Hebron University

Faculty of Graduate Studies & Academic Research

Effects of Contaminated Groundwater Irrigation on Soil, Sweet Corn and Sweet Pepper

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2007

This thesis is submitted in partial fulfillment of the requirements for the Degree of Master of Science in Department of Sustainable Natural Resources & its Management, College of Graduates Studies & Academic Research , Hebron University, Palestine.

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Dedication

To my Mother and Father who supported me and lights up my life since my birth to this date.

To my lovely "Jalal" for his efforts, moral support and endless encouragement.

To my children "Mohammad", Lama and Basmalah ", father in law and mother in law for their understanding during my absence, with my love to them all.

Adeeba

Acknowledgments

I would like to express my deepest thanks and gratitude to my supervisor Dr. Yousef Amro for his unlimited support through out the different phases of this research. Thanks are expressed to Dr. Ayed Mohammad for important and valuable advices. Great thanks and appreciation go to Dr. Hazem Al Bakeer for his support in the soil study and analysis, to Dr Qasem Abdul – Jaber the External Examiner. to Dr. Ayman Abu Yousef, for encouragement and support me in Phases of this research, to Dr. Rezq Basheer and Mr. Mohammad Al Masree and Mr. Suhiel Al-khateeb who providing me useful suggestions, also to Salman Tomaize and Omar Naser, who helped me in lab work throughout the experiment. My thanks to Dr. Akram Al-Tamimi for help me in the first Phases of this research.

The encouragement, contribution and supports of my brothers and my sister (Akram, Adeeb, Amein, Ahmad and Amal). Thanks are extended to my best friends Saleh Al- Seikh , Osama Al- Joaba, and Tareq Thawabta who helped me in this research and Eyad Thawabta together my husband Jalal who helped me in the hard field work.

Finally thanks to the farmers who supported this research by offering their lands to be available for the purposes of scientific research, and to everyone who, contributed in the other ways.

Abbreviations

CW	Contaminated water
FW	Fresh Water
FSC Seed	Seed of sweet corn irrigation with fresh groundwater
CSC Seed	Seed of sweet corn irrigation with contaminated groundwater.
FSP Fruit	Fruit of sweet pepper irrigation with fresh groundwater
CSP Fruit	Fruit of sweet pepper irrigation with contaminated groundwater
PCBS	Palestinian Central Bureau of Statistics
PNOMO	Palestine Central Bureau of Statistics (1999): small area populations
USSL	United State Salinity Laboratory
OM	Organic Matter
WHO	World Health Organization
SAR	Sodium Adsorption Ratio
TDS	Total Dissolved Solid
DTPA	Diethylene Thiamine pent a acetic

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Abstract

Contaminated groundwater is used for Sweet Corn (*Zea mays Var.rugosa*) and Sweet Pepper (*Capsicum annum*) irrigation through a drip system at Al-Arroub valley experimental site. The soil characteristics were determined prior to irrigation. Physical, chemical and biological characteristics of the groundwater were determined during the growing season.

Suitability of the contaminated groundwater for irrigation use was studied. The soil was tested for pathogenic pollution. The accumulation of salts in the soil as well as concentration of the nutrients and heavy metal accumulation in the plant tissue were determined. The soil of the contaminated water had higher EC_e, Total soluble ion concentrations (Ca^{2+}, Mg^{2+}, Cl^-, HCO^-_3 and NO_3^-), organic matter (OM). Results of the study showed moderate restriction for surface trickle irrigation.

The soil under the contaminated groundwater irrigation was found to contain higher fecal coliform than fresh groundwater.
Results of soil analysis after irrigation with contaminated water showed a slight increase in salt accumulation at the surface of the soil, and EC_e increased with depth of soil.

Contaminated sweet corn and pepper leaves and fruits crops proved to both be deficient in total N, K^+, and Ca^{2+}, while having sufficient supplies of total P, Mg^{2+}, Cu, Fe, Mn, and Zn. Plots irrigated with contaminated groundwater had the highest yields in sweet corn, and had the lowest yields in sweet pepper. Although filtration of the contaminated groundwater was not practiced, there was minimum clogging of the irrigation system. This clogging was successfully controlled with the removing the clogging materials at least once in week and clogging can be overcome by increasing pressures in the lines.

Chapter One

1. Introduction

Water resources in Wadi Al Arroub are almost exclusively dependent on rainfall. The area of the study, Wadi Al Arroub drainage basin, suffers from water scarcity as does the whole West Bank. The people experience frequent interruptions to tap water supply for long periods. This enhance them to utilize the water of unprotected spring and open pits (dug wells), and /or to pay 4 - 5 fold price obtaining water from tanks to fulfill their basic domestic needs. The scarcity of water is also a main reason, why the farmers do not cultivate their land and this allows urban expansion on agricultural land. Wadi Al Arroub basin enjoys a Mediterranean climate with hot and dry summers and mild and wet winters.

The Wadi Al Arroub drainage basin with an area of 61 km^2 is situated in the mid way between Hebron and Bethlehem. Its part of the Hebron District which represents the southern part of the West Bank/ Palestine. The selected catchment's area lies within $^{\circ}35-32-50''$ and $^{\circ}31\ \ 40\ \ 20''$ latitude respectively between 108- 120 N and 158- 170 E referenced on the Palestinian grid (Fig 1.1).

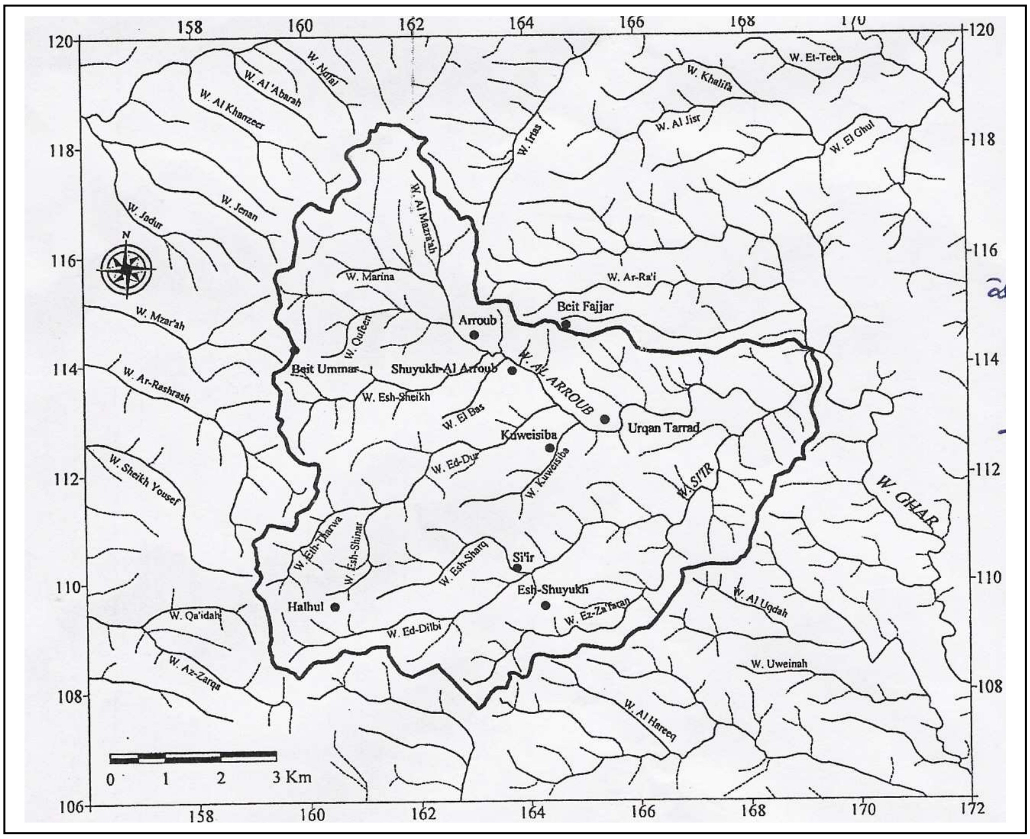


Fig1.1.A map showing the border of Wadi AL Arroub basin and its drainage system,(Local councils 1999).

According to PNOMO (1998 and 1999) the area of Wadi Al Arroub as part of the West Bank has a Mediterranean climate with hot and dry summer and mild and wet winters. The most of the rain falls during the period Novamber to April , (Fig 1.2) The average annual rainfall was 607 mm during

(1953 to 2001) . However, it was 1200 mm during (1991 to 1992) compared to 212 mm (1998 to 1999).

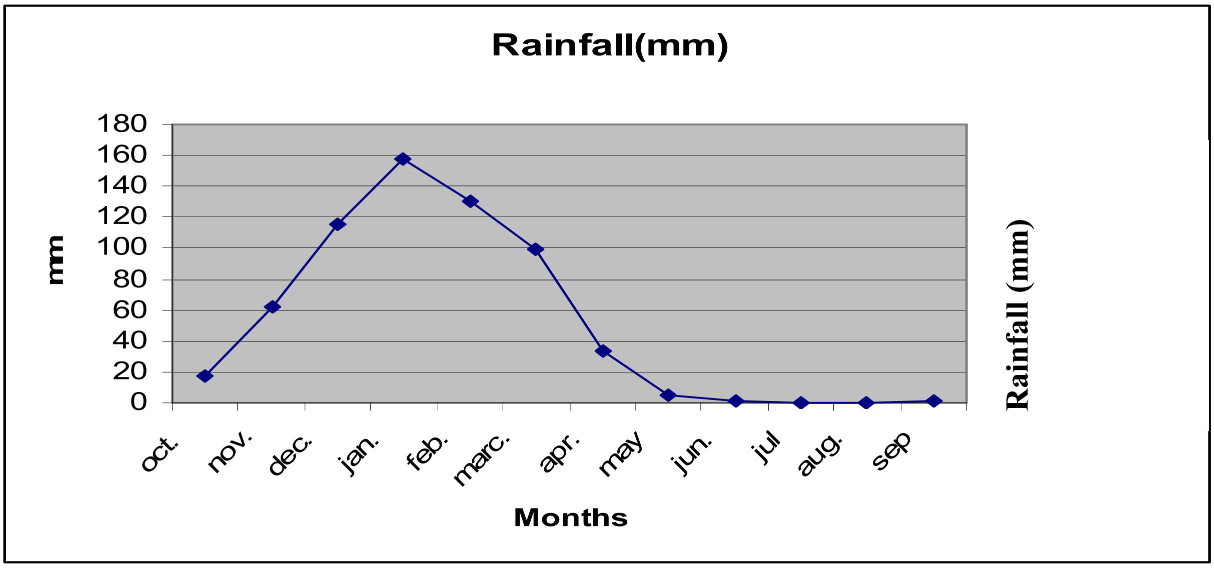


Fig 1.2. the average monthly rainfall recorded at Al Arroub Meteorological station for the period 1953- 2001

The Average annual potential evaporation was about 1600 mm and thats more than twice the average annual rainfull during the period (1965- 1998). The long term average of the monthly mean temperature ranges between 7.5 °C in January and 22.6 °C in August. The average of the monthly maximum temperature varies between 11.6 °C in January and 29.6 °C in August. Whereas the minimum monthly temperature was between 3.4 °C in January and 17. 5 °C in July. (Fig 1.3) shows clearly that January is the coldest month and August is the warmes.

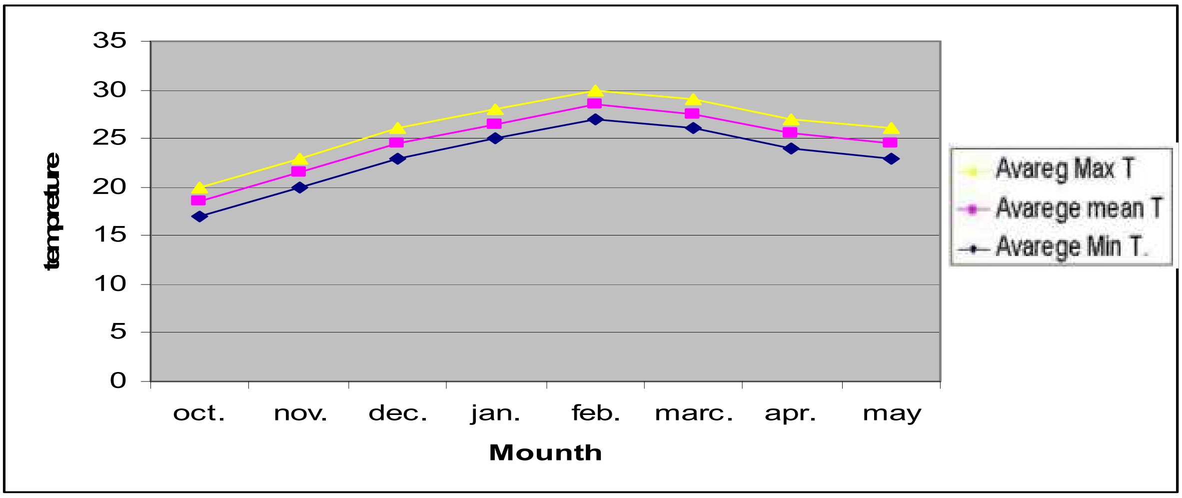


Fig 1.3. Monthly average of the mean, maximum and minimum temperatures at AL Arroub Meteorological station (1965-1998)

The relative humidity averages (RH%) in Wadi Al Arroub drainage basin during the period (1968- 1998). The extreme values of the average monthly RH% are 47.6% in May and 75.7% in January. The average monthly maximum RH% ranges between 61.6% in June and 90.8% in January, whereas the minimum monthly RH% varies between 36% in May and 59.8% in February.

The average annual RH is 61.8%, whereas RH% in January represents the highest values and in May the Lowest values Fig 1.4

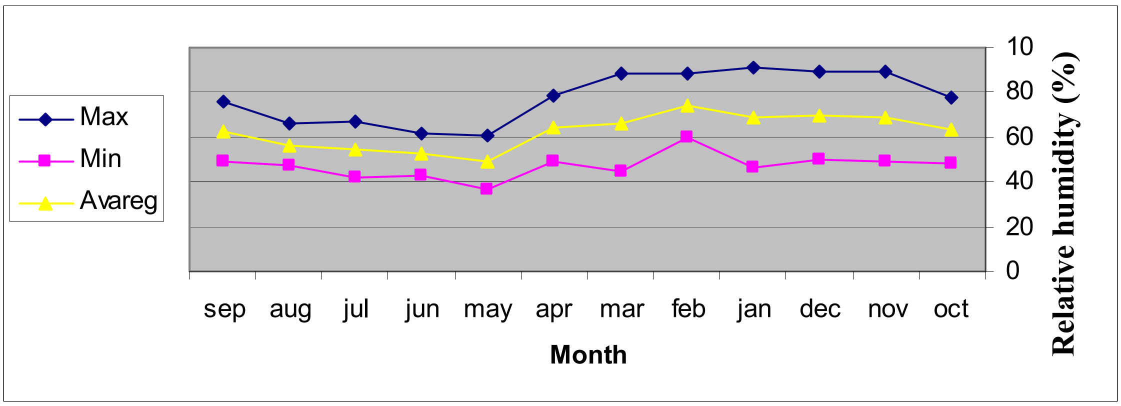
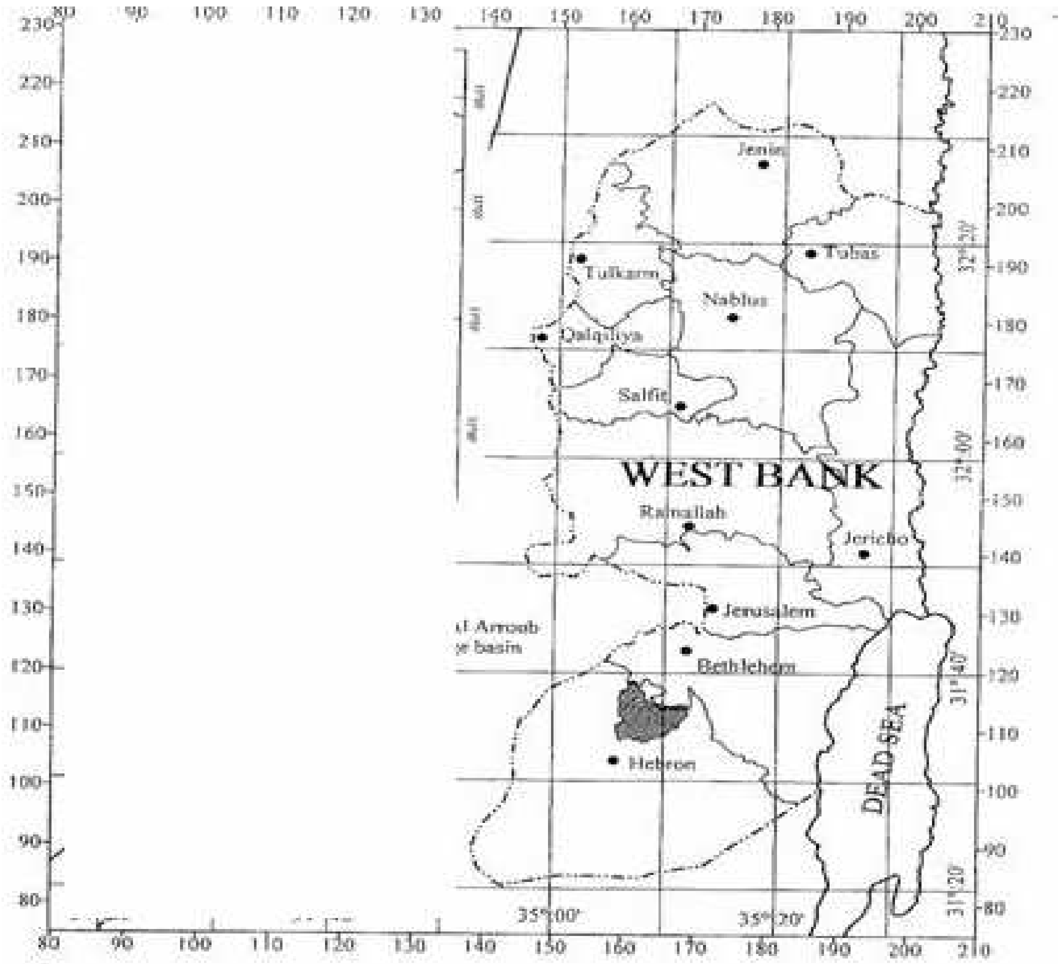


Fig 1.4 averages of monthly mean, maximum and minimum relative humidity at Al Arroub Meteorological station(1968-1998).



