA 2004],** which is reflected in bulk density reduction, as illustrated in **Table 5.6.**

Since it remove salts from root area, magnetization also help to lessen impacts of salinity close to root area. The soil's porosity and permeability increased as a result of increased plant activity, root system penetration, and improvement. We observed higher porosity and permeability at end of planting season compared to the beginning due to the improved soil structure and volume, which resulted in a decrease in the bulk density. These outcomes are in line with those found in **[Gallon PA 2004],** which showed that increasing soil porosity derives from improving soil structure. The earth becomes more permeable as the root system spreads and penetrates it more **[Hassan DF et al, 2016, Karkush MO, Ali SD, 2019].**

5.5.4 Discussion

Results showed irrigation using magnetized water from Almasab Alam better than irrigation using river water in cases of 2,000, 3,000, and 7,000 G, and that the best increase occurred if magnetized water of intensity 3,000 g is used. According to **Gallon PA (2004) and AL-Ani S, et al (2021),** this is because magnetized water enhances the physical features of soil through improving soil structure and displacing detrimental salts effect out of root area.

When roots penetrate the soil, Utilizing magnetized water expands pore spaces volume per unit volume, increasing porosity and decreasing bulk density values.

As was said above, the rise in soil porosity and decrease in bulk density are causes of increased permeability of study area's soil. Additionally, research demonstrated that plant roots enhance the surface layer's porosity, decrease its bulk density, and release certain resinous compounds that strengthen the layer's structure. Because of moisture treatments, it results in a rise in permeability value as the plant grows. This what we had discovered at planting season end. Via studying findings of magnetization effect of Almasab Alam saline water on physical characteristics of research region soil, It is feasible to utilize this salt water, which is unsuitable for irrigating, particularly for delicate crops, after each growing season. Utilizing of magnetization technology for this water made it appropriate for irrigation, even for delicate crops, also it enhanced the physical characteristics of soil, making it arable soil after being highly saline and unusable for agriculture. Its concluded that severe water scarcity, particularly in Iraq, can be alleviated by applying water magnetization technology and saline water for irrigation.

Additionally, it is feasible to cultivate heavily salinized soils and convert them into arable land, particularly in Iraqi central and southern parts. Finest example is magnetized water with strength 3,000 G, which has consistently surpassed river water in improving qualities of soil. Any soil may be grown on employing magnetic technology, regardless of how salty it is, and any salinity of sewage water can be used as irrigation. The diagram in **Figure 5.21** is a summary of how magnetic water affects plant productivity.

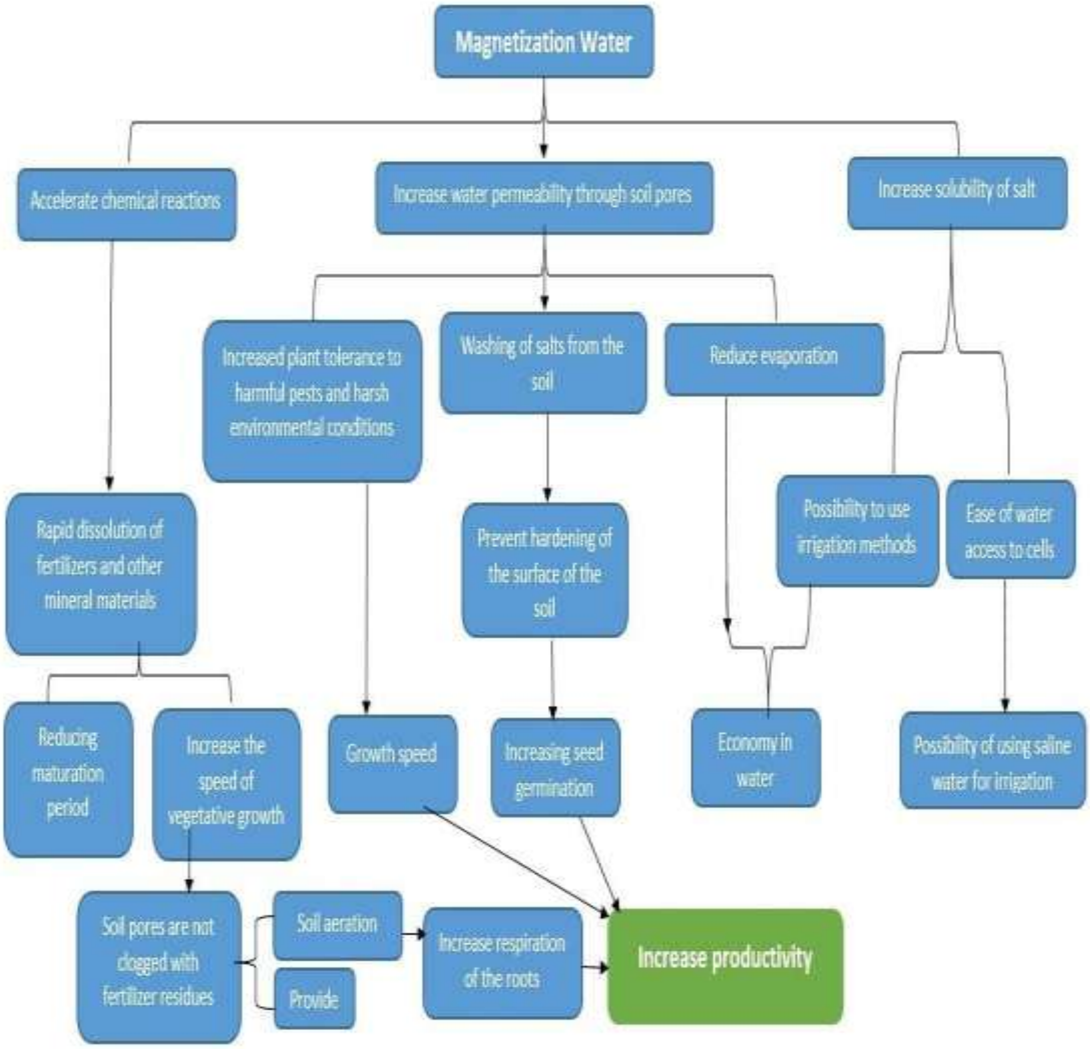

Figure 5.21: Diagram showing the effect of magnetized water on productivity

Chapter 6 Conclusions and Recommendations

6.1 Conclusions

The conclusions drawn from this study are summarized as follows:

6.1.1 For Evaluation

1. Almasab Alam water should be used for irrigation of plants with moderate to the high tolerance of salts with special salinity.
2. The soil must be washed after the end of the agricultural cycle of the cultivated crops.
3. The Water Quality Index (WQI) for Almasab Alam drainage water is a high restriction for the duration of the study.
4. The Irrigation Water Quality Guide (IWQG) developed, tested, and shown to be a reliable tool of estimating appropriateness and quality of irrigating water.
5. The application developed for this research will make it easy for farmers, designers, academics, and experts in water quality monitoring to plan, monitor, and assess water quality.

6.1.2 For Blending

1. From the results of blending for all stations, the best mixing ratio found is B1. The salinity becomes less than 3 for a duration of seven months from December 2020 to May 2021, so the water becomes suitable for irrigation according to the FAO. From May 2021 to the end of the present study the salinity becomes medium to high water.

2. For ratios B2 and B3, the salinity is more than 3 at all stations through the study duration, then the salinity of the water is medium to high. The water is unsuitable for irrigation according to FAO.

3. The amount of irrigation water increased by using the marginal water to reduce desertification by planting selected areas.

6.1.3 For Magnetization of water

6.1.3.1 Chemical properties of water

The present study focused on the impact of treatment with magnetic field on specific chemical characteristics of Almasab Alam saltwater. Therefore, these conclusions can be listed:

1. Magnitudes of chloride are decreased with increasing magnetic field intensity. The maximum ratio decreased by 10.03% occurring at a magnetic intensity of 3000 G.

2. The magnitudes of D0 are increased when passing through magnetic intensities. The maximum ratio increased by 14% at the magnetic intensity of 3000 G. This percentage improves the irrigation water and positively affects the respiration and growth of the root system. In addition, this feature can be used by the owners of fish lakes to get rid of the problem of fish deaths due to the lack of dissolved oxygen.

3. The magnitudes of Po4 and No3 are increased when passing through magnetic intensities. The maximum ratio increased 166.67% for Po4 and 42.30% for No3 occurred when the saltwater of Almasab Alam passed through a 3000 G magnetic field. This percentage improves the irrigation water and positively affects the plants' growth. An increase in phosphate and nitrate is an important fertilizer for plants.

6.1.3.2 Physical properties of water

In the work, the magnetic field treatment affect on selected of Almasab Alamsalt water physical properties. Based on the results obtained, these conclusions can be presented:

1. Almasab Alam salt water's density, boiling point, and evaporation amount are reduced by magnetization, and the degree of water solubility is increased.
2. The qualities of agricultural soil improved by increasing water solubility.
3. The surface tension of Almasab Alam water decreases when it passes through a magnetic field and the largest value of the drop is 28.19%, which occurred when the water passed through a magnetic field of the intensity of 3000 G. The lowest value of decrease is 1.70% when it passes through a magnetic field of intensity 1000 G.
4. The viscosity of Almasab Alam water decreases when it is magnetized and the largest value of the drop is 12.90% when it passes through a magnetic field of 3000 G and the lowest value of the decrease is 1.81% when it passes through the magnetic field of 1000 G.
5. It has been proven that there is a direct relationship between the surface tension and viscosity of the Almasab Alam water when it is exposed to a magnetic field of different intensities.

6.1.4 For Soil

6.1.4.1 Physical properties

According to the results of experimental test, these conclusions can be drawn:

1. The soil bulk density decreased, while, soil permeability and porosity increased after irrigated by magnetized water of Almasab Alam and river.
2. Largest percentage drop of bulk soil density 27.30%, and largest percentage increases in permeability and porosity are (64.52 and 651.54)% respectively, as 3,000G magnetized water is utilized.
3. For irrigation in the research region, magnetized water with 3,000 G is advised and is regarded as the best option among all other options, including irrigating by river water.
4. The research area's soil qualities were harmed by the usage of saline Almasab Alam water because it increased the crust's surface hardening.
5. Irrigation water suitable for irrigating crops can be produced from drainage water and saline Almasab Alam water utilizing magnetic technology, which alleviating the water shortage in the research area.
6. Improving the research area's soil's density, permeability, and porosity by irrigating it with water that uses a magnetic field and wash them or plant them with crops.

6.1.4.2 Chemical properties

The impact of magnetic field remediation on chemical characteristics of the soil was investigated. The following are the findings of the investigation:

1. The amount of salinity, positive and negative ions, and the interaction of the soil in all cases of magnetized water, as well as the state of river water,

decreases, and increases in the case of Almasab Alam non-magnetized water.

2. The values of plant nutrients NO_3, PO_4, and K decrease in the soil at the end of the growing season for all cases of magnetized water, as well as river water, and highest decrease percentage happens when strength of magnetized water was 3000 G.
3. Utilizing non magnetized saline water from Almasab Alam in investigation location damaged soil chemical properties and increase surface crust hardening.
4. It was discovered that, by utilizing magnetic technology it possible to obtain water suitable for irrigating crops from drainage water and saline Almasab Alam water and overcoming water scarcity. Also, by washing the investigation location or planting it with crops using a magnetic irrigation technique, the chemical properties of the area can be improved.
5. Magnetically treated water in the case of MW3 (3000) G can wash (70%) of the salts in the soil compared to (35.75%) for regular river water.

6.1.5 For Plants

1. The average minimum duration time of flowering is 16 days less than the duration time of flowering in river water (control). Early flowering leads to early production of the plant, this in turn leads to a reduction in the duration of plant care in terms of the amount of water and fertilizer used for it, and thus the economic return increases in this case.
2. It concludes from this study that we were able to obtain suitable water for irrigation from unsuitable water by using magnetic water technology. This leads to an increase in water suitable for irrigation, an increase in the area of cultivated land, and a decrease in desertification and drought in Iraq, especially in the central and southern regions. Due to the lack of rain over

these years. It is possible to benefit from the water of the drainage and groundwater in this country.

3. Among these important results is that the condition of irrigation with magnetized water with an intensity of 3000 G is the best for all the plants on which the study was conducted in terms of the percentage of germination, height, and duration of flowering for these plants, as well as the length of the roots for onion plants.
4. Through the results of the current study, which was conducted for two agricultural seasons, it was found that the results of the second season are almost identical to the results of the first season, and this gives strength to the results of the study.
5. The best treatment for Almasab Alam water is the magnetization method.

6.2 *Recommendations*

1. Using magnetization of different intensities and types to know their effect on water, soil, and plants.
2. Conducting field studies and different crops to find out the response and ability to adapt water properties and their impact on the production process.
3. The necessity of encouraging local manufacturers to produce technology in line with the country's environmental conditions and to reduce its price.
4. The use of magnetization with fertilizers and its ability to increase productivity.
5. Attempting to know the ability of magnetic technology to reduce the quantities of fertilizers used.
6. Using magnetic technology to treat water in soils that suffer from alkalinity problems and knowing the effect of technology on acidic soils.

7. Conducting similar studies on other areas of the Almasab Alam, as well as on other Drainage and groundwater to benefit from this water.

8. Studying the effect of magnetization time and water flow velocity.

9. The use of magnetic technology in modern irrigation methods for the area of this study and its comparison with the results of this study.

References

1. A. Abdel-Aziz, Y.A. Arafa and A. Sadik (2017). "Maximizing Water Use Efficiency for Some Plants by Treated Magnetic Water Technique under East Owainat Conditions, Egypt." J. Soil Sci. Vol. 57, No. 3, p: 353 – 369.

2. A. Nagaraju, E. Balaji, Y. Sreedhar, A. Thejaswi, and ZahedSharifi (2017). "Hydrochemical characterization of groundwater in around Tirupati Area, Chittoor District, Andhra Pradesh,South India." Appl Water Sci 7:1203–1212. DOI 10.1007/s13201-016-0448-6.

3. Hamd A.y , SardoK V., and Farrag Ghanem A. (2011)."Saline water in supplemental irrigation of wheat and barley under rainfed agriculture." African Journal of Biotechnology Vol. 10(53), pp. 10957-10963.

4. Aljawei, A.,and Kadhim N. K. (2012). "Feasibility of Blending Drainage water with River water for Irrigation in Nasiriyah." Msc thesis, College of Engineering, University of Babylon, IRAQ.

5. Abdul-Qados, A. and Hozayn, M. (2010). "Response of growth, yield, yield components, and some chemical constituents of flax for irrigation with magnetized and tap water." World Appl. Sci. J. 8, 630–634.

6. Abou El-Yazied, A., El-Gizawy, A.M., Khalf, S.M., El-Satar, and A., Shalaby, O.A. (2012). "Effect of magnetic field treatments for seeds and irrigation water as well as N, P and K levels on productivity of tomato plants." J Appl Sci Res 8, 2088–2099.

7. AL-Ani S, Karkush MO, Zhussupbekov A, and Al-Hity AA. (2021). "Influence of magnetized water on the geotechnical properties of expansive soil." In Modern applications of geotechnical engineering and construction. Singapore: Springer; p. 39–50.

8. Al-Gawthari, Hayawi (2006). "Effect of irrigation water quality, its magnetization and potassium fertilizer levels on some soil chemical

properties, growth and yield of maize." Master Thesis, Faculty of Agriculture, Baghdad University.

9. Al-Halfi, Asaad Rahman Saeed (20I0). "Magnetized water and its effect on food consumer health." Scientific Bulletin, College of Agriculture, University of Basra.

10. Ali M, et al. (2014). " Stress-dependent proteolytic processing of the actin assembly protein Lsb1 modulates a yeast prion." J BiolChem 289 (40): 27625-39.

11. Aljabali, Faeq Tawfiq (20I2). "Effect of magnetized irrigation water and fertilizer levels on yield characteristics of wheat the bread." Iraqi Journal of Agricultural Sciences.43 (04) 1–13.

12. Al-Jubouri, Aladdin Abdul Majid Ali and Hamza, Jalal Hamid (20I2). "Magnetic water treatment technology and its impact on the agricultural field." Scientific Bulletin, College of Agriculture, University of Baghdad, 22 p.

13. Al-Mawsili, Muzaffar Ahmad (20I3). "Magnetized water." Al-Yazuri Scientific Publishing and Distribution House, Jordan, 417 p.

14. Al-Sumaida'i, Buthaina Muhammad Hammoud (20I2). "Effect of magnetization of seeds and irrigation water on the tolerance of maize plant." Master's thesis, Diyala University, College of Education for Pure Sciences, Department of Life Sciences, 88 p.

15. Al-Talib, A. A. and Al-Sinjary, Z. A. (2009)."Effect of Magnetizing Water on Uniformity of Sprinkle Irrigation." Al-Rafidain Engineering Journal, Vol.17, No.1.

16. Al-Tikrity O. T. N. (2014). "Experimental Study of Effect of Magnetization of Water Supplied from Linear Trickle Source on Movement and Distribution of Moisture in Loamy Soil." M.Sc. thesis, Civil Eng. Department, Tikrit University.

17. Al-Wali, Rashad Shaker Sultan (2005). "The use of indicators of mixed soil erosion in determining the sites threatened by desertification in the south of Basra Governorate and its effects and methods of treatment." PhD thesis - College of Agriculture, University of Basra.

18. Amin, Sami Karim Muhammad and Qassem, Ali Farouk (2009). "Effect of salinity of magnetized irrigation water on growth characteristics Vegetative gerbera plant." Damascus University, Journal of Agricultural Sciences, 25 (1: 63 - 74).

19. Andrianov, A., and Orlov, E. (2018). "The assessment of magnetic water treatment on formation calcium scale on reverse osmosis membranes." MATEC Web of Conferences, 178, 09001.

20. Ayars J.E. (2002)." Field Crop Production in Areas with Saline Soil and Shallow Saline Ground Water." In: S.S. Goyal, S.K. Sharma & D.W.

21. Ayers R.S. and Westcot D.W.(1994). "Water Quality for Agriculture." FAO Irrigation and Drainage, 29.

22. Balibrea, M., M. C. Bolarin and F. Perez–Alfocea. (1999). "PEG. – Osmotic treatment in tomato seedling induces salt. " Adaptationin adult–plant Aust–plant physiol.

23. Bernstein, L. (1967)."Quantitative assessment of Irrigation water Quality." Special Technical Publication 416, Am. Soc. Test and Materials.

24. Bortolini, L., Maucieri, C., and Borin, M. (2018). "A tool for the evaluation of irrigation water quality in the arid and Semi-Arid regions." Agronomy 8 (2), 23.

25. Bressler, E. and Hoffman, G.J. (1986). "Irrigation management for soil salinity control:" theories and tests.

26. Butcher, K., Wick, A.F., DeSutter, T., Chatterjee, and A., Harmon, J. (2016). "Soil salinity: A threat to global food security." Agron. J. 108 (6), 2189–2200.

27. Daoud Y, and Halitrim A (1994). "Irrigation and Salinization in the Algerian." SahecaInstitute, National Agronomical EI Harrach, Algeria Sechae Resse, 5:3, 151-160.

28. Diaa F. Hassan, Rafal J. Mohammed, Alaa M. Akol, Esraa H. Abd, and Thameena F. Kadhim (2016**)."** Effect of Magnetization of Fresh and Salt Water for Irrigation in Some of the Physical Characteristics of the Soil and the Growth of Wheat." Copyright to IJIRSET, p: 61-72.

29. Elaoud, N. Turki, H. B. Amor, R. Jalel, and N. B. Salah(2016). “Influence of the magnetic device on water quality and production of melon”, International Journal of Current Engineering & Technology, Vol. 6, No. 6, pp. 2256-2260.

30. Ewaid, S.H.,(2018). "Irrigation water quality of Al-Gharraf Canal south of Iraq." IOP Conf. Ser., J. Phys., Conf. Ser. 1003 (2018), 012006.

31. F. Alimi, (2008). "Anti-scale Treatment of Hard Water by Magnetic Processes." PhD Thesis, National Institute of Applied Science and Technology, Tunisia.

32. Ghadiri, H., Hussein, J., Dordipour, E., and Rose, C.(2004). "The effect of soil salinity and sodicity on soil erodibility, sediment transport, and downstream water quality." In: 13th International Soil Conservation Organization Conference–Brisbane, pp. 1–6.

33. Grattan S.R. & Oster J.D. (2002). "Use and Reuse of Saline-sodic Waters for Irrigation of Crops." In: S.S. Goyal, S.K. Sharma & D.W. Rains (Eds) Crop Production in Saline Environments, Journal of Crop Production, Vol. 2, Haworth Press, New York.

34. Grewal, H.S. and Maheshwari, B.L. (2011). " Magnetic Treatment of Irrigation Water and Snow Pea and Chickpea Seeds Enhances Early Growth and Nutrient Contents of Seedlings." Bioelectromagnetics, 32, 58-65. http://dx.doi.org/10.1002/bem.20615.

35. Hamdy, A., V. Sardo and K.A. FarragGhanem (2005). "Saline water in supplemental irrigation of wheat and barley under rain fed agriculture." Agric. ICID 21st International Congress on Irrigation and Drainage, 15-23 October 2011, Tehran, Iran

36. He, Y., DeSutter, T., Casey, F., Clay, D., Franzen, D., and Steele, D., (2015). "Field capacity water as influenced by Na and EC: Implications for subsurface drainage." Geoderma 245, 83–88.

