FECT OF DIFFERENT IRRIGATION WATER QUALITIES ON THE SOIL PROPERTIESAND MICROBIAL SAFETY IN DATE PALMS IN AL-AHSSA OASIS

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ABSTRACT

The long-term effects of using different irrigation water sources on the soil properties and microbial safety of three date palm cultivars (Khalas, Sheshi and Ruzeiz) at Tamr (ripening stage) in Al-Ahassa Oasis, Saudi Arabia were evaluated. The water typeswere groundwater (GW), groundwater/agricultural drainage water (GW+DW),groundwater/tertiary-treated wastewater (GW+TTWW) and groundwater/agricultural drainage water/tertiary-treated wastewater (GW+DW+TTWW). The obtained results revealed that the irrigation water qualities used in the present study may cause one problem or another according to the water quality. By applying the criteria used for interpreting water quality for irrigation, the most dominant problems are salinity hazard, potential salinity and soluble sodium percentage. Therefore, it is expected that continuous irrigation without good water management (leaching requirements) can lead to severe problems from the salinity point of view, especially in the areas that are irrigated with (GW+DW), and the areas irrigated by (GW+DW+TTWW).

Electrical conductivity of the soils irrigated with different irrigation water qualities (GW, GW+DW, GW+TTWW, and GW+DW+TTWW) at the surface layer, (0-30 cm) depth, were 2.81, 5.04, 3.15 and 4.21 dS/m, respectively. The soil salinity increased with the depth from (0-30 to 60-90 cm) in soils profile irrigated by different irrigation water qualities;(GW+DW) have the highest adverse effect on elemental composition of soil followed by (GW+DW+TTWW), (GW+TTWW) and then (GW). There was a marked increase in the soil-soluble cations with increasing depth in all of the soils that were irrigated with different irrigation water qualities. The contamination levels of spoilage microorganisms (yeasts, molds, and aerobic mesophilic bacteria) were within an acceptable level, and did not exceed the limit of 10^2cfu/g. None of the date samples showed a detectable level of contamination by potential pathogens (coliforms).

KEY WORDS: date palm irrigation; agricultural drainage water; tertiary-treated wastewater; microbial safety.

INTRODUCTION

A challenge for agriculture in arid and semi-arid regions is the identification of new water resources for irrigation. One alternative that has become more common in recent years is the reuse of wastewater (Morugán-Coronado *et al.*, 2011). Fresh water quality for agriculture is becoming an increasingly scarce resource because of climate change effects and escalating competition from other water-use sectors (Milano *et al.*, 2012). The agricultural sector is the major consumer of water in Saudi Arabia, and it uses two-thirds of the available resources. The wastewater has been successfully used for irrigation (Mujeriego and Sala, 1991; Levine and Asano, 2004), reclaimed wastewater application may produce undesirable effects in soils and plants, such as direct effects on the soil suitability for cultivation and water resource availability (Ayers and Wescot, 1994) and microbiological factors that may cause sanitary problems (WHO, 1989). Al-Ahssa Oasis is an important area for habitation and agriculture in eastern Saudi Arabia. There are 16,000 ha of agricultural land area; however, the deficiency of water resources is a significant problem. Although all the agricultural lands were intended to be irrigated with spring water, groundwater resources are currently insufficient. Therefore, unconventional water resources, such as agricultural drainage water (DW), tertiary-treated wastewater (TTWW) and groundwater (GW) that are applied individually or in mixtures have been used for long-term soil irrigation in Al-Ahassa Oasis (Shahin and Hussein, 2005).

Al Omron *et al.* (2012) found that one of the long-term effects of irrigation with treated sewage effluent in Al-Ahssa, Saudi Arabia was a significant increase in the organic matter content of the soil. Abu-Rekab and Kerdany (2009) evaluated the safe use of Nile water and treated wastewater for irrigation and its effects on the yield and fruit quality of Sewy date palm trees and found that treated wastewater could not safely be used to irrigate virgin sandy soils. Hossner*et al.*, (1978) studied the long-term application of treated wastewater on forage grasses in San Angelo, Texas, USA and found that it did not increase the Cd, Cu or Zn content above regional background values. Only Cr and Ni displayed high concentrations, although they were within the guidelines. Metcalf and Eddy (1991) found that irrigation for 76 years with treated wastewater in Melbourne, Australia did not show a significant accumulation of Cd in the soils or plants compared with sites that had received fresh water. Simmons and Pongaskul (2002) compared different crops that were watered with sewage, a 50% dilution with fresh water and fresh water only and found that the amount of absorbed metals was dependent on both the type of crop and metal concentration in the water. Rusana*et al.* (2007) studied sites that had been irrigated with wastewater for periods of 10, 5, and 2 years and compared them to sites that had been irrigated with fresh water and found that long-term wastewater irrigation had no significant effect on the concentration of heavy metals (Pb and Cd) in the soils regardless of the duration of wastewater irrigation. The sewage effluent concentrations of Pb and Cd varied significantly compared with that of groundwater (Rattan *et al.*, 2005). Dates are similar to other agricultural produce in that they are subject to microbial contamination by bacteria, coliforms, yeast and molds in the field and during handling processes (Nussinovitch*et al.*, 1998, Hamad and Aleid, 2013). The objective of this study is to assess the impacts that may arise from the use of alternative unconventional and non-traditionalsources of irrigation water, including agricultural drainage water and tertiary-treated wastewater after mixing with groundwater, and determine the effects of such water on the Productivity, chemical composition and microbiological properties and quality of date palm fruits from the varieties Khalas, Sheshi and Ruzeiz under the conditions of Al-Ahsa Oasis.

MATERIALS AND METHODS

Farm selection

This study was conducted in Al-Ahassa Oasis during the 2010 and 2011 seasons. Four different areas that were irrigated with the four studied water types for long periods that extended for more than 15 years were chosen within the area that is served by the Al-Ahassa Irrigation and Drainage Authority (HIDA). The areas in which the farms were irrigated with GW only were named F7 (AinBahlh in northern Alkhodood), F3 (AinAlharh) and P4 (Alharh Tank). The second area in which the farms were irrigated with GW mixed with DW was named F2 (northeast Batalia-Merah). The third area in which the farms were irrigated with TTWW mixed with GW was named P1 (southwest Alkhodood). The fourth area in which the farms were irrigated with GW mixed with DW and TTWW was named F1 (southeast Al-Ahassa). The farms were randomly selected within each area, and the selection was based on the coverage of the entire area and required that interference with the objectives of the study (e.g., presence of private artisan-wells for irrigation) be avoided. Each farm contained three date palm varieties: Khalas, Sheshi and Ruzeiz, and the palms were 20 years old and in good

physical condition. The number of spathes per palm was adjusted to 11/Khalas, 12/Sheshi and 14/Ruzeiz by removing the earliest, latest and smallest spathes.

Experimental design

The layout of the experimental area was factorial in a completely randomized block design with three replicates (farms). The first factor included four irrigation water qualities (GW, GW+DW, GW+TTWW and GW+DW+TTWW), whereas the second represented three date palm cultivars (Khalas, Sheshi and Ruzeiz). Within each farm, nine palm trees were selected, and three replicates were produced for each cultivar.