Figurer 1.5: location Wadi Al Arroub drainnge bisan in the west Bank Palastine

Wadi Al Arroub drainage basin (Fig 1.1) was chosen for the present study, as there is an evidence of serious pollution from many springs in this basin as well as the sewage flow along the talweg, posing a significant health hazard for the local inhabitants.The Palestinian population of Wadi Al Arroub drainage basin was estimated to be about 39.000 inhabitants (1999); 7000 in Arroub camp, 1500 in Shuyukh Arroub, 1000 in Kuweisiba and Urqan Torrad, and 11000 in Si'ir, 6000 in Esh Shuyukh and approximate 1500 in Beit Fajjar, 5000 in Beit Ommar and 6000 in Halhul, (PCBS 1999).

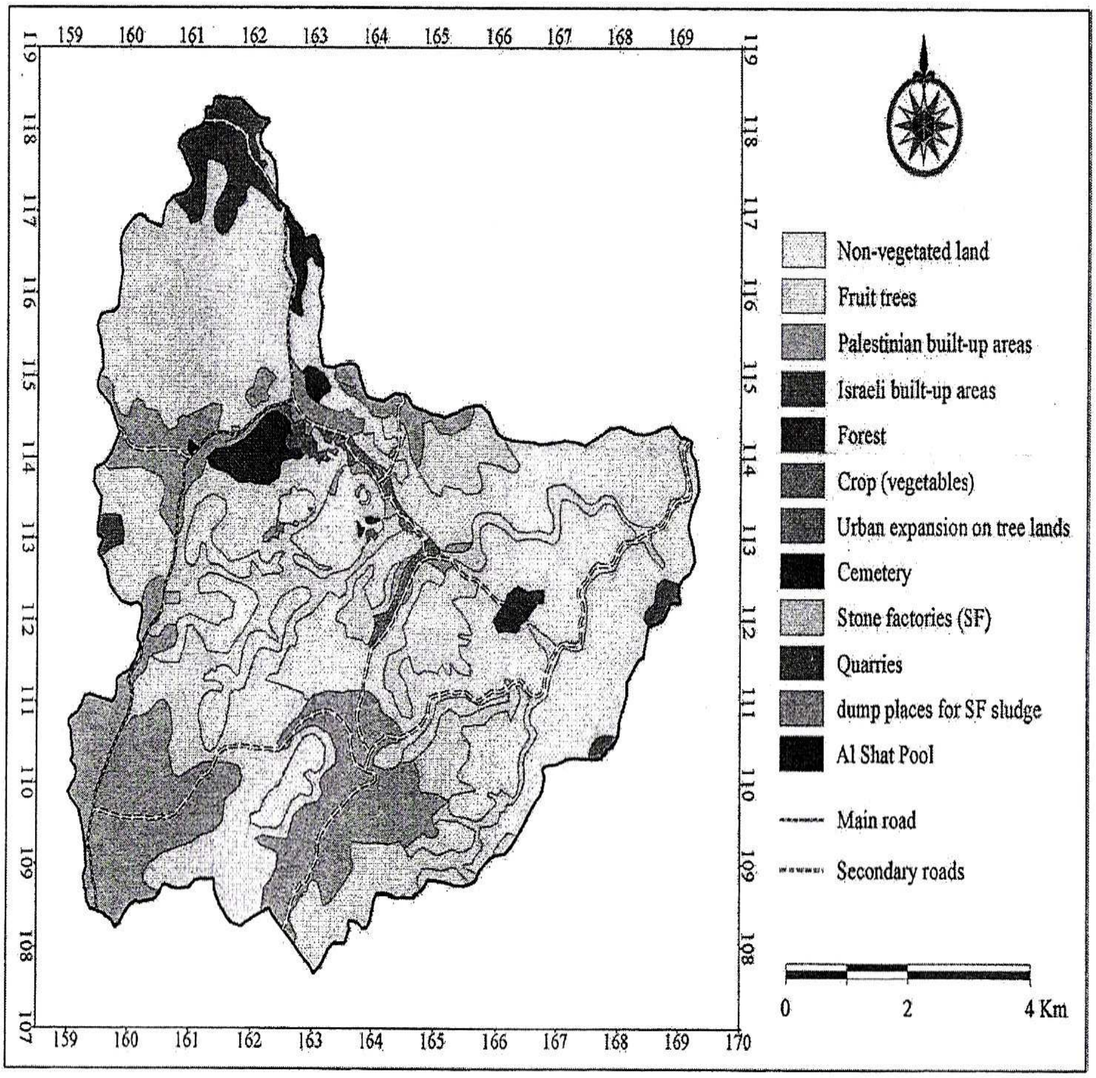


Fig. 1.6: Land use map of Wadi Al Arroub drainage,1999. (Local councils, 1999)

Due to the physiographic situation of the area, most of the infiltrated water from precipitation appears once again as springs.

The Groundwater flows through water-bearing formations (aquifers) at different rates. In some places, where groundwater has dissolved limestone forms caverns and large openings, its rate of flow can be relatively fast but this is exceptional. (Coon, 1987).

Groundwater was thought to be immune to many chemicals, but some chemicals, including nitrate, can pass through the soil and potentially contaminate groundwater. Nitrate comes from nitrogen, a plant nutrient supplied by inorganic fertilizer and animal manure. Additionally, airborne nitrogen compounds given off by industry and automobiles are deposited on the land in precipitation. (Bernard, 1998).

Groundwater is filtering an excellent mechanisms for removing particulate matter, such as leaves, soil and bugs, but dissolved chemicals gases can still occur in large enough concentrations in groundwater ensuch to cause problems. Under groundwater can get contaminated from industrial, domestic, and agricultural chemicals from the surface. (Bowen, 1986).

The soil, serving as a living filter, will effectively remove harmful toxic chemicals and microorganisms from applied wastewater as it percolates through soil. When irrigation water is applied to heavy- textured soils of neutral or alkaline pH, or soils with appreciable ($\geq 10\%$) amounts of $CaCO_3^-$ and organic matter content, significant amount of most trace metals are retained by the soil, but this renders them potentially less bioavailable. These are problems commonly encountered in the groundwater wells located near untreated waste water from the Al Arroub Refugee camp. Soil pollution can take the form soil salinity, alkalinity, the accumulation of heavy metals or a combination of thes. Soil salinity in particular may affect plant growth and development and induce Na^+ and / or Cl^- specific toxicity to plant. Deterioration of groundwater may take the form of induced Salinization and or NO_3^- pollution of groundwater reservoirs (Hooda and Alloway, 1998).

Surface irrigation entails considerable loss through seepage and evaporation, and therefore it is not recommended in countries like Palestine in which water shortage is a serouis problem. Drip irrigation, beside profitability and probable safe use, is considered the better option for contaminated groundwater, and it has other advantages. Among these is the application of small amounts of water to a limited soil volume. The volume of soil wetted by this method is less compared with other methods; also, deep percolation is negligible (Ayears and Westcot, 1985).

A major drawback of the trickle system is the susceptibility of its emitters and tubes to clogging. Clogging problems often relate to water quality. Other than clogging with silt and clay, the most common causes of clogging or precipitation of calcium carbonate, calcium phosphate compounds, iron oxide and bacterial slimes . Algae growth is a further cause (Rible and Meyer, 1986).

Drip irrigation system in Wadi Al Arroub does not have clogging problems from using contaminated groundwater. But the problem associated with the use of contaminated groundwater through drip irrigation is salt accumulation in soils, salt accumulate on the soil surface and along the soil profile at the edges of the wetted zone. Using contaminated groundwater in irrigation is associated with some health risk due to the possibility of the putrescence of a wide spectrum of pathogens such as Escherichia coil, and Shigella (Water Quality and Health Council, 2001) .

Five objectives were set for the study undertaken at Al Arroub valley, Palestine. The objectives were:

1- To determine the effects of various factors on crop yields under the controlled application of fresh and contaminated groundwater.
2- To test the effects of using contaminated groundwater on the physio-chemical properties of the soil by measuring the soil quality parameters before irrigation and after irrigation with fresh and contaminated groundwater .
3- To evaluate groundwater pollution risks associated with waste water.

4- To evaluate the elemental composition of sweet corn crops and Sweet pepper leaves and fruits grown under these conditions.
5- To evaluate the operating conditions of the drip system applying the contaminated groundwater.

Cha pter Two

2. LITERATURE REVIEW

2.1 Soil

Papadopoulos and Stylianou (1991 and 1988) found that higher EC_e, and hence inputs to soil of the major soluble ions (Na^+, Ca^{2+}, Mg^{2+}, Cl^- and SO_4^{2-}) resulted from fresh, rather than effluent irrigation water. Sodium adsorption ratio was reduced beneath drippers in the surface 15 and 30 cm depths with fresh and effluent water, respectively, and the reverse trend was observed there after. In addition, substantial increases in sodium adsorption ratio (SAR) and reductions in soil permeability were observed using fresh, rather than effluent water and the effect of effluent on soil Phosphorus was particularly greater at the surface 45cm.

Day *et al*. (1972) found that effluent-irrigated soil had higher pH and concentrations of nitrates, phosphates, and calcium plus magnesium as compared with a field irrigated with well water and fertilized with recommended N, P and K^+ concentrations.

Jame *et al*. (1984) found that after eight years of effluent irrigation, new steady state salinity profiles developed. In this stady state condition, salt contents in the upper 60cm of the root zone were generally similar, while salinity increased with depth towards bottom of the root zone from an initial low EC_e value of 2.5 to 6 ds/m.

Hills and Brenes (2001) tested different kinds of drip tape to irrigate using Wastewater effluent. The irrigation system used many sand filters to prevent clogging. It was determined that all tapes performed well under the prescribed pressures and a 94% uniformity was measured.

Tarchtzky *et. al* (1999) studied the effect of dissolved organic matter present in wastewater on the hydraulic conductivity of a sandy soil. They found out that there is a substantial decrease in the hydraulic conductivity of the soil: only 20% of initial value of hydraulic conductivity at the end of the growing season was measured due to decrease in soil pore – size.

Howe and Wagner (1999) studied the distribution of nitrogen, phosphorus, heavy metals and electrical conductivity through a 2.5 meter soil profile while irrigating saltbush plants with industrial wastewater. It was found that overall concentrations of all measured elements rose.

Shatanawi *et al* (1994) concluded that effluent irrigation induced a slight increase in soil solution pH, EC_e, P, K^+ and NO_3^-, and a reduction in Mg^{2+} and Cl^-.

Neilsen *et al*. (1991) examined the response of sweet cherry orchards to waste water irrigation. They found that sites receiving wastewater had higher extractable P and K^+ concentrations and lower extractable Ca^{2+} and Mg^{2+} than controls. As the increase in extractable Na^+ was not paralleled by comparable increases in extractable Ca^{2+} an Mg^{2+}, a significant increase in SAR was recorded . Moreover waste water affected higher soil saturation extract electrical conductivity (EC_e), which under both treatments kept increasing with time, thus reflecting salt accumulation in the profile , particularly at the surface. However, regardless of the type of irrigation water, all plots exhibited temporal pH increase since both types of irrigation water had higher pH increase since both types of irrigation water had higher pH values (9.7) compared with the soil (6.49 in 0.01 $CaCl_2$). Zinc concentrations were extremity low, averaging 0.65

and 0.44 mg/l, respectively throughout the well water and waste water –irrigated sites .

Petruzzelli *et al* (1978) found that OM removal produced a noteworthy decrease in Cu adsorption contrasted by a smaller decrease or ever as light increase in Cu , Zn and Ni completed by soil increase with OM content.

Flores *et al*. (1997) found that Cu, Cd, Pb and Zn values were predominately associated with the organic fraction in the most of the soil samples.

Tscheschke et al. (1974) found that soil salinity was higher in the upper 10 cm of the soil profile and decreased with depth . This is probably related to two factors, evaporation from the surface soil, leading to salt accumulation , and exposure of the sub soil to continuous leaching and displacement of salts towards the periphery of the wetted zone which showed increasing salt concentration.

Shahlam et al. (1998) investigated crops (alfalfa, radish, and tomato) were irrigated with fresh and wastewaters. The irrigation water was applied by sprinklers. thus found higher pH values in soil under fresh water rather than wastewater irrigation, and found higher EC_e, Valus and , Ca^{2+}, Mg^{2+}, and Na^+.concentrations in soil irrigated with waste water rather than with fresh.

2.2 plant

Day and Tucker (1977) found that wastewater – irrigated sorghum produced higher grain yields than sorghum irrigated with well water plus N, P and K^+ in a mounts equal to those present in waste water.

Papadopoulos and Stylianou (1991 and 1988) found that effluent was generally superior to fresh water in increasing yields. With no supplement to N additions, effluent lead to higher sunflower and seed cotton yields, and petiole and Laminae N concentrations.

Allhands *et al*. (1995) reported a linear increase in Bermuda grass dry matter yield and uptake of N and K with harvest interval under effluent irrigation.

Al-Nakshabandi *et al* (1997) used a trickle system to irrigate eggplants with wastewater treated by As-samra waste water treatment plant. Soil analysis showed an increase in the concentration of heavy metals and salts in the wet zone at the end of the season nutrients and heavy metals contents in the eggplants were within the normal range of eggplants grown with fresh water. Low coliform count was found on the skin of eggplant. Eggplant yield under waste water irrigation was twice the average eggplant production under fresh water. Clogging of the trickle system was observed due to algae and it was controlled by acid and chlorine.

Ether et al. (1986) reported that although EC 2-6 mS $cm^{-1}$was reduced the fresh weigh of Tomato plants it did not reduce dry weight or vegetative shoots or roots, whereas higher salinity levels of 10 mS cm^{-1} reduced dry weight of Tomato.

Shatanawi *et al*. (1994) reported enhanced eggplant availability of the micronutrients (Cu, Fe, Mn, Zn) and the heavy metals Cd, Cr and Pb under effluent, rather than under fresh. is water irrigation under both treatments, plant fruit content of Cu, Fe, Mn, Zn, Pb and Cd was still within normal range .

El Hamouri *et al*. (1996) pointed out that effluent, which had an EC of 2.94 dS/m in comparison with groundwater having an EC of 5.04 dS/m, affected increased yields of the salt sensitive cucumber and turnip as well as yields of the salt tolerant alfalfa, corn, coursettes, beans and tomato crops.

Fernandez (1997) used one – year old olives of the Manzanilo cultivar were grown in pots and irrigated for months with untreated wastewater (raw sewage). During the study period, growth was rapid and tissue Ca^{2+} and N content proved to have been increased. In addition, no toxicity symptoms or any other abnormal signs were observed .

Khattaria and Jamjoum (1988) concluded that effluent irrigation at Queen Alia International Airport (Jordan) lead to an increase in the concentration of N, P and K^{+} and thus to a total dry matter yield of sweet corn, while it had no effect on to heavy metal input to soil or sweet corn (Appendix 9).

Gorsline et el. (1965) noted that the ability of a corn plant to absorb a nutrient is an inherited characteristic and can be genetically shifted. The characteristic is one of imparting a high nutrient – accumulating ability.

Jamjoum (1996) studied response of sweet corn to effluent irrigation and found that total sweet corn dry matter, vegetative and grain yields increased with effluent application rate and that no significant differences in N and concentrations of corn leaves or grains were observed. In addition, no substantial differences in concentrations of heavy metals in leaves or seeds were observed between the various treatments.

Ayers and Westcot (1985) who found the sweet corn is more tolerancethan Sweet pepper to salt in the irrigation water and in the salty soil.

Jimenez – Cisnerous (1995) found that yields of effluent – irrigated corn crops were large above the national mean under fresh water irrigation.

Nichols et al. (1999), used sweet pepper (Capsicam Annum) plants for growing using Nutrient Film Technique (NFT) system with a nutrient solution of electrical conductivity EC value of 2 mS cm^{-1}. Higher conductivity levels of 4, 6, 8, and 10 mS cm^{-1} were achieved by adding concentrated KCl solution to the basic nutrient solution. Higher conductivity by adding concentrated KCl solution to the basic nutrient solution. Higher ionic strength of the nutrient solution resulted in smaller sized fruit, reduced fruit dry weights and decreased vegetative growth, decreased plant water consumption and it increased leaf stomatal resistance, fruit dry matter content, fruit respiration and ethylene production, and advanced fruit colour change.

Chapter Three

3. MATERIALS and METHODS.

3.1 Experimental plots and Crops.

An experimental site had the size of 10m*10m . The site was divided into two main plots then subdivided into sub plots: one irrigated with fresh groundwater and the other with contaminated groundwater. Each of main plots was then divided again into six smaller areas for two crops. At the crop level, the size of each plot was 10m*5m (Fig 3.1)

Sweet corn (Zeamays Var. rugosa) seeds were sown in June 18, 2005 in rows 1m apart and 30 cm spacing between seedlings. The germination began on June 23, and the fruiting began on August 22, 2005. The growth of the plants were measured at the maturation stage (Fig 3.1)

Sweet pepper seedling was transplanted on June 18, 2005 in rows 1m a part and 30cm on spacing between seedlings. The flowering began on July 12 and fruiting began on July 16, 2005. The growth of plants were measured at the maturation stage.See the (Fig 3.1).