37. Hilal M. H.; El-Fakhrani, Y. M.; Mabrouk, S.S.; Mohamed, A.I. and Ebead, B.M.(2013). "Effect of Magnetic Treated Irrigation Water on Salt Removal From A Sandy Soil And on the Availability of Certain Nutrients." International Journal of Engineering and Applied Sciences, Vol. 2, No.2, p 36-44.

38. Hoffman, GJ (2006). "An evaluation of irrigation and salinity research programs along the River Murray." Australia, Cooperative Research centre for irrigation futures, viewed 25 June, http://www.irrigationfutures.org.au/imagesDB/news/

39. Holysz, L., Szczes, A. and Chibowski, E. (2007). "Effects of a static magnetic field on water and electrolyte solutions." Journal of Colloid and Interface Science, 316(2), pp.996-1002.

40. Kadhim N. K. (2013). "Feasibility of Blending Drainage Water With River Water For Irrigation In Samawa (Iraq)." IJCIET**,** Volume 4, Issue 5, September – October, pp. 22-32.

41. Kadhim N. K and Abbas (2013). "Feasibility Study of AL-Masab AL-Aam Water Drainage in ThiQar and Treatment for Irrigation." Journal of Water Resources and Ocean Science, Vol. 2, No. 5, pp. 84-89.

42. Kadhim N. K & Basima A. Jaber, (2013). "Treatment of water drainage for agriculture." Global Journal of Researches in Engineering, XIII Issue V, Version 2013.

43. Karkush M. O., Ahmed, M. D., & Al-Ani, S. M. (2019). " Magnetic field influence on the characteristics of water treated by reverse osmosis."

Engineering Technology Applied Science Research, 9(4), 4433-4439.

44. Kazem, R. Jawad, (2010). "The use of magnetized water in the reclamation of salt-affected soils." Mag al-furatagric sci., 2010, 2(2): 97–10.

45. Kazim, A. A. and Mehsin H. (1980b)**.** "Effect of application of sulfer by – products and saline water on growth and yield characteristics of tomato plants." Mesopotamina J. Agric., Vol. 15, No.2: 169–187.

46. Khalid M. and Elhindi (2020). "Effect of irrigation with saline magnetized water and different soil amendments on growth and flower production of Calendula officinalis L. plants." Saudi Journal of Biological Sciences 27 3072–3078.

47. Khan, TalibWali, Lafta, Mustafa Abdul-Hussein and Sa'yo, Imran Ahmad (20I2). "Qualitative assessment of water Jableh Al-Sabra cut off from the general estuary and its suitability for irrigation purposes." Alfat Journal of Agricultural Sciences.– 3 (2 :) 77 – 85.

48. Khattab, M.; M. Q. El - Torky; M. M. Mostafa and M. S.Doaa Reda (2000)**.** "Pretreatment of gladiluscormels to produce commercial yield: 1–Effect of GA3, sea water and magnetic system on the growth and corms production." Alex. J. Agric. Res. 45 (3): 181 – 199.

49. Kiremit, M.S. and Arslan, H., (2016). "Effects of irrigation water salinity on drainage water salinity evapotranspiration and another leek (Allium porrum L.) plant parameters." Sci. Horticulturae 201, 211–217.

50. Letey J. Dinar A. and Knapp K.C. (1985). "Crop-water production function model for saline irrigation waters." Soil Science Society of America Journal.

51. Letey, J. and G. L. Feng. (2007). "Dynamic versus steady-state approaches to evaluate irrigation management of saline waters." Agric. Water Manage, 91:1–10.

52. M.C. Amiri and A. A. Dadkhah (2006). "On reduction in the surface tension of water due to magnetic treatment." Colloids and Surfaces A: Physicochemical and Engineering Aspects, 278 (1 - 3) 252–255.

53. Maas E.V. and Grattan S.R. (1999). "Crop yields as affected by salinity." In: R.W. Skaggs and J. van Schilfgaarde (Eds) Agricultural Drainage (pp 55–108).

54. Maheshwari, B.L. and Grewal, H.S. (2009). "Magnetic treatment of irrigation water: Its effects on vegetable crop yield and water productivity." Agric water Manag 96, 1229–1236.

55. Mahmood S. and Usman M. (2014). "Consequences of magnetized water application on maize seed emergence in sand culture." J. Agric. Sci. Tech. 16, 47–55.

56. Mahmoud Hozayn, Amany Attia Abd El Monem Tarek Abd El-Fatah Elwia Maha Mohamed El-Shatar (2014). "Future of Magnetic Agriculture in arid and semi-arid regions (Case Study)." scientific papers. Series A. agronomy, Vol. LVII.

57. Makhmoudov, E. (1998). "Report of the water problem Institute at the science academy of the Republic of Uzbaekistan on application of magnetic technologies for Irrigation of cotton plants." Magnetic technologies (L. L. C.) www.magneticceast.com.

58. Mitchell J.P., Shennan C., Singer M.J., Peters D., Miller R.O., Prichard T., Grattan S.R., Rhoades J.D., May D.M. and Munk D. (2000). "Impacts of gypsum and winter cover crops on soil physical properties and crop productivity when irrigated with saline water." Agriculture and Water Management.

59. Mohamed, A.I., Ebead, B.M. (2013). "Effect of magnetic treated irrigation water on salt removal from a sandy soil and on the availability of certain nutrients." Int J Eng 2, 2305–8269.

60. Seilsepour M., Rashidi M. and Borzoo G. K. (2009). "Prediction of Soil

Exchangeable Sodium Percentage Based on Soil Sodium Adsorption Ratio." American-Eurasian J. Agric. and Environ. Sci., 5 (1): 01-04.

61. Mousa, A. M. and Hmed, A. S. (2008). "The Effect of Magnetic Water on Dissolving Kidney Stone." Eng. & Tech. Journal, Vol. 26, No. 5.

62. Muhammed, Diaa Abed (20I4). "Effect of magnetically treated water and drip irrigation water depth on growth and yield Cucumber in greenhouses." Diyala Journal of Agricultural Sciences, 6 (1) 179 – 186.

63. Mulook Al-Khazan, Batoul Mohamed Abdullatif and Nabila Al-Assaf (2011). "Effects of magnetically treated water on water status, chlorophyll pigments and some elements content of Jojoba (Simmondsia Chinensis L.) at different growth stages." African Journal of Environmental Science and Technology Vol. 5(9), pp. 722-731.

64. Muzahem, Mahmoud Abdel-Ani, Iftikhar Abdel-Gawad and Marei, Nadia Ahmed (20I5). "Impact of technology applications Magnetism in the treatment of saline well water for use in the irrigation of wheat and barley.Northern Iraq." Babylon University Journal, Pure and applied sciences, 23(1): 278-286.

65. Nada Elloumi, Mohamed Zouari, Nesrine Fakhri, Hasan Youssef Mehdaoui, Leila Chaari, Ferjani Ben Abdallah and Monem Kallel**.** (2018). "Effects of Magnetic Saline Water Application for Improving Physiological Parameters of Tomato (Solanum Lycopersicum) Seedlings**."** Ethiopian Journal of Environmental Studies & Management 11(2): 131–143.

66. Oster J.D., Kaffka S.R., Shannon M.C. and Grattan S.R. (1999a). "Saline-sodic drainage water: A resource for forage production." Proceedings of 17th International Congress on Irrigation and Drainage, 11–19 Sept., Granada, Spain.

67. Pang, X.F. and Deng, B. (2008). "The changes of macroscopic features and microscopic structures of water under influence of magnetic field." Physica B: Condensed Matter, 403(19-20), pp.3571-3577.

68. Paul Galland and Alexander Pazur ((2005). " Magnetoreception in plant." J Plant Res 118:371–389.

69. R. Cai, H. Yang, J. He and W. Zhu (2009). "The Effects of Magnetic Fields on Water Molecular Hydrogen Bonds." Journal of Molecular Structure, 938:15-19.

70. Rasool,R. and Younis, H. (2012). "Effect of magnetic field and magnetized water on the growth and yield of white maize." Journal of Education And Science, Volume 25, Issue 1, Pages 85-95. doi:10.33899/edusj.2012.58985.

71. Rasheedi, Eman N, Ibrahim I. H. Al-Mashhadani, Khalid A. Rasheedi, Eman N. Ismail, and Salah M. Hassan. (2016). "Effect of Magnetic Water Treatment on Salt Tolerance of Selected Wheat Cultivars." Int. Environmental Application and Science, Vol. 11(1): 105-109.

72. Ratushnyak A.,A. Andreeva and M.GMorozova O.V (2008). "Effect of extremely high frequency electromagnetic fields on the microbiological community in rhizosphere of plants." Int. Agrophysics, 22, 71-74.

73. Rhoades J.D., Bingham F.T., Letey J., Hoffman G.J., Dedrick A.R., Pinter P.J. and Replogle J.A. (1977). "Use of saline drainage water for irrigation: Imperial Valley Study." Agric. Water Management 16: 26–36.

74. S. Alikamanoglu and Sen (2011). "Stimulation of growth and some biochemical parameters by magnetic field in wheat (Triticumaestivum L.) tissue cultures." African Journal of Biotechnology Vol. 10(53), pp. 10957-10963, 14 September.

75. S. Ferraris, B. U. Choudhury, R. W. Ashton, D. S. Powlson, and W. R. Whalley (2018). "The effect of microbial activity on soil water diffusivity." Eur J Soil Sci. May; 69(3): 407–413. doi: 10.1111/ejss.12535.

76. Shennan C., Grattan S.R., May D.M., Hillhouse C.J., Schactman D.P., Wander M., Roberts B., Burau R.G., Mc Neish C. & Zelinski L. (1995). "Feasibility of cyclic reuse of saline drainage in a tomato-cotton rotation.

Journal of Environmental Quality." Journal of environmental quality (USA),Vol. 24 (3), pp. 476-486.

77. Takashinko, Y. (1997). "Hydromagnetic systems and their role in creating microclimate." International symposium on sustainable management of salt affected soil. Cairo, Egypt, 22–28 sept. DOI:10.1016/j.molstruc.2008.01.010.

78. Toledo, E.J., Ramalho, T.C. and Magriotis, Z.M., (2008). "Influence of magnetic field on physical–chemical properties of the liquid water: Insights from experimental and theoretical models." Journal of Molecular Structure, Volume 888, Issue 1, p. 409-415.

79. Van Genuchten, MT and Hoffman, GJ (1984). "Analysis of crop salt tolerance data." In I and J Shalhevet (eds), Soil Salinity Under Irrigation, Processes and Management, Springer Verlag, New York, pp. 258 - 271.

80. Van Hoorn, J.W. (1991). "Saline irrigation problems and perspectives." Proceedings European Mediterranean Conference on the Use of Saline Water in Irrigation: 25-26 July, Bari-Italy.

81. Van Iepern W. (1996)**. "**Effects of different day and night salinity levels on vegetative growth, yield and quality of tomato." J. Hort. Sci., 71: 99 – 111.

82. Wang, Y., Zhang, B., Gong, Z., Gao, K., Ou, Y. and Zhang, J. (2013). "The effect of a static magnetic field on the hydrogen bonding in water using frictional experiments." Journal of Molecular Structure, 1052, pp.102-104.

83. Wichelns D.W., Cone D. and Stuhr G. (1990). "Evaluating the impacts of irrigation and drainage policies on agricultural stability." Irrigation and Drainage Systems.

84. Yano, H., Y. Mazaki, K. Kurokawa, S.K. Hanks, M. Matsuda, and H. Sabe. (2004). "Roles played by a subset of integrin signaling molecules in cadherin-based cell–cell adhesion." J. Cell Biol. 166:283–295.

85. Yaohu Kang, Ming Chen, and Shuqin Wan (2010). "Effects of drip irrigation with saline water on waxy maize (Zea mays L. varceratinaKulesh) in North China Plain." Agric. Water Manage. 97 1303–1309.

86. Zacharia and Rardef (1981). "Practical Organic Chemistry." Dar Al Kutub Foundation for Printing and Publishing. Ministry of Higher Education and Scientific Research, University of Al Mosul.

87. Ziyad, Ali Mohsen, Al-Safi, Suleiman Ismail and Al-Mutawakel, Muhammad Qasim (20I5). "Expo water effect the magnetic field on some properties of concrete." Journal of Science and Technology, 20 (01) 22–42.

88. Zúñiga (2016). "Magnetic treatment of irrigation water and seeds in agriculture." Ing. compet, vol.18, no.2, Cali July/Dec, 2016**.**

Appendix A Results of the Study Area

Table A.1: Test results of the study area Sta. (360+00)

Month	Oct.	Nov.	DEC.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
EC(µs/cm)	5.13	5.84	4.98	5.18	5.3	6.10	6.20	9.40	11.6	6.98	7.94	6.32
TDS (ppm)	3295	3700	3185	3200	3400	3896	3925	5932	7418	4437	5070	3955
Cl (ppm)	781	568	560	561	781	892	1130	1376	1420	1295	1330	1295
So4 (ppm)	1325	823	2010	2041	1481	1540	1566	1720	2016	1700	1710	1210
Na^{+} (ppm)	370	392	379	368	396	406	490	492	510	491	462	450
K (ppm)	9.5	9.5	9.2	9.7	9.5	9.6	14.20	10.90	10.50	11.20	10	9.75
Mg^{+2}(ppm)	96	110.5	180	208	270	278	258	278	300	146	228	220
Ca^{+2} (ppm)	210	254.5	260	320	330	335	265	260	210	270	252	240
No3 (ppm)	1.1	1.3	1.33	1.32	2.40	6.4	9	3.20	2.81	8.51	6	5
Po4 (ppm)	0.20	0.27	0.30	1	0.11	0.26	0.30	0.31	0.13	0.30	0.35	0.25
PH	6.75	7.90	8	8.10	8.20	8.26	7.91	8	8.10	7.60	7.82	7.45
Do (ppm)	9	9.50	10.50	13.1	14.6	10.75	8.60	7.50	7	7.80	7.20	8.40

Table A.2: Test results of the study area Sta. (441+00)

Month	Oct.	Nov.	DEC.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
EC(µs/cm)	4.46	5.08	4.33	4.51	4.61	5.31	5.39	8.70	10.06	6.05	6.91	5.49
TDS (ppm)	2817	3210	2771	2781	2958	3389	3415	5192	6452	3860	4410	3440
Cl (ppm)	568	528	530	538	675	835	944	1270	1290	1216	1157	1126
So4 (ppm)	823	813	998	1100	1242	2820	1495	1685	1964	1636	1487	1052
Na^{+} (ppm)	328	340	332	329	370	381	480	480	494	481	401	391
K (ppm)	9.3	9.4	9.0	9.1	9.7	9.8	13.20	10.20	10.20	11	8.7	8.48
Mg^{+2}(ppm)	82	102	160	168	230	258	250	270	289	221	198	191
Ca^{+2} (ppm)	270	238	250	282	210	290	242	265	276	238	219	208
No3 (ppm)	1.2	1.23	1.18	1.41	2.2	5.80	2.10	1.30	1.60	3.40	5.22	4.35
Po4 (ppm)	0.16	0.22	0.30	0.90	0.24	0.21	0.20	0.12	0.30	0.12	0.30	0.22
PH	6.65	7.82	7.90	7.92	8.10	8.15	7.70	8	8	7.80	6.80	6.75
Do (ppm)	9.20	9.70	12	14	12	10	7.96	7.20	6.90	7.29	7.10	7.31

Table A.3: Test results of the study area Sta. (427+00)

Month	Oct.	Nov.	DEC.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
EC(µs/cm)	4.51	5.13	4.38	4.55	4.66	5.36	5.46	8.27	10.21	6.14	6.98	5.56
TDS(ppm)	2965	3302	2800	2806	2990	3329	3454	5220	6528	3905	4461	3480
Cl (ppm)	710	538	530	540	742	862	1007	1180	1328	1175	1170	1139
So4 (ppm)	1300	780	1972	1998	3027	3481	1500	1660	1970	1641	1504	1064
Na^{+} (ppm)	360	372	360	341	379	386	483	485	497	485	406	396
K (ppm)	9.2	9.1	9.0	9.2	9.0	9.6	13.80	10.30	10.30	11	8.8	8.58
Mg^{+2}(ppm)	70	102	165	187	254	268	250	270	290	145	200	193
Ca^{+2} ppm)	340	242	256	302	265	272	245	265	280	245	221	211
No3 (ppm)	2	1.10	1.20	1.20	2.01	5.98	4	1.80	1.90	4.20	5.28	4.4
Po4 (ppm)	0.68	0.20	0.30	0.91	0.10	0.21	0.32	0.29	0.28	0.30	0.32	0.22
PH	6.60	7.70	7.91	7.98	8.00	8.10	7.50	7.94	8.05	7.50	6.88	6.58
Do (ppm)	9	10.20	11.23	13.60	12	11	8	7.30	6.90	7.45	6.35	7.39

Table A.4: Test results of the study area Sta. (416+00)

Month	Oct.	Nov.	DEC.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
EC(µs/cm)	4.61	5.25	4.48	4.66	4.77	5.49	5.58	8.46	10.44	6.28	7.15	5.69
TDS (ppm)	2965	3292	2886	2895	3060	3506	3533	5339	6676	3993	4563	3559
Cl (ppm)	710	560	553	560	768	889	1080	1220	1350	1200	1197	1165
So4 (ppm)	1300	820	2001	2036	1460	1536	1522	1676	1982	1654	1539	1089
Na^{+} (ppm)	360	388	375	364	392	400	485	486	497	488	415.8	405
K (ppm)	9.2	9.3	9.0	9.7	9.5	9.6	13.80	10.50	10.50	11.20	9	8.78
Mg^{+2}(ppm)	70	108	175	199	268	277	252	270	291	145	205	198
Ca^{+2} (ppm)	340	250	262	321	270	279	247	265	283	250	226	216
No3 (ppm)	2	1.30	1.30	1.28	2.31	6.20	3	1	1	3.50	5.4	4.5
Po4 (ppm)	0.68	0.25	0.32	0.98	0.09	0.25	0.30	0.20	0.14	0.32	0.32	0.28
PH	6.60	7.73	7.96	8.00	8.10	8.15	7.70	7.98	8.05	7.52	7.10	6.78
Do (ppm)	9	10	11	13.25	15	10.68	8.40	7.50	7	7.50	6.48	7.56

Table A.5: Test results of the study area Sta. (399+00)

Month	Oct.	Nov.	DEC.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
EC(µs/cm)	4.81	5.48	4.58	4.65	4.98	5.73	5.83	8.84	10.90	6.56	7.46	5.94
TDS (ppm)	3100	3495	2994	3014	3196	3670	3690	5580	6945	4167	4765	3717
Cl (ppm)	776	567	554	560	776	887	1100	1299	1385	1235	1250	1217
So4 (ppm)	1320	819	2000	2038	1476	1538	1546	1700	2002	1680	1607	1137
Na^{+} (ppm)	370	390	375	366	392	403	490	490	500	488	434	423
K (ppm)	9.4	9.5	9.2	9.5	9.5	9.7	14	10.70	10.50	11.20	9.4	9.18
Mg^{+2} ppm)	90	110	178	205	270	275	255	275	296	145	214	211
Ca^{+2} (ppm)	208	250	260	318	326	335	248	270	288	245	239	225
No3 (ppm)	1.20	1.28	1.30	1.30	2.36	6.35	8	3	2.60	7.50	5.64	4.7
Po4 (ppm)	0.25	0.27	0.30	1.06	0.14	0.30	0.29	0.24	0.19	0.32	0.33	0.24
PH	6.67	7.84	7.96	8.10	8.18	8.25	7.70	7.95	8	7.52	7.35	7.03
Do (ppm)	9.20	10	10.60	13.20	12.54	10.80	8.50	7.50	7	7.70	6.76	7.91

Appendix B Results of Blending

BI: Blending of month results

Table BI.1: Station: 360+00, Month: Oct.

Water Type	River	Almasab	25%	50%	75%
EC(µs/cm)	1.09	5.13	2.15	3.01	4.28
TDS ppm)	730	3295	1385	1977	2768
Cl (ppm)	80	781	250	406	625
So4 (ppm)	304	1325	861	1205	1285
Na^{+} (ppm)	140	370	187	262	302
K (ppm)	8.2	9.5	8.6	8.6	9.3
Mg^{+2} (ppm)	20	96	56	59	67
Ca^{+2} (ppm)	236	210	99	122	172
No3 (ppm)	3	1.1	2.25	1.98	1.14
Po4 (ppm)	0.7	0.20	0.50	0.44	0.24
PH	7.5	6.75	7.07	7.15	7.34
Do (ppm)	14.56	9	12.78	11.25	9.50

Table BI.2: Station: 360+00, Month: Nov.

Water Type	River	Almasab	25%	50%	75%
EC(µs/cm)	0.97	5.84	2.45	3.5	4.91
TDS ppm)	665	3700	1774	2146	2214
Cl (ppm)	68	568	182	295	455
So4 (ppm)	295	823	538	750	792
Na^{+} (ppm)	142	392	196	276	321
K (ppm)	8.1	9.5	8.3	9.1	9.4
Mg^{+2} (ppm)	50	110.5	64	68	78
Ca^{+2} (ppm)	164	254.5	120	148	209
No3 (ppm)	1.4	1.3	1.36	1.34	1.31
Po4 (ppm)	0.72	0.27	0.52	0.45	0.30
PH	7.62	7.90	7.18	7.27	7.45
Do (ppm)	14.5	9.50	12.76	11.16	10. 50

Table BI.3: Station: 360+00, Month: DEC.