Soil analysis

The physical and chemical properties, macro- and micro-nutrients of the soils were measured. Four representative soil samples were collected from each farm using an auger at three depths: (zero-30, 30-60, and 60-90 cm), and each of 4 samples representing the same depth were mixed together to make a composite sample. The sample location was recorded using a Global Positioning System (GPSmap 276C , Garmin International, Inc. 1200 E. 151st St. Olathe, KS 66062-3426, USA). All of the collected soil samples were air dried, crushed and sieved through a 2-mm sieve and stored in plastic bottles before analysis. The soil organic matter content was determined according to Walkley and Black using the rapid titration method Page *et al.*, (1982). A soil saturation paste and extracted soil solution were prepared according to the method of Page*et al.* (1982). The electrical conductivity (EC) of the total dissolved salts (TDS) was estimated in the soil paste using a conductivity meter (temperature compensating Hach EC meter), which measured the cell-expressed conductivity in dS/m according to the method of Rhoades (1992). The soil pH was measured in the soil paste (suspension) according to the method of Datta*et al.* (2001) using a pH meter (Hack 108). The soluble CO_3^{2-} and HCO_3^- were determined in the soil extract by titration with HCl according to the method of Nelson (1982). The soluble chloride in the soil extract was determined according to the method of Moore (Rhoades, 1992). The soluble sulfate in the soil extract was calculated as the difference between the concentrations of total dissolved cations and anion concentration in mEq/L. The soluble calcium and magnesium in the soil extract were determined according to the method of Rhoades(1992). The soluble sodium and potassium were determined in the saturation paste soil extract using a flame photometer (BWB-XP) according to the method of Jackson (1973). The exchangeable sodium percentage (ESP) was determined according to the methods that are outlined in Carter (1993) and Rhoades(1982). The micronutrients in the soil were extracted using the chelating agent diethylenetetraminepenta acetic acid-triethanolamine (DTPA-TEA) at pH 7.3 according to the method of Lindsay and Norvell (1978), and measured using an atomic absorption spectrophotometer (AA-6300 Shimadzu Corporation, Japan).

Water analysis:

Water samples were collected every three months, and three replicates of each water were collected; subsequently, 500 mL of each water sample with 15 mL of HNO_3 was evaporated to near dryness on a hot plate. The contents were then digested with 15 mL of HNO_3 and 20 mL of $HClO_4$ (70%) according to the method of Brar*et al.* (2000). The residue was placed in 15 mL of 6 N HCl and brought to a 50 mL volume, and the contents were filtered. The filtrate was analyzed for the contents of Fe, Mn, Cu, Zn, Cd, Co, Pb, As and Ni using an atomic absorption spectrophotometer (AA-6300). The quality parameters of the irrigation water were determined according to Ayers and Westcot (1985). The salt concentration was expressed in terms of electrical conductivity (EC_{iw}, dS/m); the concentrations of Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}, CO_3^{2-}, HCO_3^{-}, Cl^{-} and SO_4^{2-} ions were measured; and the hazard parameters were calculated as follows: sodium was expressed as sodium adsorption ratio (SAR) or soluble sodium percentage (SSP, %); the magnesium hazard (SMgP) was expressed as the soluble magnesium percentage (SMgP, %); the bicarbonate hazard was expressed as the value of residual sodium carbonate (RSC, me/L); and the ion concentration was expressed in mEq/L. The concentrations of nitrate in water samples was determined according to the method of Novone (1964). Biological content; dissolved oxygen (DO) was determined according to the method of Franson (1975). Thebiological oxygendemand (BOD_5) and chemical oxygen demand (COD) were determined according to the method of Young, *et al*(1981).

Microbiological analysis

Three replicates were analyzed, and the data points were the averages of eight date fruits. The aerobic mesophilic bacteria were counted on Plate Count Agar (PCA; Oxoid, CM0325) dishes using the pour plate method. The plates were incubated at 30°C for 2 to 3 days, and the counts were expressed as colony-forming units per gram or per milliliter (cfu/g or cfu/mL of the sample. The date samples were aseptically destoned using sterile forceps, and the microbial loads were calculated for the flesh. The flesh samples (10 g) were weighed in sterile stomacher bags with 90 mL of sterile peptone water (Oxoid, CM0009). The mixture was homogenized in a stomacher (Lab-Blender 400, Seward Medical, England) for 45 seconds, and aliquots (1.0 or 0.1 mL) were plated in triplicate as 10-fold dilutions in peptone water. Aerobic mesophilic bacteria were cultured on PCA dishes (Oxoid, CM0325) using the pour plate method. The plates were incubated at 30°C for 2 to 3 days, and the counts were expressed as colony-forming units per gram or milliliter (cfu/g or cfu/mL) of the sample. The coliforms were counted on Violet Red Bile Agar (VRBA; Oxoid, CM0107) using the pour plate/overlay method. The plates were incubated at 37°C for 24-48 hours. Round purple-red colonies (0.5-2 mm in diameter) that were surrounded by purple-red haloes on the VRBA plates were counted as coliforms. Yeasts and molds were cultured on Potato Dextrose Agar (PDA) plates (Oxoid, CM0139) using the spread plate method. The yeasts were incubated at 30°C for 3 days, and the molds were incubated at 20-30°C for 3 to 7 days; the counts were expressed as cfu/g or cfu/mL of the sample (Atlas, 2004).

Statistical analysis

The data were subjected to an analysis of variance (ANOVA) according to Gomez and Gomez (1984). The differences among treatment means were compared using the least the significant differences (LSD) test using the statistical analysis systems software (SAS, 2001).

RESULTS AND DISCUSSION

1. Quality of irrigation water:

1.1. Water chemical analysis:

Data presented in Table (1) show the average chemical composition of different water qualities which are used for irrigation. Apparently, the values of EC were (2.81 dS m^{-1}), (5.04 dSm^{-1}), (3.15 dS m^{-1}) and (4.21 dS m^{-1}) for (GW), (GW+ DW), (GW + TTWW), and (GW+DW+TTWW) water samples respectively, whereas corresponding values of TDS for different irrigation water qualities were 1798.4, 3225.6, 2016.0 and 2694.4 mg/l for (GW), (GW+ DW), (GW + TTWW), and (GW+DW+TTWW), respectively. The data illustrate that the highest value of EC was recorded in (GW+DW) followed by (GW+DW+TTWW) and (GW + TTWW) while the lowest value of EC recorded in (GW).

The acidity or basicity of irrigation water is expressed as pH,the values of pH for different irrigation water were 7.63, 7.80, 7.55 and7.77 for (GW), (GW+ DW), (GW + TTWW), and (GW+DW+TTWW), respectively.

The water quality parameters for the all investigated water types are presented in Tables (2), and shown in Figure (1). From these data, it appears that for all types of irrigation water, the EC_{iw} ranged from 2.81 to 5.04 dS/m. The critical level of EC_{iw} cause severe salinity problems is 3 dS/m as reported by FAO (1976).

Table (1): Chemical composition and biological content of different irrigation water qualities used for irrigation of Al- Hassaa soil.

Characteristics	Irrigation Water				LSD at 5%
	GW	GW+DW	GW+TTWW	GW+DW+TTWW	
EC (dS/m)	2.81 d	5.04 a	3.15 c	4.21 b	**0.002**
TDS (mg/L)	1798.4 d	3225.6 a	2016.0 c	2694.4 b	**3.700**
pH	7.63 c	7.80 a	7.55 d	7.77 b	**0.002**
Soluble Cations, m mole/L					
Ca^{2+}	7.94 d	13.26 a	9.40 c	10.44 b	**0.004**
Mg^{2+}	4.36 d	7.58 a	4.90 c	6.90 b	**0.004**
Na^{+}	14.9 d	28.42 a	16.26 c	23.92 b	**0.004**
K^{+}	0.90 c	1.14 a	0.94 b	0.84 d	**0.004**
Soluble Anions, m mole/L					
CO_3^{2-}	-	-	-	-	-
HCO_3^-	4.46 c	8.84 a	3.62 d	5.70 b	**0.004**
Cl^-	10.00 d	17.34 c	20.32 b	22.34 a	**0.120**
SO_4^{2-}	13.64 c	24.22 a	7.56 d	14.06 b	**0.004**
NO_3^-, mg/L	5.23 d	10.21 c	11.34 b	13.53 a	**0.240**
Micronutrients, mg/L					
Cu	0.012 b	0.016 ab	0.019 c	0.026 a	**0.060**
Mn	0.017 d	0.022 b	0.027 c	0.032a	**0.002**
Fe	0.072 d	0.085 c	0.095 b	0.099 a	**0.002**
Zn	0.045 d	0.076 c	0.085 b	0.090 a	**0.110**
B	0. 35 b	0. 48 a	0. 26 b	0. 57 a	**0.110**
Biological Content					
Dissolved Oxygen (DO) mg O_2 /L	9.84 a	7.09 d	7.95 b	7.46 c	**0.002**
Biological Oxygen Demand (BOD_5) mg /L	2.04 d	3.53 c	4.28 a	3.88 b	**0.110**
Chemical Oxygen Demand (COD) mg /L	4.05 d	12.48 c	14.64 b	16.78 a	**0.089**

The value of eachcharacter is the average of 24 water samples for each irrigation water quality during two seasons (2010,2011). Gw= (ground water); GW+DW= (ground water + agricultural drainage water); GW+TTWW= (ground water + tertiary treated wastewater); GW+DW+TTWW= (ground water + agricultural drainage water + tertiary treated wastewater).