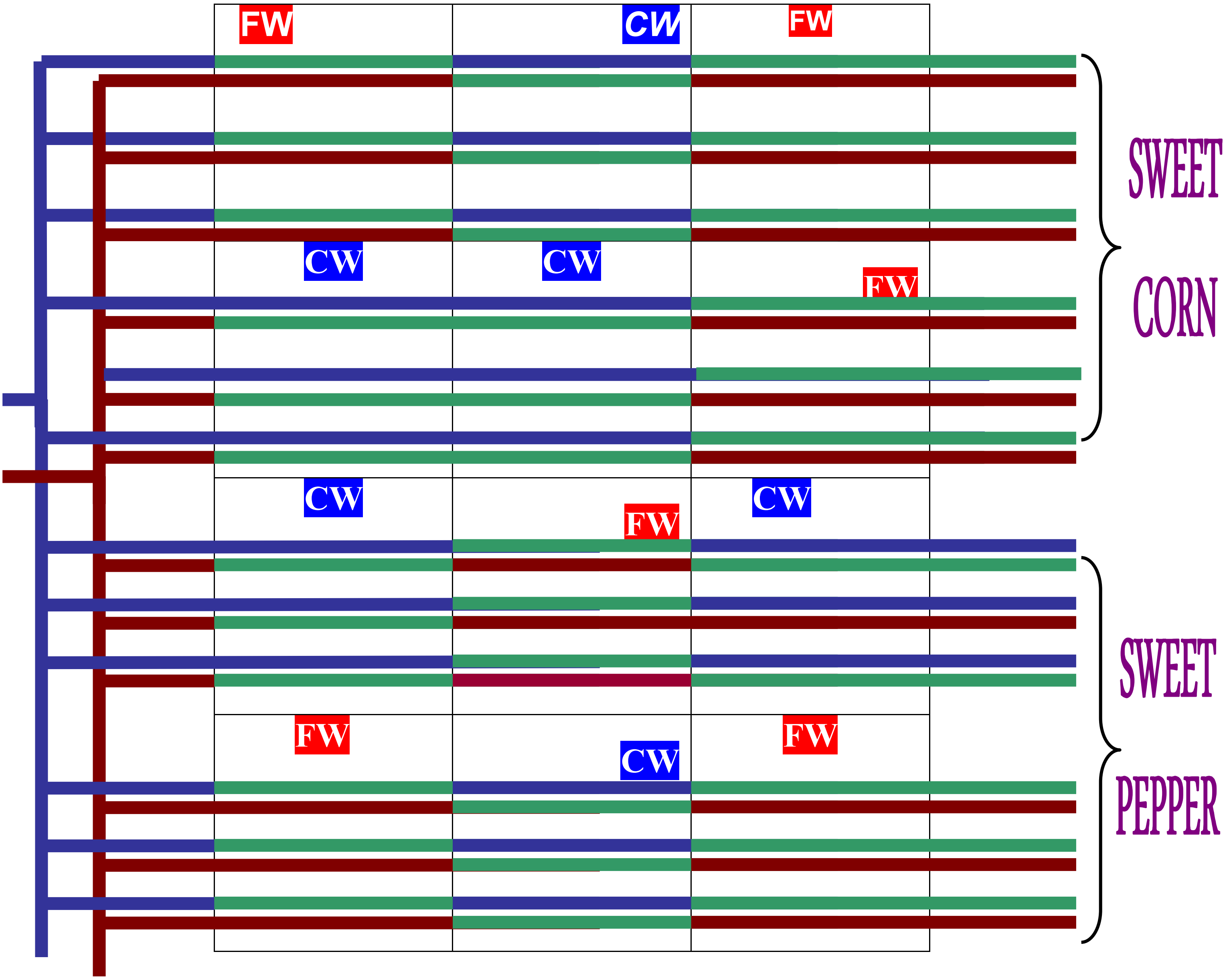


Fig 3.1: Experimental Design of plots and Crops

CW:Contaminated water FW: Fresh Water
Crops of sweet corn or sweet pepper

3.2 Soil characteristics

The soil in the study site is of clay texture, with a high water holding capacity, storing large amounts of water that plant may use. Because this soil consists of layers of clay that prevents free movement of water through and beyond the root zone, it causes accumulation of salts in root zone, because that reason we made some practices, e.g. deep cultivation of the study area, and increasing the frequency of irrigation to meet the water needs of crops. These practices aim at eliminating damaged to crops, caused by salt accumulation surrounding the roots of plants and to reduce salt in root zone.

3.3 Sample collection

The planted fields were divided into two plots. One irrigated with fresh water and the other irrigated with contaminated water by used drip irrigation. For soil, completely randomized design were used from each treatment, before irrigation and planting, will be selected two areas. Then soil samples were taken two replicates from these areas at 0-30 cm depth, then another two replicates of soil samples at 30-60 cm depth for the corn crop, then the same samples were taken for the pepper crop before irrigation. After irrigation and harvesting both crops, will be selected four replicates of soil samples at the same depths, The first two samples were irrigated by fresh water for both corn and pepper crops at two different depths. Then the other two samples at two different depth were irrigated with contaminated water for both crops. The soil, swee tcorn, sweet pepper leaf and fruit samples were randomly collected from different places. For each plot, six samples of plants and seven replicates of each sampling site of each of both studied field, were randomly selected. The fresh and dry weight was recorded. Soil samples were collected using a local made - augur. Composite sweet corn, pepper Leaf and fruit samples were collected late in September.12, 2005, during sweet corn, pepper fruit collection, from a number and different crops out and each designated site per plot. For microbiological tests, water samples were collected from the wells in sterilized bottles (200 ml).

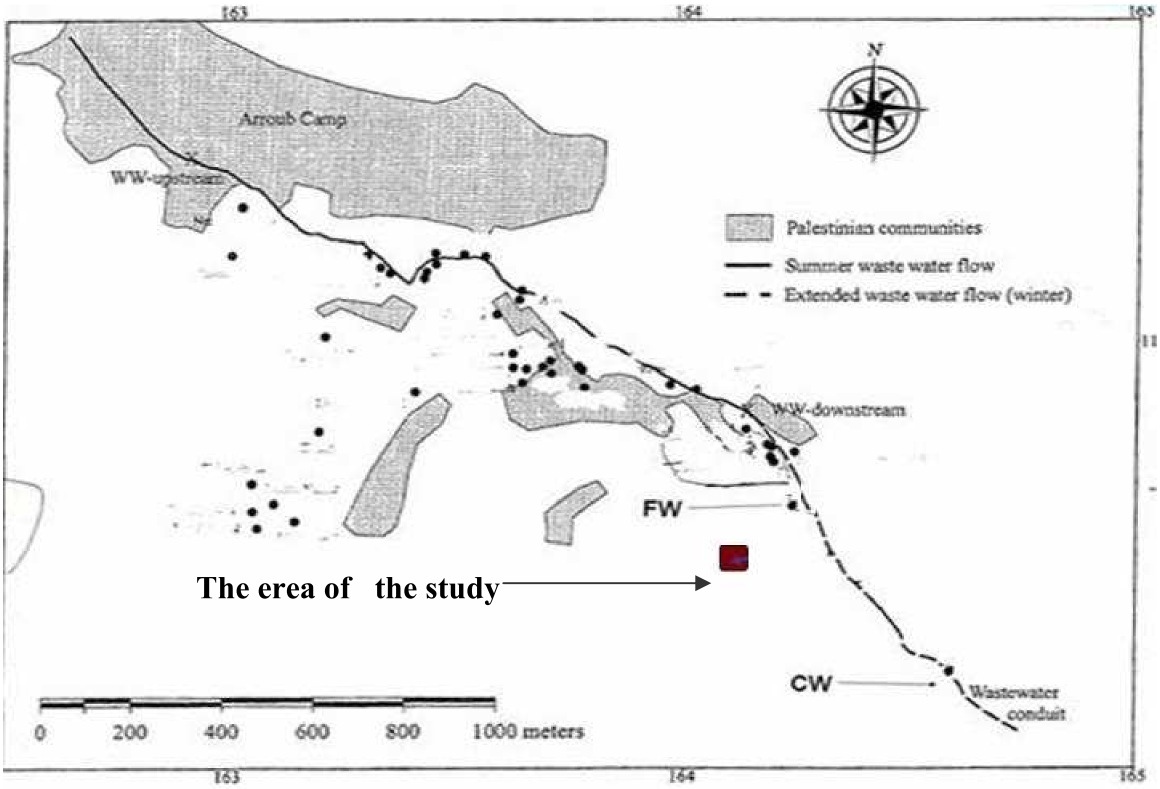


Fig 3.2 Location map of the spring and dug wells in the floor of Wadi Al Arroub and Wadi El Bas (Qnnam, 2002) .

Fig 3.3 Sewage and waste water flow in wadi Al Aarrob

3.4 Sample analysis.

3.4.1 Water analysis .

In the laboratory of Hebron University, six samples from groundwater wells were analyzed , and we selected two wells were (one as fresh water and the other as contaminated water)and the samples were analyzed according to standard methods for the water and wastewater (American public Health Association 1995) for the major ions (Ca^{2+},Mg^{2+}, Na^{+}, K^{+}, HCO_3^{-}, Cl^{-}, and NO_3^{-}) and for the total and fecal coliform bacteria, see (table 3.1). The total bacteria count of water was determined using nutrient agar plates, Its also inoculates the specimen onto the nutrient agar plate surface and streak for isolation. Incubate aerobically at 35-37C$^{\circ}$ for 24 hours. (American Public Health Association 1985).

A selection of typical Red-purple colonies are subjected to confirmed to colonies tested, or the detection of fecal coliforms bacteria, m- FC Agar used by the membrane filtration technique. The fecal coliforms, derived from the intestinal tract of warm-blooded animals, place membrane filter through which the sample has been filtered, on the surface of the agar, incubation 24 hours at 44.5 $^{\circ}$ C aerobically, lactose can be fermented by fecal coliform at a high temperature to form blue colonies, whereas other organisms show grey colonies (American Public Health Association Compendium of Methods for the microbiological examination of foods (1992).

Table 3.1: A list and the analytical methods used for determining the various parameters

Parameter	Method and analysis
pH	pH meter
EC	Conductivity meter
Ca^{2+}	Titration with EDTA using hydroxylamine, potassium cyanide, potassium Ferrocyanic NaOH, calcone indicator.
Ca + Mg	Titration with EDTA 0.02N using buff or solution hydroxylamine, potassium cyanide, potassium Ferrocyanide, Eriochrom Blue Black indicator.
Na^+ and K^+	Flame photometer.
HCO_3^-	Titration with H_2SO4 using Methyl orange indicate.
Cl^-	Titration with $AgNO_3$ using potassium chromate indictor
NO_3^-	UV- Spectrophotometer method ($\lambda = 220$ nm)
Heavy metal Fe , Zn , Mn , Cu	Atomic Absorption.
Total bacteria (TC) and Fecal (FC) coliform	Cultural method MF method

3.4.2 Soil analysis

The soil samples were analyzed at the depth of (0-30) cm before irrigation with fresh and contaminated water and the other at the depth of (30-60) cm after irrigation with fresh and contaminated water.

Soil samples were air – dried at room temperature and ground to pass a 2 – mm sieve. Plant available trace element (Cu, Fe, Mn, Zn) were determined by the Atomic Absorption after Diethylene Triamine pent a acetic Acid (DTPA) extraction (Lindsay and Norrel, 1978).

Soil Solution was analyzed for pH , EC, and major soluble ions (Ca^{2+}, Mg^{2+}, Na^+ , K^+, HCO_3^-,Cl^-, NO_3^-) using the saturated post extract (Rhoades , 1982).

Plant available phosphorus was analyzed by the ascorbic acid molybdenum blue method after sodium bicarbonate extraction (Olsen & Sommers, 1982). The OM in soil may be oxidized by treatment with hot mixture of $K_2Cr_2O_7$ and H_2SO_4 according to the Walkley- Black procedure (Nelson, 1982). Soil NO_3^- content was determined by using a colorimetric method acidified 1N KCl with pH 1.0; in additional to dissolve $CaSO_4$ to be used for the purpose of extracting NO^-_3 from the soil samples. Soil texture is determined by using the sieve and pipet at different stages. Determination of Soil bulk density, mineral density and porosity, is determined by knowing soil mass and the volume occupied by this mass. Carbonate in soil determined by neutralization of the carbonate with acid and back titration of the excess acid with NaOH.

The total bacterial count of soil solution is determined by using the nutrient agar medium, it's also directly in oculate the specimen on to the nutrient agar plate surface and streak for isolation. Incubate aerobically at 35- 37 C° for 24 hours (American public Health Association 1985). For the detection of fecal coliforms bacteria, m - FC agar used by the membrane filtration technique

3.4.3 Plant Analysis

The plant samples were analyzed for leaves of sweet corn and sweet pepper and fruits of both sweet corn and Sweet pepper after irrigation with fresh and contaminated water.

Elemental content in sweet corn and pepper leaves were determined by dry ashing which can be used for sample preparation . It may also be applicable to other elements. 1 gram from each sample and plant material is placed in a crucible and ashed by heating it in a muffle furnace at temperature 550℃ for several hours. The residue is then dissolved in an Acid solution, filtered and diluted to a specific volume(Walsh and Beaton, 1973). Sodium and Potassium ions were determined by Atomic Absorption. And (Ca^{2+}, Mg^{2+}, Cu, Fe, Mn , Zn) by Atomic Absorption.

Plant available P was analyzed by Sodium bicarbonate and determined by Spectrophotometer (Vandomolibdate Method). Sweet corn and pepper fruit analyzed for fruit from mass as reflexives of yield and for elemental content as an indicator of plant uptake. Fruit fresh weight was determined from 42 plant per sampling site.

Tabulated data correspond to average fresh weight of the single fruit after pit removal (fruit fresh weight). After pit removal , fruits were dried at 60 – 70̊C for 24 hours and the sample is grinded in order to have a homogenous finely grinded powder .

The content of proteins in sweet corn and pepper leaves and fruit were determined by Kjeldahls method , referred to dry weight (105 ̊C).

Nitrogen content was determined by Kjeldahl method by titration with NH_4OH, distillation with NaOH and digestion with H_2SO_4 and end point titration to pH 4.7. Chloride was determined by $AgNO_3$ Titration using Potassium chromate indicator (Mohr Method).

Chapter Four

4. Results

4.1 Irrigation water.

4.1.1 Fresh groundwater.

No detectable concentrations of CO_3^{2-} in fresh groundwater were found (Table 4.1). This water had EC values of 420 m^2/cm, and SAR values of (3.62) in irrigation water. But according to Rhoades et al. (1992), the fresh water is classified as non saline, reflects medium salinity and low sodium hazards.

No P was detected in this water, Shallow groundwater normally has low concentrations of P, with values ranging from 0.005 to 0.1 mg L^{-1} and typical concentrations of < 0.005mg L^{-1} (Reneau et al., 1989).

Fresh water had **not a** NO_3^- concentration more than the WHO upper limit of 45mg $NO_3^-L^{-1}$ for drinking water (WHO, 1984), and not more than the 30 mg $NO_3^-L^{-1}$ corresponding, According to Ayers and Westcot mg $NO_3^-L^{-1}$ (1985), slight to moderate restriction on use for irrigation purposes .

Chloride ion concentration of this water was not in excess of 31.3 mg/l. In the study area we reported six samples of wells to have Cl^- concentration to range from 31.3 to 280.2 mg/l of wells in Wadi Al Arroub where agricultural activites are wide spread .

If we combine the effects of fresh water EC and SAR values, we reach to the conclusion that no water infiltration problems are due to be forced upon soil by such irrigation water. On the opposite, slightly - moderated restriction on irrigation use of this water is not imposed by the individual effects of its EC and extremely enhanced concentrations of Na^+, Cl^-, HCO_3^-, NO_3^- . In light of the discussion, it turns out that fresh water deviates sharply from suitability for drinking uses.

4.1.2 Contaminated Groundwater In Wadi Al Arroub Valley.

While contaminated water has significantly higher values than fresh water of pH and EC, Na^+, Ca^{2+}, Mg^{2+}, Cl^-, NO_3^-, and HCO_3^- concentrations, available data on contaminated water chemical characteristics reveal higher values of all other tested parameters than this fresh water.

According to Rhoades et al. (1992), this water is classified as which moderate salinity classification. If the USSL (United States Salinity laboratory, 1954) classification of irrigation water was adopted , this well would be classified as an irrigation water of high salinity and medium sodium hazards . According to Nakayama (1982), this water did not restriction on drip irrigation use .

However, if we decide to examine compliance of contaminated water with the local effluent irrigation guideline 1995 (Appendix 6), we reach to the conclusion that:

1) Contaminated water pH, Ca^{2+} and Mg^{2+} concentrations fit the use for irrigation of all types of crops.

2) Nitrate concentration reflected severe suitability for irrigation purpose.

3) Concentration of Na^+ in contaminated water was slight suitable for irrigation purpose.

4) Concentration of Cl^- in contaminated groundwater well was slight suitable for irrigation purpose.

5) Except in this study, bicarbonate concentration is not suitable for irrigation use. This might, as a matter of fact, to be ascribed the high bicarbonate concentrations in drinking water sources in the study area , where potable water supplies are not derived primarily from carbonate (limestone and dolomite) aquifers (Bajjali, 1997).

In addition, once we subject contaminated water characteristics to comparison with guidelines of Ayers and Westcot (1985),and Nakayama (1982), (Appendix 5,8), we reach to the conclusions:

1. Available EC values of contaminated water entail slight to moderate restriction on irrigation use of this water.

2. The combined effect of contaminated water SAR value promises slight to moderate infiltration problems and hence pose slight restriction on irrigation use.

3. TDS indicate slight to moderate restriction contaminated water on irrigation use and clogging problems in drip irrigation.

4. Data available for this study assure that the individual effect of Na^+concentration exerts severe restriction on contaminated water use for sprinkler, and severe restriction for surface irrigation purposes. As regards

Cl^-, slight to moderate restriction on sprinkle irrigation was posed in this study, and severe restriction for surface irrigation purposes in this study.

5. water Contaminated by HCO_3^- and NO_3^- indicate severe restriction on irrigation use.The high NO_3^- and HCO_3^- concentrations enters environment from fertilizer, sewage, and human or animal– farm waste.

6. The concentrations of Heavy metals was low and should not have any influence on contaminated water use for irrigation. Similar results were obtained at (Al-Nakshabandi,1996) who found that effluent water has low heavy metal content.It showed moderate restriction for surface trickle irrigation.

7. For bacterial population (Fecal and Total coliform bacteria) exert no restriction on contaminated water use for Drip irrigation purposes. According to (Al-Nakshabandi, 1996)

In brief, contaminated groundwater well in Wadi Al-Arroub is rendered non-suitable for irrigation purposes due to significant high concentration of NO_3^- (151.9 mg/l) and concentration of SAR (11.8). In addition, captive of the some what flaunting EC values, HCO_3^-, Na^+ and Cl^- concentration, degree of restriction on contaminated water use for irrigation purposes varies between slight to moderate and severe.Table (4.1)

Table (4.1) The physical and chemical analysis of the groundwater some wells in Wadi Al Arroub drainage basin(2005).