Water Type	River	Almasab	25%	50%	75%
EC(µs/cm)	0.98	4.98	2.04	2.91	4.08
TDS ppm)	680	3185	1306	1888	2640
Cl (ppm)	71	560	174	285	442
So4 (ppm)	304	2010	1286	1809	1930
Na^{+} (ppm)	140	379	194	270	312
K (ppm)	8.5	9.2	8.7	9.0	9.1
Mg^{+2} (ppm)	55	180	104	110	126
Ca^{+2} (ppm)	170	260	122	150	213
No3 (ppm)	1.7	1.33	1.48	1.42	1.35
Po4 (ppm)	0.74	0.30	0.60	0.48	0.35
PH	7.9	8	7.82	7.89	7.96
Do (ppm)	15.5	10.50	13.64	11.94	10.54

Table BI.4: Station: 360+00, Month: Jan.

Water Type	River	Almasab	25%	50%	75%
EC(µs/cm)	0.97	5.18	2.18	3.11	4.35
TDS ppm)	675	3200	1330	1914	2600
Cl (ppm)	70	561	179	281	448
So4 (ppm)	298	2041	1289	1860	1970
Na^{+} (ppm)	127	368	184	257	298
K (ppm)	8.0	9.7	8.2	9.1	9.5
Mg^{+2} (ppm)	57	208	121	127	146
Ca^{+2} (ppm)	172	320	152	188	268
No3 (ppm)	1.56	1.32	1.50	1.44	1.36
Po4 (ppm)	0.72	1	0.75	0.86	0.95
PH	7.88	8.10	7.92	7.99	8.05
Do (ppm)	15.56	13.10	14.70	14.01	13.75

Table BI.5: Station: 360+00, Month: Feb.

Water Type	River	Almasab	25%	50%	75%
EC(µs/cm)	0.97	5.3	2.23	3.20	4.47
TDS ppm)	664	3400	1428	2040	2865
Cl (ppm)	114	781	249	398	656
So4 (ppm)	271	1481	950	1348	1440
Na^{+} (ppm)	123	396	198	275	325
K (ppm)	8.0	9.5	8.2	8.9	9.2
Mg^{+2} (ppm)	40	270	155	162	187
Ca^{+2} (ppm)	220	330	155	191	257
No3 (ppm)	0.8	2.40	2.31	2.36	2.39
Po4 (ppm)	0.06	0.11	0.08	0.10	0.11
PH	8.10	8.20	8.12	8.14	8.18
Do (ppm)	15	14.60	14.90	14.75	14.57

Table BI.6: Station: 360+00, Month: Mar.

Water Type	River	Almasab	25%	50%	75%
EC(µs/cm)	1.13	6.10	2.56	3.7	5.12
TDS ppm)	717	3896	1597	2340	3233
Cl (ppm)	71	892	285	446	713
So4 (ppm)	296	1540	986	1416	1486
Na^{+} (ppm)	129	406	202	285	329
K (ppm)	11.0	9.6	10.7	10.3	9.8
Mg^{+2} (ppm)	60	278	156	165	189
Ca^{+2} (ppm)	230	335	158	193	260
No3 (ppm)	1.9	6.4	4.58	5.20	6.10
Po4 (ppm)	.58	0.26	0.48	0.40	0.29
PH	7.5	8.26	7.78	7.90	8.01
Do (ppm)	13.5	10.75	12.95	12	11.05

Table BI.7: Station: 360+00, Month: April

Water Type	River	Almasab	25%	50%	75%
EC(µs/cm)	1.08	6.20	2.48	3.60	5.10
TDS ppm)	675	3925	1570	2278	3224
Cl (ppm)	122	1130	239	565	892
So4 (ppm)	380	1566	982	1409	1503
Na^{+} (ppm)	132	490	245	343	402
K (ppm)	10	14.20	10.68	12.10	13.92
Mg^{+2} (ppm)	25	258	146	160	186
Ca^{+2} (ppm)	122	265	119	157	225
No3 (ppm)	2.05	9	3.54	6	7.58
Po4 (ppm)	0.15	0.30	0.18	0.22	0.28
PH	7	7.91	7.45	7.54	7.74
Do (ppm)	14.62	8.60	12.86	11.26	9.92

Table BI.8: Station: 360+00, Month: May

Water Type	River	Almasab	25%	50%	75%
EC(µs/cm)	1.07	9.40	3.76	5.45	7.72
TDS ppm)	690	5932	2370	3441	4866
Cl (ppm)	124	1376	412	688	1103
So4 (ppm)	380	1720	1085	1548	1652
Na^{+} (ppm)	121	492	246	344	394
K (ppm)	9.50	10.90	10	10.28	10.71
Mg^{+2} (ppm)	30	278	161	170	196
Ca^{+2} (ppm)	120	260	122	151	215
No3 (ppm)	3	3.20	3	3.01	3.15
Po4 (ppm)	0.12	0.31	0.18	0.25	0.29
PH	6.95	8	7.53	7.61	7.80
Do (ppm)	14.21	7.50	12.80	11.21	9.82

Table BI.9: Station: 360+00, Month: July

Water Type	River	Almasab	25%	50%	75%
EC(µs/cm)	1.15	6.98	2.79	4.05	5.73
TDS ppm)	732	4437	2129	2575	3640
Cl (ppm)	134	1295	388	648	1010
So4 (ppm)	436	1700	1071	1530	1632
Na^{+} (ppm)	124	491	245	344	393
K (ppm)	10	11.20	10	10.50	11.10
Mg^{+2} (ppm)	30	146	85	90	104
Ca^{+2} (ppm)	125	270	127	157	223
No3 (ppm)	1.22	8.51	3.10	5.10	7.94
Po4 (ppm)	0.10	0.30	0.18	0.20	0.26
PH	6.94	7.60	7.14	7.22	7.30
Do (ppm)	13.66	7.80	12.02	10.52	9.29

Table BI.10: Station: 360+00, Month: Aug.

Water Type	River	Almasab	25%	50%	75%
EC(µs/cm)	1.31	7.94	3.33	4.67	6.60
TDS ppm)	840	5070	2129	2042	4210
Cl (ppm)	132	1330	426	692	1064
So4 (ppm)	350	1710	1112	1556	1642
Na^{+} (ppm)	110	462	236	328	379
K (ppm)	10	10	6	6.80	8
Mg^{+2} (ppm)	30	228	137	141	167
Ca^{+2} (ppm)	120	252	124	152	210
No3 (ppm)	0.15	6	4.50	3.90	2.50
Po4 (ppm)	0.17	0.35	0.10	0.12	0.18
PH	6.98	7.82	7.37	7.47	7.65
Do (ppm)	15	7.20	13.40	11.75	10

Table BI.11: Station: 360+00, Month: Sept.

Water Type	River	Almasab	25%	50%	75%
EC(µs/cm)	1.33	6.32	2.65	3.92	5.30
TDS ppm)	850	3955	1661	2452	3322
Cl (ppm)	130	1295	415	777	1036
So4 (ppm)	320	1210	787	1101	1173
Na^{+} (ppm)	131	450	230	320	369
K (ppm)	10	9.75	6	7.20	8
Mg^{+2} (ppm)	22	220	132	136	158
Ca^{+2} (ppm)	116	240	117	144	200
No3 (ppm)	0.16	5	3.80	3.40	2
Po4 (ppm)	024	0.25	0.24	0.25	0.25
PH	7	7.45	7.02	711	7.30
Do (ppm)	16	8.40	14.40	12.50	11.20

Table BI.12: Station: 399+00, Month: Oct.

Water Type	River	Almasab	25%	50%	75%
EC(µs/cm)	0.98	4.81	1.92	2.79	3.92
TDS ppm)	670	3100	1226	1780	1512
Cl (ppm)	78	776	232	385	600
So4 (ppm)	297	1320	916	1310	1400
Na^{+} (ppm)	130	370	186	259	300
K (ppm)	8.0	9.4	8.4	8.8	9.3
Mg^{+2} (ppm)	15	90	52	55	63
Ca^{+2} (ppm)	230	208	98	121	171
No3 (ppm)	3	1.20	2.95	2.80	1.46
Po4 (ppm)	0.68	0.25	0.71	0.56	0.26
PH	7.2	6.67	6.90	6.82	6.70
Do (ppm)	15	9.20	14.10	13	10

Table BI.13: Station: 399+00, Month: Nov.

Water Type	River	Almasab	25%	50%	75%
EC(µs/cm)	0.94	5.48	2.19	3.18	4.49
TDS ppm)	627	3495	1398	2027	2865
Cl (ppm)	60	567	170	283	442
So4 (ppm)	265	819	516	737	786
Na^{+} (ppm)	120	390	195	273	316
K (ppm)	7.8	9.5	8.0	9.1	9.5
Mg^{+2} (ppm)	48	110	64	67	77
Ca^{+2} (ppm)	158	250	118	149	208
No3 (ppm)	1	1.28	1.26	1.28	1.29
Po4 (ppm)	0.66	0.27	0.58	0.42	0.28
PH	7.58	7.84	7.60	7.76	7.83
Do (ppm)	15.2	10	14.70	13.06	11.05

Table BI.14: Station: 399+00, Month: DEC.

Water Type	River	Almasab	25%	50%	75%
EC(µs/cm)	0.94	4.68	1.87	2.71	3.84
TDS ppm)	618	2994	1198	1736	2455
Cl (ppm)	60	554	166	277	432
So4 (ppm)	262	2000	1260	1800	1920
Na^{+} (ppm)	122	375	188	263	304
K (ppm)	7.7	9.2	8.0	8.7	9.2
Mg^{+2} (ppm)	45	178	103	109	125
Ca^{+2} (ppm)	155	260	122	151	213
No3 (ppm)	0.98	1.30	1	1.18	1.29
Po4 (ppm)	0.65	0.30	0.71	0.58	0.30
PH	7.60	7.96	7.68	7.81	7.95
Do (ppm)	15.2	10.60	14	12.92	11.20

Table BI.15: Station: 399+00, Month: Jan.

Water Type	River	Almasab	25%	50%	75%
EC(µs/cm)	0.87	4.65	1.85	2.68	3.80
TDS ppm)	570	3014	1190	1730	2447
Cl (ppm)	75	560	168	280	435
So4 (ppm)	192	2038	1266	1820	1931
Na^+ (ppm)	118	366	184	260	300
K (ppm)	8.0	9.5	8.6	8.8	9.4
Mg^{+2} (ppm)	42	205	119	125	144
Ca^{+2} (ppm)	164	318	149	182	261
No3 (ppm)	1	1.30	1.15	1.20	1.27
Po4 (ppm)	0.62	1.06	0.70	0.82	1.05
PH	7.6	8.10	7.75	8	8.08
Do (ppm)	15.5	13.20	14.68	14.10	13.70

Table BI.16: Station: 399+00, Month: Feb.

Water Type	River	Almasab	25%	50%	75%
EC(µs/cm)	0.9	4.98	2.	2.9	4.01
TDS ppm)	576	3196	1312	1892	2645
Cl (ppm)	78	776	233	388	605
So4 (ppm)	206	1476	930	1328	1417
Na^+ (ppm)	120	392	196	274	318
K (ppm)	8.0	9.5	8.5	8.8	9.5
Mg^{+2} (ppm)	40	270	155	164	189
Ca^{+2} (ppm)	160	326	153	189	267
No3 (ppm)	2.5	2.36	2.41	2.37	2.34
Po4 (ppm)	0.06	0.14	0.10	0.12	0.14
PH	8.10	8.18	8.11	8.15	8.16
Do (ppm)	14.4	12.54	14	13.51	12.70

Table BI.17: Station: 399+00, Month: Mar.

Water Type	River	Almasab	25%	50%	75%
EC(µs/cm)	1.01	5.73	2.29	3.32	4.70
TDS ppm)	686	3670	1468	2128	3009
Cl (ppm)	76	887	266	443	692
So4 (ppm)	305	1538	968	1384	1476
Na^{+} (ppm)	95	403	202	282	326
K (ppm)	9.7	11.4	10	10.5	11.2
Mg^{+2} (ppm)	56	275	160	168	192
Ca^{+2} (ppm)	228	335	157	194	275
No3 (ppm)	0.9	6.35	2.45	5.30	5.98
Po4 (ppm)	0.08	0.30	0.28	0.29	0.30
PH	7.48	8.25	7.50	8.09	8.22
Do (ppm)	14.20	10.80	13.86	12	11

Table BI.18: Station: 399+00, Month: April

Water Type	River	Almasab	25%	50%	75%
EC(µs/cm)	1.03	5.83	2.33	3.38	4.78
TDS ppm)	660	3690	1476	2142	3028
Cl (ppm)	120	1100	332	552	860
So4 (ppm)	372	1546	974	1420	1484
Na^{+} (ppm)	124	490	242	346	405
K (ppm)	10	14	11	1250	13.18
Mg^{+2} (ppm)	24	255	158	170	200
Ca^{+2} (ppm)	120	248	118	146	210
No3 (ppm)	3	8	3.85	6	6.78
Po4 (ppm)	0.14	0.29	0.18	0.25	0.28
PH	6.97	7.70	7.17	7.40	7.65
Do (ppm)	14.35	8.50	12.6	11.20	9.89

Table BI.19: Station: 399+00, Month: May

Water Type	River	Almasab	25%	50%	75%
EC(µs/cm)	1.05	8.84	3.52	5.13	7.25
TDS ppm)	680	5580	2230	3236	4577
Cl (ppm)	122	1299	390	652	1040
So4 (ppm)	375	1700	1076	1496	1649
Na^{+} (ppm)	120	490	239	347	404
K (ppm)	10	10.70	10.10	10.36	10.62
Mg^{+2} (ppm)	28	275	162	176	205
Ca^{+2} (ppm)	118	270	120	150	215
No3 (ppm)	3	3	3	3	3
Po4 (ppm)	0.12	0.24	0.17	0.20	0.23
PH	6.95	7.95	7.48	7.51	7.82
Do (ppm)	14.70	7.50	13.8	12	8.50

Table BI.20: Station: 399+00, Month: June

Water Type	River	Almasab	25%	50%	75%
EC(µs/cm)	1.32	10.90	4.36	6.32	8.94
TDS ppm)	810	6945	2778	4028	5695
Cl (ppm)	145	1385	416	693	1060
So4 (ppm)	442	2002	1261	1804	1922
Na^{+} (ppm)	125	500	250	351	485
K (ppm)	12	10.50	11.52	11.20	11
Mg^{+2} (ppm)	25	296	170	179	207
Ca^{+2} (ppm)	112	288	135	165	234
No3 (ppm)	1.20	2.60	1.40	1.95	2.57
Po4 (ppm)	0.10	0.19	0.10	0.16	0.19
PH	7	8	7.57	7.57	7.90
Do (ppm)	13	7	11.50	10	8.50

Table BI.21: Station: 399+00, Month: July

Water Type	River	Almasab	25%	50%	75%
EC(µs/cm)	1.12	6.56	2.60	3.80	5.40
TDS ppm)	720	4167	1666	2417	3417
Cl (ppm)	129	1235	358	666	988
So4 (ppm)	436	1680	1092	1512	1613
Na^{+} (ppm)	125	488	240	345	401
K (ppm)	10	11.20	10.20	10.90	11.15
Mg^{+2} (ppm)	30	145	92	95	113
Ca^{+2} (ppm)	123	245	122	153	218
No3 (ppm)	1.20	7.50	3.20	4.56	7
Po4 (ppm)	0.08	0.32	0.10	0.24	0.30
PH	6.90	7.52	7	7.14	7.30
Do (ppm)	13.7	7.70	12.10	10.60	9.30

Table BI.22: Station: 399+00, Month: Aug.

Water Type	River	Almasab	25%	50%	75%
EC(µs/cm)	1.27	7.46	2.90	4.26	5.95
TDS ppm)	815	4765	1935	2662	3765
Cl (ppm)	132	1250	366	615	952
So4 (ppm)	435	1607	983	1410	1497
Na^{+} (ppm)	140	434	210	296	342
K (ppm)	10	9.4	5.52	6.30	7.20
Mg^{+2} (ppm)	18	214	120	128	151
Ca^{+2} (ppm)	124	239	108	136	193
No3 (ppm)	1.18	5.64	2.20	3.60	4.26
Po4 (ppm)	0.10	0.33	0.30	0.31	0.33
PH	6.92	7.35	6.72	6.80	6.98
Do (ppm)	13.75	6.76	12.20	10.46	9.21

Table BI.23: Station: 399+00, Month: Sept.

Water Type	River	Almasab	25%	50%	75%
EC(µs/cm)	1.25	5.94	2.30	3.32	4.71
TDS ppm)	800	3717	1396	2025	2867
Cl (ppm)	130	1217	356	592	896
So4 (ppm)	428	1137	675	970	1027
Na^{+} (ppm)	135	423	210	295	340
K (ppm)	11	9.18	5.67	7.50	8.10
Mg^{+2} (ppm)	22	211	106	127	148
Ca^{+2} (ppm)	130	225	101	120	173
No3 (ppm)	1.21	4.7	3.42	3.81	4.20
Po4 (ppm)	0.10	0.24	0.17	0.22	0.23
PH	6.90	7.03	6.72	6.85	6.92
Do (ppm)	14	7.91	12.4	10.71	9.46

Table BI.24: Station: 416+00, Month: Oct.

ater Type	River	Almasab	25%	50%	75%
EC(µs/cm)	0.98	4.61	1.84	2.67	3.78
TDS ppm)	670	2965	1186	1720	2431
Cl (ppm)	78	710	213	355	554
So4 (ppm)	297	1300	819	1172	1249
Na^{+} (ppm)	130	360	180	248	288
K (ppm)	8.0	9.2	8.5	8.8	9.0
Mg^{+2} (ppm)	15	70	40	43	48
Ca^{+2} (ppm)	230	340	160	197	278
No3 (ppm)	3	2	2.75	2.55	2
Po4 (ppm)	0.68	0.68	0.68	0.68	0.68
PH	7	6.60	6.92	6.70	6.62
Do (ppm)	15	9	13.56	12.48	10

Table BI.25: Station: 416+00, Month: Nov.

Water Type	River	Almasab	25%	50%	75%
EC(µs/cm)	0.94	5.25	2.1	3.04	4.3
TDS ppm)	627	3292	1317	1909	2700
Cl (ppm)	60	560	169	278	435
So4 (ppm)	265	820	516	738	787
Na^{+} (ppm)	120	388	194	271	314
K (ppm)	7.8	9.3	8.2	8.8	9.1
Mg^{+2} (ppm)	48	108	62	66	76
Ca^{+2} (ppm)	158	250	117	145	205
No3 (ppm)	1	1.30	1.15	1.22	1.28
Po4 (ppm)	0.66	0.25	0.57	0.43	0.30
PH	7.58	7.73	7.60	7.66	7.71
Do (ppm)	15.2	10	14.98	12.50	11.5

Table BI.26: Station: 416+00, Month: DEC.

Water Type	River	Almasab	25%	50%	75%
EC(µs/cm)	0.94	4.48	1.79	2.60	3.67
TDS ppm)	618	2886	1154	1675	2362
Cl (ppm)	60	553	170	280	438
So4 (ppm)	262	2001	1261	1800	1921
Na^{+} (ppm)	122	375	188	261	304
K (ppm)	7.7	9.0	8.0	8.8	9.0
Mg^{+2} (ppm)	45	175	101	106	123
Ca^{+2} (ppm)	155	262	123	152	215
No3 (ppm)	0.98	1.30	1.16	1.25	1.29
Po4 (ppm)	0.65	0.32	0.62	0.46	0.33
PH	7.60	7.96	7.65	7.77	7.94
Do (ppm)	15.2	11	14.10	13.25	12.10

Table BI.27: Station: 416+00, Month: Jan.

Water Type	River	Almasab	25%	50%	75%
EC(µs/cm)	0.87	4.66	1.86	2.7	3.82
TDS ppm)	570	2895	1160	1681	2366
Cl (ppm)	75	560	172	286	440
So4 (ppm)	192	2036	1266	1806	1928
Na^{+} (ppm)	118	364	182	256	298
K (ppm)	8.0	9.7	9.0	9.2	9.6
Mg^{+2} (ppm)	42	199	115	121	139
Ca^{+2} (ppm)	164	321	151	186	263
No3 (ppm)	1	1.28	1.10	1.22	1.30
Po4 (ppm)	0.62	0.98	0.70	0.82	0.97
PH	7.6	8.00	7.70	7.92	8
Do (ppm)	15.5	13.25	14.70	14.06	13.75

Table BI.28: Station: 416+00, Month: Feb.

