8TH GULF WATER CONFERENCE AND EXHIBITION

EVALUATING DIFFERENT TYPES OF IRRIGATION WATER AND ITS EFFECT ON LEVEL OF HEAVY METALS IN SOIL AND PLANT IN AL- HASSA OASIS, SAUDI ARABIA

A.H.A. Hussein,
Yousef.Y. Al-Dakheel, M.A. Massoud
Water Studies Center, King Faisal University
M. Shahin,
Hassa Irrigation & Drainage Authority, Ministry of Agriculture
Saudi Arabia

INTRODUCTION

- Water insufficiency is one of the most critical problems that confront the world particularly in the arid and semi arid regions.
- The water policy of any country is to use all water resources.
- Al-Hassa Oasis is one of the important agricultural regions in the Kingdom of Saudi Arabia.
- In the past, the ground water was the main source of irrigation water. Nowadays, other water resources are used to meet agriculture expansion due to the limited ground water resource.
- Drainage water (DW), tertiary treated wastewater (TTWW) and groundwater (GW) individually or mixed were used for long term irrigatation in Al-Hassa Oasis.
- Before using any source of water that mentioned before, it should be tested to find out its effect on soil chemical, physical, nutritional, fertility and toxicity properties. The effects on plant growth, yield and elemental analysis must be calibrated.
- The present study is conducted to evaluating different types of irrigation water and its effect on level of heavy metals in soil and plant in Al- Hassa Oasis, Saudi Arabia.

MATERIALS AND METHODS

The investigated irrigation waters include:

- Groundwater (GW),
- Mixture of groundwater and drainage water (GW+DW),
- Mixture of groundwater and tertiary treated wastewater (GW+TTWW) and
- Mixture of groundwater, drainage water and tertiary treated wastewater (GW+DW+TTWW)

Average characteristics of irrigation water quality used for irrigation in the present study

Characteristics	Irrigation Water			
	GW	GW+DW	GW+TTWW	GW+DW+TTWW
pH	7.37	7.41	7.44	7.55
EC (dS/m)	2.24	2.85	3.84	4.24
TDS (mg/L)	1433.6	1824.0	2457.6	2713.6
Soluble Cations, me/L				
Ca^{2+}	6.29	7.37	12.09	9.21
Mg^{2+}	4.56	4.58	5.63	6.12
Na^{+}	10.31	15.21	19.85	25.14
K^{+}	0.96	0.53	0.42	0.89
Soluble Anions, me/L				
CO_3^{2-}	-	-	-	-
HCO_3^{-}	3.38	4.59	3	5.57
Cl^{-}	8.12	11.61	25	21.11
SO_4^{2-}	10.42	11	9.16	14.58
NO^{-}_3 , mg/L	3.43	6.9	13.13	11.21
Micronutrients, mg/L				
Fe	2.29	3.05	2.31	4.43
Mn	0.34	0.43	0.38	0.39
Cu	0.11	0.09	0.08	0.17
Zn	0.18	2.12	2.34	3.31
B	0.23	0.42	0.33	0.41
Heavy metals, mg/L				
Cd	0.040	0.050	0.090	0.130
Co	0.012	0.015	0.017	0.021
Ni	0.010	0.014	0.020	0.026

Quality of irrigation water was determined according to the following parameters.

1. The salt concentration of water, which can be expressed in terms of electrical conductivity (EC_{iw}, dS/m).
2. The chemical composition of water, by determining the concentrations of Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}, CO_3^{2-}, HCO_3^{-}, Cl^{-} and SO_4^{2-} ions.