Parameter	Unit	Well1 (c)	Well2	Well3	Well4 (F)	Well5	Well6
pH		8.53	8.02	7.99	7.72	7.40	7.53
EC	**mS/cm**	1.65	0.690	0.720	0.420	0.830	1.32
TDS	**mg/l**	1065	441.6	460.8	268.8	677.3	844.8
Ca^{2+}	**mg/l**	180.2	75.2	95.5	53.1	143.5	163.2
Mg^{2+}	**mg/l**	43.2	23.5	27.6	14.3	29.1	37.8
Na^{+}	**mg/l**	125.3	39.4	41.7	21.0	32.5	90.8
K^{+}	**mg/l**	15.7	11.8	17.0	1.7	2.7	8.9
HCO_3^{3-}	**mg/l**	372.6	231.2	292.3	277.1	245.4	386.0
Cl^{-}	**mg/l**	280.2	93.7	77.8	31.3	91.6	159.1
NO_3	**mg/l**	151.9	30.7	37.1	14.6	76.3	121.3
P	**mg/l**	* b.d	-	-	b.d	-	-
Fe	**mg/l**	0.21	0.13	0.017	0.23	0.35	0.07
Cu	**mg/l**	0.25	0.07	0.02	0.12	0.24	0.008
Mn	**mg/l**	0.14	0.03	0.09	0.08	0.16	0.022
Zn	**mg/l**	0.97	0.015	0.045	0.009	0.03	0.025
SAR		11.8	5.6	5.3	3.6	3.50	9.06
FC	**colonies/100ml**	1330	370	430	6	>1000	25
TC	**colonies/100ml**	370	620	620	16	>2000	60

- b.d: below detection
- W: well. WF: Fresh groundwater well. WC: contaminated groundwater well.

Table (4.2) The physical and chemical analysis of the fresh groundwater and contaminad wells in Wadi Al Arroub drainage basin(2005).

Parameter	Unit	Well4 (F)	Well 1 (C)
pH		7.72 b	8.53 a
EC	mS/cm	0.420 b	1.65 a
TDS	mg/l	268.8 b	1065 a
Ca^{2+}	mg/l	53.1 b	180.2 a
Mg^{2+}	mg/l	14.3 b	43.2 a
Na^{+}	mg/l	21.0 b	125.3 a
K^{+}	mg/l	1.7 b	15.7 a
HCO_3^{3-}	mg/l	277.1 b	372.6 a
Cl^{-}	mg/l	31.3 b	280.2 a
NO_3	mg/l	14.6 a	151.9 a
P	mg/l	b.d	b.d
Fe	mg/l	0.23 a	0.21 a
Cu	mg/l	0.12 a	0.25 a
Mn	mg/l	0.08 b	0.14 a
Zn	mg/l	0.009 b	0.97 a
SAR	mg/l	3.6 b	11.8 a
FC	colonies/100ml	6 b	1330 a
TC	colonies /100ml	16 b	370 a

4.2 Soil

The clay soil at the experimental station has high water retaining capacity, storing large amounts of water that plant may use, but soil under fresh water had higher clay content than soil in contaminated water. Soil after irrigation with contaminated and fresh water had lower mineral and bulk density rather than soil before irrigation, but soil in contaminated water had lower mineral and bulk density than fresh water. Soil in contaminated water had significantly higher (p ≤ 0.05) $CaCO_3^{-}$content than soil in fresh water. This may indicate that we have problems regarding phosphorous availability in the soil.

Contaminated water irrigation and fresh water increased soil pH and soil solution concentration of K^+. Under contaminated water irrigation, soil had higher Ca^{2+}, Mg^{2+}, Cl^-, HCO_3^- concentrations and OM content, rather than fresh water table (5,6).

Under contaminated irrigation water, soil had higher Na^+ concentration, than fresh irrigation water. Soil in contaminated water irrigation had significantly higher, Na^+, NO_3^- concentrations. This result is expected since the soil is of high organic matter. Furthermore, in deep hormony with differences in the chemical composition of both types of irrigation water and with its respective one. Contaminated groundwater had significantly higher than Fresh water, soil solution EC, Na^+, Ca^{2+}, Cl^-, HCO_3^- and NO_3^- concentration. Soil in contaminated water irrigation had higher EC_e value, soil solution Ca^{2+}, concentrations compared with soil in fresh water irrigation. In addition, its main root zone had low soil solution K in fresh water and contaminated water irrigation.

Soil irrigated with fresh water irrigation had higher values of available P and lower OM content than soil in contaminated water irrigation. Main root zone of soil in fresh water had lower EC_e values and TDS than soil in contaminated water.

Soil solution contains Na^+, Cl^- irrigated with fresh water and Na^+, Cl^- of soils in contaminated water were found to follow the distribution patterns of their respective EC_e values.
This indicates that Na^+ and Cl^- are the main components of soil salinity at both fields. In addition, soil salinity followed a general trend of increase with depth at both fields. This is quite sufficient indicator that soils of both fields are well-drained and / or well-leached.

SAR values in soil after planting and irrigation with contaminated water and fresh water had higher than soil before planting and irrigation. But soil irrigated with contaminated water had significantly higher ($p \leq 0.05$) SAR values rather than soil in fresh water.

Microbiological quality:

Hetrotrophic bacterial counts tended to be significantly higher in soil irrigated with contaminated groundwater than soil before irrigation table (3,4) and (5,6).

In irrigated soil, bacterial counts tended to be higher in the surface soil (0-30) cm than in samples taken from (30-60) cm, because of aeration. Total coliform counts in the soil irrigation with contaminated water ranged from 1500 to 2000 MPN per 100 ml. Fecal coliforms were in the range 1320-1450 MPN per 100 ml.

Table (4.3)Characteristics of the soil at the depth of (0-30 cm) before irrigation with fresh and contaminated groundwater(2005).

	Unit	A1 30 cm - F_c	A2 30 cm – F_P	A3 30 cm – C_c	A4 30 cm – C_P
pH		7.41	7.46	7.63	7.58
EC	**mS/cm**	1.31	0.98	1.43	1.22
TDS	**mg/l**	838.4	627.2	915.2	780.8
Ca^{2+}	**mg/l**	65.2	60.7	68.1	59.9
Mg^{2+}	**mg/l**	21.3	16.5	20.3	15.7
Na^{+}	**mg/l**	58.1	42.3	45.9	29.8
K^{+}	**mg/l**	1.70	1.20	1.60	1.10
HCO_3^-	**mg/l**	238.4	181.9	229.1	180.1
Cl^-	**mg/l**	81.3	48.7	59.5	39.7
NO_3	**mg/l**	57.2	36.7	44.9	61.3
P	**mg/l**	8.10	9.80	8.60	8.00
Fe	**mg/l**	3.29	3.18	3.03	3.41
Cu	**mg/l**	0.23	0.72	0.43	0.68
Mn	**mg/l**	1.40	1.23	1.33	1.10
Zn	**mg/l**	0.52	0.64	0.40	0.55
SAR		8.00	6.40	6.91	4.85
$CaCo_3$	**%**	25.1	23.3	25.5	26.1
OM	**%**	1.18	0.97	1.37	1.48
FC	**colonies /100ml**	90	110	370	270
TC	**colonies /100ml**	116	250	640	320

A1- F_c : area of soil before irrigation with fresh water and before planting with sweet corn ,

A2- F_p: area of soil before irrigation with fresh water and before planting with sweet pepper.

A3- Cc:: area of soil before irrigation with contaminated Water and before planting with sweet corn.

A4 – Cp: area of soil before irrigation with contaminated Water and before planting with sweet pepper.

Table (4.3.1)The physical Characteristics of the soil at the depth of (0-30 cm) and (30- 60 cm) before irrigation with fresh and contaminated groundwater(2005).

	Unit	A1 30 cm - F_c	A2 30 cm – F_P	A3 30 cm – C_c	A4 30 cm – C_P
Mineral density	**g/cm^3**	2.65	2.71	2.60	2.75
Bulk density	**g/cm^3**	1.59	1.32	1.46	1.52
Porosity	**%**	40.00	49.00	56.00	45.00
	Unit	**A1 60 cm - F_c**	**A2 60 cm – F_P**	**A3 60 cm – C_c**	**A4 60 cm – C_P**
Mineral density	**g/cm^3**	2.80	2.72	2.69	2.78
Bulk density	**g/cm^3**	1.61	1.45	1.53	1.58
Porosity	%	42.00	47.00	44.00	43.00

Table(4.4)Characteristics of the soil at the depth of (30-60) cm before irrigation with fresh and contaminated groundwater at Al Arroub valley(2005).

	Unit	A1 60 cm - F_c	A2 60 cm – F_P	A3 60 cm – C_c	A4 60 cm – C_P
pH		7.22	7.28	7.30	7.43
EC	**mS/cm**	1.29	1.12	1.48	1.35
TDS	**mg/l**	825.6	717.8	947.2	864.0
Ca^{2+}	**mg/l**	93.4	80.1	91.8	69.7
Mg^{2+}	**mg/l**	33.3	3.07	28.9	19.4
Na^{+}	**mg/l**	93.3	80.9	71.1	43.5
K^{+}	**mg/l**	1.40	1.70	2.3	1.1
HCO_3^-	**mg/l**	284.3	207.1	287.5	201.0
Cl^-	**mg/l**	115.6	78.3	108.4	70.9
NO_3	**mg/l**	86.5	58.6	71.2	43.4
P	**mg/l**	8.7	10.1	9.3	8.7
Fe	**mg/l**	3.18	3.10	3.01	3.23
Cu	**mg/l**	0.19	0.54	0.26	0.58
Mn	**mg/l**	1.21	1.12	1.24	1.06
Zn	**mg/l**	0.44	0.53	0.38	0.49
SAR		10.0	8.47	9.1	6.52
$CaCo_3$	**%**	25.4	23.9	26.0	26.2
OM	**%**	1.13	0.89	1.20	1.24
FC	**colonies/100ml**	87	92	150	110
TC	**colonies/100ml**	105	210	270	180

Table (4.5)Characteristics of the soil at the depth of (0 – 30) cm after irrigation with fresh and contaminated groundwater at Al Arroub valley(2005).

	Unit	A1 30 cm - F_c	A2 30 cm – F_P	A3 30 cm – C_c	A4 30 cm – C_P
pH		7.82 a	7.85 a	7.61 a	7.59 a
EC	**mS/cm**	2.17 b	1.81 b	4.93 a	4.43 a
TDS	**mg/l**	1388.8 b	1158.4 b	3155.2 a	2835.2 a
Ca^{2+}	**mg/l**	78.1 b	81.5 b	140.7 a	117.3 a
Mg^{2+}	**mg/l**	23.2 b	19.4 b	45.6 a	33.8 a
Na^{+}	**mg/l**	52.6 b	39.8 b	125.5 a	108.7 a
K^{+}	**mg/l**	15.25 a	21.71 a	10.12 b	11.40 b
HCO_3^-	**mg/l**	255.4 b	229.7 b	420.3 a	350.7 a
Cl^-	**mg/l**	86.8 b	65.5 b	261.0 a	145.7 a
NO_3	**mg/l**	31.1 b	27.2 b	36.4 a	41.9 a
P	**mg/l**	16.7 a	15.6 a	15.5 a	15.1 a
Fe	**mg/l**	5.04 a	4.43 a	4.12 b	3.67 b
Cu	**mg/l**	1.12 a	1.02 a	1.34 a	1.24 a
Mn	**mg/l**	2.26 a	2.13 a	2.51 a	2.41 a
Zn	**mg/l**	0.89 b	1.08 b	1.56 a	1.62 a
SAR		6.02 b	5.95 b	13.00 a	12.5 a
$CaCo_3$	**%**	27.4 b	25.3 b	31.2 a	30.8 a
OM	**%**	1.30 a	1.01 b	1.37 a	1.48 a
FC	**colonies/100ml**	450 b	380 b	1450 a	1320 a
TC	**colonies/100ml**	630 b	420 b	>2000 a	>1500 a

A1- F_C : area of soil after irrigation with fresh water and after planting with sweet corn .

A2- $F_{p:}$ area of soil after irrigation with fresh water and after planting with sweet pepper.

A3- Cc: area of soil after irrigation with contaminated. Water and before planting with sweet corn.

A4 – Cp: area of soil after irrigation with contaminated. Water and after planting with sweet pepper.

Table(4.6)The Characteristics of the soil at the depth of 30-60 cm after irrigation with fresh and contaminated groundwater at Al Arroub valley(2005).

	Unit	A1 60 cm - F_c	A2 60 cm – F_P	A3 60 cm – C_c	A4 60 cm – C_P
pH		7.71 a	7.80 a	7.57 a	7.68 a
EC	**mS/cm**	2.30 b	1.98 b	4.98 a	4.62 a
TDS	**mg/l**	1472 b	1267.2 b	3187.2 a	2956.8 a
Ca^{2+}	**mg/l**	102.3 b	98.7 b	174.7 a	148.5 a
Mg^{2+}	**mg/l**	40.5 a	78.4 a	47.1 a	43.6 b
Na^{+}	**mg/l**	80.0 b	62.7 b	177.1 a	132.3 a
K^{+}	**mg/l**	19.3 a	15.3 a	8.31 b	9.52 b
HCO_3^-	**mg/l**	301.2 b	267.4 b	429.1 a	398.5 a
Cl^-	**mg/l**	154.6 b	89.9 b	283.2 a	178.5 a
NO_3	**mg/l**	80.3 b	47.8 b	88.1 a	65.4 a
P	**mg/l**	16.1 a	15.3 a	12.7 a	10.8 a
Fe	**mg/l**	4.41 a	3.86 a	3.66 a	3.37 a
Cu	**mg/l**	0.85 a	0.78 a	0.97 a	0.86 a
Mn	**mg/l**	2.22 a	2.10 a	2.38 a	2.33 a
Zn	**mg/l**	0.82 b	0.99 b	1.49 a	1.52 a
SAR		11.72 b	8.60 b	16.86 a	13.5 a
$CaCo_3$	**%**	27.9 b	26.1 b	32.6 a	31.1 a
OM	**%**	1.2 a	0.83 b	1.25 a	1.27 a
FC	**colonies/100ml**	130 b	170 b	370 a	260 a
TC	**colonies/100ml**	240 b	220 b	650 a	480 a

To decide on effects of contaminated water irrigation on Wadi Al Arroub soil properties, overall averages of soil in contaminated water analysis results, Table (3,4) and (5,6). will be compared with the soil in fresh water irrigation and soil before irrigation.

Before wil be proceed in comparisons, several points should be pointed out.First will be experimented the first study before the process of irrigation of the two crops; pepper and corn, for the purpose of comparing the results we will obtain before irrigation with the results we will obtain after irrigating the two crops with fresh water and with contaminated water. Second, these results will be obtained after nearly three months of the growing stage of both crops (i.e. after the termination of the first stage). Third, soil samples were taken from the depths 0-30 and 30-60 cm.

Overall average soil solution pH data obtained in fresh and contaminated water shown on, Table (5,6). Raised soil solution – pH values in soil irrigated with fresh water could be explained by leaching (Qannam, 2002).

In our results reveal no large variation in soil solution pH from the first sampling to second and all pH values obtained comply with the fact that our studied soils are dominated by $CaCO_3^-$ which buffers soil in the pH range of 7.14 to 8.5 (Lindsay and Schwab, 1982).

Soil salinity, expressed as EC of soil after irrigation with contaminated water and fresh water more than EC before irrigation with contaminated water and fresh water. In these studies it was observed that concentrations of Na^+, and NO_3^- in soil after irrigation with fresh water are lower than in soil before and after irrigation with contaminated water , and this reflects the soil losses of these ions through leaching, plant uptake and high concentration NO_3^- in soil in contaminated water rather than in soil in fresh water. Soil HCO_3^- concentrations after irrigation with contaminated water and fresh water in this study are highest in comparison to concentration before irrigation, with contaminated water where and fresh water no CO_3^{2-} was detected in our study. Free carbonate was detected by Shatanawi et al. (1994) before the first effluent application to soil but never after.

After the contaminated water application, the upper 30cm of soil profile was reported to have nearly double the solution Ca^{2+} and Mg^{2+} contents.

With the exception of the 30cm depth before any contaminated water and fresh water application at the end of the sweet corn and pepper growing season, concentrations of phosphates appeared in this study to be increased by prolonged contaminated water and fresh water irrigation.
Sodium adsorption ratio of fresh water field soil exhibited a little decrease value from values observed at contaminated groundwater field.

The very limited and short time period between contaminated water and fresh water application to soil and crop harvest, and the seasonal nature of crop grown are due to clarify and explain the observed differences between their results and those obtained in this study.

Under relatively very short growing season condition, seasonal crop uptake of these macro-nutrients is due to care for extremely very low removal losses from soil. This is particularly evident when comparison is held with ever – green fruit crops like sweet pepper characterized by increased biomass production and accordingly nutrients requirements.

Further, within this prescribed condition of short time interval between contaminated water and fresh water application and crop harvest, such reactions like fixation of K^+ by clay minerals, adsorption and precipitation of P in addition to extended plant exhaustion of P and K^+ reserves were not yet evident and will too within such short time interval core for a very slight proportion of nutrient of removal losses. The soil irrigated with contaminated water has significantly higher concentration of HCO_3^- content than the soil before irrigation or than the irrigated by fresh. The concentration of Cu in the soil irrigated by contaminated water was no significantly higher than the concentration percentage in the soil before irrigation or in the soil irrigated by fresh water.

Manganese was available to plant throughout the whole soil profile of soil in contaminated water field at concentrations was no significantly ($p \geq 0.05$) higher than soil in fresh water. Zn concentration within the soil profile under contaminated water irrigation at the end of sweet corn, pepper growing season. They were significantly higher than soil in fresh water samples. But Iron(Fe) concentration within the soil under fresh water irrigation had higher but was no than soil irrigation with contaminated water .

Soduim Adsorption Ratio values in soil after planting and irrigation with contaminated water, fresh water had higher than soil before planting and irrigation but soil in contaminated water had significantly higher SAR values rather than soil in fresh water.