Water Type	River	Almasab	25%	50%	75%
EC(µs/cm)	0.9	4.77	1.91	2.77	3.91
TDS ppm)	576	3060	1224	1775	2509
Cl (ppm)	78.1	768	230	384	599
So4 (ppm)	206	1460	920	1314	1402
Na^{+} (ppm)	120	392	196	239	274
K (ppm)	8.0	9.5	8.7	9.3	.95
Mg^{+2} (ppm)	40	268	155	163	188
Ca^{+2} (ppm)	160	270	127	156	221
No3 (ppm)	2.5	2.31	2.45	2.35	2.30
Po4 (ppm)	0.6	0.09	0.08	0.09	0.09
PH	8.10	8.10	8.10	8.10	8.10
Do (ppm)	13.4	12	13	12.81	12.50

Table BI.29: Station: 416+00, Month: Mar.

Water Type	River	Almasab	25%	50%	75%
EC(µs/cm)	1.01	5.49	2.20	3.18	4.50
TDS ppm)	686	3506	1402	2033	2875
Cl (ppm)	76	889	267	444	693
So4 (ppm)	305	1536	968	1382	1474
Na^{+} (ppm)	95	400	200	280	322
K (ppm)	9.5	11	10	10.5	11
Mg^{+2} (ppm)	56	277	161	169	194
Ca^{+2} (ppm)	228	279	131	162	229
No3 (ppm)	0.9	6.20	2.40	4.38	5.79
Po4 (ppm)	0.08	0.25	0.10	0.18	0.24
PH	7.48	8.15	7.80	7.96	8.12
Do (ppm)	14.20	10.68	13.85	12.62	10.71

Table BI.30: Station: 416+00, Month: April

Water Type	River	Almasab	25%	50%	75%
EC(µs/cm)	1.03	5.58	2.23	3.24	4.58
TDS ppm)	660	3533	1413	2052	2900
Cl (ppm)	120	1080	324	540	846
So4 (ppm)	372	1522	958	1362	1463
Na^{+} (ppm)	124	485	242	338	391
K (ppm)	10	13.80	10.98	12.35	13.10
Mg^{+2} (ppm)	24	252	145	156	180
Ca^{+2} (ppm)	120	247	117	145	210
No3 (ppm)	3	3	3	3	3
Po4 (ppm)	0.14	0.30	0.18	0.24	0.28
PH	6.97	7.70	7.20	7.42	7.63
Do (ppm)	14.35	8.40	12.62	11	10

Table BI.31: Station: 416+00, Month: May

Water Type	River	Almasab	25%	50%	75%
EC(µs/cm)	1.05	8.46	3.32	4.87	6.85
TDS ppm)	680	5339	2105	3040	4291
Cl (ppm)	122	1220	360	600	958
So4 (ppm)	375	1676	1000	2010	1670
Na^+ (ppm)	120	486	242	345	400
K (ppm)	10	10.50	10	10.10	10.50
Mg^{+2} (ppm)	28	270	160	171	201
Ca^{+2} (ppm)	118	265	131	156	221
No3 (ppm)	3	1	2.71	2	1.50
Po4 (ppm)	0.12	0.20	0.15	0.16	018
PH	6.95	7.98	7.50	7.57	7.78
Do (ppm)	14.70	7.50	13	11.20	9.87

Table BI.32: Station: 416+00, Month: June

Water Type	River	Almasab	25%	50%	75%
EC(µs/cm)	1.32	10.44	4.15	6	8.50
TDS ppm)	810	6676	2615	3790	5120
Cl (ppm)	145	1350	400	670	1056
So4 (ppm)	442	1982	1246	1780	1899
Na^+ (ppm)	125	497	249	352	402
K (ppm)	12	10.50	11.80	11.20	10.81
Mg^{+2} (ppm)	25	291	168	178	207
Ca^{+2} (ppm)	112	283	133	164	232
No3 (ppm)	1.20	1	1.10	1.10	1.08
Po4 (ppm)	0.10	0.14	0.10	0.12	0.13
PH	7	8.05	7.60	7.71	7.92
Do (ppm)	13	7	12.25	11	8

Table BI.33: Station: 416+00, Month: July

Water Type	River	Almasab	25%	50%	75%
EC(µs/cm)	1.12	6.28	2.53	3.60	5.10
TDS ppm)	720	3993	1610	2271	3212
Cl (ppm)	129	1200	360	590	924
So4 (ppm)	436	1654	1036	1462	1580
Na^{+} (ppm)	125	488	241	345	400
K (ppm)	10	11.20	10	10.82	11.12
Mg^{+2} (ppm)	30	145	90	93	112
Ca^{+2} (ppm)	123	250	120	151	215
No3 (ppm)	1.20	3.50	2.70	3.10	3.38
Po4 (ppm)	0.08	0.32	0.10	0.22	0.30
PH	6.90	7.52	7.10	7.16	7.40
Do (ppm)	13.7	7.50	12.40	10.60	8.80

Table BI.34: Station: 416+00, Month: Aug.

Water Type	River	Almasab	25%	50%	75%
EC(µs/cm)	1.27	7.15	2.86	4.15	5.86
TDS ppm)	815	4563	1920	2647	3741
Cl (ppm)	132	1197	359	600	934
So4 (ppm)	435	1539	970	1390	1477
Na^{+} (ppm)	140	415.8	208	290	336
K (ppm)	10	9	5.50	6	7.10
Mg^{+2} (ppm)	18	205	118	125	144
Ca^{+2} (ppm)	124	226	106	131	185
No3 (ppm)	1.18	5.4	2.16	3.56	4.05
Po4 (ppm)	0.10	0.32	0.31	0.32	0.32
PH	6.92	7.10	6.68	6.77	6.94
Do (ppm)	13.75	6.48	12.30	10.50	9.24

Table BI.35: Station: 416+00, Month: Sept.

Water Type	River	Almasab	25%	50%	75%
EC(µs/cm)	1.25	5.69	2.28	3.30	4.67
TDS ppm)	800	3559	1424	2065	2920
Cl (ppm)	130	1165	350	582	910
So4 (ppm)	428	1089	686	980	1045
Na^+ (ppm)	135	405	202	284	324
K (ppm)	11	8.78	5.10	5.27	6.25
Mg^{+2} (ppm)	22	198	115	121	140
Ca^{+2} (ppm)	130	216	101	125	177
No3 (ppm)	1.21	4.5	1.71	2.97	3.76
Po4 (ppm)	0.10	0.28	0.24	0.27	0.27
PH	6.90	6.78	6.39	6.46	6.63
Do (ppm)	14	7.56	13	11.20	10

Table BI.36: Station: 427+00, Month: Oct.

Water Type	River	Almasab	25%	50%	75%
EC(µs/cm)	0.98	4.51	1.90	2.70	3.81
TDS ppm)	670	2965	1186	1720	2428
Cl (ppm)	78	710	213	348	537
So4 (ppm)	297	1300	819	1170	1248
Na^+ (ppm)	130	360	180	252	292
K (ppm)	8.0	9.2	8.2	8.6	9.0
Mg^{+2} (ppm)	15	70	41	43	49
Ca^{+2} (ppm)	230	340	160	197	279
No3 (ppm)	3	2	2.85	2.71	2.20
Po4 (ppm)	0.68	0.68	0.68	0.68	0.68
PH	7	6.60	6.98	6.81	6.62
Do (ppm)	15	9	13.82	11.52	10

Table BI.37: Station: 427+00, Month: Nov.

Water Type	River	Almasab	25%	50%	75%
EC(µs/cm)	0.94	5.13	2.2	3.1	4.30
TDS ppm)	627	3302	1585	1915	2674
Cl (ppm)	60	538	167	278	438
So4 (ppm)	265	780	491	702	748
Na^{+} (ppm)	120	372	186	260	301
K (ppm)	7.8	9.1	8.0	8.6	9.0
Mg^{+2} (ppm)	48	102	59	62	71
Ca^{+2} (ppm)	158	242	114	140	198
No3 (ppm)	1	1.10	1.02	1.08	1.10
Po4 (ppm)	0.66	0.20	0.64	0.40	0.23
PH	7.58	7.70	7.60	7.64	7.70
Do (ppm)	15.2	10.20	14.82	11.80	10.70

Table BI.38: Station: 427+00, Month: DEC.

Water Type	River	Almasab	25%	50%	75%
EC(µs/cm)	0.94	4.38	1.75	2.54	3.6
TDS ppm)	618	2800	1110	1614	2279
Cl (ppm)	60	530	160	270	413
So4 (ppm)	262	1972	1242	1784	1903
Na^{+} (ppm)	122	360	180	252	292
K (ppm)	7.7	9.0	8.0	8.6	8.9
Mg^{+2} (ppm)	45	165	96	101	116
Ca^{+2} (ppm)	155	256	120	148	210
No3 (ppm)	0.98	1.20	1	1.12	1.18
Po4 (ppm)	0.65	0.30	0.60	0.45	0.32
PH	7.6	7.91	7.63	7.78	7.89
Do (ppm)	15.2	11.23	15	13.20	11.30

Table BI.39: Station: 427+00, Month: Jan.

Water Type	River	Almasab	25%	50%	75%
EC(µs/cm)	0.87	4.55	1.91	2.73	3.85
TDS ppm)	570	2806	1115	1618	2286
Cl (ppm)	75	540	161	272	418
So4 (ppm)	192	1998	1258	1798	1918
Na^{+} (ppm)	118	341	170	239	276
K (ppm)	8.0	9.2	8.2	8.8	9.1
Mg^{+2} (ppm)	42	187	108	114	131
Ca^{+2} (ppm)	164	302	142	175	248
No3 (ppm)	1	1.20	1.08	1.14	1.20
Po4 (ppm)	0.62	0.91	0.64	0.76	0.90
PH	7.6	7.98	7.62	7.77	7.96
Do (ppm)	15.5	13.60	15	14.22	13.65

Table BI.40: Station: 427+00, Month: Feb.

Water Type	River	Almasab	25%	50%	75%
EC(µs/cm)	0-9	4.66	1.86	2.7	3.82
TDS ppm)	576	2990	1196	1734	2452
Cl (ppm)	7810	742	222	371	578
So4 (ppm)	206	3027	1907	2724	2906
Na^{+} (ppm)	120	379	190	265	306
K (ppm)	8.0	9.0	8.3	8.6	8.9
Mg^{+2} (ppm)	40	254	147	155	178
Ca^{+2} (ppm)	160	265	124	154	217
No3 (ppm)	2.5	2.01	2.48	2.29	2.01
Po4 (ppm)	0.06	0.10	0.07	0.09	0.10
PH	8.1	8.00	8.05	8.02	8
Do (ppm)	13.4	12	13	12.62	12.15

Table BI.41: Station: 427+00, Month: Mar.

Water Type	River	Almasab	25%	50%	75%
EC(µs/cm)	1.01	5.36	2.24	3.22	4.5
TDS ppm)	686	3329	1591	1930	2729
Cl (ppm)	76	862	258	431	672
So4 (ppm)	305	3481	2193	3132	3342
Na^{+} (ppm)	95	386	193	270	312
K (ppm)	9	9.6	9.1	9.3	9.4
Mg^{+2} (ppm)	56	268	155	163	188
Ca^{+2} (ppm)	228	272	127	158	223
No3 (ppm)	0.90	5.98	3.98	4.70	5.90
Po4 (ppm)	0.08	0.21	0.10	0.18	0.21
PH	7.48	8.10	7.78	7.85	8.05
Do (ppm)	14.2	11	14	13.20	12

Table BI.42: Station: 427+00, Month: April

Water Type	River	Almasab	25%	50%	75%
EC(µs/cm)	1.03	5.46	2.18	3.17	4.48
TDS ppm)	660	3454	1380	1970	2836
Cl (ppm)	120	1007	302	504	791
So4 (ppm)	372	1500	945	1350	1448
Na^{+} (ppm)	124	483	241	339	396
K (ppm)	10	13.80	11	11.75	13
Mg^{+2} (ppm)	24	250	143	154	179
Ca^{+2} (ppm)	120	245	115	142	209
No3 (ppm)	3	4	3.25	3.62	3.93
Po4 (ppm)	0.14	0.32	0.18	0.28	0.30
PH	6.97	7.50	7.07	7.15	7.34
Do (ppm)	14.35	8	12.54	10.97	9.60

Table BI.43: Station: 427+00, Month: May

Water Type	River	Almasab	25%	50%	75%
EC(µs/cm)	1.05	8.27	329	4.80	6.79
TDS ppm)	680	5220	2088	3028	4286
Cl (ppm)	122	1180	354	592	944
So4 (ppm)	375	1660	996	1997	1594
Na^{+} (ppm)	120	485	241	344	402
K (ppm)	10	10.30	10	10.18	10.28
Mg^{+2} (ppm)	28	270	162	173	202
Ca^{+2} (ppm)	118	265	132	159	223
No3 (ppm)	3	1.80	2.81	2.43	2
Po4 (ppm)	0.12	0.29	0.15	0.21	0.26
PH	6.95	7.94	7.48	7.57	7.75
Do (ppm)	14.70	7.30	13	11.31	9.91

Table BI.44: Station: 427+00, Month: June

Water Type	River	Almasab	25%	50%	75%
EC(µs/cm)	1.32	10.21	4.10	5.92	8.37
TDS ppm)	810	6528	2610	3788	5416
Cl (ppm)	145	1328	398	665	1050
So4 (ppm)	442	1970	1241	1775	1892
Na^{+} (ppm)	125	497	248	350	400
K (ppm)	12	10.30	11.79	11.21	10.78
Mg^{+2} (ppm)	25	290	168	177	206
Ca^{+2} (ppm)	112	280	131	164	230
No3 (ppm)	1.20	1.90	1.31	1.54	1.74
Po4 (ppm)	0.10	0.28	0.14	0.21	0.26
PH	7	8.05	7.58	7.67	7.87
Do (ppm)	13	6.90	12.14	10.50	9.22

Table BI.45: Station: 427+00, Month: July

Water Type	River	Almasab	25%	50%	75%
EC(µs/cm)	1.12	6.14	2.51	3.56	5.04
TDS ppm)	720	3905	1604	2265	3202
Cl (ppm)	129	1175	350	587	917
So4 (ppm)	436	1641	1031	1460	1576
Na^+ (ppm)	125	485	238	340	399
K (ppm)	10	11	10	10.53	10.80
Mg^{+2} (ppm)	30	145	88	91	107
Ca^{+2} (ppm)	123	245	117	148	212
No3 (ppm)	1.20	4.20	1.80	3.65	4
Po4 (ppm)	0.08	0.30	0.10	0.18	0.30
PH	6.90	7.50	7.07	7.13	7.35
Do (ppm)	13.7	7.45	12.33	10.55	8.51

Table BI.46: Station: 427+00, Month: Aug.

Water Type	River	Almasab	25%	50%	75%
EC(µs/cm)	1.27	6.98	2.79	4.05	5.72
TDS ppm)	815	4461	1784	2587	3660
Cl (ppm)	132	1170	351	678	912
So4 (ppm)	435	1504	947	1354	1445
Na^+ (ppm)	140	406	204	284	329
K (ppm)	10	8.8	5.10	5.28	6.25
Mg^{+2} (ppm)	18	200	116	122	145
Ca^{+2} (ppm)	124	221	104	128	182
No3 (ppm)	1.18	5.28	2	3.50	3.98
Po4 (ppm)	0.10	0.32	0.32	0.32	0.32
PH	6.92	6.88	6.50	6.65	6.80
Do (ppm)	13.75	6.35	11.85	10.30	9.10

Table BI.47: Station: 427+00, Month: Sept.

Water Type	River	Almasab	25%	50%	75%
EC(µs/cm)	1.25	5.56	2.22	3.20	4.62
TDS ppm)	800	3480	1382	2000	2850
Cl (ppm)	130	1139	340	570	879
So4 (ppm)	428	1064	661	947	1007
Na^{+} (ppm)	135	396	195	277	315
K (ppm)	11	8.58	620	7.40	8.10
Mg^{+2} (ppm)	22	193	110	116	139
Ca^{+2} (ppm)	130	211	100	118	170
No3 (ppm)	1.21	4.4	3.42	3.80	4.10
Po4 (ppm)	0.10	0.22	0.14	0.16	0.21
PH	6.90	6.58	6.45	6.54	6.66
Do (ppm)	14	7.39	12	10.40	9.20

Table BI.48: Station: 441+00, Month: Oct.

Water Type	River	Almasab	25%	50%	75%
EC(µs/cm)	0.98	4.46	1.78	2.59	3.65
TDS ppm)	690	2817	1126	1633	2310
Cl (ppm)	78	568	1704	284	443
So4 (ppm)	297	823	518	741	790
Na^{+} (ppm)	130	328	164	230	266
K (ppm)	8.0	9.3	8.2	8.6	9.1
Mg^{+2} (ppm)	15	82	48	50	58
Ca^{+2} (ppm)	230	270	127	159	221
No3 (ppm)	3	1.2	2.82	2.28	1.40
Po4 (ppm)	0.68	0.16	0.60	0.54	0.35
PH	7	6.65	6.80	6.73	6.67
Do (ppm)	15	9.20	14.20	11.35	10

Table BI.49: Station: 441+00, Month: Nov.

Water Type	River	Almasab	25%	50%	75%
EC(µs/cm)	0.96	5.08	2.03	2.95	4.17
TDS ppm)	627	3210	1540	1862	2600
Cl (ppm)	60	528	158	264	410
So4 (ppm)	265	813	512	730	781
Na^{+} (ppm)	120	340	171	238	276
K (ppm)	7.8	9.4	8.2	8.7	9.0
Mg^{+2} (ppm)	48	102	59	62	72
Ca^{+2} (ppm)	158	238	112	138	195
No3 (ppm)	1	1.23	1.10	1.16	1.21
Po4 (ppm)	0.66	0.22	0.60	0.42	0.26
PH	7.58	7.82	7.64	7.72	7.80
Do (ppm)	15.20	9.70	14.60	12.10	10

Table BI.50: Station: 441+00, Month: Jan.

Water Type	River	Almasab	25%	50%	75%
EC(µs/cm)	0.87	4.51	1.80	2.62	3.70
TDS ppm)	570	2781	1112	1613	2280
Cl (ppm)	75	538	160	270	416
So4 (ppm)	192	1100	650	912	1006
Na^{+} (ppm)	118	329	165	230	267
K (ppm)	8.0	9.1	8.2	8.8	9.0
Mg^{+2} (ppm)	42	168	97	102	118
Ca^{+2} (ppm)	164	282	133	164	231
No3 (ppm)	1	1.41	1.20	1.30	1.39
Po4 (ppm)	0.62	0.90	0.68	0.76	0.85
PH	7.6	7.92	7.65	7.76	7.90
Do (ppm)	15.5	14	15	14.60	14.10

Table BI.51: Station: 441+00, Month: Feb.

Water Type	River	Almasab	25%	50%	75%
EC(µs/cm)	0.9	4.61	1.85	2.67	3.78
TDS ppm)	576	2958	1183	1715	2425
Cl (ppm)	78	675	201	337	526
So4 (ppm)	206	1242	782	1118	1192
Na^+ (ppm)	120	370	184	256	297
K (ppm)	8.0	9.7	8.5	9.0	9.6
Mg^{+2} (ppm)	40	230	135	141	163
Ca^{+2} (ppm)	160	210	99	122	174
No3 (ppm)	2.5	2.2	2.42	2.37	2.18
Po4 (ppm)	0.06	0.24	0.12	0.20	0.23
PH	8.10	8.10	8.10	8.10	8.10
Do (ppm)	14.4	12	14	13.02	12.60

Table BI.52: Station: 441+00, Month: Mar.