The values of EC_{iw} for (GW) were less than the critical limit and there are no problems of using (G.W) for irrigation waterfollowed by (GW + TTWW). The values of EC_{iw} for (GW+ DW) and (GW+DW+TTWW) are more than the critical level. It could be considered as high salinity and may cause severe salinity problems.

Water salinity refers to the total amount of salts dissolved in the water but it does not indicate which salts are present in it. High level of salts in the irrigation water reduces water availability to the crop (because of osmotic pressure) and causes yield reduction. The most common parameters used for determining the irrigation water quality, in relation with its salinity, are EC and TDS, FAO (1976).

1.2. Water Biological analysis:

Biological Content of different irrigation water qualities.

Dissolved Qxygen (DO): It is one of the most important parameters in water quality assessment and reflects the physical and biological processes prevailing in the waters. Its presence is essential to maintain the higher forms of biological life in water and effects of a wastewater discharge in a water body are largely determined by the oxygen balance of the system. Oxygen can be rapidly removed from water by discharge of the oxygen demanding wastes. Other organic reductions are H_2S, NH_3, $N0_3$, Fe and other oxidizing substances also tend to decrease dissolved oxygen in water. Low oxygen can kill organisms present in water. The concentration of oxygen will also reflect whether the process

undergoing is aerobic or anaerobic. Low oxygen concentrations are generally associated with heavy contamination by organic matter. In such a condition oxygen sometimes totally disappears from water. The data of DO value of different irrigation water qualities revealed that all values of DO were morethan the critical limit (> 7 mg O_2 /L) as reported by Pescod (1992).

Chemical Oxygen Demand (COD): Itis a measure of the amount of Carbon in many types of organic matter. It is some value in identifying the performance of the various steps of treatment in a given plant and of considerable value as an estimate of the strength of those sewage and industrial waste waters for which the BOD_5 cannot be determined, because they contain substances that are toxic to the organisms activating the BOD_5 test. The COD test is very important parameter in management and design of the treatment plant because of its rapidity in determination. For all practical purposes its values are very close to the amount of chemically oxidized carbonaceous matter which may be quite useful in control of treatment process. COD values are more than BOD_5 values for most of industrial wastes. COD values are taken as basis for calculation of the efficiency of the treatment plants and also figure in the standards for discharging industrial domestic effluents in different types of waters. The data of COD value of different irrigation water qualities revealed that all values of COD were less than the critical limit (< 50 mg /L) as reported by Pescod (1992).

Bio-Chemical Oxygen Demand (BOD5): It is the amount of Oxygen utilized by microorganisms in stabilizing the organic matter. On an average, the demand for oxygen is proportional to the amount of organic waste to be degraded aerobically. Hence BOD_5 approximates the amount of oxidized organic matter present in the solution and BOD_5 value can be used as a measure of waste strength. It is highly important to know the amount of organic matter present in the waste treatment system and that the quantity of oxygen required for its stabilization. Thus these values are very useful in process design, loading calculations as well as the measure of treatment plant efficiency and operation. Types of micro-organisms, pH, presence of toxins, some reduced mineral matter & nitrification process are important factors influencing the BOD_5 tests.The data of BOD_5 value of different irrigation water qualities revealed that all values of BOD_5 were less than the critical limit (< 10 mg /L) acceptable range based on FAO standards (Pescod1992).

1. 3. Irrigation water quality parameters:

The data presented in Tables (2), also revealed that the SAR value of all water sources is relatively low in comparison with the critical level of sodium hazard (less than 10) as reported byFAO acceptable level (Pescod1992).

Table (2): Average of irrigation water quality parameters.

Irrigation water	ECw dS/m	SAR	SAR adj.	SSP %	Mg Hazard%	RSC me/L	Potential salinity me/L	Cl^- me/L	B mg/L	NO_3^- mg/L
GW	2.81 d	6.01 c	11.05 c	53.02 c	35.45 c	-7.84 a	16.82 c	10.00 d	0.35 d	5.23 d
GW+DW	5.04 a	8.80 a	18.23 a	56.39 a	38.21 b	-12.00 b	29.45 a	17.34 c	0.48 b	10.21 c
GW+TTWW	3.15 c	6.08 d	10.30 d	51.62 d	34.27 d	-10.68 a	24.10 b	20.32 b	0.26 c	11.34 b
GW+DW+TTWW	4.21 b	8.12 b	16.96 b	56.82 b	39.79 a	-11.64 b	29.37 a	22.34 a	0.57 a	13.53 a
LSD at 5%	**0.089**	**0.109**	**0.109**	**0.334**	**0.126**	**1.151**	**0.063**	**0.063**	**0.002**	**0.363**

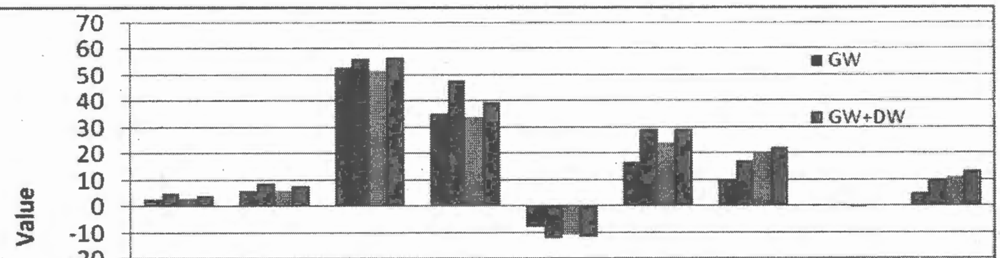
Means in each column followed by the same letter(s) did not differ at < 0.50 according to Duncan's multiple-range test.

The value of each parameters average of 24 water samples for each irrigation water quality during two seasons (2010,2011).

Theadj. SAR means adjusted Sodium Adsorption Ratio that can be calculated using adj. SAR = SAR [1 + (8.4-pHc). The pHc relates to Ca, Mg, CO_3 and HCO_3 concentrations and readers are referred to Ayers & Westcott (1985) for further details. pHc<8.4 indicates tendency to dissolve lime from the soil while for pHc>8.4 the tendency is for lime to precipitate from the water applied.

Adjusted SAR takes into consideration calcium and magnesium loss through precipitation caused by the presence of carbonates and bicarbonates in solution. Therefore, although various methods to calculate adjusted ESP and SAR exist, they all result in adjusted values greater than the original ones, as the proportion of sodium increases as calcium and magnesium decrease; the values of SARadj. for all types of

water were 11.05,18.23,10.30 and16.96 for (GW), (GW+ DW), (GW + TTWW), and (GW+DW+TTWW) water samples respectively (table 3). With respect to the SSP as indicator for sodium hazard, the values of SSP for all types of water were 53.02, 56.39, 51.62 and 56.82 %. For (GW), (GW+ DW), (GW + TTWW), and (GW+DW+TTWW), respectively Table (2). The data revealed that all values of SSP were less than the critical limit (< 60%) as reported by Wilcox (1958).



	dS/m ECW	SAR	SSP %	Mg Hazard %	RSC me/L	Potential salinity me/L	Cl- me/ L	B mg/L	NO3 mg/L
GW	2.81	6.1	53.02	35.45	-7.84	16.82	10	0.35	5.23
GW+DW	5.04	8.8	56.39	48.21	-12	29.45	17.34	0.48	10.21
GW+TTWW	3.15	6.08	51.62	34.27	-10.68	24.1	20.32	0.26	11.34
GW+DW+TTWW	4.21	8.12	56.82	39.79	-11.64	29.37	22.34	0.57	13.53

Figure (1):The average of irrigation water quality parameters.