   The quality parameters were calculated from as follows:

   a) Sodium Hazard: Can be expressed in terms of Sodium Adsorption Ratio (SAR) or Soluble Sodium Percentage (SSP, %).

   b) Magnesium hazard (SMgP):It can be expressed by the value of Soluble Magnesium Percentage (SMgP, %),

   c) Bicarbonate hazard:It can be expressed by the value of Residual Sodium

3. The concentration of toxic compounds, can be expressed by the values of:

   a) Potential Salinity (PS) PS (me/L) = $Cl^{-} + 0.5 * SO_4^{2-}$

   b) The boron concentration (B, mg/L)

   c) The nitrate concentration (NO_3^{-} , mg/L)

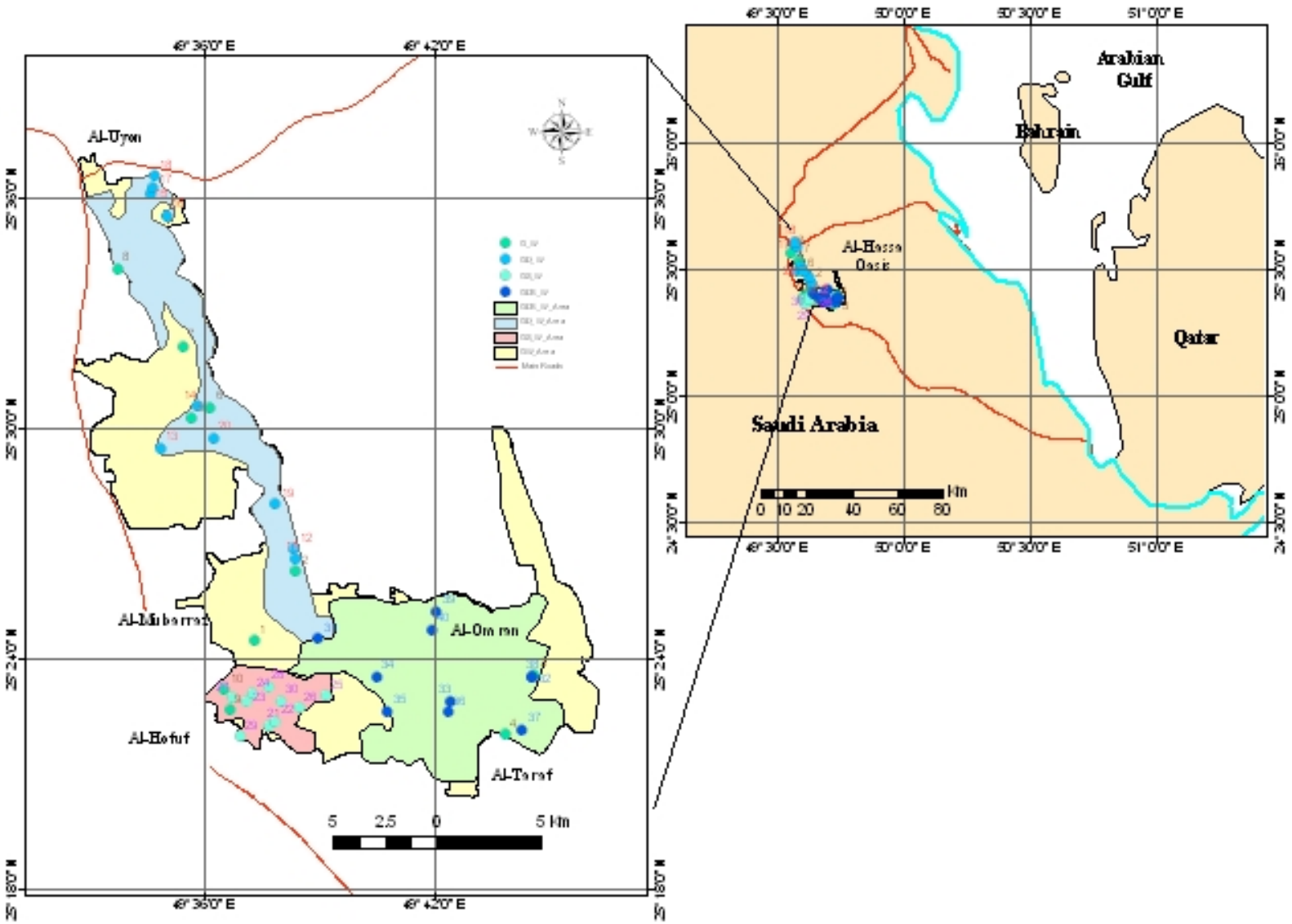
   d) Carbonate (RSC, me/L)