Water Type	River	Almasab	25%	50%	75%
EC(µs/cm)	1.1	5.31	2.12	3.08	4.35
TDS ppm)	686	3389	1356	1965	2780
Cl (ppm)	75	835	250	416	651
So4 (ppm)	305	2820	1776	2538	2707
Na^+ (ppm)	95	381	191	267	309
K (ppm)	9	9.8	9.1	9.4	9.7
Mg^{+2} (ppm)	56	258	150	157	181
Ca^{+2} (ppm)	228	290	136	170	243
No3 (ppm)	0.90	5.80	2.45	4.70	5.40
Po4 (ppm)	0.08	0.21	0.10	0.12	0.18
PH	7.48	8.15	7.60	7.81	8.10
Do (ppm)	14.2	10	13.45	12.50	11

Table BI.53: Station: 441+00, Month: April

Water Type	River	Almasab	25%	50%	75%
EC(µs/cm)	1.03	5.39	2.16	3.13	4.42
TDS ppm)	660	3415	1368	1985	2820
Cl (ppm)	120	944	280	475	745
So4 (ppm)	372	1495	940	1345	1436
Na^{+} (ppm)	124	480	241	336	390
K (ppm)	10	13.20	11.20	12.10	13
Mg^{+2} (ppm)	24	250	145	153	178
Ca^{+2} (ppm)	120	242	132	149	200
No3 (ppm)	3	2.10	2.81	2.51	2.23
Po4 (ppm)	0.14	0.20	0.17	0.16	0.18
PH	6.97	7.70	7	7.12	7.65
Do (ppm)	14.35	7.96	13	11.36	10

Table BI.54: Station: 441+00, Month: May

Water Type	River	Almasab	25%	50%	75%
EC(µs/cm)	1.05	8.70	3.48	5.13	7.20
TDS ppm)	680	5192	2128	3064	4312
Cl (ppm)	122	1270	394	648	1058
So4 (ppm)	375	1685	1078	1518	1620
Na^{+} (ppm)	120	480	242	340	390
K (ppm)	10	10.20	10	10	10.20
Mg^{+2} (ppm)	28	270	150	156	180
Ca^{+2} (ppm)	118	265	135	148	210
No3 (ppm)	3	1.30	2.90	2.61	2.25
Po4 (ppm)	0.12	0.12	0.12	0.12	0.12
PH	6.95	8	7.51	7.62	7.83
Do (ppm)	14.70	7.20	12.90	11.30	10

Table BI.55: Station: 441+00, Month: June

Water Type	River	Almasab	25%	50%	75%
EC(µs/cm)	1.32	10.06	4.02	5.84	8.28
TDS ppm)	810	6452	2576	3868	5355
Cl (ppm)	145	1290	412	657	1032
So4 (ppm)	442	1964	1276	1768	1866
Na^{+} (ppm)	125	494	256	350	395
K (ppm)	12	10.20	11.70	11.10	10.57
Mg^{+2} (ppm)	25	289	170	179	208
Ca^{+2} (ppm)	112	276	140	162	193
No3 (ppm)	1.20	1.60	1.28	1.39	1.49
Po4 (ppm)	0.10	0.30	0.25	0.28	0.30
PH	7	8	7.54	7.62	7.83
Do (ppm)	13	6.90	11.88	10.55	9.78

Table BI.56: Station: 441+00, Month: July

Water Type	River	Almasab	25%	50%	75%
EC(µs/cm)	1.12	6.05	2.40	3.45	4.90
TDS ppm)	720	3860	1544	2200	3128
Cl (ppm)	129	1216	365	608	962
So4 (ppm)	436	1636	1030	1472	1573
Na^{+} (ppm)	125	481	240	337	385
K (ppm)	10	11	10.10	10.50	11
Mg^{+2} (ppm)	30	221	130	139	156
Ca^{+2} (ppm)	123	238	110	138	198
No3 (ppm)	1.20	3.40	1.42	2.75	3.12
Po4 (ppm)	0.08	0.12	0.09	0.10	0.11
PH	6.90	7.80	7.34	7.44	7.64
Do (ppm)	13.7	7.29	12.10	10.55	9.30

Table BI.57: Station: 441+00, Month: Aug.

Water Type	River	Almasab	25%	50%	75%
EC(µs/cm)	1.27	6.91	2.76	4	5.66
TDS ppm)	815	4410	1764	2560	3616
Cl (ppm)	132	1157	347	578	902
So4 (ppm)	435	1487	936	1335	1412
Na^{+} (ppm)	140	401	200	281	324
K (ppm)	10	8.7	10	9.50	9
Mg^{+2} (ppm)	18	198	115	121	139
Ca^{+2} (ppm)	124	219	103	127	180
No3 (ppm)	1.18	5.22	2.10	3.44	3.90
Po4 (ppm)	0.10	0.30	0.16	0.22	0.24
PH	6.92	6.80	6.52	6.57	6.70
Do (ppm)	13.75	7.10	12.10	10.59	9.35

Table BI.58: Station: 441+00, Month: Sept.

Water Type	River	Almasab	25%	50%	75%
EC(µs/cm)	1.25	5.49	2.20	3.18	4.50
TDS ppm)	800	3440	1376	1995	2825
Cl (ppm)	130	1126	338	563	867
So4 (ppm)	428	1052	652	936	998
Na^{+} (ppm)	135	391	194	275	312
K (ppm)	11	8.48	10.50	10	9.25
Mg^{+2} (ppm)	22	191	107	114	134
Ca^{+2} (ppm)	130	208	98	115	166
No3 (ppm)	1.21	4.35	3.40	3.75	4
Po4 (ppm)	0.10	0.22	0.12	0.15	0.18
PH	6.90	6.75	6.49	6.56	6.70
Do (ppm)	14	7.31	12.50	10.78	9.52

Appendix B ***Results of Blending***

BII: Month: June 2020 at Station 360+00

BII.1: Blending ratio with 25%.

Water Quality Index (WQI)	44.46	High restriction
%Error of Ion Balance	-11.12	Error not acceptable

Crop	ECen	ECmax	ECe	Expected yield%
Barley	5.3	19	4.64	100.00
Cotton	5.1	18	4.64	100.00
Sugar beet	4.7	16	4.64	100.00
Date palms	2.7	21.0	4.64	89.41
Wheat	4.0	13.0	4.64	95.46
Maize	1.1	6.7	4.64	36.81
Potato	1.1	6.7	4.64	57.52
Bean	0.7	4.2	4.64	0.00

Crop	ECen	ECmax	ECe	Expected yield%
Onions	0.8	5.0	4.64	8.61
Rice	2.0	7.6	4.64	52.85
Citrus (Orange)	1.1	5.3	4.64	15.71
Groundnut	2.1	4.4	4.64	0.00
Carrots	0.7	5.4	4.64	16.20
Apriot	1.1	3.8	4.64	0.00
Tomato	1.7	8.4	4.64	56.14
Lettuce	0.9	6.0	4.64	26.70
Broccoli	1.9	9.1	4.64	61.97
Grapes	1.0	7.9	4.64	47.26
Alfalfa	1.3	10.0	4.64	61.62
Sugarcane	1.1	12.0	4.64	67.54
Clover, Barseem	1.0	13.0	4.64	69.68
Sorghum	4.5	8.7	4.64	96.67
Soybean	3.3	6.7	4.64	60.59

Crop	ECen	ECmax	ECe	Expected yield%
Cowpea	3.3	8.8	4.64	75.64
Spinach	1.3	10	4.64	61.62
Beet, red	2.7	10	4.64	73.44

Indicators of Water Quality for Irrigation	Value	Result
Electrical conductivity (EC):	4.64	Moderately saline (Primary drainage water and groundwater)
The sodium percentage (Na %):	37.14	Good
Chloride (Cl-):	12.02	Sever problems
Sodium adsorption ratio (SAR)	3.58	Sodium hazard of water is Low
Adj. Sodium Adsorption Ratio (SAR.adj)	4.28	
Salinity potential (PS)	25.12	safely used only in coarse textured soils
Total Hardness mg/L	961.77	Very hard “Very Hard ground.” Dissolution of soil organic matter (“slick spots”) and dispersion of clays results in poor soil structure. Soil surface seals. Water moves very slowly into and through soil.
Magnesium hazard (MH)	74.54	suitable for irrigation purpose.

Indicators of Water Quality for Irrigation	Value	Result
The Permeability Index (PI)	36.60	suitable
Kelley Index (KI)	0.58	suitable
Soluble sodium percentage (SSP)	37.14	Good

Issue & Management

High restriction May be used in soils with high permeability without compact layers. High frequency irrigation schedule should be adopted for water with EC above 2.000 dS m-1 and SAR above 7.0.

Should be used for irrigation of plants with moderate to high tolerance to salts with special salinity control practices, except water with low Na, Cl and HCO3 values.

Electrical conductivity (EC): High hazard. Generally unacceptable for irrigation, except for very salt-tolerant plants where there is excellent drainage, frequent leaching, and intensive management.

Options for managing irrigation water to avoid Dilution, Salt removal from irrigation water.

The sodium percentage (Na %): appreciable sodium hazard in certain fine-textured soils.

Sodium adsorption ratio (SAR): SAR Use on sodium sensitive crops such as avocados must be cautioned.

Total Hardness: Equipment clogging and foliar staining problems at levels above 150 mg/L. Treatment with water softening but may result in increased sodium effect on pipelines.

Irrigation and farm equipment Calcium salts can form a white encrustation of lime (calcium carbonate). These deposits eventually block irrigation equipment and affect hot water systems. Deposits on heating elements make them overheat and burn out.

Therefore, it is recommended not to use metal parts in irrigation systems.

Treatment: Reducing hardness is called water softening. Ways to soften water include: (ion exchange, water-softening agents, desalination processes such as reverse osmosis, use of lime, pH adjustment, and controlling water temperatures).

The Permeability Index (PI): Growth Responsible (range at which affected) Crop (Beans) Stunted growth at low ESP values even though the physical condition of the soil may be good.

Kelley Index (KI): Growth Responsible (range at which affected) Crop (Deciduous fruits, Nuts, Citrus, Avocado) Under Field Conditions from Sodium toxicity symptoms low ESP values.

Soluble sodium percentage (SSP): Growth Responsible (range at which affected) Crop (Beans) Stunted growth at low ESP values even though the physical condition of the soil may be good.

BII.2: Blending ratio with 50%.

Water Quality Index (WQI)	44.31	High restriction
%Error of Ion Balance	-21.71	Error not acceptable

Crop	ECen	ECmax	ECe	Expected yield%
Barley	5.3	19	5.38	99.42
Cotton	5.1	18	5.38	97.84
Sugar beet	4.7	16	5.38	93.98
Date palms	2.7	21.0	5.38	85.37
Wheat	4.0	13.0	5.38	90.20
Maize	1.1	6.7	5.38	23.60
Potato	1.1	6.7	5.38	48.64
Bean	0.7	4.2	5.38	0.00

Crop	ECen	ECmax	ECe	Expected yield%
Onions	0.8	5.0	5.38	0.00
Rice	2.0	7.6	5.38	39.63
Citrus (Orange)	1.1	5.3	5.38	0.00
Groundnut	2.1	4.4	5.38	0.00
Carrots	0.7	5.4	5.38	0.46
Apriot	1.1	3.8	5.38	0.00
Tomato	1.7	8.4	5.38	45.09
Lettuce	0.9	6.0	5.38	12.19
Broccoli	1.9	9.1	5.38	51.70
Grapes	1.0	7.9	5.38	36.53
Alfalfa	1.3	10.0	5.38	53.12
Sugarcane	1.1	12.0	5.38	60.75
Clover, Barseem	1.0	13.0	5.38	63.51
Sorghum	4.5	8.7	5.38	79.06
Soybean	3.3	6.7	5.38	38.83

Crop	ECen	ECmax	ECe	Expected yield%
Cowpea	3.3	8.8	5.38	62.19
Spinach	1.3	10	5.38	53.12
Beet, red	2.7	10	5.38	63.31

Indicators of Water Quality for Irrigation	Value	Result
Electrical conductivity (EC):	5.3775	Moderately saline (Primary drainage water and groundwater)
The sodium percentage (Na %):	42.74	Permissible
Chloride (Cl-):	20.03	Sever problems
Sodium adsorption ratio (SAR)	4.78	Sodium hazard of water is Low
Adj. Sodium Adsorption Ratio (SAR.adj)	5.71	
Salinity potential (PS)	38.73	safely used only in coarse textured soils
Total Hardness mg/L	1,058.87	Very hard “Very Hard ground.” Dissolution of soil organic matter (“slick spots”) and dispersion of clays results in poor soil structure. Soil surface seals. Water moves very slowly into and through soil.
Magnesium hazard (MH)	71.21	suitable for irrigation purpose.

Indicators of Water Quality for Irrigation	Value	Result
The Permeability Index (PI)	42.34	suitable
Kelley Index (KI)	0.73	suitable
Soluble sodium percentage (SSP)	42.74	Good

Issue & Management

High restriction May be used in soils with high permeability without compact layers. High frequency irrigation schedule should be adopted for water with EC above 2.000 dS m-1 and SAR above 7.0.

Should be used for irrigation of plants with moderate to high tolerance to salts with special salinity control practices, except water with low Na, Cl and HCO3 values.

Electrical conductivity (EC):High hazard. Generally unacceptable for irrigation, except for very salt-tolerant plants where there is excellent drainage, frequent leaching, and intensive management.

Options for managing irrigation water to avoid Dilution, Salt removal from irrigation water.

The sodium percentage (Na %): harmful levels of exchangeable sodium in most soils, require special soil management such as good drainage, leaching, and additions of organic matter. So it is not recommended using sprinkler irrigation.

Sodium adsorption ratio (SAR): SAR Use on sodium sensitive crops such as avocados must be cautioned.

Total Hardness: Equipment clogging and foliar staining problems at levels above 150 mg/L. Treatment with water softening but may result in increased sodium effect on pipelines،

Irrigation and farm equipment Calcium salts can form a white encrustation of lime (calcium carbonate). These deposits eventually block irrigation equipment and affect hot water systems. Deposits on heating elements make them overheat and burn out .

Therefore, it is recommended not to use metal parts in irrigation systems.

Treatment: Reducing hardness is called water softening. Ways to soften water include: (ion exchange, water-softening agents, desalination processes such as reverse osmosis, use of lime, pH adjustment, and controlling water temperatures)

The Permeability Index (PI) : Growth Responsible (range at which affected) Crop (Beans) Stunted growth at low ESP values even though the physical condition of the soil may be good.

Kelley Index (KI) : Growth Responsible (range at which affected) Crop (Deciduous fruits, Nuts,Citrus, Avocado) Under Field Conditions from Sodium toxicity symptoms low ESP values.

Soluble sodium percentage (SSP): Growth Responsible (range at which affected) Crop (Beans) Stunted growth at low ESP values even though the physical condition of the soil may be good.

BII.3: Blending ratio with 75%.

Water Quality Index (WQI)	44.19	High restriction
%Error of Ion Balance	-23.62	Error not acceptable

Crop	ECen	ECmax	ECe	Expected yield%
Barley	5.3	19	7.61	83.37
Cotton	5.1	18	7.61	80.67
Sugar beet	4.7	16	7.61	74.25
Date palms	2.7	21.0	7.61	73.19
Wheat	4.0	13.0	7.61	74.37
Maize	1.1	6.7	7.61	0.00

Crop	ECen	ECmax	ECe	Expected yield%
Potato	1.1	6.7	7.61	21.88
Bean	0.7	4.2	7.61	0.00
Onions	0.8	5.0	7.61	0.00
Rice	2.0	7.6	7.61	0.00
Citrus (Orange)	1.1	5.3	7.61	0.00
Groundnut	2.1	4.4	7.61	0.00
Carrots	0.7	5.4	7.61	0.00
Apriot	1.1	3.8	7.61	0.00
Tomato	1.7	8.4	7.61	11.82
Lettuce	0.9	6.0	7.61	0.00
Broccoli	1.9	9.1	7.61	20.75
Grapes	1.0	7.9	7.61	4.22
Alfalfa	1.3	10.0	7.61	27.50
Sugarcane	1.1	12.0	7.61	40.30
Clover, Barseem	1.0	13.0	7.61	44.94

Crop	ECen	ECmax	ECe	Expected yield%
Sorghum	4.5	8.7	7.61	25.98
Soybean	3.3	6.7	7.61	0.00
Cowpea	3.3	8.8	7.61	21.64
Spinach	1.3	10	7.61	27.50
Beet, red	2.7	10	7.61	32.78

Indicators of Water Quality for Irrigation	Value	Result
Electrical conductivity (EC):	7.6075	Moderately saline (Primary drainage water and groundwater)
The sodium percentage (Na %):	40.97	Permissible
Chloride (Cl-):	31.26	Sever problems
Sodium adsorption ratio (SAR)	4.93	Sodium hazard of water is Low
Adj. Sodium Adsorption Ratio (SAR.adj)	5.89	
Salinity potential (PS)	51.22	safely used only in coarse textured soils
Total Hardness mg/L	1,299.64	Very hard “Very Hard ground.” Dissolution of soil organic matter (“slick spots”) and dispersion of clays results in poor soil structure. Soil surface

Indicators of Water Quality for Irrigation	Value	Result
		seals. Water moves very slowly into and through soil.
Magnesium hazard (MH)	66.56	suitable for irrigation purpose.
The Permeability Index (PI)	40.61	suitable
Kelley Index (KI)	0.68	suitable
Soluble sodium percentage (SSP)	40.97	Good

Issue & Management

High restriction May be used in soils with high permeability without compact layers. High frequency irrigation schedule should be adopted for water with EC above 2.000 dS m-1 and SAR above 7.0.

Should be used for irrigation of plants with moderate to high tolerance to salts with special salinity control practices, except water with low Na, Cl and HCO3 values.

Electrical conductivity (EC): High hazard. Generally unacceptable for irrigation, except for very salt-tolerant plants where there is excellent drainage, frequent leaching, and intensive management.

Options for managing irrigation water to avoid Dilution, Salt removal from irrigation water.

The sodium percentage (Na%): harmful levels of exchangeable sodium in most soils, require special soil management such as good drainage, leaching, and additions of organic matter. So it is not recommended using sprinkler irrigation.

Sodium adsorption ratio (SAR): SAR Use on sodium sensitive crops such as avocados must be cautioned. .

Total Hardness: Equipment clogging and foliar staining problems at levels above 150 mg/L. Treatment with water softening but may result in increased sodium effect on pipelines.

irrigation and farm equipment Calcium salts can form a white encrustation of lime (calcium carbonate). These deposits eventually block irrigation equipment and affect hot water systems. Deposits on heating elements make them overheat and burn out.

Therefore, it is recommended not to use metal parts in irrigation systems.

Treatment: Reducing hardness is called water softening. Ways to soften water include: (ion exchange, water-softening agents, desalination processes such as reverse osmosis, use of lime, pH adjustment, and controlling water temperatures)

The Permeability Index (PI): Growth Responsible (range at which affected) Crop (Beans) Stunted growth at low ESP values even though the physical condition of the soil may be good.

Kelley Index (KI): Growth Responsible (range at which affected) Crop (Deciduous fruits, Nuts, Citrus, Avocado) Under Field Conditions from Sodium toxicity symptoms low ESP values.

Soluble sodium percentage (SSP): Growth Responsible (range at which affected) Crop (Beans) Stunted growth at low ESP values even though the physical condition of the soil may be good.

Appendix C

Results of Magnetization

Table C.1: Station: 360+00 Month: Oct.

Water Type	Almasab	1000G	2000G	3000G	5000G	7000G
EC(µs/cm)	5.13	5.13	5.14	5.16	5.19	5.23
TDS ppm)	3295	3298	3305	3310	3331	3361
Cl (ppm)	781	781	762	687	710	777
So4 (ppm)	1325	1326	1335	1351	1359	1365
Na^{+} (ppm)	370	370	373	376	378	381
K (ppm)	9.5	9.50	9.75	10	9.50	9.50
Mg^{+2} (ppm)	96	96	99	109	111	113
Ca^{+2} (ppm)	210	212	217	240	243	248
No3 (ppm)	1.1	1.10	1.29	1.58	1.12	1.18
Po4 (ppm)	0.20	0.20	0.23	0.49	0.30	0.33
PH	6.75	6.76	6.81	6.93	7	7.05
Do (ppm)	9.00	9.00	9.40	10.28	9.63	9.87

Table C.2: Station: 360+00 Month: Nov.

Water Type	Almasab	1000G	2000G	3000G	5000G	7000G
EC(µs/cm)	5.84	5.85	5.86	5.88	5.90	5.96
TDS ppm)	3700	3704	3711	3715	3741	3774
Cl (ppm)	568	568	554	501	516	565
So4 (ppm)	823	824	829	839	844	848
Na^{+} (ppm)	392	392	395	399	401	403
K (ppm)	9.5	9.50	9.50	9.75	9.50	9.60
Mg^{+2} (ppm)	110.5	111	114	126	128	130
Ca^{+2} (ppm)	254.5	255	263	290	295	301
No3 (ppm)	1.3	1.30	1.53	1.85	1.32	1.39
Po4 (ppm)	0.27	0.27	0.32	0.66	0.40	0.45
PH	7.90	7.90	7.97	8.10	8.20	8.25
Do (ppm)	9.50	9.50	9.96	10.90	10.10	10.35

Table C.3: Station: 360+00 Month: DEC.

Water Type	Almasab	1000G	2000G	3000G	5000G	7000G
EC(µs/cm)	4.98	4.98	4.99	5	5.03	5.08
TDS ppm)	3185	3188	3195	3198	3220	3248
Cl (ppm)	560	560	546	494	509	557
So4 (ppm)	2010	2012	2024	2227	2062	2070
Na^{+} (ppm)	379	379	382	386	389	394
K (ppm)	9.2	9.20	9.25	10	9.25	9.25
Mg^{+2} (ppm)	180	180	186	204	208	212
Ca^{+2} (ppm)	260	260	269	297	300	307
No3 (ppm)	1.33	1.33	1.56	1.90	1.35	1.41
Po4 (ppm)	0.30	0.31	0.35	0.75	0.43	0.50
PH	8	8	8.07	8.20	8.30	8.35
Do (ppm)	10.50	10.50	11	11.99	11.23	11.52

Table C.4: Station: 360+00 Month: Jan.

Water Type	Almasab	1000G	2000G	3000G	5000G	7000G
EC(µs/cm)	5.18	5.19	5.20	5.21	5.23	5.28
TDS ppm)	3200	3204	3210	3213	3235	3264
Cl (ppm)	561	560	547	495	510	557
So4 (ppm)	2041	2043	2055	2080	2094	2102
Na^{+} (ppm)	368	368	371	374	376	377
K (ppm)	9.7	9.70	9.72	10.22	9.72	9.75
Mg^{+2} (ppm)	208	208	215	236	241	245
Ca^{+2} (ppm)	320	320	330	366	370	378
No3 (ppm)	1.32	1.32	1.54	1.89	1.33	1.41
Po4 (ppm)	1.00	1.00	1.16	2.43	1.50	1.67
PH	8.10	8.10	8.17	8.31	8.40	8.46
Do (ppm)	13.10	13.15	13.74	14.99	14.01	14.37

Table C.5: Station: 360+00 Month: Feb.