Magnesium hazard is one of the criteria for suitability of water for irrigation. In this respect, the values of SMgP tabulated in Table (3) indicated that all types of water have values ranging from 34.27 to 39.79 %, the values are below the harmful level (>50%). This means that there is no problem of Magnesium hazard. The magnesium salts have toxic effects on the plant and the toxicity of Mg ion is higher than the toxicity of Na ion having the same concentrations.

The residual calcium carbonates RSC value evaluates the tendency of irrigation water to form carbonates and to dissolve or to precipitate calcium and to less degree magnesium carbonates. The precipitation of poorly soluble carbonates increases the sodium hazard of irrigation water and as a result increases the sodicity of irrigated soils. The present values of RSC have negative values, this means that $Ca^{2+} + Mg^{2+}$ is more than the CO_3^{2-} + HCO^-_3 resulted in no problem of sodium hazard and the values below the recommended safe limit for irrigation water which is 1.25 meq/L.

Potential salinity (PS) for all water types used ranged from 16.82, 29.45, 24.10and 29.37 meq /L For (GW) , (GW+ DW), (GW + TTWW), and (GW+DW+TTWW) water samples respectively. The high values of PS over the critical level (5 meq /L) as reported by Richards (1972) may be due to the soluble salts content in the irrigation water.

Chloride ion (Cl^-) is extremely high and ranged from 10.00 to 22.34 meq /L. According to the guidelines for interpreting water quality (FAO,1976) The values of Chloride ion (Cl^-) in different irrigation water qualities were less than the critical limit (< 554mg/L) as reported by (Bauder, *et al.*, 2011).

Boron - Toxicity due to specific ions such as boron occurs when the ion is taken up by the plant and accumulates in the plant in amounts that result in damage or reduced yields. Discharges from industrial plants and household detergents are the common source for boron in wastewater. Acceptable levels of boron ranged from 1ppm to3ppm. The concentration of Boron for all the water types in this study is < 1 mg/L. The date palm trees are considered as semi-tolerant to Boron, while the limit of boron in irrigation water is from 1 to 3 mg/L as given by (Wilcox, 1958). This would put these waters in the range of no problem of toxicity with respect to palm trees.

The US Environmental Protection Agency developed three specific boron guidelines for irrigation waters since crops show different sensitivity to boron. For sensitive crops (e.g., citrus trees) the value is between 0.3 and 1.25 mg B/L. For semi-tolerant crops, such as cereals and grains, the value is 0.67 to 2.5 mg B/L and for tolerant crops, that include most vegetables, the guideline is 1.0 to 4.0 mg B/L;for long term irrigation on sensitive crops, the US EPA recommended a guideline of 0.75 mg/L (EPA, 1988). The nitrate contents (NO_3^-) in this water varied from type to another, but it did not exceed the critical limit (45 mg/L) that cause nitrate poisoning (Wilcox, 1958).

Generally, from the data previously presented, it is clear that the different irrigation water qualities used in the present study may cause one problem or another according to the water type. By applying the criteria used for interpreting water quality for irrigation, the most dominant problems are salinity hazard, potential salinity and soluble sodium percentage.

2. Effect of irrigation water qualities on soil properties :

2.1. Soil chemical properties:

2.1.1. Electrical conductivity (EC dS/m) in soil extraction:

Data in Table (3) illustrates the effect of different irrigation water qualities on the chemical properties of soil (twelve sites) cultivated with palm cultivars.The data revealed that soil chemical properties: soil pH, electrical conductivity (EC dS/m) and organic matter (O.M. g/kg) content as affected by different irrigation water qualities at different soil depths: 0-30 cm, 30-60 cm and 60-90 cm. Theaverage values of EC reached up to: 2.74, 3.16, 2.57 and 3.52 dS/m at 0-30 cm depth, while the corresponding value of ECdS/m at the depth 30-60 cm were 2.93, 4.06, 2.77 and 3.67dS/m, and the values of EC dS/m at depth 60-90 cm were: 3.02, 4.29, 2.83 and 3.87dS/m for the soils irrigated by GW, (GW+DW), (GW+TTWW) and (GW+ DW + TTWW) respectively. Also the data reveal that there is a marked increase in soil salinity with

depth in all soil irrigated by different irrigation water qualities regardless the quality of irrigation water.

Table (3): Chemical analysis of soil irrigated by different irrigation water qualities in the present study.

Means in each row followed by the same letter(s) did not differ at < 0.50 according to Duncan's multiple-range test.

The value of each properties is the average of 6 soil samples for each depth collected over two seasons (2010,2011).

Generally the data showed that a significant increase in soil EC_e (EC of soil paste) occurs as the salinity of irrigation water increases. Dahdoh and Hassan (1997) confirmed this result. Also, Abdel-Nasser *et al.* (2000) mentioned that the increase in soil EC_edue to accumulation of salts in soil occurs as a result of salinity of applied irrigation water. Plant development will be affected when the soil has high levels of soluble salts, and the salt may become concentrated enough to be toxic to plants. Presence of salts on the soil is usually associated with osmotic and ionic negative effects, which will then lower the biological activity. Furthermore, salts have significant effect on soil fertility as well as its physical, chemical and biological characteristics. When plant exposed to low-moderate salinity, it may metabolize normally and does not show symptoms of injury. However, more energy is required to maintain normal metabolism demand, which may cause reduction in growth and

yield. In most crops, loss of production can be significant even before the appearance of foliar injury Francois and Maas, (2010). Moreover, salts accumulated more in the deeper soil layersdue leaching the soluble salts into deeper soil Abu-Awwad, (1996). Since these salts are water soluble, wastewater irrigation management should consider ensuring leaching them below the root systems with leaching fraction of the irrigation rate. Otherwise, continuous build up of salts in the topsoil will adversely affect the activity of the soil microorganisms Garcia and Hernandez (1996). Also Papadopoulos, (1995) reported that build up of salts in the topsoil will adversely affect on plant growth and soil productivity.

2.1.2. soil pH:

The average values of soil pH amounted to 7.63, 7.67, 7.61 and 7.70 at 0-30 cm depth for the soils irrigated by GW, (GW+DW),(GW+TTWW) and (GW+ DW + TTWW) respectively. A significant effect of different irrigation water qualities on soil pH values was noticed; the highest value recorded at soil irrigated by (GW+ DW + TTWW) followed by soil irrigated by (GW+DW) and soil irrigated by (GW),this increase is due to chemistry and high content of basic cations such as Na, Ca and Mg in the irrigation water applied for a long period, while the pH of soil irrigated by (GW+TTWW) had a least value. The effect ofirrigation water quality on soil pH was reported by other researchers. Schipper*et al.* (1996) found that soil pH increased following long term irrigation by different water qualities, and they attributed this increase to chemistry and high content of basic cations such as Na, Ca and Mg in the irrigation water applied for a long period. Other researchers found that soil pH decreased with irrigation by treated wastewater due to the oxidation of organic compounds and nitrification of ammonium, applied,Mohamed and Mazahreh(2003).

These results stood in agreement with the finding of (Al Omron *et al.,* 2012) who mentioned that the soil pH in the farm irrigated for more than 13 years with treated sewage effluent dropped by 0.3 pH unit as a result of sewage irrigation compared with soil pH irrigated with well water (groundwater).