4.3 Plant

4.3.1 Sweet corn and Pepper leaves.

The yield of sweet corn in the plot which is irrigated with contaminated groundwater is the higher than that of the plot irrigated with fresh groundwater, table(4.7). But the yield of sweet pepper in the plot which is irrigated with contaminated groundwater is the lowest followed by that of the plot irrigated with fresh groundwater. Fresh and dry weight leaves of sweet corn after irrigation with contaminated water had higher than leaves of sweet corn after irrigation with fresh water, but not substantial differences between them, (Fig 4.1 and 4.2). But leaves of sweet pepper after irrigation with contaminated water had lowest of fresh and dry weight. (Fig 4.3 and 4.4) .

Table (4.7) :Fresh and Dry Weight of 42 plants of Sweet Corn and Sweet Pepper from six different plots (g).

Plot	Parts of plants	Fresh Weight	Dry Weight
Sweet Corn irrigated with Contaminated groundwater	Leavs	403.16 a	290.68 b
	Stem	342.66 a	250.27 b
	Seed	3445.74 a	2767.16 a
Sweet Corn irrigated with fresh groundwater	Leavs	383.5 a	289.39 b
	Stem	349.18 a	223.39 b
	Seed	2161.64 b	1146.98 b
Sweet Pepper irrigated with contaminated groundwater	Leaf	289.39 b	244 b
	Stem	349.2 b	308.93 a
	Fruit	2552.6 b	614.13 b
Sweet Pepper irrigated with fresh groundwater	Leavs	432 a	368.4 a
	Stem	446 a	327.8 a
	Friut	2782.6 a	646.33 a

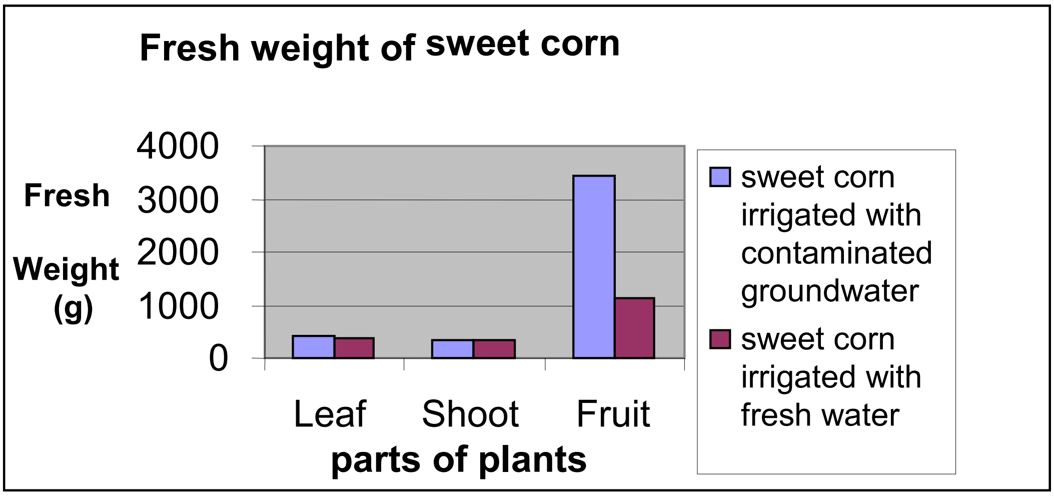


Fig (4.1): Fresh weight parts of sweet corn after irrigation with fresh and contaminated water.

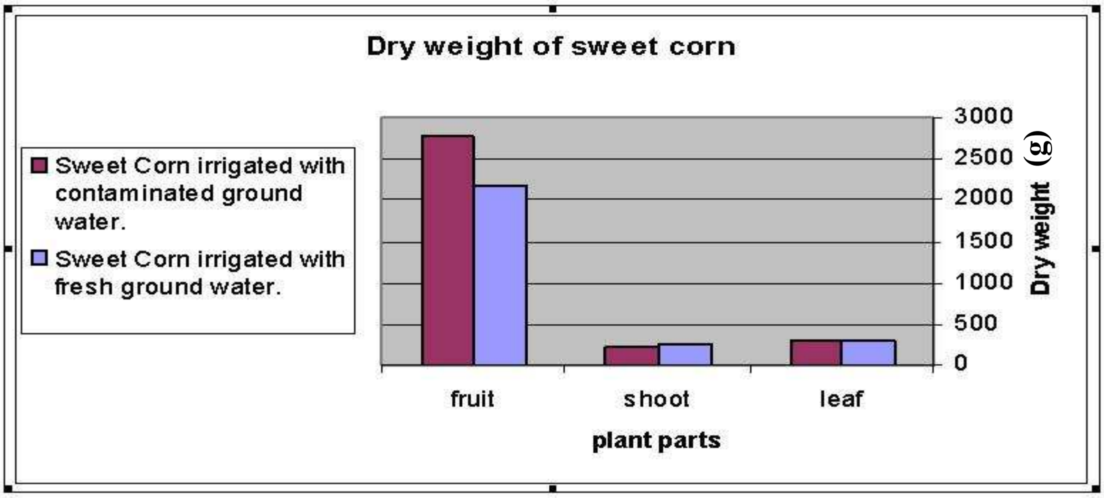
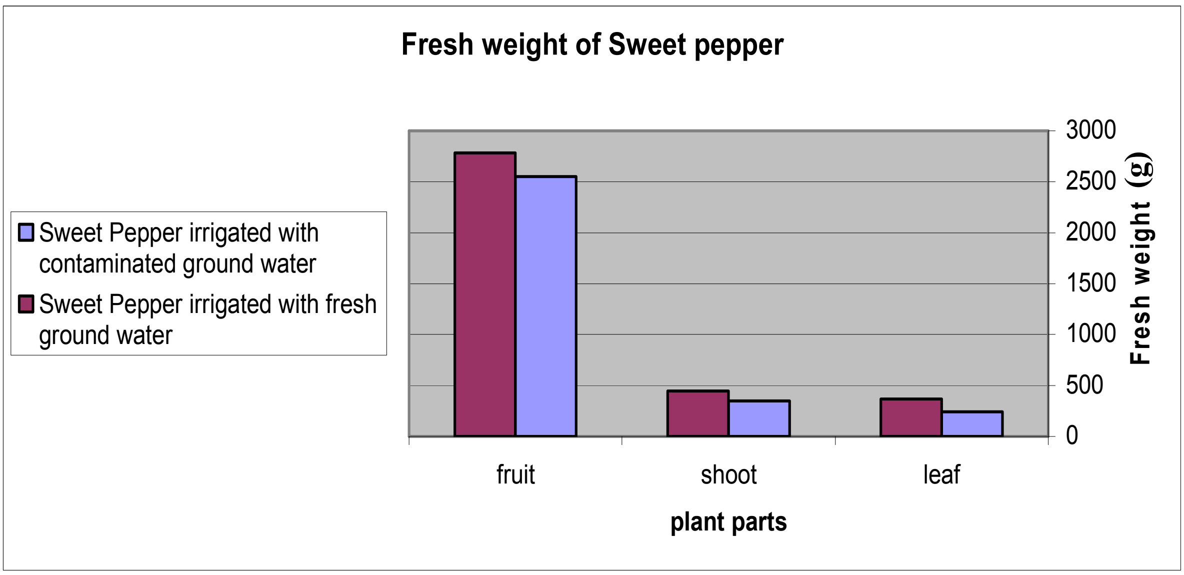
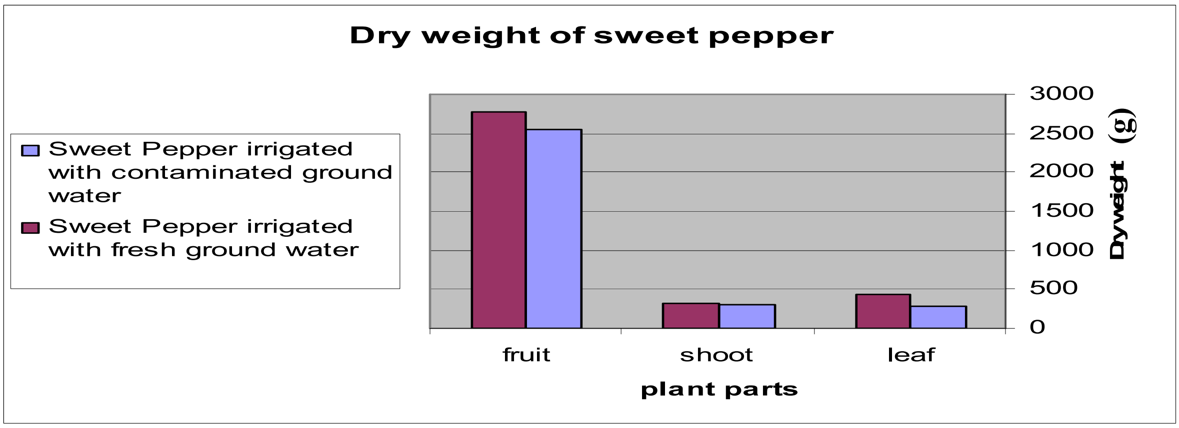


Fig (4.2): Dry weight parts of sweet corn after irrigation with fresh and contaminated water.



Fig(4.3): Fresh weight parts of sweet pepper after irrigation with fresh and contaminated water.



Fig(4.4): Dry weight parts of sweet pepper after irrigation with fresh and contaminated water.

The length and the width of sweet corn and sweet pepper is determined by using meter, but the diameter determined by using digital caliber, (Fig 4.5). The results of sweet corn irrigation with contaminated water had higher than fresh water, but the results of sweet pepper irrigation with contaminated water irrigation had lower than fresh water irrigation.

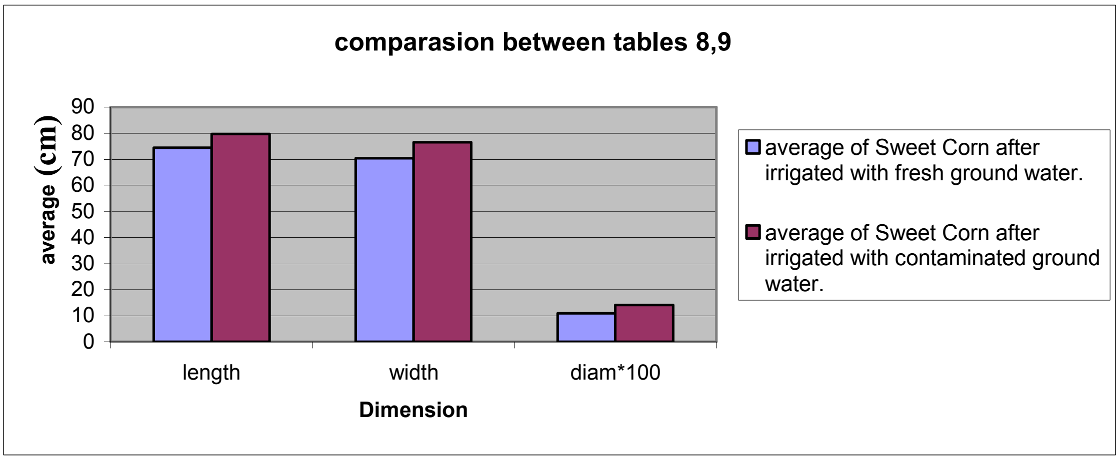
Fig(4.5) Diameter determined by using digital caliber.

Table (4.8) Average characteristic of Sweet Corn after irrigation with fresh groundwater(cm).

Number of Weeks	**Date**	**length**	**width**	**diameter**
Week 1	24-6-2005	21.41	9.59	0.0245
Week 2	1-7-2005	30.87	12.35	0.0317
Week 3	8-7-2005	46.77	41.74	0.0614
Week 4	15-7-2005	55.08	47.95	0.0706
Week 5	23-7-2005	76.53	77.21	0.1147
Week 6	31-7-2005	101.64	86.72	0.1320
Week 7	7-8-2005	137.05	91.45	0.1426
Week 8	14-8-2005	143.69	93.08	0.1493
Week 9	22-8-2005	152.06	94.93	0.1536
Week 10	30-8-2005	183.73	108.91	0.1607
Week 11	**8-9-2005**	**208.04**	**110.50**	0.1680

Table (4. 9) Average characteristic of Sweet Corn after irrigation with contaminated groundwater(cm).

Number of weeks	**Date**	**length**	**width**	**diameter**
Week 1	24-6-2005	32.39	9.14	0.0254
Week 2	1-7-2005	56.62	28.28	0.0457
Week 3	8-7-2005	82.68	47.61	0.0711
Week 4	15-7-2005	94.18	65.27	0.1304
Week 5	23-7-2005	121.16	80.91	0.1547
Week 6	31-7-2005	134.17	90.33	0.1576
Week 7	7-8-2005	152.50	94.71	0.1689
Week 8	14-8-2005	168.32	97.71	0.1727
Week 9	22-8-2005	182.97	100.35	0.186
Week 10	30-8-2005	209.33	110.62	0.286
Week 11	**8-9-2005**	**230.61**	**116.61**	0.234



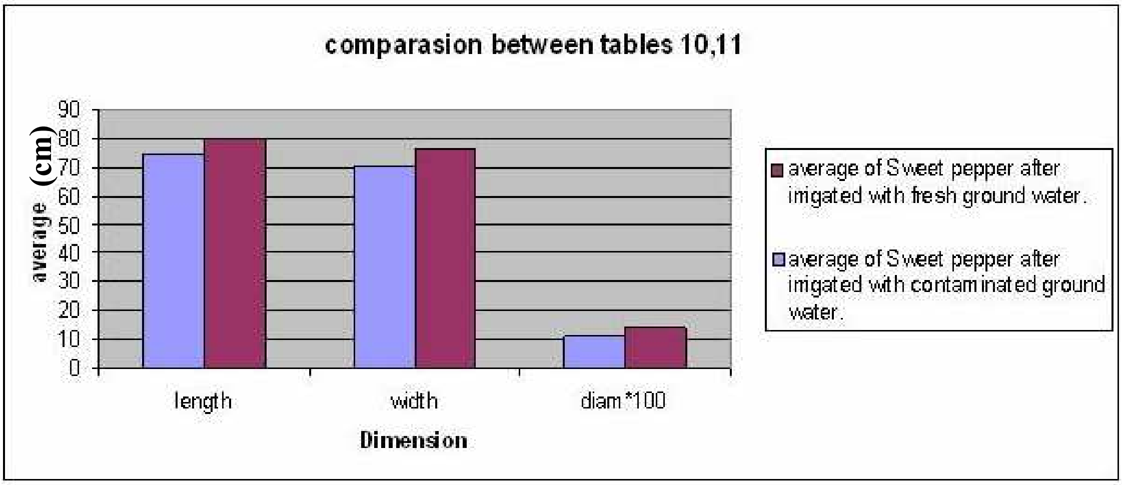
Fig(4.6): Comparasion between characteristic of sweet corn after irrigation with fresh groundwater and after irrigation with contaminated water.

Table(4.10) Average characteristic of Sweet pepper after irrigation with fresh groundwater(cm).

week	Date	length	width	Diameter
Week 1	24-6-2005	11.75	9.94	0.03021
Week 2	1-7-2005	12.87	12.35	0.0324
Week 3	8-7-2005	14.76	13.55	0.0475
Week 4	15-7-2005	16.33	16.07	0.0502
Week 5	23-7-2005	17.25	17.64	0.0575
Week 6	31-7-2005	19.76	18.02	0.0602
Week 7	7-8-2005	22.15	21.25	0.06721
Week 8	14-8-2005	22.34	23.40	0.0740
Week 9	22-8-2005	24.95	24.58	0.0711
Week 10	30-8-2005	25.15	25.76	0.0778
Week 11	**8-9-2005**	**26.31**	**25.81**	0.0896

Table(4.11) Average characteristic of Sweet pepper after irrigation with contaminated groundwater(cm).

week	Date	length	width	Diameter
Week 1	24-6-2005	11.67	9.04	0.0247
Week 2	1-7-2005	12.92	10.45	0.029
Week 3	8-7-2005	12.62	10.55	0.032
Week 4	15-7-2005	12.87	12.31	0.041
Week 5	23-7-2005	13.35	14.64	0.045
Week 6	31-7-2005	14.68	16.03	0.053
Week 7	7-8-2005	19.65	18.16	0.0604
Week 8	14-8-2005	18.45	19.39	0.061
Week 9	22-8-2005	18.91	21.92	0.068
Week 10	30-8-2005	19.92	22.12	0.070
Week 11	**8-9-2005**	**20.62**	**23.29**	0.07



Fig(4.7): Comparison between characteristic of Sweet pepper after irrigated with fresh groundwater and after irrigation with contaminated water.

The leaves of sweet corn after irrigated with Contaminated water had significantly higher concentrations of N, Ca^{2+}, Mg^{2+}, and K^{+} and had less concentrations of Zn, Cu, Fe, Mn, P than leaves of sweet corn after irrigated with fresh water. While leaves of sweet Pepper after irrigated with contaminated water had significantly higher concentrations Mg^{2+}, Na^{+}, Cl^{-} and less concentrations of all other parameters than leaves of sweet pepper after irrigated with fresh water.

As far as sweet corn and sweet pepper nutritional status is concerned, the discussion will merely focus on sweet corn and sweet pepper leaf, due to the extreme scarcity of information in the nutritional status of sweet corn and sweet pepper, in our study, Outputs of sweet corn and sweet pepper leaf chemical analyses were submitted to comparisons with five documented standards. Two of which deal exclusively with sweet corn and sweet pepper leaf elemental content ranges (Bennett, 1933; and Nonnecke, 1989), and the other three are quite of a more general nature (Marr and Cresser, 1983; Cajuste et al. 1991; and Bennett, 1993), (Appendices 15 to 22). Results of nutritional status characterization are collectively presented in table (4.12).

Sweet corn and pepper crops irrigated with fresh and contaminated water both proved to be deficient in total N, K^+, and Ca^{2+}, while sufficient supplies of total P, Mg^{2+}, Cu, Fe, Mn, and Zn.Table (4.12).

Higher concentrations of Ca^{2+}, Mg^{2+} and K^+ in sweet corn leaves, were generally found under contaminated groundwater than under fresh water irrigation. The concentrations of Ca^{2+}, Mg^{2+}, and K^+ lie within their usual range in agricultural crops (Sutcliffe, 1962; Wild and Jones, 1988). As expected, under treated water irrigation, Ca^{2+} concentration was higher in eggplant leaves than in fruits.