Water Type	Almasab	1000G	2000G	3000G	5000G	7000G
EC(µs/cm)	5.3	5.31	5.32	5.33	5.36	5.41
TDS ppm)	3400	3404	3410	3414	3437	3468
Cl (ppm)	781	781	762	689	710	777
So4 (ppm)	1481	1482	1491	1510	1520	1525
Na^{+} (ppm)	396	397	399	403	404	406
K (ppm)	9.5	9.50	9.50	10.10	9.57	9.60
Mg^{+2} (ppm)	270	271	280	306	313	318
Ca^{+2} (ppm)	330	332	341	377	381	390
No3 (ppm)	2.40	2.41	2.82	3.42	2.44	2.56
Po4 (ppm)	0.11	0.11	0.13	0.27	0.17	0.18
PH	8.20	8.21	8.27	8.41	8.51	8.56
Do (ppm)	14.60	14.60	15.32	16.70	15.62	16.02

Table C.6: Station: 360+00 Month: Mar.

Water Type	Almasab	1000G	2000G	3000G	5000G	7000G
EC(µs/cm)	6.10	6.11	6.12	6.14	6.17	6.22
TDS ppm)	3896	3874	3881	3884	3912	3946
Cl (ppm)	892	891	870	787	811	888
So4 (ppm)	1540	1542	1551	1571	1580	1586
Na^{+} (ppm)	406	407	409	413	414	416
K (ppm)	9.6	9.60	9.62	10.20	9.64	9.72
Mg^{+2} (ppm)	278	279	288	316	322	327
Ca^{+2} (ppm)	335	335	346	383	388	397
No3 (ppm)	6.4	6.40	7.53	9.11	6.50	6.84
Po4 (ppm)	0.26	0.26	0.30	0.63	0.39	0.43
PH	8.26	8.27	8.33	8.36	8.37	8.62
Do (ppm)	10.75	10.76	11.27	12.30	11.50	11.79

Table C.7: Station: 360+00 Month: April

Water Type	Almasab	1000G	2000G	3000G	5000G	7000G
EC(µs/cm)	6.20	6.21	6.22	6.23	6.27	6.32
TDS ppm)	3925	3930	3937	3942	3970	4005
Cl (ppm)	1130	1128	1102	995	1028	1124
So4 (ppm)	1566	1568	1577	1595	1609	1615
Na^{+} (ppm)	490	491	493	499	502	505
K (ppm)	14.20	14.20	14.24	14.75	14.21	14.25
Mg^{+2} (ppm)	258	259	267	293	298	303
Ca^{+2} (ppm)	265	265	274	303	306	313
No3 (ppm)	9.00	9.00	10.60	13.20	9.14	9.62
Po4 (ppm)	0.30	0.30	0.35	0.73	0.45	0.50
PH	7.91	7.92	7.98	8.12	8.20	8.26
Do (ppm)	8.60	8.60	9.02	9.83	9.20	9.43

Table C.8: Station: 360+00 Month: May

Water Type	Almasab	1000G	2000G	3000G	5000G	7000G
EC(µs/cm)	9.40	9.41	9.43	9.45	9.50	9.58
TDS ppm)	5932	5938	5949	5956	5997	6051
Cl (ppm)	1376	1374	1342	1214	1251	1369
So4 (ppm)	1720	1722	1732	1757	1765	1771
Na^{+} (ppm)	492	492	496	501	504	508
K (ppm)	10.90	10.90	10.95	11.70	10.98	11
Mg^{+2} (ppm)	278	279	288	316	323	328
Ca^{+2} (ppm)	260	260	268	297	300	307
No3 (ppm)	3.20	3.20	3.76	4.56	3.25	3.42
Po4 (ppm)	0.31	0.32	0.36	0.75	0.47	0.52
PH	8.00	8.00	8.07	8.21	8.30	8.35
Do (ppm)	7.50	7.51	7.87	8.60	8.02	8.23

Table C.9: Station: 360+00 Month: July

Water Type	Almasab	1000G	2000G	3000G	5000G	7000G
EC(µs/cm)	6.98	6.99	7	7.05	7.07	7.12
TDS ppm)	4437	4442	4450	4456	4487	4528
Cl (ppm)	1295	1295	1260	1141	1175	1290
So4 (ppm)	1700	1702	1712	1735	1744	1754
Na^{+} (ppm)	491	491	494	499	503	505
K (ppm)	11.20	11.22	11.30	12.25	11.28	11.80
Mg^{+2} (ppm)	146	146	151	167	169	172
Ca^{+2} (ppm)	270	270	279	309	312	320
No3 (ppm)	8.51	8.52	10	12.20	8.64	9.10
Po4 (ppm)	0.30	0.30	0.35	0.73	0.45	0.50
PH	7.60	7.61	7.67	7.79	7.88	7.93
Do (ppm)	7.80	7.81	8.18	8.92	8.35	8.56

Table C.10: Station: 360+00 Month: Aug.

Water Type	Almasab	1000G	2000G	3000G	5000G	7000G
EC(µs/cm)	7.94	7.95	7.96	7.97	8.03	8.10
TDS ppm)	5070	5076	5085	5090	5126	5171
Cl (ppm)	1330	1298	1174	1173	1209	1323
So4 (ppm)	1710	1712	1722	1744	1755	1761
Na^{+} (ppm)	482	482	486	491	492	495
K (ppm)	10	10	10	10.25	10.10	10.10
Mg^{+2} (ppm)	228	228	236	259	264	268
Ca^{+2} (ppm)	252	252	260	280	291	298
No3 (ppm)	6.00	6.00	7.06	8.54	6.10	6.41
Po4 (ppm)	0.35	0.35	0.41	0.85	0.53	0.58
PH	7.82	7.83	7.89	8.02	8.12	8.16
Do (ppm)	7.20	7.20	7.55	8.22	7.70	7.89

Table C.11: Station: 360+00 Month: Sept.

Water Type	Almasab	1000G	2000G	3000G	5000G	7000G
EC(µs/cm)	6.32	6.33	6.34	6.35	6.39	6.45
TDS ppm)	3955	3960	3967	3971	3999	4034
Cl (ppm)	1295	1294	1263	1142	1177	1233
So4 (ppm)	1210	1211	1218	1234	1241	1246
Na^{+} (ppm)	450	451	454	458	490	462
K (ppm)	9.75	9.75	9.75	10	9.75	9.75
Mg^{+2} (ppm)	220	220	227	250	254	259
Ca^{+2} (ppm)	240	240	248	274	277	283
No3 (ppm)	5.00	5.00	5.89	7.12	5.08	5.35
Po4 (ppm)	0.25	0.25	0.29	0.61	0.37	0.42
PH	7.45	7.45	7.51	7.64	7.73	7.77
Do (ppm)	8.40	8.40	8.81	9.60	8.99	9.20

Table C.12: Station: 399+00 Month: Oct.

Water Type	Almasab	1000G	2000G	3000G	5000G	7000G
EC(µs/cm)	4.82	4.82	4.83	4.85	4.88	4.92
TDS ppm)	3097.3	3100.12	3106.7	3111.4	3131.14	3159.34
Cl (ppm)	734.14	734.14	716.28	645.78	667.4	730.38
So4 (ppm)	1245.5	1246.44	1254.9	1269.94	1277.46	1283.1
Na^{+} (ppm)	347.8	347.8	350.62	353.44	355.32	358.14
K (ppm)	8.93	8.93	9.165	9.4	8.93	8.93
Mg^{+2} (ppm)	90.24	90.24	93.06	102.46	104.34	106.22
Ca^{+2} (ppm)	197.4	199.28	203.98	225.6	228.42	233.12
No3 (ppm)	1.03	1.03	1.21	1.46	1.05	1.11
Po4 (ppm)	0.19	0.19	0.22	0.46	0.28	0.31
PH	6.34	6.35	6.40	6.51	6.58	6.63
Do (ppm)	8.46	8.46	8.84	9.66	9.05	9.28

Table C.13: Station: 399+00 Month: Nov.

Water Type	Almasab	1000G	2000G	3000G	5000G	7000G
EC(µs/cm)	5.49	5.50	5.51	5.53	5.55	5.60
TDS ppm)	3478	3481.76	3488.34	3492.1	3516.54	3547.56
Cl (ppm)	533.92	533.92	520.76	470.94	485.04	531.1
So4 (ppm)	773.62	774.56	779.26	788.66	793.36	797.12
Na^+ (ppm)	368.48	368.48	371.3	375.06	376.94	378.82
K (ppm)	8.93	8.93	8.93	9.165	8.93	9.024
Mg^{+2} (ppm)	103.87	104.34	107.16	118.44	120.32	122.2
Ca^{+2} (ppm)	239.23	239.7	247.22	272.6	277.3	282.94
No3 (ppm)	1.22	1.22	1.44	1.74	1.24	1.31
Po4 (ppm)	0.25	0.25	0.30	0.62	0.37	0.42
PH	7.43	7.43	7.49	7.61	7.71	7.76
Do (ppm)	8.93	8.93	9.36	10.25	9.49	9.73

Table C.14: Station: 399+00 Month: DEC.

Water Type	Almasab	1000G	2000G	3000G	5000G	7000G
EC(µs/cm)	4.68	4.68	4.69	4.70	4.72	4.77
TDS ppm)	2993.9	2996.72	3003.3	3006.12	3026.8	3053.12
Cl (ppm)	526.4	526.4	513.24	464.36	478.46	523.58
So4 (ppm)	1889.4	1891.28	1902.56	2093.38	1938.28	1945.8
Na^+ (ppm)	356.26	356.26	359.08	362.84	365.66	370.36
K (ppm)	8.64	8.64	8.69	9.40	8.69	8.70
Mg^{+2} (ppm)	169.2	169.2	174.84	191.76	195.52	199.28
Ca^{+2} (ppm)	244.4	244.4	252.86	279.18	282	288.58
No3 (ppm)	1.25	1.25	1.47	1.78	1.27	1.33
Po4 (ppm)	0.28	0.29	0.33	0.71	0.40	0.47
PH	7.52	7.52	7.59	7.71	7.80	7.85
Do (ppm)	9.87	9.87	10.34	11.27	10.56	10.83

Table C.15: Station: 399+00 Month: Jan.

Water Type	Almasab	1000G	2000G	3000G	5000G	7000G
EC(µs/cm)	4.86	4.87	4.88	4.89	4.91	4.96
TDS ppm)	3008	3011.76	3017.4	3020.22	3040.9	3068.16
Cl (ppm)	527.34	526.4	514.18	465.3	479.4	523.58
So4 (ppm)	1918.54	1920.42	1931.7	1955.2	1968.36	1975.88
Na^{+} (ppm)	345.92	345.92	348.74	351.56	353.44	354.38
K (ppm)	9.12	9.12	9.14	9.60	9.13	9.16
Mg^{+2} (ppm)	195.52	195.52	202.1	221.84	226.54	230.3
Ca^{+2} (ppm)	300.8	300.8	310.2	344.04	347.8	355.32
No3 (ppm)	1.24	1.24	1.45	1.77	1.25	1.3254
Po4 (ppm)	0.94	0.94	1.09	2.28	1.41	1.56
PH	7.61	7.61	7.67	7.81	7.89	7.95
Do (ppm)	12.31	12.36	12.91	14.09	13.161	13.51

Table C.16: Station: 399+00 Month: Feb.

Water Type	Almasab	1000G	2000G	3000G	5000G	7000G
EC(µs/cm)	4.98	4.99	5.00	5.01	5.04	5.08
TDS ppm)	3196	3199.76	3205.4	3209.16	3230.78	3259.92
Cl (ppm)	734.14	734.14	716.28	647.66	667.4	730.38
So4 (ppm)	1392.14	1393.08	1401.54	1419.4	1428.8	1433.5
Na^{+} (ppm)	372.24	373.18	375.06	378.82	379.76	381.64
K (ppm)	8.93	8.93	8.93	9.49	8.99	9.02
Mg^{+2} (ppm)	253.8	254.74	263.2	287.64	294.22	298.92
Ca^{+2} (ppm)	310.2	312.08	320.54	354.38	358.14	366.6
No3 (ppm)	2.25	2.26	2.65	3.21	2.29	2.41
Po4 (ppm)	0.10	0.10	0.12	0.25	0.16	0.17
PH	7.71	7.71742	7.77	7.90	7.99	8.05
Do (ppm)	13.72	13.72	14.40	15.69	14.68	15.06

Table C.17: Station: 399+00 Month: Mar.

Water Type	Almasab	1000G	2000G	3000G	5000G	7000G
EC(µs/cm)	5.73	5.74	5.75	5.77	5.79	5.85
TDS ppm)	3662.24	3641.56	3648.14	3650.96	3677.28	3709.24
Cl (ppm)	838.48	837.54	817.8	739.78	762.34	834.72
So4 (ppm)	1447.6	1449.48	1457.94	1476.74	1485.2	1490.84
Na^{+} (ppm)	381.64	382.58	384.46	388.22	389.16	391.04
K (ppm)	9.02	9.02	9.04	9.58	9.06	9.13
Mg^{+2} (ppm)	261.32	262.26	270.72	297.04	302.68	307.38
Ca^{+2} (ppm)	314.9	314.9	325.24	360.02	364.72	373.18
No3 (ppm)	6.02	6.02	7.07	8.56	6.11	6.42
Po4 (ppm)	0.24	0.24	0.28	0.59	0.36	0.40
PH	7.76	7.77	7.83	7.85	7.87	8.10
Do (ppm)	10.11	10.11	10.59	11.56	10.81	11.08

Table C.18: Station: 399+00 Month: April

Water Type	Almasab	1000G	2000G	3000G	5000G	7000G
EC(µs/cm)	5.82	5.83	5.84	5.85	5.89	5.94
TDS ppm)	3689.5	3694.2	3700.78	3705.48	3731.8	3764.7
Cl (ppm)	1062.2	1060.32	1035.88	935.3	966.32	1056.56
So4 (ppm)	1472.04	1473.92	1482.38	1499.3	1512.46	1518.1
Na^{+} (ppm)	460.6	461.54	463.42	469.06	471.88	474.7
K (ppm)	13.35	13.35	13.38	13.86	13.35	13.39
Mg^{+2} (ppm)	242.52	243.46	250.98	275.42	280.12	284.82
Ca^{+2} (ppm)	249.1	249.1	257.56	284.82	287.64	294.22
No3 (ppm)	8.46	8.46	9.964	12.408	8.5916	9.0428
Po4 (ppm)	0.28	0.28	0.33	0.68	0.42	0.47
PH	7.43	7.44	7.50	7.63	7.71	7.76
Do (ppm)	8.08	8.08	8.47	9.24	8.65	8.86

Table C.19: Station: 399+00 Month: May

Water Type	Almasab	1000G	2000G	3000G	5000G	7000G
EC(µs/cm)	8.83	8.84	8.86	8.88	8.93	9.00
TDS ppm)	5576.08	5581.72	5592.06	5598.64	5637.18	5687.94
Cl (ppm)	1293.44	1291.56	1261.48	1141.16	1175.94	1286.86
So4 (ppm)	1616.8	1618.68	1628.08	1651.58	1659.1	1664.74
Na^{+} (ppm)	462.48	462.48	466.24	470.94	473.76	477.52
K (ppm)	10.24	10.24	10.29	10.99	10.32	10.34
Mg^{+2} (ppm)	261.32	262.26	270.72	297.04	303.62	308.32
Ca^{+2} (ppm)	244.4	244.4	251.92	279.18	282	288.58
No3 (ppm)	3.00	3.00	3.53	4.28	3.05	3.21
Po4 (ppm)	0.29	0.30	0.34	0.70	0.44	0.48
PH	7.52	7.52	7.58	7.72	7.80	7.84
Do (ppm)	7.05	7.05	7.40	8.08	7.54	7.74

Table C.20: Station: 399+00 Month: June

Water Type	Almasab	1000G	2000G	3000G	5000G	7000G
EC(µs/cm)	10.90	10.91	10.93	10.95	11.02	11.13
TDS ppm)	6972.92	6981.38	6993.6	7029.32	7050	7112.04
Cl (ppm)	1334.8	1331.98	1301.9	1177.82	1213.54	1328.22
So4 (ppm)	1895.04	1896.92	1908.2	1932.64	1943.92	1951.44
Na^{+} (ppm)	479.4	480.34	483.16	488.8	490.68	492.56
K (ppm)	9.87	9.87	9.9264	10.528	9.964	10.105
Mg^{+2} (ppm)	282	283.88	292.34	319.6	326.18	331.82
Ca^{+2} (ppm)	197.4	198.34	203.98	225.6	228.42	233.12
No3 (ppm)	2.64	2.66	3.09	3.74	2.66	2.81
Po4 (ppm)	0.12	0.12	0.14	0.30	0.18	0.21
PH	7.61	7.62	7.67	7.81	7.90	7.95
Do (ppm)	6.58	6.58	6.89	7.61	7.05	7.22

Table C.21: Station: 399+00 Month: July

Water Type	Almasab	1000G	2000G	3000G	5000G	7000G
EC(µs/cm)	6.56	6.57	6.58	6.62	6.64	6.69
TDS ppm)	4170.78	4175.48	4183	4188.64	4217.78	4256.32
Cl (ppm)	1217.3	1217.3	1184.4	1072.54	1104.5	1212.6
So4 (ppm)	1598	1599.88	1609.28	1630.9	1639.36	1648.76
Na^{+} (ppm)	461.54	461.54	464.36	469.06	472.82	474.7
K (ppm)	10.53	10.54	10.62	11.51	10.60	11.09
Mg^{+2} (ppm)	137.24	137.24	141.94	156.98	158.86	161.68
Ca^{+2} (ppm)	253.8	253.8	262.26	290.46	293.28	300.8
No3 (ppm)	7.99	8.01	9.40	11.46	8.12	8.55
Po4 (ppm)	0.28	0.28	0.30	0.67	0.42	0.47
PH	7.14	7.15	7.21	7.32	7.40	7.45
Do (ppm)	7.33	7.34	7.68	8.38	7.84	8.04

Table C.22: Station: 399+00 Month: Aug.

Water Type	Almasab	1000G	2000G	3000G	5000G	7000G
EC(µs/cm)	7.46	7.47	7.48	7.49	7.54	7.61
TDS ppm)	4765.8	4771.44	4779.9	4784.6	4818.44	4860.74
Cl (ppm)	1250.2	1220.12	1103.56	1102.62	1136.46	1243.62
So4 (ppm)	1607.4	1609.28	1618.68	1639.36	1649.7	1655.34
Na^{+} (ppm)	453.08	453.08	456.84	461.54	462.48	465.3
K (ppm)	9.4	9.4	9.4	9.64	9.49	9.49
Mg^{+2} (ppm)	214.32	214.32	221.84	243.46	248.16	251.92
Ca^{+2} (ppm)	236.88	236.88	244.4	263.2	273.54	280.12
No3 (ppm)	5.64	5.64	6.63	8.03	5.73	6.02
Po4 (ppm)	0.33	0.33	0.38	0.80	0.49	0.54
PH	7.35	7.36	7.41	7.54	7.63	7.67
Do (ppm)	6.76	6.76	7.09	7.73	7.23	7.42

Table C.23: Station: 399+00 Month: Sept.

Water Type	Almasab	1000G	2000G	3000G	5000G	7000G
EC(µs/cm)	5.94	5.95	5.95	5.96	6.01	6.06
TDS ppm)	3717.7	3722.4	3728.98	3732.74	3759.06	3791.96
Cl (ppm)	1217.3	1216.36	1187.22	1073.48	1106.38	1159.02
So4 (ppm)	1137.4	1138.34	1144.92	1159.96	1166.54	1171.24
Na^{+} (ppm)	423	423.94	426.76	430.52	460.6	434.28
K (ppm)	9.16	9.16	9.17	9.40	9.16	9.16
Mg^{+2} (ppm)	206.8	206.8	213.38	235	238.76	243.46
Ca^{+2} (ppm)	225.6	225.6	233.12	257.56	260.38	266.02
No3 (ppm)	4.70	4.70	5.53	6.69	4.77	5.03
Po4 (ppm)	0.23	0.23	0.27	0.57	0.34	0.39
PH	7.00	7.00	7.05	7.18	7.26	7.30
Do (ppm)	7.89	7.89	8.28	9.02	8.45	8.64

Table C.24: Station: 416+00 Month: Oct.

Water Type	Almasab	1000G	2000G	3000G	5000G	7000G
EC(µs/cm)	4.61	4.61	4.62	4.64	4.67	4.71
TDS ppm)	2965.5	2968.2	2974.5	2979	2997.9	3024.9
Cl (ppm)	702.9	702.9	685.8	618.3	639	699.3
So4 (ppm)	1192.5	1193.4	1201.5	1215.9	1223.1	1228.5
Na^{+} (ppm)	333	333	335.7	338.4	340.2	342.9
K (ppm)	8.55	8.55	8.775	9	8.55	8.55
Mg^{+2} (ppm)	86.4	86.4	89.1	98.1	99.9	101.7
Ca^{+2} (ppm)	189	190.8	195.3	216	218.7	223.2
No3 (ppm)	0.99	0.99	1.16	1.42	1.01	1.06
Po4 (ppm)	0.18	0.18	0.20	0.44	0.27	0.29
PH	6.08	6.08	6.13	6.24	6.30	6.34
Do (ppm)	8.10	8.10	8.46	9.25	8.66	8.88

Table C.25: Station: 416+00 Month: Nov.