2.1.3. soil organic matter content*:*

According to the data presented in Table (3) the soil organic matter content (OM g/kgm) increase in soil irrigated by (GW+TTWW) followed by (GW+ DW + TTWW), (GW+DW) and lowest value in soil irrigated by GW, where the value of O.M were: 6.5, 7.6, 8.8 and 7.4g/kgm,respectively, which is attributed directly to the contents of the nutrients and organic compounds in the (TTWW) applied. The relative increase of (O.M. g/kg) contents in soil irrigated by (GW+DW),(GW+TTWW),(GW+ DW + TTWW) at depth 0-30 cm compared to the soil irrigated with (GW) were 17.0%, 35.4% and 22.0%

respectively.Also the data reveal that there is a marked decrease in soil organic matter content with depth in all soil irrigated by different irrigation water qualities regardless the quality of irrigation water. Similar results were obtained by Vazquezmontiel*et al.* (1996); they found a positive effect on soil organic matter content with irrigation by (TTWW), an increase in the soil organic matter accumulated in the topsoil. These results stood in agreement with the findings of Rattan *et al.*(2005). As it is well known that pH, and soil organic matter (O.M. g/kg) is the most important indicator of soil quality and in addition to acting as a store-house of the plant nutrients which plays a major role in nutrient cycling.

2.1.4. soluble salts content in soil:

According to the data presented in Table (3) showed that the trend of total soluble salt content and distribution in soil profile and factors affected them are reflected on the total amounts and distributions of most ions as follows:

CationsCa^{++}, Mg^{++} and K^+ concentration in soils irrigated by different water qualities a significant difference was found the heights value of this cations were in soils irrigated by (GW+ DW + TTWW) followed by (GW+DW) and (GW + TTWW), the lowest value in soil irrigated by (GW). The Ca^{++}concentration at the depth of 0-30 cm was 11.76, 11.14, 9.02 and 8.70 m mole/L for (GW+ DW + TTWW), (GW+DW), (GW) and (GW+TTWW) respectively. The Mg^{++} and K^+ concentration m mole/L were higher in the soils irrigated with (GW+DW) followed by (GW+ DW + TTWW) and (GW + TTWW), while the lowest concentration ofMg^{++} and K^+ at 0-30 cm was found in soil irrigated by (GW).

Especially sodium Na^+cation there is a significant relation between $Na,^+$ concentration in irrigation water quality and Na^+ concentration in soils under investigation. The high Na^+ concentration was found in soil irrigated by (GW+DW) followed by (GW+ DW + TTWW), (GW) and lowest value in soil irrigated by (GW+TTWW). Their average values of Na^+ concentrations were: 22.24, 21.02, 16.46 and15.12 m mole/L at 0-30 cm depth, respectively. Also the data reveal that there is a marked increase in soil soluble cations with depth in all soil irrigated by different irrigation water qualities regardless the quality of irrigation water.

Increasing sodium concentration in irrigation water lead to increase of sodium on soil complex i.e. exchangeable sodium percentage (ESP %). The values reached 11.80, 10.27, 6.21 and5.70% in soils irrigated by (GW+DW) followed by (GW+ DW + TTWW), (GW+TTWW) and GW respectively. These results are in harmony with those obtained by Abdel-Nasser *et al.* (2000), they reported that Increasing salinity of irrigation water lead to an increase in the exchangeable sodium percentage (ESP %) on soil complex.

Increasing ESP resulted in poor physical characteristics of soil such as increasing soil dispersion and then decreasing the water movement in soil (infiltration rate). Decreasing infiltration rate leads to accumulation of water on soil surface (water pending) and decrease the ability of roots to absorbed water. In the present study, increasing the water salinity resulted in an increase in ESP especially for the soil irrigated by (GW+DW). Therefore, to avoide the salinity hazards, leaching requirements must be considered at irrigation to leach the excess salt accumulated in soil resulting from high salinity water.

Therefore, to avoide the salinity hazards, leaching requirements must be considered at irrigation to leach the excess salt accumulated in soil resulting from high salinity water. Also, gypsum requirements must be added to remove the excess adsorbed sodium especially for the soil irrigated by (GW+DW), to avoide the sodicity problem of irrigation water that have high content of sodium.

2.2. Soil physicalcharacteristics:

The data in Table (4) and Figures (2- 4) revealed the effects of different irrigation water qualities on some physical properties of soils cultivated with date palm cultivars. The results showed that the soils irrigated with groundwater had mean values of clay % reached 12.55, 12.33 and 12.10 for depth 0-30, 30-60 and 60- 90cm respectively in soil irrigated with (GW+ TTW). The soil of farms irrigated with (GW) has low percentage of silt % mean values were reached (7.47, 6.85 and 6.55 for depth 0-30 cm, 30-60 cm and 60-90 cm) and clay % mean valuesreached (11.08, 11.03 and 10.97 for depth 0-30cm, 30-60 cm and 60-90 cm, respectively at the soil of farms irrigated with ground water). These results may be due to the fact that the farmers add sand to cover soil surface to minimize salt crust formation caused by the capillary rise in these farms.The results also showed the impact of different irrigation water qualities on moisture contents of the investigation soils i.e. saturation percentage, field capacity, wilting point and available water.

The results revealed that their main values for saturation percentage of soil in farms irrigated with GWreached to 34.07%, 31.76% and 30.53% for depth 0-30 cm, 30-60 cm and 60-90 cm respectively). While the mean values for saturation percentage of soil in farms irrigated with (GW + DW)reached to 35.39, 32.52 and 33.63 % for depth 0-30, 30-60 and 60-90 cm, respectively). This may be due to the impact of dissolved salts in these types of irrigation water and its effect on increasing the capacity of the soil water retention due to increase of osmotic pressure in the soil solution as a result of salinity of irrigation water.

These results are in agreement with those obtained by Tabiz*et al.* (2011)who showed that long-term wastewater application to two

different light textured soils, over 12 and 22 years, did not negatively affect soil physical properties, and even improved some of them, such as aggregate stability and the infiltration rate close to saturation. In general the physical properties of fine-textured soils are affected more adversely at given saline irrigation water than coarse-textured soils.The data of moisture contents for the soils irrigated by different irrigation water qualities at field capacity and wilting point illustrate that themoisture content of soil at field capacity was within the same direction or the previous trend in the order of the saturation percentage values for the soil farms that were irrigated by different irrigation water qualities. The salinity of irrigation water lead to the effect on the available water contents on soil irrigated by different irrigation water quality. These results are in agreement with those obtained by Krista *et al.* (2003).

With regard to the role of dissolved salts concentration of irrigation water and its effects on decreasing the available water content by increasing the soil water retention and then reduced plant available water as result of the lower amount of water available to the plant, regardless of the amount of water actually in the root zone. As the water is taken up by plants through transpiration or lost to the atmosphere by evaporation, soil water salinity increases because salts become more concentrated in the remaining soil water. Thus, evapotranspiration (ET) between irrigation periods can further increase salinity.

Table (4): The average of some physical characteristics for the experimental soil (farms).