Higher concentration of Na^+, Cl^- in sweet corn leaves are generally found under contaminated groundwater than under fresh water irrigation.

Table (4.12)The chemical analysis of sweet corn and pepper leaves after irrigated with fresh and contaminated groundwater

Element	FSC Leaves	CSC Leaves	FSP Leaves	CSP Leaves
N%	1.71 b	2.18 a	4.86 a	4.08 b
P%	0.51 a	0.43 a	0.18 a	0.21 a
K%	1.36 a	1.47 a	4.61 a	2.71 b
Ca%	0.12 a	0.18 a	1.08 a	1.01 a
Mg%	0.27 b	0.35 a	0.31 b	0.43 a
Na%	0.08 b	0.21 a	0.05 b	0.17 a
Cl%	0.02 a	0.13 a	0.01 b	0.11 a
Fe mg/l	117.3 a	109.4 b	123.2 a	101.7 b
Cu mg/l	15.5 a	10.2 b	8.3 a	6.1 b
Mn mg/l	53.7 b	62.1 a	73.2 a	46.7 b
Zn mg/l	40.5 a	42.5 a	55.8 a	49.5 a

FSC Leaves: Leaves of sweet corn irrigation with fresh groundwater.

CSC Leaves: Leaves of sweet corn irrigation with contaminated ground water.

FSP Leaves: Leaves of sweet pepper irrigation with fresh groundwater.

CSP Leaves: Leaves of sweet pepper irrigation with contaminated ground water.

4.3.2 Sweet Corn and Pepper fruits.

Sweet corn seed irrigated with contaminated water had significantly higher ($p \leq 0.05$) yield rather than that, irrigated with fresh water, but yield of sweet pepper fruits irrigated with contaminated water had significantly lower than that irrigated with fresh water,table(4.7). Fresh and dry weights of sweet corn seeds irrigation with contaminated water had highest,Fig (4.8.1) and (4.8.2) but fresh and dry weights of sweet pepper fruits irrigation with contaminated water, had significantly lower than sweet pepper fruits irrigation with fresh water.Fig (4.9.1) and (4.9.2).

Fig(4.8.1): **Sweet corn irrigation with fresh water**

Fig(4.8.2): **Sweet corn irrigation with contaminated water**

Fig(4.9.1): Sweet Pepper irrigation with fresh water

Fig(4.9.2): Sweet Pepper irrigation with contaminated water

Sweet corn seed responded to contaminated irrigation by exhibiting significantly higher total N, Ca^{2+}, K, Cu, but there was no higher significant differences in Mg^{2+}, Zn and Mn concentrations between two fields, and had lower contents of

P and Fe, table(4.13). Contaminated sweet pepper fruits had higher concentration of P and Mg and lower contents of other tested parameters.

Table(4.13): The chemical analysis of sweet corn seed and pepper fruits after being irrigated with fresh and contaminated groundwater

Element	FSC Seed	CSC Seed	FSP Fruit	CSP fruit
N%	1.20 b	1.52 a	4.52 a	3.81 b
P%	0.73 a	0.62 b	0.24 b	0.38 a
K%	1.48 b	1.56 a	4.82 a	3.51 b
Ca%	0.63 b	0.82 a	1.27 a	1.14 a
Mg%	0.34 a	0.36 a	0.29 a	0.31 a
Fe mg/l	99.2 a	87.8 b	107.3 a	97.6 b
Cu mg/l	6.8 b	9.4 a	6.3 a	5.4 a
Mn mg/l	56.7 a	58.2 a	67.1 a	40.3 b
Zn mg/l	38.3 a	40.1 a	38.1 b	46.6 a

FSC Seed: Seed of sweet corn irrigation with fresh groundwater.

CSC Seed: Seed of sweet corn irrigation with contaminated groundwater.

FSP Fruit: Fruit of sweet pepper irrigation with fresh groundwater.

CSP Fruit: Fruit of sweet pepper irrigation with contaminated groundwater.

Chapter five

5. Discussion

5.1 Soil

From the salinity point of view, Wadi Al-Aroub soil irrigated with fresh water falls according to (Appendix 10), in the low salinity classification. Accordingly, only yields of very sensitive crops are restricted. Overall average soil solution electrical conductivity (EC_e) values of contaminated water main root zone (0-30cm) fall within the medium salinity soil classification. Therefore, EC_e values increase to the extent that only tolerant crops yield are satisfactory. However, according to (Appendixes 10, 13) classification of salt – affected soils,), soil irrigated with contaminated water field is classified as saline soil.

Further, significantly higher concentrations of Ca^{2+} and Mg^{2+} were detected in contaminated water rather than in soil irrigated by fresh water, presence of divalent cations, such as Ca^{2+}, Mg^{2+}, greatly reduces the efficiency of heavy metal adsorption by permanent charge clays as these metals compete more efficiently and strongly with heavy metals for exchange sites (McBride et al, 1981; Cavallero and M Bide, 1977; and Garcia and Miragaya, 1977). Its thus much expected that relatively comparable plant available metals contents in soil of contaminated water and fresh water reflect less amounts being adsorbed by exchange sites of the former soil while a better chance existed for metals to occupy some fraction of soil in fresh water exchange sites.

A general trend was observed of the soil irrigated by contaminated water increase concentrations of Na^{+}, EC_e, Ca^{2+}, and Mg^{2+} with increasing depth of soil. This derives from the fact that Contaminated water continued relatively higher concentrations from fresh water.

Outputs of soil chemical analysis were evaluated by comparison with available diagnostic criteria presented in (Appendix 14) (Ryan et al., 1996, and Walsh and Beaton, 1973). According to Ryan et al. (1996), organic matter content of soil in contaminated water is classified as adequate at the surface (0-30) and marginal in lower depth horizons. As to soil in fresh water, adequate, marginal and low contents respectively of OM were found at 0-30 cm, and rest of depth increments in sampling.

Available P proved adequate throughout soil in fresh water soil profile. Whereas in soil of contaminated water field had adequate available P supplies, remainding depth horizons were marginal in their supplying capacity for P. Throughout the whole soil profile in contaminated water and soil in fresh water contained low K^+ concentrations, respectively .

DTPA – extractable micronutrient cations at both sites follow the general trends of declines with depth and soil OM content decline.

Moreover, both field soils entertained adequate levels of each. These results run in accordance with Katyal and Sharma (1991) who point up that as similar soil factors govern distribution of micronutrient cations in soil , soils rich in the rest and vice versa.

DTPA – extractable Cu proved adequate at both site throughout the whole soil profile sampled. Available Fe content within the whole soil profile of both fields is marginal, though in the main root zone of soil in fresh water it fluctuates between marginal and adequate. Both fields had Mn concentrations very much higher than adequate. Contaminated, which once compared with soil in fresh water, soil had significantly higher OM content and lower pH, had higher DTPA-extractable Mn. This result follow quite parallel to results obtained by Katyal and Sharma (1991) who found that DTPA-extractable Mn correlated negatively with pH, and positively with soil organic matter content. However, in deep contrast with Katyal and Sharma (1991) who found that DTPA-extractable Mn and Fe distributions in the profile to follow one the other, our results revealed there are reverse.

Of all factors considered (Soil OM, Clay content, $CaCO_3^-$ equivalent, and pH), dictate Mn availability in soils (Katyal and Sharma, 1991, Lindsay and Schwab, 1982; and Sims and Patrick, 1978), it might be inferred that soil in contaminated water is subjected to higher rates of Mn concentration than soil in fresh water, may be due to the soil in contaminated water had higher concentration of OM than soil in fresh water. As to Zn, the main root zone of soil in contaminated water is sufficient in its supplying for Zn while soil in fresh water contains adequate supplies in soil .

Numerous studies, e.g., Katyal and Sharma (1991), have pointed out that high levels of OM content are believed to be important in increased bioavailability of Zn and Cu and demonstrated high correlation between OM content and extractable or phytoavailable Cu and Zn. Sims and Patrick (1978) reported amounts of trace nutrients complexed with OM to decrease in the order Zn > Cu > Fe > Mn. Accordingly, higher soil irrigated by contaminated water than soil in fresh water phytoavailable Cu and Zn may be ascribed to the higher OM content of the former than the latter. Petruzzelli et al. (1978) found that OM removal produced a noteworthy decrease in Cu adsorption .

The proporation of Zn complexed by soil increase with OM content (Soon and Bates, 1982) . Similar results were obtained by Flores et al.(1997)who found that Cu and Zn were predomintaly associated with the organic fraction in most soil samples.

Contaminated water adds Cu to soil, while no detectable Cu was found in fresh water. Paradoxically, the soil in fresh water is much expected to have attenuated higher amounts of Cu than soil in contaminated water which had higher concentrations of Cu. This inference in turn will bear comparison with results obtained by Dillon et al. (1981) who found the adsorption capacities of soils were related to cation exchange capacity, clay content and $CaCO_3^-$ equivalent. In addition, higher plant availability of Cu in soil could be linked to its higher solution activity since; according to Dillon et al. (1981), higher soil solution ionic strength is expected to decrease the activity of Cu and amount of Cu adsorption.

Furthermore, chloride was found to exert a marked effect on the mobility of divalent Cu, which are mobilized as chlorocomplexes (Doner, 1978). Accordingly, more ample Cl^- concentrations in soil irrigation with contaminated water must have mobilized Cu down the profile to exceed concentrations in parallel depths of soil irrigated with fresh water.

In addition, the soil in contaminated water solution ionic strength, which exacerbates leaching, has a more pronounced effect on, and hence cores for a larger proportion of, leaching of these metals. Movement of Ca^{2+} and Mg^{2+} in soil is slow because these divalent cations are more strongly bonded to the exchange complex than such monovalent ions as Na^+ (stewart et al., 1990). The greater mobility of Na^+ was experienced further in our study by slight increases in SAR with depth at both fields Table (3,4) and (5,6). This reflect displacement of Ca^{2+} and Mg^{2+} from exchange sites by Na^+. Higher soil SAR values at both fields in comparison with respective irrigation water are due accordingly to raise and heigh levels of concern about development of soil sodicity.

If we decide to define Ca^{2+} concentration in normal soils to be 120 mg L^{-1} (Ma, 1996), we can then conclude that soil in contaminated water solution contain Ca^{2+} concentration above normal throughout the whole soil profile samples while soil in fresh water solution content of Ca^{2+} was always below normal.The high concentration of Ca^{2+} in contaminated water solution may be related to the high concentration of NO_3^- in soil. Troncoso et al. (1987) found that application of urea, as a result of increasing NO_3^- concentrations within the soil profile, mobilizes other nutrients, particularly Ca^{2+}.

However, despite high concentrations of NO_3^- in contaminated water, (Table 2), soil in contaminated water had significantly higher NO_3^- concentrations. This may, be due to extensive N fertilization and the higher soil OM content of contaminated water which serve as pools of N.

The existence of pH in soil irrigated with fresh water has higher concentration within the main root zone (0-30cm). Increasing soil pH must have enhanced the loss of N as NH_3 (NH_3 volatilization).This may be ascertained by the higher solution of pH at soil irrigated by fresh water compared with soil irrigated by contaminated water which evidently has better aeration. Consequently, the rates of nitrification of each mole of NH_4^+ furnishes the soil solution with two moles of H^+.

The soil irrigated by fresh water has more clay content, particularly in the main root zone, than the soil irrigated by contaminated water, and consequently, the clay soil in the upper layer has lower infiltiration rate and poorer aeration and hence more N volatilization (White and Dornbush, 1988) and thus explains lower total N as well as NO_3^- concentrations at soil irrigated by fresh water compared to soil irrigated by contaminated water.

Phosphorus (P) concentration is much higher within the whole soil in fresh water profile than that of soil in contaminated water. Irrigation water of contaminated water field contained no detectable P while fresh water is characterized by relatively high P. Still, according to Walsh and Beaton (1973), soil in fresh water rank high in soil available P content (Appendix 14) but soil in contaminated water rank marginal in soil available P content.

Heterotrophic bacterial counts tended to be higher in irrigated soil than in dry soil . It is higher in soil irrigated with contaminated water than that in fresh water Table (3,4) and (5,6). This probably reflects the high numbers of bacteria in irrigation water, probably due to the high concentration of dissolve oxygen (Al- Nakshabandi, 1996) who found soil surface under the effluent irrigation water was found to contain fecal coliform, but the count drastically decreased with depth, this is due to the infiltration and less aeration effect of the soil.

5.2 Plant

5.2.1 Sweet Corn and Pepper Leaves.

It is noted from the results of sweet corn and sweet pepper Figs(9)that fresh and dry weight of sweet corn leaves in the six plots irrigated with contaminated water is higher than the fresh and dry weight of sweet corn leaves irrigated with fresh water. While fresh and dry weight of sweet pepper after irrigation with contaminated water in the other six plots is the lowest. And the yield of leaves of sweet corn after irrigation with contaminated water had higher sweet corn after irrigation with fresh water.

This difference in production is probably related to two factors:

1- An increase in the concentration percentage of Nitrogen supply as NO_3^- in the contaminated water is higher than that its concentration in the fresh water.

2- The high concentration of readily available nutrients of Ca^{2+} and K^{+} in the contaminated water.

But the yield of sweet pepper leaves which is irrigated by contaminated water is lower than Fresh. This is may be due to high concentration of salt in contaminated soil, a matter increases the osmotic pressure of the soil water and produces conditions that prevent the roots from absorbing water and elements. This results in physiological drought condition. Even though the soil appears to have plenty of moisture, the plants may wither away because the roots don't absorb enough water to replace water. And because sweet pepper is more sensitive to salts than to sweet corn, the yields of sweet pepper after irrigation with contaminated water is lower than yields of sweet pepper after irrigation with fresh water (Ayers and Westcot, 1976).

Plant uptake of heavy metals is highly dependent on soil pH, OM competing cations, and plant species. However, every under high root concentrations, only fraction of the trace element is translocated to tops with an even small fraction eventually reaching the fruit.

The root thus acts as a trap or filter which removes mineral nutrients and trace elements from the contaminated groundwater while translocating relatively little to the tops (Berry et al, 1980).

The concentration of N, Ca^{2+}, Mg^{2+}, K^{+}, Na^{+}, Cl^{-}, and heavy metals in sweet corn and pepper leaves under contaminated groundwater compared fresh groundwater irrigation are presented in table (12).

The concentrations of N, Ca^{2+} , Mg^{2+} , and K^{+} in sweet corn leaves were higher under the contaminated groundwater than those irrigated by fresh groundwater.

This is probably related to the high concentration of NO_3^-, Ca^{2+}, Mg^{2+}, and K^+ in the contaminated groundwater used for irrigation.

Leaf nitrogen of sweet corn was also significantly increased by irrigation with contaminated groundwater. Leaf nitrogen was strongly correlated with grain yield of corn because nitrogen is contained in chlorophyll molecule. Nitrogen is absorbed by plants in both the nitrate (NO_3^-) and ammonium (NH_4^+) forms. Its generally understood that NH_4^+ is absorbed and utilized primarily by young plants whereas NO_3^- is the principle form utilized during the grand growth period. The NO_3^- ion under goes transformation after it is absorbed and is reduced to the Amine form (NH_2^-). Its then utilized to form amino acid, because nitrogen is contained in the chlorophyll molecule, N is also a structural constituent of cell walls and N moves from older plant parts to younger leaves.

Sweet corn leaf Zn contents at both fields were very nearly the same while contaminated sweet corn leaves accumulated a somewhat higher Zn concentration.

The combined effect of high soil pH and P content at fresh irrigation could have resulted in this relative reduction in Zn uptake by plants (Melton et al., 1973). This bears resemblance with results obtained by El-gazzar et al. (1979) who reported that Zn concentrations of olive leaves and roots showed a gradual decrease with increasing P fertigation.

Though contaminated Sweet Corn had higher total N and K^+ than that of fresh sweet corn .This complies with the fact that contaminated soil had higher NO_3^-, $K^+$and Ca^{2+} concentrations than fresh soil. But Leaf of Sweet Pepper irrigated with contaminated water had lower N, Ca^{2+}, and K^+ than the sweet pepper leaf which is irrigated by fresh water , this is may be due to the excessive salt in soil irrigated by contaminated water that prevent roots from absorbing sufficient amounts of N, Ca^{2+}, and K^+.

The Leaves of Sweet Corn and sweet pepper after irrigated with fresh had higher concentration of P content rather than leaves of Sweet Corn and sweet pepper after irrigated with contaminated water. Higher concentrations of soil available P which irrigated with fresh water relative to soil irrigated with contaminated water affected higher sweet corn and sweet pepper leaf P as well as fruit total P concentrations, but no substantial differences in sweet corn and sweet pepper leaf P content were observed between the two fields. Besides, though negligible differences in leaf Cl^- contents were affected by type of irrigation water, high Cl^- concentrations of contaminated than fresh soil must have inhibited P uptake since inhibition of P uptake is one of Cl^- induced nutritional disorders (Cutrin et al., 1993).

Inspite that fact that the two studied fields practically had no substantial differences in foliar Cl^- contents, in contrast to Na^+, foliar Cl^- was always less than Na^+. Such trend was documented by (Tattani, 1992). Furthermore, no toxicity is due to be exerted upon sweet corn and sweet pepper crops at both fields by their respective leaf Cl^- concentrations , were well below the toxicity limit of 0.50% (Reuter and Robinson, 1986).

Sweet corn and pepper at both fields had sufficient P concentration while had deficient of N concentration . Sweet corn leaves of fresh field had lower concentration of N than contaminated. In addition, sweet corn and sweet pepper at both fields proved to lack sufficient supplies of Ca^{2+}as well as of N.

A synergistic relationship was reported between $Ca^{2+}$and N in olive leaves by (Therios and Sakellaridis, 1988) who found increasing in Ca^{2+} concentration to follow N concentration increases in olive leaf tissue.

Paradoxically, no toxicity symptoms are due to appear at Na^+ concentration less than 0.42% according to (Childers, 1966). But during the growing stage of sweet corn after irrigation with contaminated water, some salt injures to some leaves were noticed. The problem was believed to be caused by Na^+ and Cl^- absorption into the plant tissues under high evaporative condition.Fig(14).