Sampling of soil and plant

- Forty sites (10 sites for each irrigation type) were selected to represent the irrigated soil with the above mentioned water types.
- From each site, three soil samples (0 – 30 cm) were collected and mixed to represent a composite sample. (Fe, Mn, Cu, Zn, Cd, Co and Ni)
- Some physical and chemical properties of the soil were also caculated, such as:

clay, %	Silt, %	Sand, %	Texture	ECe (dS/m)	pH	Ca^{++}	Mg^{++}	Na^{+}	K^{+}	HCO_3^{-}	Cl^{-}	SO_4^{2-}

The locations of sampling sites irrigated by different irrigation water types



- For each soil site, three date palms were chosen randomly to collect a composite leaf sample from each date palm using five pinnate from the middle of the third leaf (from top) in all directions, i.e. 20 pinnate per date palm.
- Also, for each site, fifteen plants of squash crop as another crop, 10 leaves from each five plant were taken to represent a composite leaf sample (Fe, Mn, Cu, Zn, Cd, Co and Ni).

RESULTS

1. **Soil characteristics:**

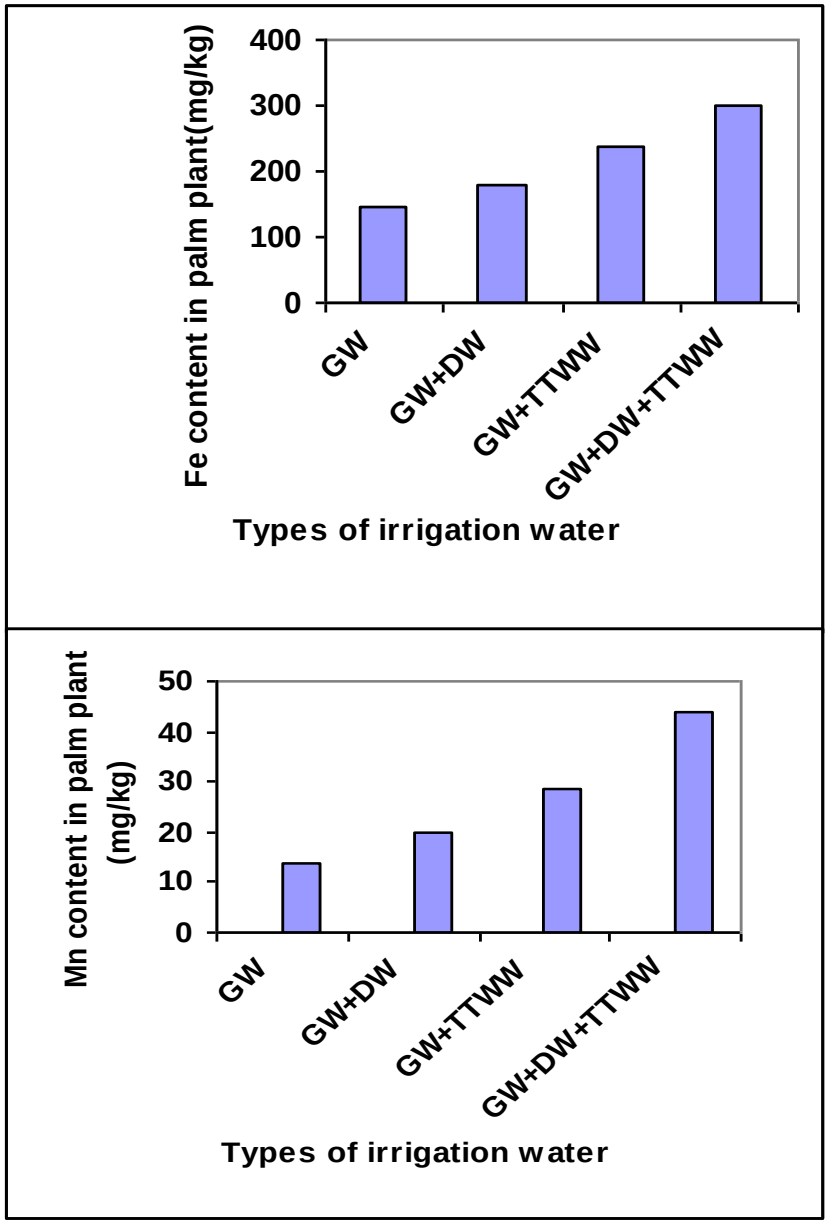
- To make sure, that water type is the main factor in the heavy metals accumulation in soil and plants, the relationship between all characterization of the investigated soil and all heavy metals determined in soil and plants were statistically analyzed.
- The statistical analysis indicated that the correlation coefficient between all characterizations of the investigated soil and all heavy metals determined in soil and plants were insignificant.
- This means that, accumulation of heavy metals in the soil and plants are attributed to the water type not to soil properties.