Chemical Properties	Depth cm	Irrigation Water Quality				LSD at 5%
		GW	GW+DW	GW+TTWW	GW+DW+TTWW	
Clay %	00-30	11.08 d	11.23 c	12.55 a	11.91 b	0.002
	30-60	11.03 c	10.83 d	12.33 a	11.30 b	0.002
	60-90	10.97 b	9.95 d	12.10 a	10.85 c	0.002
Silt %	00-30	7.74 d	8.62 c	9.10 b	9.52 a	0.002
	30-60	6.85 d	7.42 c	7.97 c	8.85 a	0.002
	60-90	6.55 d	6.93 c	7.86 b	8.35 a	0.002
Sand %	00-30	81.18 a	80.15 b	78.35 d	78.56 c	0.002
	30-60	82.12 a	81.74 b	79.70 d	79.85 c	0.063
	60-90	82.48 d	83.13 a	80.04 d	80.80 c	0.002
Soil Texture	00-30	Sandy Loam	Lamy Sand	Sandy Loam	Sandy Loam	--
	30-60	Lamy Sand	Lamy Sand	Sandy Loam	Lamy Sand	--
	60-90	Lamy Sand	Lamy Sand	Lamy Sand	Sandy Loam	--
Saturation %	00-30	34.07 d	35.93 c	37.85 b	37.85 a	0.002
	30-60	31.76 d	32.78 c	35.52 a	35.28 b	0.002
	60-90	30.53 d	31.69 c	33.63 b	35.08 a	0.063
F. C. %	00-30	18.33 d	19.43 c	22.08 a	19.43 c	0.002
	30-60	17.44 d	18.83 c	22.62 b	18.83 c	0.063
	60-90	16.95 d	17.35 c	21.86 b	17.35 c	0.063
W. P. %	00-30	9.64 d	11.35 c	13.56 a	11.35 c	0.063
	30-60	9.32 d	13.26 c	14.43 a	13.26 c	0.002
	60-90	9.75 d	13.84 c	15.90 a	13.84 c	0.002
A. W.%	00-30	8.68 c	8.08 d	9.53 a	8.08 d	0.063
	30-60	8.12 c	5.57 d	8.19 b	5.57 d	0.063
	60-90	5.98 a	3.51 d	7.20 c	3.51 d	0.063

Means in each row followed by the same letter(s) did not differ at < 0.50 according to Duncan's multiple-range test.

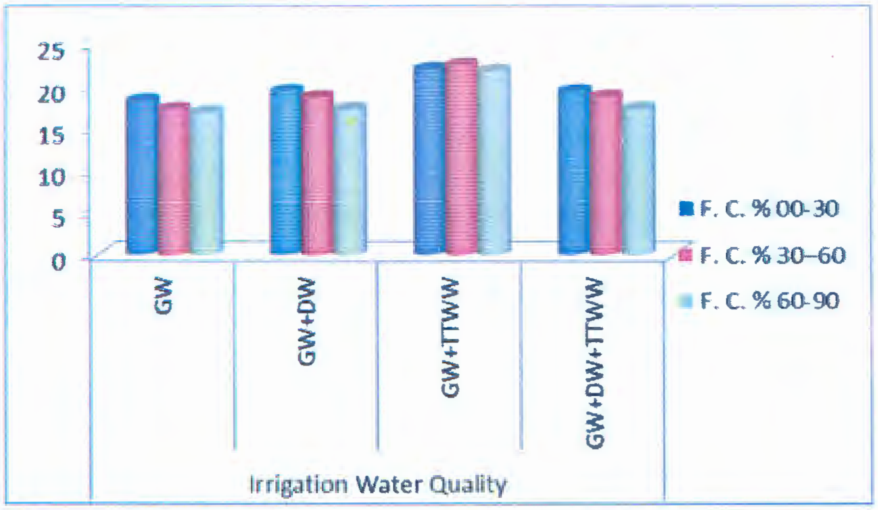


Figure (2): The average of field capacity % of the soils (farms) used in the study.

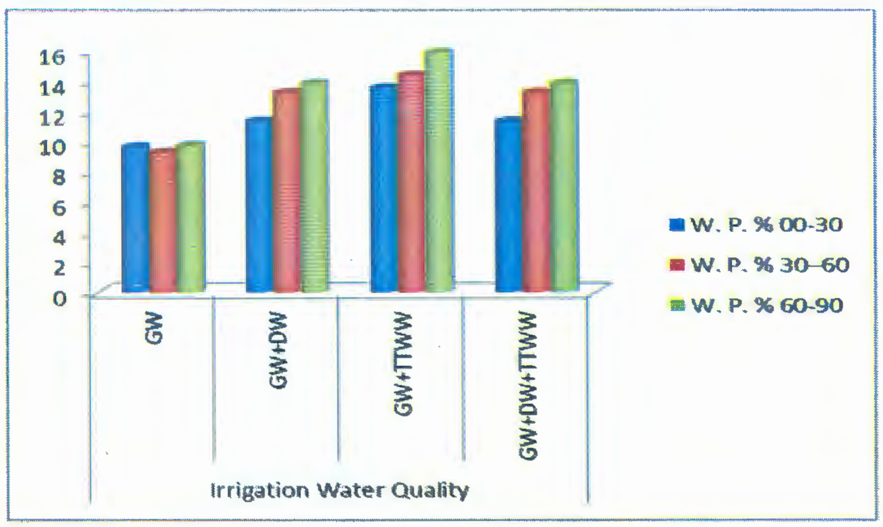
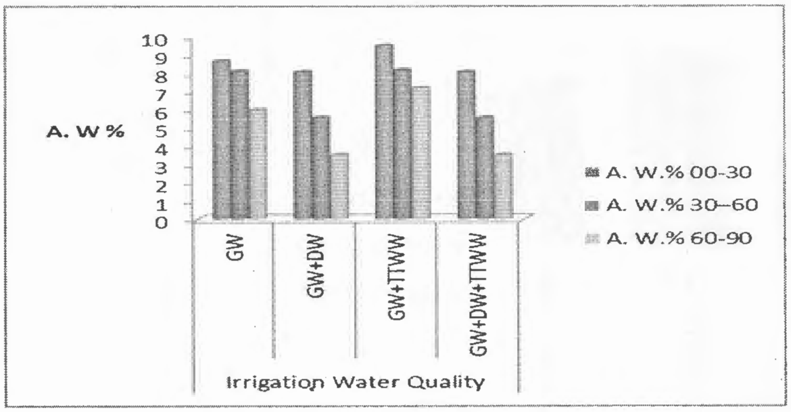


Figure (3): The average of wilting point% for the soils (farms) used in the study.



Figure(4): The average of available water%for the soils (farms) used in the study.

3- Fruit microbial quality:

The spoilage organism counts for yeast, mold, and aerobic mesophilic bacteria as well as the counts for the potential pathogen coliforms on the date palm fruits are presented in Table (5).

3-1-Yeast and mold:

All of the date samples were contaminated with yeast and mold. The Khalas, Sheshiand Ruzeiz fruits from farms that were irrigated with GW, GW+DW, GW+TTWW and GW+DW+TTWW contained less than 10^2cfu/g yeast and mold. However, the dates from farms that were irrigated with GW+DW+TTWW water exhibited significantly greater counts of yeast and mold than those of the other treatments (Table 5). Abu-Zinada and Ali (1982) reported fungal contamination in different date varieties, and Nussinovitch*et al.* (1989) reported colony counts of soft dates in the Tamr stage on the order 10^2cfu/g yeast. *Aspergillusniger* was the most common fungus associated with the dates El-Ammari and Naser, (1998).

3- 2-Total bacterial count and coliforms:

The Khalas, Sheshi and Ruzeiz varieties from farms that were irrigated with all of the irrigation water sources contained less than 10^2cfu/g of total bacteria (Table 5). However, two samples for Khalas dates from the farms that were irrigated with GW+TTWW exhibited total bacterial counts that were greater than 10^2cfu/g but less than 2.0×10^2cfu/g. Nussinovitch*et al.* (1989) reported colony counts on soft dates in the Tamr stage of 10^4 cfu/g lactic acid bacteria. El-Sherbeeny*et al.* (1985) detected *Staphylococcusaureus* and aerobic colony counts of 6.3×10^5cfu/g in loose dates. GW exhibited the lowest total bacterial count for all of the date samples. All of the samples were free from detectable levels of contamination with coliforms, which is shown in Table 5.

Table (5): Effect of irrigation water on the microbial load of the date fruits

Treatment		Yeast & Mold (cfu/g)	Total Bacterial Count (cfu/g)	Coliforms (cfu/g)
GW	Khalas	27.7 e	24.2 g	-ve
	Sheshi	35.8 d	32.5 efg	-ve
	Ruzeiz	28.2 e	26.0 fg	-ve
GW+DW	Khalas	37.3 d	92.2 b	-ve
	Sheshi	39.8 d	33.5 ef	-ve
	Ruzeiz	92.3 a	42.2 d	-ve
GW+TTWW	Khalas	80.5 b	112.3 a	-ve
	Sheshi	35.5 d	38.7 de	-ve
	Ruzeiz	85.7 b	58.7 c	-ve
GW+DW+TTWW	Khalas	58.7 c	52.3 c	-ve
	Sheshi	26.7 e	31.0 efg	-ve
	Ruzeiz	23.7 e	15.7 h	-ve
LSD at 5%		6.5	7.9	---

Within each column, means with the same letter are not significantly different ($p \leq 0.05$).