Fig(5.1): Salts injures to some leaves in sweet corn.

The concentrations of micronutrients in sweet corn leaves and fruits under contaminated and fresh water are shown in Tables (12,13). Fe, Zn, Mn, Cu were higher in leaves than in fruits,these results are similar to the results of (Fardous and Jamjoum, 1996) who found that heavy metal concentrations in sweet corn tissue at Samra treatment plant (STP) field is higher in leaves than in fruits.

5.2.2 Sweet Corn and Pepper Fruits.

In brief, soil salinity is not expected to affect sweet pepper crops growth and yield at fresh field, while yield reduction is much expected to get affected by the significantly higher of soil solution salinity of contaminated fields, irrigated by contaminated water. Sweet pepper yield reductions of 10, 25, and 50% have been reported to be included respectively by EC_e value of 4, 6, 8, and 10 mS cm^{-1} higher conductivity by adding concentrated KCl solution to the basic nutrient solution. Higher ionic strength of the nutrient solution resulted in smaller sized fruit, reduced fruit dry weights and decreased vegetal growth, (Nichols, 1999).

Fresh and dry weight of sweet pepper which is irrigated by contaminated water had lowest, this is may be due to the high concentration of salt in soil irrigated by contaminated water, according to (Adams, 1994) who reported that salinity in the range of 3-8 mS cm^{-1} reduced dry weight in cucumber, and dry weight fruits of sweet pepper after irrigation with contaminated water which can be reduced because the higher EC_e in soil decreased stomatal conductance and reduced CO_2 fixation of plants.Hence, the reduction in plant dry weight could be because to low photosynthetic capacity and smaller leaf area resulting from stomatal closure (Xu et al. 1994).

But the yield of fresh and dry weight of sweet corn seed irrigated by contaminated water had higher than seeds of sweet corn irrigated by fresh water. This is probably to high concentrations of N, Ca^{2+}, K^{+} in leaves of sweet corn after irrigation with contaminated water than leaves of sweet corn after being irrigated with fresh water and sweet corn have more tolerance for salinity than sweet pepper, and sweet corn are known to be more sensitive to salinity during the early growth period than during germination and later growth periods (Ayers and West cot, 1974) .

The concentration of N , Ca^{2+}, Mg^{2+}, and K^{+} in sweet corn seeds irrigated with contaminated groundwater compared with fresh water irrigation are presented in table(13). The concentration of N, Ca^{2+}, Mg^{2+} and K^{+} in sweet corn seeds were higher in contaminated groundwater irrigation. This is probably due to the higher concentration of NO_3^- , Ca^{2+}, Mg^{2+} and K^{+} in the contaminated used for irrigation, see table(2.1).

High concentration of Ca^{2+} in seeds of sweet corn after irrigated with contaminated water, while the low concentrations of Ca^{2+}in fruits of sweet pepper after being irrigated with contaminated water, this is may be due to the high concentration of Ca^{2+} in leaves of sweet corn after irrigation with contaminated water and to the low concentration of Ca^{2+} in the leaves of pepper after irrigation with contaminated water, and according to Gorsline and others, (1965) who noted that the ability of a corn plant to absorb a nutrient Ca^{2+} is an inherited characteristic and can be genetically transferred, and may be Ca^{2+} is not mobile element, and Ca^{2+} level in plants is increased with the age of the plant.

Nitrogen concentration in sweet corn seed irrigated with contaminated water was higher than those irrigated by fresh water and lower than sweet pepper after being irrigated with fresh water. This is may be due to the high concentration of N in the leaves of sweet pepper after being irrigated with fresh water.

Magnisum concentration in seeds of sweet corn and fruits of sweet pepper after irrigation with contaminated and fresh water, were very nearly the same concentration. This is may be due to the amount of contaminated and fresh soil pH values were very nearly, and soil pH can markedly increase the uptake of Mg^{2+} irrespective of the Mg^{2+} soil test level, and Mg^{2+} deficiency may not occur when the Mg^{2+} level is not below 0.15% percent (Clark, 1970).

Sweet pepper fruit irrigated by Contaminated water, had lower K^+ content than fresh sweet pepper. This is probably due to the low N content and to the high Mg^{2+}content in fruits of sweet pepper after irrigation with contaminated water. The K^+ / Ca^{2+} + Mg^{2+} balance, and more recently, the K^+ to N balance must be maintained at a proper level to a void deficiencies in most plants and crops. Plants which are of Mg^{2+} high contents may have deficient K^+ and Ca^{2+} content as the plant tends to maintain a constant cation concentration. And because of K^+ mobility; both in the plant and soil, deficiency can develop quickly. Deficiencies frequently occur during both the early stages of growth and during fruiting, and the K^+concentration in the plants decrease with age (USDA salinity laboratory Hand book, 1954). Low concentration of K^+ in fruits of sweet pepper after irrigation with contaminated water, which is enquired for burg or build up in plants and mentions the osmotic potential of cells. Which in guard cells governs the opening of stomata. This osmotic regulation indicates the role K^+ plays in water relations in the plant. Its involved decrease in water uptake from soil, water retention in the plant tissue, and long-distance transport of water and assimilates in the phloem and xylem, and cause reduction in yield, (Bennett, 1993).

Fruits of sweet pepper after irrigation with contaminated water had lower Zn, Mn, Fe than fruits of sweet pepper after irrigation with fresh water, and sweet pepper fruits Cu contents at both fields were very nearly the same while sweet pepper fruits irrigated by contaminated water accumulated a somewhat lower Cu concentration. This is may be due to high Phosphorus (P) content in fruits of sweet pepper after irrigation with contaminated water , may cause imbalances and deficiencies of other elements, such as Cu, Zn, Fe, Mn and because contaminated soil had pH greater than 7.2, the phosphate ion is absorbed by plants is ($HPO4^{2-}$), (Bennett, 1993)and when the soil pH and organic matter increases, the deficiencies of Cu, Zn, and Fe will occur, (USDA salinity laboratory Hand book, 1954).

The low concentration of Zinc in fruits of sweet pepper after irrigation with contaminated water, may be Zn immobile element in plant deficiency symptoms occur in the newly emerging leaves. And may be because relationship appears to be the Ca^{2+}:Zn ration in the tissue, the other noted that when the Ca^{2+}: Zn concentrations could approximately 50:1 Zn toxicity symptoms were evedent. The deficiencies of these micronutrients could cause a reduction in the formation of green pigments and chlorophyll, giving the plant a distinctive yellowish appearance (Shainberg and Oster, 1978). During the study, such problems were not observed.

The low concentration of phosphorus in seed and leaves of sweet corn after irrigation with contaminated water, this is probably due to a lower concentration of P in the contaminated groundwater used for irrigation according to (Al-Nakshabandi, 1996).

Low of Cu in fruits of sweet pepper after irrigation with contaminated water than seed of sweet corn after irrigation with contaminated water depend on plant species or variety and the stage of deficiency. In early stages of deficiency, symptoms are generally reduced growth. In the moderate to acute stages of deficiency on leaves of sweet pepper after irrigation with contaminated water are pale green and become rolled and yellowish leaf (Renther and Labanauskas, 1966).

Mn concentration in sweet Corn and Pepper fruits does not produce toxicity. The concentration of Fe, Mn , Cu, and Zn in sweet corn fruit and Pepper fruits are shown in table (13). Fe > Mn >Zn > Cu in sweet corn and Pepper leaves and fruits.Table(4.12).

5.3 Hygienic aspects

Public health considerations are centered around pathogenic organisms that could be present in contained groundwater in great numbers and variety , which may cause disease in farm workers, in the people who consume the crops , and in the people who inhale aerosols generated from the applications of the contamination groundwater .

Water borne pathogens that cause disease fall into three general classes bacteria (i. e . Salmonella , Shigella , Escherichia coli and coliform bacteria , Vibrio) , viruses (i . e . Reovirns , Hepatitis A . Norwalk – like) and parasitic protozoa (i. e . Giarda lamblia, Entamoeba histolytica and Cryptosporides) . Bacteria and viruses contaminate both surface and groundwater, whereas parasite protozoa appear predominantly in the surface water and tape water networks respectively water reservoirs, however, especially cryptosporides , have been found as well as in groundwater.

Bacteria and protozoa generally induce gastrointestinal disorders with a wide range of severity – Bacteria also cause life – threatening disease such as typhoid and cholera. viruses cause serious diseases such as Aseptic meningitis , Encephalitis , Poliomyelitis , Hepatitis , Myocorctitis and Diabetes (water quality and Health council, 2001) .

The examination for total and fecal indicator organisms is the most sensitive and specific way for assessing the hygienic quality of water, therefore this test was used in this study.

Total coliform bacteria is group of naturally occurring bacteria that are present in all surface waters. As surface water percolates through the soil, a natural filtration process take, but soil is not removing bacteria and viruses. Due to the size of bacteria we observe a retardation presses" bacteria are moving much slower than water " but they are still moving, however, due to limited survival time in this type of environment (200…400 days), it is basically question of distance between sources (cesspit) and sampling point (well) . Fecal coliform bacteria is agroup of bacteria which are present in sewage material. The presence of fecal coliform bacteria indicates that a fecal sources such as animal feed lot run-off, septic tank or cesspool leakage, etc. is in the vicity. Their presence also indicates that the water may be contaminated with organisms that can cause disease which represents a serious and even deathly health concern (WHO, 1993).

5.4 Drip irrigation .

During the growing stage of sweet corn and sweet pepper, water is applied around each plant so as to wet locally and the root zone only. The application rate is adjusted to meet evapotranspiration needs so that percolation losses are minimized .

The Drip irrigation method selection dependes on water supply conditions, climate, soil, crops to be grown, cost of irrigation method and the ability of the farmer to manage the system .

However, when using contaminated groundwater as the source of irrigation other factors, such as contamination of plants and harvested product, farm workers, the environment, salinity and toxicity hazards, must be considered . During the growing stage of sweet corn , foliar injury occurs under this method of irrigation, and salt movement is radial along the direction of water movement. The problem was eliminated adopting a schedule of applying water at very early hours of the day.

A salt wedge is formed between emitters. and salts accumulate in the soil around the edges of the wet area under drip irrigation. Its possible to maintain high soil water potential throughout the growing season and minimize the effect of salinity .

Drip emitters were clogged by wind – blow grass , weeds , and algae when contaminated groundwater is used . The Dripper emitters needed disassembly for the removing the clogging materials at least one in week. And clogged were a decrease flow in spite of good pressure in the lines .

Drip irrigation is good to Excellent. Almost sweet corn grown by drip irrigation has no loss in yield. On the contrary drip irrigation system increases the growth and the yields of sweet corn with acertain percentage of water, nutrients and proper aeration in the root zone. The main advantages of drip irrigation seem to be of minimal contact between the farm workers and contaminated water, and this system is of high irrigation effeiciency where no drop of water can be lost through infiltration or by the wind drift. There is no water losses by applying the drip irrigation system.

Besides that, drip irrigation is useful suitable for growing pepper on condition that the water should be fresh, not contaminated as in the case of growing corn. Its line low energy requirement – the trickle system requires a water pressure of only 100 – 300 Kpa (1-3 bar) .

Drip irrigation overcomes this traditional watering problem by keeping water and oxygen levels within absorption limits of the plants . It reduces water loss by up to 60% percent or more as compared to traditional watering methods . Water applied in excessive use of water this penetration rate can only run off the surface removing valuable topsoil and nutrients.

Less total salt is added with drip irrigation since less water is applied. In addition, a uniformly soil moisture level is maintained with drip irrigation , which keeps the salt concentration in the soil at a lower level .

Chapter Six

6. Conclusions and Recommendations.

6.1. Conclusions .

The following conclusions can be obtained;

1- Increasing populations and uncertain climatic changes will cause high demands on water requirements in the future.

2- High nitrate concentration in contaminated groundwater is generally an indication of contamination from major nitrogen sources such as a sewage disposal system, animal manure, or nitrogen fertilizers.

3- The soil irrigation with contaminated groundwater contains high levels of organic matter in which coliforms and other heterotrophic bacteria could survive the sudden stress imposed by chlorine. When the soil irrigation with contaminated groundwater, a high coliform count was found on the surface soil. The coliform count on the soil surface decreased drastically with depth .

4- Clogging of the trickle irrigation system was not a significant problem when contaminated groundwater was used for irrigation.

5- There was an increase in sweet corn production, but there was decrease in Sweet pepper production, probably due to sweet pepper more sensitive to salt than Sweet Corn ,and ability of corn plant to absorb a nutrient is an inherited characteristic and can be genetically transferred.

6- High conductivity levels (EC) reduce the vegetative as well as reproductive yields of the crops . This is associated with a reduction in the uptake of water, leaf water content, and a reduction of photosynthetic capacity of the crop.

7- All the springs and dug wells are contaminated with coliform bacteria; therefore they are not suitable for drinking unless being treated. Boiling, sun disinfection, or chlorination of the water are possible treatment techniques.

6.2. Recommendations.

1. Prevention of uncontrolled disposal of wastewater in the near by fields and wadis.
2. Although the former recommendation represents current irrigation practices at Wadi Al Arroub site, further improvement on irrigation soil quality, fruit and sweet corn, sweet pepper yields can be achieved by optimizing irrigation water depth and schedule.
3. It is recommend not to use the water from springs and wells especially those adjacent to the sewage conduit or in the vicity of houses for drinking purpose unless it is treated properly.
4. Long- term spatial and temporal monitoring of the water quality, especially the fecal coli form count, EC, NO_3^- Who Cause Blue Babies diseases and concentrations in major springs.
5. Where the contaminated springs are the major or the only water source for domestic purpose it is recommended to supply at least the pregnant women and infants with low nitrate bottled water.
6. Where disinfection of the drinking water (chlorination) is not available, a boiling water and sun disinfection before use is highly recommended.

7. The contamination groundwater is of bad irrigation water quality as it has the high values of EC and SAR. Soil is not recommended to be used for irrigation in fine-textured soils and with sensitive plants.

8. The production of its media programs for the education of citizens and their persuasion on a use i organized it its processor the polluted groundwaters and the repetition of their use in the agriculture. Like the use of the precipitation ways, the aerial decomposition, the water lentil, the working for the persuasion of farmers of the use of agriculture and the organic fertilization.

9. The use of the polluted groundwaters in the agriculture of the forest plants, and the plants resistant to its kinship the saltiness like cotton, tobacco, linen, and also fodder agriculture. On condition that is applicable but not by using the sprinklers system.

10. Subsequently, additional studies are needed to identify optimum irrigation practices, especially irrigation scheduling and leaching fraction management.

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Appendices

Appendix (1) : General classification of groundwater according to TDS.

Category of water	TDS (mg/L)
Fresh	0-1000
Brackish	1000-10000
Saline	10000-100000
Brine	> 100000

Source: Carroll 1962.

Appendix (2): The physical and chemical analysis of the drinking water network (tap water) in Arroub Camp (1996-2000).

Sample	Unit	Sample 1	Sample 2	Sample 3	Sample 4
pH		7.53	7.46	7.45	7.8
EC	µS/cm	563	558	580	597
TDS	mg/L	298.05	286.05	310	321
DO	mg/L	7.63	7.92	7.55	7.42
Temp	°C	20.30	14.90	16.7	13.8
Ca^{2+}	mg/L	72.5	67.6	68.9	66.2
Mg^{2+}	mg/L	12.1	10.7	22.3	26.8
Na^{+}	mg/L	21.8	23.8	13.5	16.5
K^{+}	mg/L	1.9	2.1	1.2	2.0
HCO_3^-	mg/L	245.5	229.3	295.3	302.5
Cl^-	mg/L	39.3	42.3	32.0	35.6
SO_4^{2-}	mg/L	13.2	12.1	14.5	10.2
No_3^-	mg/L	14.5	12.8	10.3	12.5

Source: Qannam. Z., (2002).

Appendix (3): Irrigation water classification .

Salinity Hazard		
Classification	EC	Code
Low	0.1-0.25	C1
Medium	0.25-0.75	C2
High	0.75-2.25	C3
Very high	2.25-5.0	C4
Sodium Hazard		
Classification	SAR	Code
Low	0-10	S1
Medium	10-18	S2
High	18-26	S3
Very high	26-31	S4

Source: USSL, 1954.

Appendix (4). Classification of saline water[(1)].

Water class	**EC (dS m^{-1})**	**Salt concentration (mg L^{-1})**	**Water Type**
Non-saline	< 0.7	< 500	Drinking and irrigation water
Slightly saline	0.7-2	500-1500	Irrigation water
Moderately saline	2-10	1500-7000	Primary drainage and groundwater
Highly saline	10-25	7000-15000	Secondary drainage and ground water
Very highly saline	25-45	15000-35000	Very saline groundwater
Brine	> 45	> 35000	Seawater

(1)Source: Roades et al. 1992.

Appendix (5): Guidelines for interpretation of water quality for irrigation.