Water Type	Almasab	1000G	2000G	3000G	5000G	7000G
EC(µs/cm)	5.25	5.26	5.27	5.29	5.31	5.36
TDS ppm)	3330	3333.6	3339.9	3343.5	3366.9	3396.6
Cl (ppm)	511.2	511.2	498.6	450.9	464.4	508.5
So4 (ppm)	740.7	741.6	746.1	755.1	759.6	763.2
Na^{+} (ppm)	352.8	352.8	355.5	359.1	360.9	362.7
K (ppm)	8.55	8.55	8.55	8.77	8.55	8.64
Mg^{+2} (ppm)	99.45	99.9	102.6	113.4	115.2	117
Ca^{+2} (ppm)	229.05	229.5	236.7	261	265.5	270.9
No3 (ppm)	1.17	1.17	1.37	1.67	1.18	1.25
Po4 (ppm)	0.24	0.24	0.28	0.59	0.36	0.40
PH	7.11	7.11	7.173	7.29	7.38	7.42
Do (ppm)	8.55	8.55	8.96	9.81	9.09	9.31

Table C.26: Station: 416+00 Month: DEC.

Water Type	Almasab	1000G	2000G	3000G	5000G	7000G
EC(µs/cm)	4.48	4.48	4.49	4.50	4.52	4.57
TDS ppm)	2866.5	2869.2	2875.5	2878.2	2898	2923.2
Cl (ppm)	504	504	491.4	444.6	458.1	501.3
So4 (ppm)	1809	1810.8	1821.6	2004.3	1855.8	1863
Na^{+} (ppm)	341.1	341.1	343.8	347.4	350.1	354.6
K (ppm)	8.28	8.28	8.32	9	8.32	8.32
Mg^{+2} (ppm)	162	162	167.4	183.6	187.2	190.8
Ca^{+2} (ppm)	234	234	242.1	267.3	270	276.3
No3 (ppm)	1.19	1.19	1.40	1.71	1.21	1.26
Po4 (ppm)	0.27	0.28	0.31	0.68	0.38	0.45
PH	7.2	7.2	7.263	7.38	7.47	7.515
Do (ppm)	9.45	9.45	9.90	10.79	10.10	10.36

Table C.27: Station: 416+00 Month: Jan.

Water Type	Almasab	1000G	2000G	3000G	5000G	7000G
EC(µs/cm)	4.66	4.67	4.68	4.68	4.70	4.75
TDS ppm)	2880	2883.6	2889	2891.7	2911.5	2937.6
Cl (ppm)	504.9	504	492.3	445.5	459	501.3
So4 (ppm)	1836.9	1838.7	1849.5	1872	1884.6	1891.8
Na^+ (ppm)	331.2	331.2	333.9	336.6	338.4	339.3
K (ppm)	8.73	8.73	8.74	9.19	8.74	8.77
Mg^{+2} (ppm)	187.2	187.2	193.5	212.4	216.9	220.5
Ca^{+2} (ppm)	288	288	297	329.4	333	340.2
No3 (ppm)	1.18	1.18	1.38	1.70	1.19	1.27
Po4 (ppm)	0.90	0.90	1.04	2.18	1.35	1.50
PH	7.29	7.29	7.35	7.47	7.56	7.61
Do (ppm)	11.79	11.84	12.366	13.49	12.61	12.93

Table C.28: Station: 416+00 Month: Feb.

Water Type	Almasab	1000G	2000G	3000G	5000G	7000G
EC(µs/cm)	4.77	4.77	4.78	4.79	4.82	4.86
TDS ppm)	3060	3063.6	3069	3072.6	3093.3	3121.2
Cl (ppm)	702.9	702.9	685.8	620.1	639	699.3
So4 (ppm)	1332.9	1333.8	1341.9	1359	1368	1372.5
Na^+ (ppm)	356.4	357.3	359.1	362.7	363.6	365.4
K (ppm)	8.55	8.55	8.55	9.09	8.61	8.64
Mg^{+2} (ppm)	243	243.9	252	275.4	281.7	286.2
Ca^{+2} (ppm)	297	298.8	306.9	339.3	342.9	351
No3 (ppm)	2.16	2.16	2.54	3.08	2.19	2.30
Po4 (ppm)	0.09	0.09	0.11	0.24	0.15	0.16
PH	7.38	7.39	7.44	7.56	7.65	7.70
Do (ppm)	13.14	13.14	13.78	15.03	14.05	14.42

Table C.29: Station: 416+00 Month: Mar.

Water Type	Almasab	1000G	2000G	3000G	5000G	7000G
EC(µs/cm)	5.49	5.49	5.50	5.52	5.55	5.59
TDS ppm)	3506.4	3486.6	3492.9	3495.6	3520.8	3551.4
Cl (ppm)	802.8	801.9	783	708.3	729.9	799.2
So4 (ppm)	1386	1387.8	1395.9	1413.9	1422	1427.4
Na^{+} (ppm)	365.4	366.3	368.1	371.7	372.6	374.4
K (ppm)	8.64	8.64	8.65	9.18	8.67	8.74
Mg^{+2} (ppm)	250.2	251.1	259.2	284.4	289.8	294.3
Ca^{+2} (ppm)	301.5	301.5	311.4	344.7	349.2	357.3
No3 (ppm)	5.76	5.76	6.77	8.19	5.85	6.15
Po4 (ppm)	0.23	0.23	0.27	0.57	0.35	0.38
PH	7.43	7.44	7.49	7.52	7.53	7.75
Do (ppm)	9.67	9.68	10.14	11.07	10.35	10.61

Table C.30: Station: 416+00 Month: April

Water Type	Almasab	1000G	2000G	3000G	5000G	7000G
EC(µs/cm)	5.58	5.58	5.59	5.60	5.64	5.68
TDS ppm)	3532.5	3537	3543.3	3547.8	3573	3604.5
Cl (ppm)	1017	1015.2	991.8	895.5	925.2	1011.6
So4 (ppm)	1409.4	1411.2	1419.3	1435.5	1448.1	1453.5
Na^{+} (ppm)	441	441.9	443.7	449.1	451.8	454.5
K (ppm)	12.78	12.78	12.81	13.27	12.78	12.82
Mg^{+2} (ppm)	232.2	233.1	240.3	263.7	268.2	272.7
Ca^{+2} (ppm)	238.5	238.5	246.6	272.7	275.4	281.7
No3 (ppm)	8.10	8.10	9.54	11.88	8.22	8.65
Po4 (ppm)	0.27	0.27	0.31	0.65	0.40	0.45
PH	7.12	7.13	7.18	7.30	7.38	7.43
Do (ppm)	7.74	7.74	8.11	8.85	8.28	8.48

Table C.31: Station: 416+00 Month: May

Water Type	Almasab	1000G	2000G	3000G	5000G	7000G
EC(µs/cm)	8.46	8.47	8.49	8.50	8.55	8.62
TDS ppm)	5338.8	5344.2	5354.1	5360.4	5397.3	5445.9
Cl (ppm)	1238.4	1236.6	1207.8	1092.6	1125.9	1232.1
So4 (ppm)	1548	1549.8	1558.8	1581.3	1588.5	1593.9
Na^{+} (ppm)	442.8	442.8	446.4	450.9	453.6	457.2
K (ppm)	9.81	9.81	9.85	10.53	9.88	9.9
Mg^{+2} (ppm)	250.2	251.1	259.2	284.4	290.7	295.2
Ca^{+2} (ppm)	234	234	241.2	267.3	270	276.3
No3 (ppm)	2.88	2.88	3.384	4.104	2.925	3.078
Po4 (ppm)	0.27	0.28	0.32	0.67	0.42	0.46
PH	7.2	7.2	7.26	7.38	7.47	7.51
Do (ppm)	6.75	6.76	7.08	7.74	7.22	7.41

Table C.32: Station: 416+00 Month: June

Water Type	Almasab	1000G	2000G	3000G	5000G	7000G
EC(µs/cm)	10.44	10.45	10.46	10.48	10.55	10.65
TDS ppm)	6676.2	6684.3	6696	6730.2	6750	6809.4
Cl (ppm)	1278	1275.3	1246.5	1127.7	1161.9	1271.7
So4 (ppm)	1814.4	1816.2	1827	1850.4	1861.2	1868.4
Na^{+} (ppm)	459	459.9	462.6	468	469.8	471.6
K (ppm)	9.45	9.45	9.50	10.08	9.54	9.67
Mg^{+2} (ppm)	270	271.8	279.9	306	312.3	317.7
Ca^{+2} (ppm)	189	189.9	195.3	216	218.7	223.2
No3 (ppm)	2.53	2.55	2.96	3.58	2.56	2.69
Po4 (ppm)	0.12	0.12	0.14	0.29	0.18	0.20
PH	7.29	7.30	7.35	7.48	7.57	7.61
Do (ppm)	6.30	6.30	6.60	7.29	6.75	6.91

Table C.33: Station: 416+00 Month: July

Water Type	Almasab	1000G	2000G	3000G	5000G	7000G
EC(µs/cm)	6.28	6.29	6.30	6.34	6.36	6.41
TDS ppm)	3993.3	3997.8	4005	4010.4	4038.3	4075.2
Cl (ppm)	1165.5	1165.5	1134	1026.9	1057.5	1161
So4 (ppm)	1530	1531.8	1540.8	1561.5	1569.6	1578.6
Na^{+} (ppm)	441.9	441.9	444.6	449.1	452.7	454.5
K (ppm)	10.08	10.09	10.17	11.02	10.15	10.62
Mg^{+2} (ppm)	131.4	131.4	135.9	150.3	152.1	154.8
Ca^{+2} (ppm)	243	243	251.1	278.1	280.8	288
No3 (ppm)	7.65	7.66	9	10.98	7.77	8.19
Po4 (ppm)	0.27	0.27	0.31	0.65	0.40	0.45
PH	6.84	6.85	6.90	7.01	7.09	7.13
Do (ppm)	7.02	7.03	7.36	8.03	7.51	7.70

Table C.34: Station: 416+00 Month: Aug.

Water Type	Almasab	1000G	2000G	3000G	5000G	7000G
EC(µs/cm)	7.14	7.15	7.16	7.17	7.22	7.29
TDS ppm)	4563	4568.4	4576.5	4581	4613.4	4653.9
Cl (ppm)	1197	1168.2	1056.6	1055.7	1088.1	1190.7
So4 (ppm)	1539	1540.8	1549.8	1569.6	1579.5	1584.9
Na^{+} (ppm)	433.8	433.8	437.4	441.9	442.8	445.5
K (ppm)	9	9	9	9.22	9.09	9.09
Mg^{+2} (ppm)	205.2	205.2	212.4	233.1	237.6	241.2
Ca^{+2} (ppm)	226.8	226.8	234	252	261.9	268.2
No3 (ppm)	5.4	5.4	6.35	7.68	5.49	5.76
Po4 (ppm)	0.31	0.31	0.37	0.77	0.47	0.52
PH	7.03	7.04	7.10	7.22	7.30	7.34
Do (ppm)	6.48	6.48	6.79	7.39	6.93	7.10

Table C.35: Station: 416+00 Month: Sept.

Water Type	Almasab	1000G	2000G	3000G	5000G	7000G
EC(µs/cm)	5.68	5.69	5.70	5.71	5.75	5.80
TDS ppm)	3559.5	3564	3570.3	3573.9	3599.1	3630.6
Cl (ppm)	1165.5	1164.6	1136.7	1027.8	1059.3	1109.7
So4 (ppm)	1089	1089.9	1096.2	1110.6	1116.9	1121.4
Na^{+} (ppm)	405	405.9	408.6	412.2	441	415.8
K (ppm)	8.77	8.77	8.76	9	8.77	8.78
Mg^{+2} (ppm)	198	198	204.3	225	228.6	233.1
Ca^{+2} (ppm)	216	216	223.2	246.6	249.3	254.7
No3 (ppm)	4.50	4.50	5.30	6.41	4.57	4.81
Po4 (ppm)	0.23	0.23	0.26	0.55	0.33	0.38
PH	6.70	6.70	6.75	6.87	6.95	6.99
Do (ppm)	7.56	7.56	7.92	8.64	8.09	8.28

Table C.36: Station: 427+00 Month: Oct.

Water Type	Almasab	1000G	2000G	3000G	5000G	7000G
EC(µs/cm)	4.51	4.51	4.52	4.54	4.56	4.60
TDS ppm)	2899.6	2902.24	2908.4	2912.8	2931.28	2957.68
Cl (ppm)	687.28	687.28	670.56	604.56	624.8	683.76
So4 (ppm)	1166	1166.88	1174.8	1188.88	1195.92	1201.2
Na^{+} (ppm)	325.6	325.6	328.24	330.88	332.64	335.28
K (ppm)	8.36	8.36	8.58	8.8	8.36	8.36
Mg^{+2} (ppm)	84.48	84.48	87.12	95.92	97.68	99.44
Ca^{+2} (ppm)	184.8	186.56	190.96	211.2	213.84	218.24
No3 (ppm)	0.97	0.97	1.14	1.39	0.98	1.04
Po4 (ppm)	0.17	0.17	0.20	0.43	0.26	0.29
PH	5.94	5.94	5.99	6.09	6.16	6.20
Do (ppm)	7.92	7.92	8.27	9.05	8.47	8.68

Table C.37: Station: 427+00 Month: Nov.

Water Type	Almasab	1000G	2000G	3000G	5000G	7000G
EC(µs/cm)	5.14	5.148	5.1568	5.1744	5.192	5.2448
TDS ppm)	3256	3259.52	3265.68	3269.2	3292.08	3321.12
Cl (ppm)	499.84	499.84	487.52	440.88	454.08	497.2
So4 (ppm)	724.24	725.12	729.52	738.32	742.72	746.24
Na^{+} (ppm)	344.96	344.96	347.6	351.12	352.88	354.64
K (ppm)	8.36	8.36	8.36	8.58	8.36	8.45
Mg^{+2} (ppm)	97.24	97.68	100.32	110.88	112.64	114.4
Ca^{+2} (ppm)	223.96	224.4	231.44	255.2	259.6	264.88
No3 (ppm)	1.14	1.14	1.34	1.62	1.16	1.22
Po4 (ppm)	0.24	0.24	0.28	0.58	0.35	0.40
PH	6.95	6.95	7.01	7.13	7.21	7.26
Do (ppm)	8.36	8.36	8.76	9.59	8.88	9.11

Table C.38: Station: 427+00 Month: DEC.

Water Type	Almasab	1000G	2000G	3000G	5000G	7000G
EC(µs/cm)	4.38	4.38	4.39	4.40	4.42	4.47
TDS ppm)	2802.8	2805.44	2811.6	2814.24	2833.6	2858.24
Cl (ppm)	492.8	492.8	480.48	434.72	447.92	490.16
So4 (ppm)	1768.8	1770.56	1781.12	1959.76	1814.56	1821.6
Na^{+} (ppm)	333.52	333.52	336.16	339.68	342.32	346.72
K (ppm)	8.09	8.09	8.14	8.80	8.14	8.14
Mg^{+2} (ppm)	158.4	158.4	163.68	179.52	183.04	186.56
Ca^{+2} (ppm)	228.8	228.8	236.72	261.36	264	270.16
No3 (ppm)	1.1704	1.1704	1.3728	1.672	1.188	1.2408
Po4 (ppm)	0.26	0.27	0.31	0.66	0.37	0.44
PH	7.04	7.04	7.10	7.22	7.30	7.34
Do (ppm)	9.24	9.24	9.68	10.55	9.88	10.13

Table C.39: Station: 427+00 Month: Jan.

Water Type	Almasab	1000G	2000G	3000G	5000G	7000G
EC(µs/cm)	4.55	4.56	4.57	4.58	4.60	4.64
TDS ppm)	2816	2819.52	2824.8	2827.44	2846.8	2872.32
Cl (ppm)	493.68	492.8	481.36	435.6	448.8	490.16
So4 (ppm)	1796.08	1797.84	1808.4	1830.4	1842.72	1849.76
Na^{+} (ppm)	323.84	323.84	326.48	329.12	330.88	331.76
K (ppm)	8.53	8.53	8.55	8.99	8.55	8.58
Mg^{+2} (ppm)	183.04	183.04	189.2	207.68	212.08	215.6
Ca^{+2} (ppm)	281.6	281.6	290.4	322.08	325.6	332.64
No3 (ppm)	1.16	1.16	1.35	1.66	1.17	1.24
Po4 (ppm)	0.88	0.88	1.02	2.14	1.32	1.46
PH	7.12	7.12	7.18	7.31	7.39	7.44
Do (ppm)	4.55	4.56	4.57	4.58	4.60	4.64

Table C.40: Station: 427+00 Month: Feb.

Water Type	Almasab	1000G	2000G	3000G	5000G	7000G
EC(µs/cm)	4.664	4.6728	4.6816	4.6904	4.7168	4.7608
TDS ppm)	2992	2995.52	3000.8	3004.32	3024.56	3051.84
Cl (ppm)	687.28	687.28	670.56	606.32	624.8	683.76
So4 (ppm)	1303.28	1304.16	1312.08	1328.8	1337.6	1342
Na^{+} (ppm)	348.48	349.36	351.12	354.64	355.52	357.28
K (ppm)	8.36	8.36	8.36	8.888	8.4216	8.448
Mg^{+2} (ppm)	237.6	238.48	246.4	269.28	275.44	279.84
Ca^{+2} (ppm)	290.4	292.16	300.08	331.76	335.28	343.2
No3 (ppm)	2.112	2.1208	2.4816	3.0096	2.1472	2.2528
Po4 (ppm)	0.0968	0.0968	0.1144	0.2376	0.1496	0.1584
PH	7.216	7.2248	7.2776	7.4008	7.4888	7.5328
Do (ppm)	12.848	12.848	13.4816	14.696	13.7456	14.0976

Table C.41: Station: 427+00 Month: Mar.

Water Type	Almasab	1000G	2000G	3000G	5000G	7000G
EC(µs/cm)	5.368	5.3768	5.3856	5.4032	5.4296	5.4736
TDS ppm)	3428.48	3409.12	3415.28	3417.92	3442.56	3472.48
Cl (ppm)	784.96	784.08	765.6	692.56	713.68	781.44
So4 (ppm)	1355.2	1356.96	1364.88	1382.48	1390.4	1395.68
Na^+ (ppm)	357.28	358.16	359.92	363.44	364.32	366.08
K (ppm)	8.448	8.448	8.4656	8.976	8.4832	8.5536
Mg^{+2} (ppm)	244.64	245.52	253.44	278.08	283.36	287.76
Ca^{+2} (ppm)	294.8	294.8	304.48	337.04	341.44	349.36
No3 (ppm)	5.632	5.632	6.6264	8.0168	5.72	6.0192
Po4 (ppm)	0.2288	0.2288	0.264	0.5544	0.3432	0.3784
PH	7.2688	7.2776	7.3304	7.3568	7.3656	7.5856
Do (ppm)	9.46	9.4688	9.9176	10.824	10.12	10.3752

Table C.42: Station: 427+00 Month: April

Water Type	Almasab	1000G	2000G	3000G	5000G	7000G
EC(µs/cm)	5.45	5.46	5.47	5.48	5.51	5.56
TDS ppm)	3454	3458.4	3464.56	3468.96	3493.6	3524.4
Cl (ppm)	994.4	992.64	969.76	875.6	904.64	989.12
So4 (ppm)	1378.08	1379.84	1387.76	1403.6	1415.92	1421.2
Na^+ (ppm)	431.2	432.08	433.84	439.12	441.76	444.4
K (ppm)	12.49	12.49	12.53	12.98	12.50	12.54
Mg^{+2} (ppm)	227.04	227.92	234.96	257.84	262.24	266.64
Ca^{+2} (ppm)	233.2	233.2	241.12	266.64	269.28	275.44
No3 (ppm)	7.92	7.92	9.32	11.61	8.04	8.46
Po4 (ppm)	0.26	0.26	0.30	0.64	0.39	0.44
PH	6.96	6.96	7.02	7.14	7.21	7.26
Do (ppm)	7.56	7.56	7.93	8.65	8.09	8.29

Table C.43: Station: 427+00 Month: May

Water Type	Almasab	1000G	2000G	3000G	5000G	7000G
EC(µs/cm)	8.27	8.28	8.29	8.31	8.36	8.43
TDS ppm)	5220.16	5225.44	5235.12	5241.28	5277.36	5324.88
Cl (ppm)	1210.88	1209.12	1180.96	1068.32	1100.88	1204.72
So4 (ppm)	1513.6	1515.36	1524.16	1546.16	1553.2	1558.48
Na^{+} (ppm)	432.96	432.96	436.48	440.88	443.52	447.04
K (ppm)	9.59	9.59	9.63	10.30	9.66	9.68
Mg^{+2} (ppm)	244.64	245.52	253.44	278.08	284.24	288.64
Ca^{+2} (ppm)	228.8	228.8	235.84	261.36	264	270.16
No3 (ppm)	2.81	2.82	3.30	4.01	2.86	3.01
Po4 (ppm)	0.27	0.28	0.31	0.66	0.41	0.45
PH	7.04	7.04	7.10	7.22	7.30	7.35
Do (ppm)	6.60	6.60	6.92	7.56	7.05	7.24

Table C.44: Station: 427+00 Month: June

Water Type	Almasab	1000G	2000G	3000G	5000G	7000G
EC(µs/cm)	10.20	10.21	10.23	10.25	10.32	10.42
TDS ppm)	6527.84	6535.76	6547.2	6580.64	6600	6658.08
Cl (ppm)	1249.6	1246.96	1218.8	1102.64	1136.08	1243.44
So4 (ppm)	1774.08	1775.84	1786.4	1809.28	1819.84	1826.88
Na^{+} (ppm)	448.8	449.68	452.32	457.6	459.36	461.12
K (ppm)	9.24	9.24	9.29	9.85	9.33	9.46
Mg^{+2} (ppm)	264	265.76	273.68	299.2	305.36	310.64
Ca^{+2} (ppm)	184.8	185.68	190.96	211.2	213.84	218.24
No3 (ppm)	2.47	2.49	2.89	3.50	2.49	2.63
Po4 (ppm)	0.11	0.11	0.13	0.28	0.17	0.19
PH	7.12	7.13	7.18	7.31	7.40	7.44
Do (ppm)	6.16	6.16	6.45	7.13	6.60	6.75

Table C.45: Station: 427+00 Month: July

Water Type	Almasab	1000G	2000G	3000G	5000G	7000G
EC(µs/cm)	6.14	6.15	6.16	6.20	6.22	6.26
TDS ppm)	3904.56	3908.96	3916	3921.28	3948.56	3984.64
Cl (ppm)	1139.6	1139.6	1108.8	1004.08	1034	1135.2
So4 (ppm)	1496	1497.76	1506.56	1526.8	1534.72	1543.52
Na^{+} (ppm)	432.08	432.08	434.72	439.12	442.64	444.4
K (ppm)	9.85	9.87	9.94	10.78	9.92	10.38
Mg^{+2} (ppm)	128.48	128.48	132.88	146.96	148.72	151.36
Ca^{+2} (ppm)	237.6	237.6	245.52	271.92	274.56	281.6
No3 (ppm)	7.48	7.49	8.80	10.74	7.60	8.01
Po4 (ppm)	0.26	0.26	0.31	0.64	0.39	0.44
PH	6.68	6.69	6.74	6.85	6.93	6.97
Do (ppm)	6.86	6.87	7.19	7.85	7.35	7.53

Table C.46: Station: 427+00 Month: Aug.