The value of each character is the average of two seasons (2010 and 2011).

A possible source of coliform contamination is the soil onto which fruits fall during harvest. Aidoo*et al.* (1996) found bacteria, coliforms and mold contaminants of dates (Tamr) that were purchased in stores within greater Glasgow.

CONCLUSIONS

The results indicate that the irrigation water types used in this study may cause various problems that are dependent on the water type. By applying the criteria used to interpret water quality for irrigation, the most dominant problems are salinity, potential salinity and the soluble sodium percentage. Therefore, continuous irrigation without proper water management (leaching requirements) can lead to severe salinity problems, especially in areas that are irrigated with GW+DWand GW+DW+TTWW.

REFERENCES:

Abdel-Nasser G, Harhash MM, EL-Shazly SM. 2000. Response of some olive cultivars grown in Siwa Oasis to well water quality. J. Agric. Sci. Mansoura Univ. 25, 2877-2896.

Abu-AwwadAM. (1996). Irrigation water management for onion trickle irrigated with saline drainage water.*Dirasat* 23, 46–55.

Abu-Rekab ZAM, El-Kerdany AY. 2009. Evaluation of Sewy date palm cultivar irrigated by both treated waste water and Nile water. *4th Conference on Recent Technologies in Agriculture*.670-683.

Abu-Zinada AH and Ali MI. 1982. Fungi associated with dates in Saudi Arabia. *J.of food Protec.* 45, 842-844.

Aidoo KE, Tester RF, Morrison JE, MacFarlane D. 1996. The composition and microbial quality of pre-packed dates purchased in Greater Glasgow. *Internat.J. of food Sci. and Techn.* 31, 33-438.

Al Omron AM, EL- Maghraby SE, Nadeem MEA, EL-Eter AM, EL-Mohani H. 2012. Long Term Effect of Irrigation with the Treated Sewage Effluent on some Soil Properties of Al -Hassa Governorate-Saudi Arabia.*J. of the Saudi Society of Agri. Sci.* 11, 15-18.

Atlas RM. 2004. Handbook of Microbiological Media, 3rd Edition, CRC Press: Boca Raton, Florida p. 2051.

Ayers, R. S. and Westcot, D.W. 1985. Water Quality for Agriculture.FAO Irrigation and Drainage Paper No. 29, Rev.1. Rome; FAO.

Ayers, R. S, Westcot, D. W. 1994. Water quality for agriculture.FAO irrigation and drainage.paper 29, FAO, Rome p. 174.

Bauder TA, Waskom RM, Davis JG. 2011. Irrigation Water quality criteria. Colorado state Univ. Extension Fact sheet No. 506.

Brar MS, Mahli SS, Singh AP, Arora CL, Gill KS. 2000. Sewer water irrigation effects on some potentially toxic trace elements in soil and potato plants in northwestern India. *Can. J. Soil Sci.* 80, 465–471.

Carter MR. 1993. Soil Sampling and Methods of Analysis.Can. Society of Soil Sci., Lewis Publishers. London, Tokyo.

Dahdoh, M.S.; A. and F.A. Hassan1997. Combined effect of sewage sludge and saline water irrigation on growth and elemental composition of Broad Bean. Egypt. J. Soil Sci. 37 (2): 189-204.

Datta A, Sanyal SK, Saha S. 2001.A study of natural and synthetic humic acids and their complexing ability towards cadmium.*Plant Soil* 235, 115–125.

El-Ammari SS, Naser N. 1998. A report on post-harvest fungi on date fruits in Libya. Proceedings of the First International Conference on Date Palms. Al-Ain, United Arab Emirates. March 8-10.

El-Sherbeeny MR, Saddik M F, Bryan FL. 1985. Microbial profiles of foods served by street vendors in Egypt. *Internat.J. of Food Microbiol.* 2, 355-364.

Environmental Protection Agency (EPA), Office of Water. 1988. Water Quality Standards Criteria Summaries: A Compilation of State/Federal Criteria. EPA/440/5-88/011.

FAO 1976. Water quality for Agriculture. Irrigation and Drainage paper 29, R.S. Ayers and D.W. Westcot.

Francois EF, Maas EV 2010. Crop response and management of salt-affected soils.CRC Press. Florida, USA.pp. 169-201.

Franson, M. A. (1975). Standard methods for examination oof water wastewater (14thed)

americanpublic health asscation, American Water Works AssociationWater PolluationControl Federation, Washington. D.C.

Garcia, C. and I. Hernandez1996. Influence of salinity on the biological and biochemical activity of a calciorthird soil, Plant Soil., 178 (2) (1996) 255–263.

Gomez, K. A. and A. A. Gomez 1984. Statistical procedures for Agricultural research.2nd Ed. John Wally & Sons.

Hamad SH, Aleid SM. 2013. Use of electrolyzed oxidizing water for the control of microbial contamination of date fruits.*Internat.J. of Microbiol.andImmunol. Research* 2, 29-36.

Hossner LR, Kao CW, Waggoner JA. 1978. Sewage disposal on agricultural soils; chemical and microbiological implications. Washington, DC, United States Environ. Protect.Agency (EPA-600/s-78-131a).

Jackson ML. 1973. Soil chemical analyses.Prentice Hall of India Private Limited-New Delhi, India.

Krista E., Nikos J. Warrence, and James W.2003. The Basics of Salinity andSodicity Effects on Soil Physical Properties Information Highlight for the General Public

Levine A, Asano T. 2004. Recovering sustainable water from wastewater.*Environ. Sci. Technol.*2004.

Lindsay,W.L. and W.A. Novell, 1978. Development of DTPA soil test for zinc,iron, manganese and copper. Soil Sci. Soc. Am. J, 42: 421- 428.

Metcalf and Eddy, Inc. 1991: Wastewater: treatment, reuse and disposal. New York, McGraw-Hill.

MilanoM,RuellandD,FernandezS,DezetterA,FabreJ, ServatE.2012. Facing climaticandanthropogenicchangesintheMediterraneanbasin:whatwill be themedium-termimpactonwaterstress?C.R.Geosci.344,432–440.

Mohammad M.J. and N. Mazahreh, 2003. Changes in soil fertility parameters in response to irrigation of forage crops with secondary treated wastewater, Comm. Soil Sci. Plant Anal., 34 (9 & 10) (2003) 1281–1294.

Morugán-Coronado A, García-Orenes F, Mataix-Solera J, Arcenegui V, MataixBeneyto J. 2011. Short-termeffectsoftreatedwastewaterirrigationon Mediterraneancalcareoussoil.*SoilTill.Res.*112,18–26.

Mujeriego R, Sala L. 1991. Golf course irrigation with reclaimed wastewater.*Water Sci. Technol.* 24, 161– 172.

Nelson RE. 1982. Methods of Soil Analyses. Part 2, Page AL *et al.*, (ed). Agronomy Monograph No. 9, pp 181- 198.

Novone, R. 1964. Proposed method for nitrate in potable waters. J. Amer. Water Works Assoc. 56: 781.

Nussinovitch A, Rosen B, Salik H, Kopelman IJ. 1989. Effect of heating media on the microbiology and shelf life of heat pasteurized soft dates. *Lebensmittel-Wissenschaft und Technologie* 22, 245-247.

Page AL, Miller RH, Keeney DR. 1982. Methods of soil analysis pert 2 Chemical and microbiological properties.Second Edition.

Papadopoulos, I. 1995. Wastewater management for agriculture protection in the Near East Region, Technical Bulletin, FAO, Regional Office for the Near East, Cairo, Egypt, 1995.