Potential irrigation problem	Unit	Degree of restriction on use		
		None	Slight to moderate	Severe
Salinity				
EC_W	dS m^{-1}	< 0.7	0.7-3.0	> 3.0
Or, TDS	Mg L^{-1}	< 450	450-2000	> 2000
Infiltration				
SAR = 0-3 and EC_W =	dS m^{-1}	> 0.7	0.7-0.2	< 0.2
SAR = 3-6 and EC_W =		> 1.2	1.2-0.3	< 0.3
SAR = 6-12 and EC_W =		> 1.9	1.9-0.5	< 0.5
SAR = 12-20 and EC_W =		> 2.9	2.9-1.3	< 1.3
SAR = 20-40 and EC_W =		> 5.0	5.0-2.9	< 2.9
Specific ion toxicity				
(1) Na^+				
Surface irrigation	SAR	< 3	3-9	> 9
Sprinkler irrigation		< 3	> 3	-
(2) Cl^-				
Surface irrigation	me L^{-1}	< 4	4-10	> 10
Sprinkler irrigation	me L^{-1}	< 3	> 3	-
(3) Boron				
B	mg L^{-1}	< 0.7	0.7-3.0	> 3.0
Miscellaneous effects				
NO_3^-	mg L^{-1}	< 5	5-30	> 30
HCO_3^-		< 1.5	1.5-8.5	> 8.5
pH	Normal Range 6.5-8.4			

(1) unit: $(me\ L^{-1})^{1/2}$

Appendix (5). Guidelines for interpretation of water quality for irrigation (Continued).[1]

Recommended Maximum Concentration	
Cd	0.01
Cu	0.20
Fe	5.0
Mn	0.20
pb	5.0
Zn	2.0

(1) Source: Ayers and Westcot, 1985

Appendix (6). Effluent irrigation guidelines 1995 (Jordan).[(1),(3)]

No.	Parameter[(2)])	Cooked vegetables	Fruit and forestry trees and corps	Fodder crops
1-	PH	6.0-9.0	6.0-9.0	6.0-9.0
2-	BOD_5	150	150	250
3-	COD	500	500	700
4-	DO	> 2	> 2	> 1
5-	TDS	2000	2000	2000
6-	TSS	200	200	250
7-	Na^+	230	230	230
8-	Ca^{2+}	400	400	400
9-	Mg^{2+}	60	60	60
10-	SAR	9	9	9
11-	Cl^-	350	350	350
12-	SO_4^{2-}	1000	1000	1000
13-	CO_3^{2-}	6	6	6
14-	HCO_3^-	520	520	520
15-	NO_3^--N	50	50	50
16-	Total N	100	100	100
17-	B	1	1	1
18-	Cu	0.2	0.2	0.2
19-	Fe	5	5	5
20-	Mn	0.2	0.2	0.2
21-	Zn	2	2	2
22-	Pb	5	5	5
23-	Cd	0.1	0.1	0.1

(1) Source: Tuffaha (1996) (2) Apart from pH, all parameters are assigned the unit mg L^{-1}.

(3) Remark: This standard did not include any specification for $EC_{iw,}$ NH^+ and PO_4^{3-}.

Appendix (7): The physical and chemical analysis of the waste water collected of the sewage conduit in Wadi Al Arroub (1999-2000).

Sample	Unit	Sample 1	Sample 2	Sample 3	Sample 4
Date		10.05.99	10.05.99	07.02.00	07.02.00
pH		8.78	8.75	7.54	7.55
EC	µS/cm	2850	3250	1675	1540
TDS	mg/L	1851	2042	1088	956
DO	mg/L	0.25	0.11	3.15	5.75
T	°C	24.6	23.4	9.2	8.7
Ca^{2+}	mg/L	135.0	123.0	141.2	134.4
Mg^{2+}	mg/L	34.8	36.7	42.7	33.5
Na^{+}	mg/L	618.0	720.0	195.0	165.0
K^{+}	mg/L	57.0	85.0	25.0	18.0
HCO_3^-	mg/L	487.0	550.0	463.0	420.0
Cl^-	mg/L	452.0	525.0	191.0	205.0
SO_4^{2-}	mg/L	59.0	43.0	67.0	45.0
No_3^-	mg/L	65.0	59.0	95.0	45.0
F^-	mg/L	0.89	0.67	0.54	0.42
SiO_2	mg/L	1.5	1.3	8.8	6.9
Po_4^{3-}	mg/L	60.2	47.3	1.78	1.1
FC	Colony/100ml	$8*10^6$	$15*10^7$	$5*10^4$	$2*10^4$
TC	Colony/100ml	$16*10^7$	$25*10^8$	$10*10^4$	$14*10^4$
BOD_5	mg O_2/L	890	1432	145	87
COD	mg O_2/L	2746	3571	275	124
TSS	mg/L	2115	1980	950	430
Fe	µg/L	0.62	0.43	0.2	0.5
Mn	µg/L	0.13	0.055	0.05	0.11
Zn	µg/L	0.21	0.18	0.045	0.074
Cd	µg/L	0.09	0.1	0.08	0.05
Cr	µg/L	6	13	4	9
Cu	µg/L	13	18	3	7
Ni	µg/L	12	15	2	6
Pb	µg/L	1.1	1.5	0.8	1.1
As	µg/L	1	5	1	1.5

Source: Qannam. Z., (2002).

Appendix (8): Water quality and clogging potential in drip irrigation systems.

Potential problem	Units	Degree of restriction on use		
		None	Slight to moderate	Severe
Physical				
Suspended solids	Mg/I	<50	50-100	>100
Chemical				
PH		< 7.0	7.0-8.0	>8.0
Dissolved solids	Mg/I	< 500	500-2000	>2000
Manganese	Mg/I	< 0.1	0.1-1.5	>1.5
Iron	Mg/I	< 0.1	0.1-1.5	>1.5
Hydrogsulphide	Mg/I	< 0.5	0.5-2.0	>2.0
Biological	Maximum			
Bacterial populations	Number/ml	<10000	10000-50000	50000

Source: Nakayama, 1982 .

Appendix (9). Heavy metal concentrations in soil and corn tissue under effluent irrigation at Queen Alia international airport experimental station.[1]

Pool	Irrigation	Cu	Fe	Mn	Zn	Cd	Pb
	Water	mg kg^{-1}					
Soil	Effluent	2.91	5.80	9.56	0.94	0.14	1.03
0-20cm	Fresh	2.84	5.56	8.50	0.91	0.13	0.96
20-40cm	Effluent	2.74	5.20	8.94	0.88	0.14	1.06
	Fresh	2.62	4.98	8.05	0.60	0.14	1.03
Leaves	Effluent	13.00	257.30	139.0	133.2	0.60	11.90
	Fresh	12.40	212.30	136.3	128.0	0.60	11.90
Seeds	Effluent	9.60	66.80	6.70	38.20	Bd[2]	Bd
	Fresh	9.60	66.80	6.70	32.10	Bd	bd

(1) Khattari and jamjoum (1988).

(2) Below detection limites.

Appendix (10): Soil salinity classification.

Classification	EC_e (dS m^{-1})	Plant Growth
Normal	< 1.5	(1)
Low salinity	1.5-3.0	(2)
Medium salinity	3.0-5.0	(3)
High salinity	5.0-10.0	(4)
Very high salinity	> 10.0	(5)

(1) Normal for all crops.

(2) Yields of very sensitive crops restricted.

(3) Yields of many crops restricted.

(4) Only tolerant crops yield satisfactorily.

(5) Only few very tolerant crops yield satisfactorily.

(6) Gupta and Gupta (1987).

Appendix (11). Soil DTPA – Extractable micronutrient cation concentrations at Arizona. [(1), (2)]

Irrigation Water	Potable				effluent			
period	Cu	Fe	Mn	Zn	Cu	Fe	Mn	Zn
April, 1986	1.4	3.9	3.0	2.1	1.3	3.5	2.7	1.9
June, 1988	1.4	6.6	5.4	1.3	1.4	6.4	6.6	1.1

(1) Hayes et al. (1990).

(2) Unit: mg/l.

Appendix (12). Heavy metal concentratins in Sweet Corn tissue at STP field. [(1), (2)]

Corn Tissue	Cu	Fe	Mn	Zn	Cd
	mg kg-1				
Leaves	7.760	258.200	137.700	17.600	0.470
Seeds	1.900	55.200	11.700	21.300	bd[(3)]

(1) Fardous and Jamjoum (1996).

(2) Concentrations corresponding to 100% class A pan evaporation.

(3) Below detection.

Appendix (13): Classification of salt-affected soils

Classification	EC_e (1)	pH (2)	Physical
	dS m^{-1}		Condition
Saline	> 4.0	7.5-8.5	Normal
Sodic	< 4.0	8.2-10.0	Poor
Saline-Sodic	> 4.0	8.5-10.0	Normal

(1) Source: Follet et al., 1981

(2) Source: Gupta and Gupta, 1987.

Appendix (14): Generalized guidelines for interpretation of soil analysis data.

Parameter	Unit	Low	Marginal	Adequate
OM (1)	%	<0.86	0.86-1.29	1.29
P (1)	mg/l	<8	8-15	> 15
K (1)	mg/l	< 100	100-150	> 150
Cu (1), (2)	mg/l	< 0.2	-	> 0.20
Fe (1), (2)	mg/l	< 4.5	-	> 4.5
Mn (1), (2)	mg/l	< 1.0	1.0-2.0	> 2.0
Zn (1), (2)	mg/l	< 0.5	0.5-1.0	> 1.0

(1) Source: Ryan et al. (1996).

(2) Source: Walsh and Beaton (1973).

Appendix (15): Metal levels in plant tissue.

Metal	Normal	Phytotoxic
	mg kg^{-1}	
Cu	3-20	25-40
Mn	15-150	400-2000
Zn	15-150	500-1500
Cd	0.1-1.0	5-700
pb	**2-5**	-

Source: Cajuste et al., 1991.

Appendix (16):Sufficiency ranges of nutrients in selected parts of corn plants.

Element	Sufficiency range in plant	
	Ear Leaf At silk	Whole plant, 3-to 4-leaf stage
N, %	2.7 - 3.5	3.5-5.0
P, %	0.2 - 0.4	0.4-0.8
K, %	1.7 - 2.5	3.5-5.0
Ca, %	0.2 - 1.0	0.9-1.6
Mg, %	0.2 - 0.6	0.3-0.8
S, %	0.1 - 0.3	0.2-0.3
Fe, mg/l	21 – 250	50-300
Zn, mg/l	20 – 70	20-50
Mn, mg/l	20 -150	50-160
Cu, mg/l	6 – 20	7-20
B, mg/l	4 - 25	7-25
Mo, mg/l	0.6 – 1.0	…

Source: Bennett, 1993.

Appendix (17): General guidelines for critical, sufficient, and toxic levels of plant nutrients.

Element	Critical level	Sufficient range	Toxicity level
N, %	<2.0	2.0-5.0	Nontoxic
P, %	<0.2	0.2-0.5	Nontoxic
K, %	<1.0	1.0-5.0	Nontoxic
Ca, %	<0.1	0.1-1.0	Nontoxic
Mg, %	<0.1	0.1-0.4	Nontoxic
S, %	<0.1	0.1-0.3	Nontoxic
Fe, mg/l	<50	50-250	Nontoxic
Zn, mg/l	15 - 20	20-100	>400
Mn, mg/l	10 – 20	20-300	>300
Cu, mg/l	3 – 5	5-20	>20
B, mg/l	<10	10-100	>100
Mo, mg/l	<0.1	0.1-0.5	>0.5
CI, %	<0.2	0.2-2.0	>2.0
Si, %	<0.2	0.2-2.0	Nontoxic
Na, %	<1.0	1.0-10	Nontoxic
Co, mg/l	<0.2	0.2-0.5	>0.5
V, mg/l	<0.2	0.2-0.5	>1

Source: Bennett, 1993.

Appendix (18).Sufficient Nutrient in Sweet peppers .

Nutrient	Sufficient level
N %	4.0-6.0
Phosphorus %	0.35-1.0
Potassium %	4.0-6.0
Calcium %	1.0-2.5
Magnesium %	0.3-1.0
Iron mg/l	60-300
Manganese mg/l	50-250
Copper mg/l	6-25
Zinc mg/l	20-200
Boron mg/l	25-75

Sources: Salisbury and Ross 1978.

Appendix (19). The essential mineral elements for plants .

Element	Symbol	Type	Mobility in Plant	Symptoms of Deficiency
Nitrogen	N	macronutrient	mobile	Plant light green, lower (older) leaves yellow.
Phosphorus	P	macronutrient	mobile	Plant dark green turning to purple.
Potassium	K	macronutrient	mobile	Yellowish green margins on older leaves.
Magnesium	Mg	macronutrient	mobile	Chlorosis between the veins on older leaves first, turning to necrotic spots, flecked appearance at first.
Calcium	Ca	macronutrient	immobile	Young leaves of terminal bud dying back at tips and margins. Blossom end rot of fruit (tomato and pepper).
Sulfur	S	macronutrient	immobile	Leaves light green in color.
Iron	Fe	micronutrient	immobile	Yellowing between veins on young leaves (interveinal chlorosis), netted pattern.
Manganese	Mn	micronutrient	immobile	interveinal chlorosis, netted pattern
Boron	B	micronutrient	immobile	Leaves of terminal bud becoming light green at bases, eventually dying. Plants "brittle."
Copper	Cu	micronutrient	immobile	Young leaves dropping, wilted appearance.
Zinc	Zn	micronutrient	immobile	interveinal chlorosis of older leaves.
Molybdenum	Mo	micronutrient	immobile	Lower leaves pale, developing a scorched appearance.

Sources: Salisbury and Ross 1978.

Appendix (20). Salt Crops Tolerance .

Field	Forage crops	Vegetable crops	Fruit crops
Good Salt Tolerance			
Barley **Beets** **Cotton**	Saltgrass Birdsfoot trefoil Bermuda grass Barlay hay	Garden beets Kale Asparagus spinach	
Moderate salt tolerance			
Rye **Wheat** **Oats** **Sorghum** **corn**	Sweetclover Dallisgrass Sundangrass Alfalfa Smooth brome Tall fescue Wheat and oats hey Orchardgrass Ryegrass vetch	Tomato Broccoli Cabbage Potato Lettuce Sweet corn Pepper Squash Carrot Onion Peas cucumber	Fig Grape Cantaloupe Watermelon
Poor salt tolerance			
Field beans	Whit clover Red clover Ladino clove Alsike clover	Radish Celery Green beans Strawberries	Pear Apple Orange Grapefruit Plum Apricot Peach lemon

Source : Ayers and Westcot, 1976.

Appendix (21): Typical concentrations of elements in dried healthy foliage.

Element	Unit	Range
N	%	0.8-3.0
P		0.08-0.35
K		0.5-2.5
Ca		1.5-2.8
Mg		0.15-0.45
B	mg kg^{-1}	10-50
Cu		5-12
Fe		40-150
Mn		30-100
Zn		30-200

Source: Marr and Cresser, 1983.

Appendix (22): mineral and Vitamin Content of Pepper (100-gm edible portion).

	Ca (mg)	**P (mg)**	**Fe (mg)**	**Na (mg)**	**K (mg)**	**Vit. A (I.U)**	**Thia-mine (mg)**	**Ribo-flavin (mg)**	**Nia-cin (mg)**	**Ascorbic Acid b (mg)**
Immature Green										
Raw	.09	.22	.7	.13	213	420	.08	.08	.5	125
Cooked										
Mature	9	16	.5	9	149	420	.06	.07	.5	96
red										
Raw	13	30	.6	---	…	4.450	.08	.08	.5	204

Source: Lorenz and Maynard, 1980.

Abstract in Arabic

ملخص

تأثير الري بالمياه الجوفية الملوثة على نوعية التربة

و الذرة و الفليفله في موقع وادي العروب

إعداد

أديبه محمود علي ثوابته

إشراف

د. يوسف عمرو

تم المشروع بهدف تحديد الأثر للري بمياه الآبار الجوفية الملوثة في وادي العروب على خصائص تربه الموقع الكيميائية ونوعيه نبات الذرة و الفليفله .

ابتدئ بري نبات الذرة و الفليفله ريا بالتنقيط بالمياه الجوفية الملوثة في واد العروب.

بعد جمع عينات لست آبار جوفيه في العروب و أخضعت الآبار للتحليل الكيميائي و الفيزيائي و البيولوجي ، وتم اختيار بئران على حسب النتائج ، بئر بمياه عذبه و آخر بمياه ملوثه.

تضمنت الدراسة جمع عينات تربه ، ورق وثمار الذرة والفليفله في تزامن مع موسم جمع هذه المحاصيل. قمنا بقياس الوزن الرطب و الوزن الجاف بعد الحصاد ، كما قمنا بقياس الابعاد لكل من المحصولين خلال نموهما وأخضعت العينات المجموعة لتحاليل كيميائيه حسب الطرق القياسية المعتمدة.

أفادت معطيات النتائج ان الري بالمياه الجوفية الملوثة ادت الى زيادة انتاجية الذره كما ادت الى نقص في انتاجية الفليفله كما افادت معطيات التحاليل أن تركيز البوتاسيوم (**K^+**) و الفوسفور (**P**) المتاح للنبات و كذلك الحديد (**Fe**) كانت أعلى في التربة المروية بالمياه الجوفية العذبة منها في التربة المروية بالمياه الجوفية الملوثة.

وقد كانت الموصلية الكهربائيه (EC) لمستخلص تربه المياه الجوفية الملوثة وكذلك تراكيز (Na^+) ، الكالسيوم(Ca^{2+}) ، المغنيسيوم(Mg^{2+})، الكلورايد(Cl^-) ، البيكربونات(HCO_3^-) ، و النترات (NO_3^-) أعلى منها في محلول التربة المروية بالمياه العذبة . أما نسبه المادة العضوية (OM) ، النحاس(Cu) ، الزنك (Zn) ،و المنغنيز(Mn) المتاح للنبات فقد كانت أعلى في التربة المروية بالمياه الملوثة منها في التربة المروية بالمياه العذبة.

كما أفادت المعطيات الناتجة من تحاليل نسبه التلوث البكتيري (**TC, FC**) على التربة أنها أعلى في محلول التربة المروية بالمياه الجوفية الملوثة عنها في محلول التربة المروية بالمياه الجوفية العذبة .

بالنسبة لنبات الذرة والفليفله ، أ تضح أن الري بالمياه الجوفية الملوثة أدى إلى رفع محتوى ورق الذرة من النيتروجين(**N**) ، والكالسيوم(Ca^{2+}) ، المغنيسيوم(Mg^{2+})، البوتاسيوم(K^+)، وكذلك تراكيز الصوديوم (Na^+) و الكلور(Cl^-) في المستخلص المائي لورق الذرة مقارنه بأوراق الذرة المروية بالمياه الجوفية العذبة. أما بالنسبة للفليفله فقد أدى إلى رفع محتوى(Cl^-)، (Na^+), (Mg^{2+}) في الورق المروي بالمياه الملوثة.

أما بالنسبه للثمر ، فقد أدى الري بالمياه الجوفيه الملوثه مقارنه بالمياه الجوفيه العذبه إلى زياده تركيزالنيتروجين(**N**) ، الكالسيوم(Ca^{+2}) ، البوتاسيوم(K^+) ، المغنيسيوم (Mg^{2+}) ، النحاس(Cu)، الزنك(Zn) ، والمنغنيز(Mn) في الذره. كما ادى الى زيادة الفسفور(P)، والمغنيسيوم(Mg^{2+}) في الفليفله، ونقص في تركيز باقي العناصر، المرويه بالمياه الجوفيه الملوثه .