Water Type	Almasab	1000G	2000G	3000G	5000G	7000G
EC(µs/cm)	6.98	6.99	7.00	7.01	7.06	7.12
TDS ppm)	4461.6	4466.88	4474.8	4479.2	4510.88	4550.48
Cl (ppm)	1170.4	1142.24	1033.12	1032.24	1063.92	1164.24
So4 (ppm)	1504.8	1506.56	1515.36	1534.72	1544.4	1549.68
Na^{+} (ppm)	424.16	424.16	427.68	432.08	432.96	435.6
K (ppm)	8.80	8.80	8.80	9.02	8.88	8.88
Mg^{+2} (ppm)	200.64	200.64	207.68	227.92	232.32	235.84
Ca^{+2} (ppm)	221.76	221.76	228.8	246.4	256.08	262.24
No3 (ppm)	5.28	5.28	6.21	7.52	5.36	5.64
Po4 (ppm)	0.30	0.31	0.36	0.75	0.465	0.51
PH	6.88	6.89	6.94	7.05	7.14	7.18
Do (ppm)	6.33	6.34	6.64	7.23	6.77	6.94

Table C.47: Station: 427+00 Month: Sept.

Water Type	Almasab	1000G	2000G	3000G	5000G	7000G
EC(µs/cm)	5.56	5.57	5.57	5.58	5.62	5.67
TDS ppm)	3480.4	3484.8	3490.96	3494.48	3519.12	3549.92
Cl (ppm)	1139.6	1138.72	1111.44	1004.96	1035.76	1085.04
So4 (ppm)	1064.8	1065.68	1071.84	1085.92	1092.08	1096.48
Na^{+} (ppm)	396	396.88	399.52	403.04	431.2	406.56
K (ppm)	8.58	8.58	8.58	8.80	8.58	8.58
Mg^{+2} (ppm)	193.6	193.6	199.76	220	223.52	227.92
Ca^{+2} (ppm)	211.2	211.2	218.24	241.12	243.76	249.04
No3 (ppm)	4.40	4.40	5.18	6.26	4.47	4.71
Po4 (ppm)	0.22	0.22	0.25	0.54	0.32	0.36
PH	6.55	6.55	6.61	6.72	6.80	6.83
Do (ppm)	7.39	7.39	7.75	8.45	7.91	8.09

Table C.48: Station: 441+00 Month: Oct.

Water Type	Almasab	1000G	2000G	3000G	5000G	7000G
EC(µs/cm)	4.46	4.46	4.47	4.48	4.51	4.55
TDS ppm)	2866.65	2869.26	2875.35	2879.7	2897.97	2924.07
Cl (ppm)	679.47	679.47	662.94	597.69	617.7	675.99
So4 (ppm)	1152.75	1153.62	1161.45	1175.37	1182.33	1187.55
Na^{+} (ppm)	321.9	321.9	324.51	327.12	328.86	331.47
K (ppm)	8.26	8.27	8.48	8.70	8.26	8.27
Mg^{+2} (ppm)	83.52	83.52	86.13	94.83	96.57	98.31
Ca^{+2} (ppm)	182.7	184.44	188.79	208.8	211.41	215.76
No3 (ppm)	0.95	0.96	1.12	1.37	0.97	1.02
Po4 (ppm)	0.17	0.17	0.20	0.43	0.26	0.28
PH	5.87	5.88	5.92	6.03	6.09	6.13
Do (ppm)	7.83	7.83	8.18	8.94	8.38	8.58

Table C.49: Station: 441+00 Month: Nov.

Water Type	Almasab	1000G	2000G	3000G	5000G	7000G
EC(µs/cm)	5.08	5.09	5.10	5.12	5.13	5.18
TDS ppm)	3219	3222.48	3228.57	3232.05	3254.67	3283.38
Cl (ppm)	494.16	494.16	481.98	435.87	448.92	491.55
So4 (ppm)	716.01	716.88	721.23	729.93	734.28	737.76
Na^{+} (ppm)	341.04	341.04	343.65	347.13	348.87	350.61
K (ppm)	8.26	8.26	8.27	8.48	8.26	8.35
Mg^{+2} (ppm)	96.135	96.57	99.18	109.62	111.36	113.1
Ca^{+2} (ppm)	221.415	221.85	228.81	252.3	256.65	261.87
No3 (ppm)	1.13	1.13	1.33	1.61	1.15	1.21
Po4 (ppm)	0.23	0.23	0.27	0.57	0.34	0.39
PH	6.87	6.87	6.93	7.04	7.13	7.17
Do (ppm)	8.26	8.26	8.66	9.48	8.78	9.00

Table C.50: Station: 441+00 Month: Jan.

Water Type	Almasab	1000G	2000G	3000G	5000G	7000G
EC(µs/cm)	4.50	4.50	4.52	4.53	4.55	4.59
TDS ppm)	2784	2787.48	2792.7	2795.31	2814.45	2839.68
Cl (ppm)	488.07	487.2	475.89	430.65	443.7	484.59
So4 (ppm)	1775.67	1777.41	1787.85	1809.6	1821.78	1828.74
Na^{+} (ppm)	320.16	320.16	322.77	325.38	327.12	327.99
K (ppm)	8.43	8.43	8.45	8.89	8.46	8.48
Mg^{+2} (ppm)	180.96	180.96	187.05	205.32	209.67	213.15
Ca^{+2} (ppm)	278.4	278.4	287.1	318.42	321.9	328.86
No3 (ppm)	1.14	1.15	1.34	1.64	1.16	1.23
Po4 (ppm)	0.87	0.87	1.01	2.11	1.30	1.45
PH	7.04	7.05	7.11	7.23	7.30	7.36
Do (ppm)	11.39	11.44	11.95	13.04	12.19	12.50

Table C.51: Station: 441+00 Month: Feb.

Water Type	Almasab	1000G	2000G	3000G	5000G	7000G
EC(µs/cm)	4.61	4.62	4.63	4.64	4.66	4.70
TDS ppm)	2958	2961.48	2966.7	2970.18	2990.19	3017.16
Cl (ppm)	679.47	679.47	662.94	599.43	617.7	675.99
So4 (ppm)	1288.47	1289.34	1297.17	1313.7	1322.4	1326.75
Na^{+} (ppm)	344.52	345.39	347.13	350.61	351.48	353.22
K (ppm)	8.26	8.26	8.26	8.78	8.32	8.35
Mg^{+2} (ppm)	234.90	235.77	243.6	266.22	272.31	276.66
Ca^{+2} (ppm)	287.1	288.84	296.67	327.99	331.47	339.3
No3 (ppm)	2.08	2.09	2.45	2.97	2.12	2.22
Po4 (ppm)	0.06	0.06	0.11	0.23	0.15	0.16
PH	7.13	7.14	7.19	7.31	7.40	7.44
Do (ppm)	12.70	12.70	13.33	14.53	13.58	13.93

Table C.52: Station: 441+00 Month: Mar.

Water Type	Almasab	1000G	2000G	3000G	5000G	7000G
EC(µs/cm)	5.30	5.3	5.32	5.34	5.36	5.41
TDS ppm)	3389.52	3370.38	3376.47	3379.08	3403.44	3433.02
Cl (ppm)	776.04	775.17	756.9	684.69	705.57	772.56
So4 (ppm)	1339.8	1341.54	1349.37	1366.77	1374.6	1379.82
Na^{+} (ppm)	353.22	354.09	355.83	359.31	360.18	361.92
K (ppm)	8.35	8.35	8.36	8.87	8.38	8.45
Mg^{+2} (ppm)	241.86	242.73	250.56	274.92	280.14	284.49
Ca^{+2} (ppm)	291.45	291.45	301.02	333.21	337.56	345.39
No3 (ppm)	5.56	5.56	6.55	7.93	5.65	5.95
Po4 (ppm)	0.22	0.23	0.26	0.55	0.34	0.37
PH	7.18	7.19	7.24	7.27	7.28	7.49
Do (ppm)	9.35	9.36	9.80	10.70	10.00	10.25

Table C.53: Station: 441+00 Month: April

Water Type	Almasab	1000G	2000G	3000G	5000G	7000G
EC(µs/cm)	5.39	5.40	5.41	5.42	5.45	5.49
TDS ppm)	3414.75	3419.1	3425.19	3429.54	3453.9	3484.35
Cl (ppm)	983.1	981.36	958.74	865.65	894.36	977.88
So4 (ppm)	1362.42	1364.16	1371.99	1387.65	1399.83	1405.05
Na^{+} (ppm)	426.3	427.17	428.91	434.13	436.74	439.35
K (ppm)	12.35	12.35	12.38	12.8325	12.36	12.39
Mg^{+2} (ppm)	224.46	225.33	232.29	254.91	259.26	263.61
Ca^{+2} (ppm)	230.55	230.55	238.38	263.61	266.22	272.31
No3 (ppm)	7.83	7.83	9.22	11.48	7.95	8.36
Po4 (ppm)	0.26	0.26	0.30	0.64	0.39	0.44
PH	6.88	6.89	6.94	7.06	7.13	7.18
Do (ppm)	7.48	7.48	7.84	8.55	8.00	8.20

Table C.54: Station: 441+00 Month: May

Water Type	Almasab	1000G	2000G	3000G	5000G	7000G
EC(µs/cm)	8.17	8.18	8.20	8.22	8.26	8.33
TDS ppm)	5160.84	5166.06	5175.63	5181.72	5217.39	5264.37
Cl (ppm)	1197.12	1195.38	1167.54	1056.18	1088.37	1191.03
So4 (ppm)	1496.4	1498.14	1506.84	1528.59	1535.55	1540.77
Na^{+} (ppm)	428.04	428.04	431.52	435.87	438.48	441.96
K (ppm)	9.48	9.48	9.52	10.18	9.55	9.57
Mg^{+2} (ppm)	241.86	242.73	250.56	274.92	281.01	285.36
Ca^{+2} (ppm)	226.2	226.2	233.16	258.39	261	267.09
No3 (ppm)	2.78	2.78	3.27	3.97	2.83	2.97
Po4 (ppm)	0.26	0.27	0.31	0.65	0.41	0.45
PH	6.96	6.96	7.02	7.14	7.22	7.26
Do (ppm)	6.52	6.53	6.84	7.48	6.97	7.16

Table C.55: Station: 441+00 Month: June

Water Type	Almasab	1000G	2000G	3000G	5000G	7000G
EC(µs/cm)	10.09	10.10	10.11	10.13	10.20	10.30
TDS ppm)	6453.66	6461.49	6472.8	6505.86	6525	6582.42
Cl (ppm)	1235.4	1232.79	1204.95	1090.11	1123.17	1229.31
So4 (ppm)	1753.92	1755.66	1766.1	1788.72	1799.16	1806.12
Na^{+} (ppm)	443.7	444.57	447.18	452.4	454.14	455.88
K (ppm)	9.13	9.14	9.18	9.74	9.22	9.35
Mg^{+2} (ppm)	261	262.74	270.57	295.8	301.89	307.11
Ca^{+2} (ppm)	182.7	183.57	188.79	208.8	211.41	215.76
No3 (ppm)	2.44	2.46	2.86	3.46	2.47	2.60
Po4 (ppm)	0.11	0.11	0.13	0.28	0.17	0.19
PH	7.04	7.05	7.10	7.22	7.31	7.36
Do (ppm)	6.09	6.09	6.38	7.05	6.52	6.68

Table C.56: Station: 441+00 Month: July

Water Type	Almasab	1000G	2000G	3000G	5000G	7000G
EC(µs/cm)	6.07	6.08	6.09	6.13	6.15	6.19
TDS ppm)	3860.19	3864.54	3871.5	3876.72	3903.69	3939.36
Cl (ppm)	1126.65	1126.65	1096.2	992.67	1022.25	1122.3
So4 (ppm)	1479	1480.74	1489.44	1509.45	1517.28	1525.98
Na^{+} (ppm)	427.17	427.17	429.78	434.13	437.61	439.35
K (ppm)	9.74	9.76	9.83	10.65	9.81	10.26
Mg^{+2} (ppm)	127.02	127.02	131.37	145.29	147.03	149.64
Ca^{+2} (ppm)	234.9	234.9	242.73	268.83	271.44	278.4
No3 (ppm)	7.40	7.41	8.70	10.61	7.51	7.92
Po4 (ppm)	0.26	0.26	0.30	0.63	0.39	0.43
PH	6.61	6.62	6.67	6.77	6.85	6.89
Do (ppm)	6.78	6.79	7.12	7.76	7.26	7.45

Table C.57: Station: 441+00 Month: Aug.

Water Type	Almasab	1000G	2000G	3000G	5000G	7000G
EC(µs/cm)	6.90	6.91	6.92	6.93	6.98	7.04
TDS ppm)	4410.9	4416.12	4423.95	4428.3	4459.62	4498.77
Cl (ppm)	1157.1	1129.26	1021.38	1020.51	1051.83	1151.01
So4 (ppm)	1487.7	1489.44	1498.14	1517.28	1526.85	1532.07
Na^{+} (ppm)	419.34	419.34	422.82	427.17	428.04	430.65
K (ppm)	8.70	8.70	8.70	8.91	8.78	8.78
Mg^{+2} (ppm)	198.36	198.36	205.32	225.33	229.68	233.16
Ca^{+2} (ppm)	219.24	219.24	226.2	243.6	253.17	259.26
No3 (ppm)	5.22	5.22	6.14	7.42	5.30	5.57
Po4 (ppm)	0.30	0.30	0.36	0.74	0.46	0.50
PH	6.80	6.81	6.86	6.97	7.06	7.09
Do (ppm)	6.26	6.26	6.56	7.15	6.69	6.86

Table C.58: Station: 441+00 Month: Sept.

Water Type	Almasab	1000G	2000G	3000G	5000G	7000G
EC(µs/cm)	5.49	5.50	5.51	5.52	5.55	5.61
TDS ppm)	3440.85	3445.2	3451.29	3454.77	3479.13	3509.58
Cl (ppm)	1126.65	1125.78	1098.81	993.54	1023.99	1072.71
So4 (ppm)	1052.7	1053.57	1059.66	1073.58	1079.67	1084.02
Na^{+} (ppm)	391.5	392.37	394.98	398.46	426.3	401.94
K (ppm)	8.48	8.48	8.48	8.70	8.48	8.48
Mg^{+2} (ppm)	191.4	191.4	197.49	217.5	220.98	225.33
Ca^{+2} (ppm)	208.8	208.8	215.76	238.38	240.99	246.21
No3 (ppm)	4.35	4.35	5.12	6.19	4.41	4.65
Po4 (ppm)	0.22	0.22	0.25	0.53	0.32	0.36
PH	6.48	6.48	6.53	6.64	6.72	6.76
Do (ppm)	7.31	7.31	7.661	8.351	7.821	8.00

الخلاصة

أجريت هذه الدراسة على مبزل المصب العام الواقع ضمن قاطع محافظة بابل والذي يبدا من المحطة 360 وينتهي بالمحطة 441. تناولت هذه الدراسة تقييم ومعالجة ماء المصب العام. تم تحديد خمس محطات لأخذ النماذج منها واجراء الفحوصات الكيميائية والفيزيائية لها حيث يتم فحص كل نموذج ثلاث مرات وبمختبرات مختلفة ويؤخذ المعدل. يتم ادخال نتائج الفحوصات ببرنامج دليل جودة مياه الري **(IWQG V.1)** الذي تم استخدامه في هذه الدراسة لمعرفة صلاحية هذه المياه للري وكذلك معرفة النبات الملائم الذي يمكن زراعته بهذه المياه. أما المعالجة لهذه المياه فقد استخدمت طريقتين الأولى هي مزج هذه المياه المالحة مع مياه الأنهار الموجودة في منطقة الدراسة والمستخدمة للري. تم استخدام ثلاث نسب للمزج وهي الأولى مزج 75% ماء نهر مع 25% ماء المصب العام B1 والثانية مزج 50% ماء نهر مع 50% ماء المصب العام B2 والثالثة مزج 25% ماء نهر مع 75% ماء المصب العام B3 .بعد ذلك تفحص الخصائص الكيميائية والفيزيائية للنماذج ويتم إدخالها ببرنامج **(IWQG V.1)** لغرض تقييمها ومعرفة صلاحيتها للري وتحديد نوع النبات الذي يمكن زراعته لكل حالة ويتم تحديد افضل نسبة مزج. الطريقة الثانية للمعالجة هي طريقة مغنطة المياه بأمرارها بمجال مغناطيسي بشدات مختلفة 1000، 2000، 3000، 5000، و 7000 غاوس وتفحص العناصر الكيميائية والفيزيائية لهذه المياه بعد مغنطتها. لمعرفة تاثير الماء الممغنط على التربة والنبات تم أخذ سنادين وملأها بتربة من منطقة الدراسة وقريبة من المحطتين 00+360و 00+441 متشابهة في الخصائص والوزن . وضعت هذه السنادين داخل بيت بلاستيكي لغرض منعها من التاثر بالظروف الجوية كالأمطار وغيرها. استمرت فترة الدراسة لموسمين هما 2020-2021 و 2021-2022 . الماء المستخدم للري هو ماء المصب العام الممغنط وغير الممغنط وماء النهر ، الماء الممغنط مرر بجهاز مغناطيسي بخمس شدات هي 1000، 2000، 3000، 5000، و7000 غاوس. تم زراعة نباتات البصل والفاصولياء والذره والباقلاء في السنادين. لتاكيد دقة النتائج تم عمل ثلاث مكررات لكل سندانة تحت ظروف متطابقة لكل نبتة. استخدمت 336 سندانه في هذه الدراسة.تم اجراء الفحوصات الكيميائية والفيزيائية للتربة قبل وبعد التجربة. تم دراسة نسبة الانبات والارتفاع ومدة التزهير للنباتات وكذلك قياس طول الجذور لنبات البصل. من النتائج التي تم التوصل اليها ان ماء المصب العام يصلح فقط لري النباتات المتوسطة والعالية التحمل للملوحة وافضل نسبة مزج هي **(B1)** .

الماء الممغنط يحسن الخواص الكيميائية والفيزيائية للماء والتربة وكذلك يحسن خواص النبات من حيث النمو الخضري والجذري ويسرع من عملية التزهير بمعدل 16 يوم عن الحالة الأعتيادية ويزيد الأنتاجية. الماء الممغنط بشدة3000 غاوس يزيل 70% من املاح التربة عند استخدامه للري وتعتبر هذه الحالة هي الأفضل لتحسين خواص الماء والتربة والنبات ونوصي باستخدامها في منطقة الدراسة. ان طريقة مغنطة المياه هي الطريقة الملائمة لمعالجة مياه المصب العام .

جمهورية العراق

وزارة التعليم العالي والبحث العلمي

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أطروحة

مقدمة الى كلية الهندسة / جامعة بابل

كجزء من متطلبات نيل درجة الدكتوراه فلسفة في الهندسة / الهندسة المدنية / موارد مائية

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