Pescod, M. 1992. Wastewater treatment and use in agriculture. Bull. FAO #47 (125) (Rome).

Rattan RK, Datta SP, Chhonkar, PK, Suribabu K, Singh AK. 2005. Long-term impact of irrigation with sewage effluents on heavy metal content in soils, crops and groundwater-a case study. *Agri., Ecosyst.and Environ.* 109, 310–322.

Rhoades JD. 1982. Cation exchange capacity, in Page A.L.: Am .Soc .Agron., Madison, Wl, USA. pp. 149-157.

Rhoades JD. 1992. Potential of using saline agricultural drainage for irrigation. In Proc. Water management for irrigation and drainage.ASAE, Reno, Nevada, pp.85-96.

Richards, L.A. 1972. Diagnosis and Improvement of Saline and Alkaline Soils. U.S. Dept. of Agric., Agric. Handbook No. 60. Washington, D. C.

Rusana, M. M. Sami H. andRousanc L. 2007. Long term effect of wastewater irrigation of forage crops on soil and plant quality parameters. *Journal of Desalination* 215, 143- 152.

SAS Institute Inc. 2001. The SAS System for Windiows.Release 6.12, SAS Institute Inc., Cary, NC, USA.

Schipper, L.A. Williamson J.C. Kettles H.A. and Speir T.W. 1996. Impact of land- applied tertiary treated effluent on soil biochemical properties. *J. Enviro. Quality* 25, 1073- 1077.

Shahin M.M. and Hussein A. H. 2005. Effect of irrigation water quality on cadmium content in some soils and plant grown in the Al-Hassa Oasis, Kingdom of Saudi Arabia. *Al-Azhar J. Agric. Res.* 42, 61-74.

Simmons, R. W. and Pongsakul, P. 2002. Toward the development of an effective sampling protocol to "rapidly" evaluate the distribution of Cd in contaminated, irrigated rice-based agricultural systems, in Kheoruenromne I: Transactions of the 17th world congress of soil science, Bangkok, 14 - 21 August 2002. Vienna, International Union of Soil Science.

Tabriz, S. S. Mojid, M. A. and Wyseurel G. C. L.2011. Irrigation suitability of North Bengal sugar mill's effluent and itsimpact on soil properties.J. Bangladesh Agril. Univ. 9(2): 283–290, 2011

Vazquezmontiel, N.J. Horan and D.D. Mara, (1996). Management of domestic wastewater for reuse in irrigation, Water Sci. Technol., 33 (10–11) (1996) 355–362.

WHO1989. In: Cairncross, S. and Mara, D.editors. Guidelines for the Safe Use of Wastewater and Excreta in Agriculture and Aquaculture. Geneva, Switzerland: World Health Organisation, p. 194.

Wilcox, L.V. 1958. Determining quality of irrigation water.Agr. Inf. Bull. No. 147, USDA, Washington.

Young, J.C. Mc Dermott, G. N. and Jenkins D. (1981). Alteration in the BOD_5 and COD procedure for the 15[th]edstandard Water Pollution Control Federation 53 (7):1253-1259.

الملخص العربي:

أجريت هذه الدراسة لمعرفة التأثير طويل المدي لأستخدام نوعيات مختلفة من مياه ري (المياه الجوفية، والمياه الجوفية المخلوطة بمياه الصرف الزراعي ، والمياه الجوفية المخلوطة بمياه الصرف الصحي المعالجة ثلاثياً، والمياه الجوفية المخلوطة بمياه الصرف الزراعي + مياه الصرف الصحي المعالجة ثلاثياً) على ثلاثة أصناف من نخيل التمر (الخلاص ، والشيشي والرزيز) عمر ٢٠ سنة تحت ظروف واحة الأحساء بالمملكة العربية السعودية.

الدراسة تضمنت تقدير الخواص الكيميائية لنوعيات مياه الري من المصادر المختلفة، وكذلك تحديد معايير صلاحية كل مصدر من هذه المصادر للري وفقاًللمعاييرالموصيبها ، وتأثير كل نوعية من نوعيات مياه الري على الخواص الكيميائية والطبيعية للتربة في المناطق التي تروي بالنوعيات مختلفة من مياه الري. وكذلكتم دراسة الخواص الميكروبيولجية للثمار التي تروى بالنوعيات المختلفة لمياه الري وخصوصاً الثمار التي تلامس الأرض عند الحصاد وتحديد مدى صلاحيتها للإستخدام من الناحية الميكروبيوجية.

وقد صممت الدراسة صممت في تجربة عاملية في قطاعات كاملة العشوائية بثلاث مكررات العامل الأول يشمل نوعية مياه الري (أربعة مصادر) والعامل الثاني يمثل أصناف النخيل (الخلاص والشيشي والرزيز).

وأوضحت النتائج أن نوعيات المياه المستخدمة في هذه الدراسة قد تسبب مشكلة أو أكثر وفقا لنوعية مياه الري. وذلك طبقا للمعايير المستخدمة لتقييم مدي صلاحية هذه النوعيات من المياه للري، وأكثر المشاكل هي خطر الملوحة، وكذلك جهد الملوحة، ونسبة الصوديوم

المدمص. ولذلك فمن المتوقع أن أستمرار استخدام هذه النوعيات من مياه الري بدون إدارة جيدة (مثل إضافة الإحتياجات الغسيلية للتربة التي تروي بمثل هذه النوعيات من مياه الري) يمكن أن يؤدي إلى مشاكل خطيرة وخصوصاً من حيث مشكلة ملوحة التربة التي تروي بالمياهالجوفيةالمخلوطةبمياهالصرفالزراعي.

كما أوضحت النتائج أن التوصيل الكهربائي لمستخلص التربة المشبع والمروية بنوعيات مياه الري المختلفة (المياه الجوفية، والمياه الجوفية المخلوطة بمياه الصرف الزراعي ، والمياه الجوفية المخلوطة بمياه الصرف الصحي المعالجة ثلاثياً ، والمياه الجوفية المخلوطة بمياه الصرف الزراعي + مياه الصرف الصحي المعالجة ثلاثياً) في الطبقة السطحية (عند عمق من ٠-٣٠ سم) وصلت إلي ٢,٨١، ٥,٠٤، ٣,١٥ و٤,٢١ للأراضي التي تروي بنوعيات مياه الري المذكورة سابقاً على التوالي وزادت نسبة الملوحة في قطاع التربة مع زيادة العمق من (عمق صفر-٣٠سم إلى عمق ٦٠-٩٠ سم) في جميع المناطق التي تروي بنوعيات مختلفة من مياه الري .

وكان تأثر التربة بالملوحة أكبر في الأراضي المروية بالمياه الجوفية المخلوطة بمياه الصرف الزراعي حيث سجلت أعلي قيم لمحتواها من الأملاح الذائبة ثم يليها الأراضي التي تروي (بالمياه الجوفية المخلوطة بمياه الصرف الزراعي + مياه الصرف الصحي المعالجة ثلاثياً) ثم **الأراضي التي تروي** (بمياه جوفية مخلوطة بمياه الصرف الصحي المعالجة ثلاثياً) وكانت أقلها **في المحتوي الملحي** الأراضي التي تروي بالمياه الجوفية .

تتأثر التربة باستخدام مياه الصرف الصحي المعالجة ثلاثياً على المدى الطويل وكذلك بإعادة استخدام مياه الصرف الزراعي في أغراض الري. ويتم تحديد هذا التأثر بصورة رئيسية من خلال رصد ومراقبة معايير صلاحية هذه النوعيات من مياه الري (مياه الصرف الصحي المعالجة ثلاثياً أو مياه الري الصرف الزراعي) طبقا لتركيبها الكيميائي . وقد يؤدي الري المستمر بمياه الصرف الصحي المعالجة ومياه الري الزراعي إلى تراكم الأملاح فى قطاع التربة بالأراضي المروية بهذه النوعيات من مياه الري.