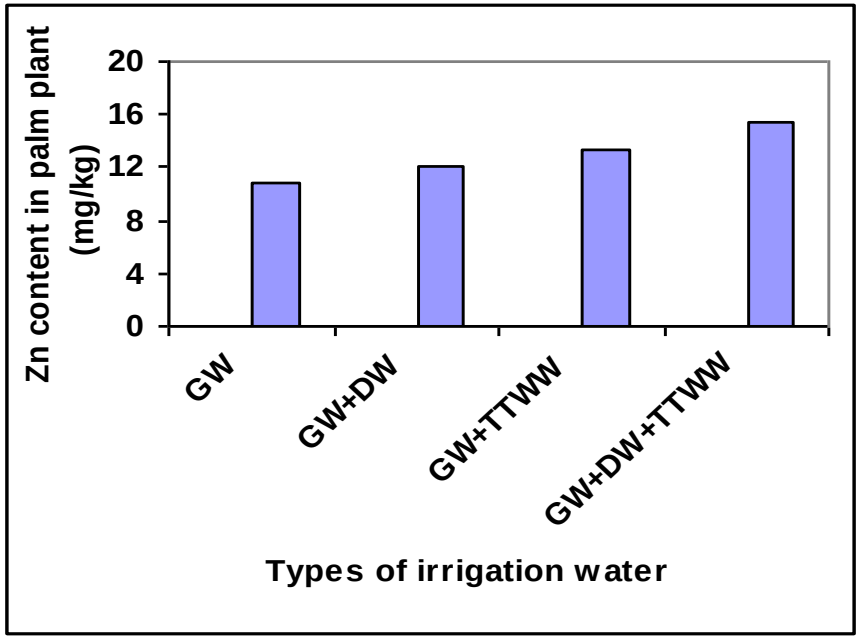
2. Quality of irrigation water:

- The water quality parameters for the all investigated water types are presented.
- From these data, it appears that for all types of water, the ECiw ranged from 2.24 to 4.24 dS/m.
- The critical level of ECiw to cause severe salinity problems is 3 dS/m as reported by FAO (1976).
- The values of ECiw for (GW) and (GW+DW) are less than the critical limit and no problems of using these types of irrigation water. (GW+ TTWW) and (GW+ DW+TTWW) have ECiw values more than the critical level. It could be considered as high salinity and may cause severe salinity problems.
- Therefore, it is expected that continuous irrigation without good water management (leaching requirements) can led to severe problems from the salinity point of view.

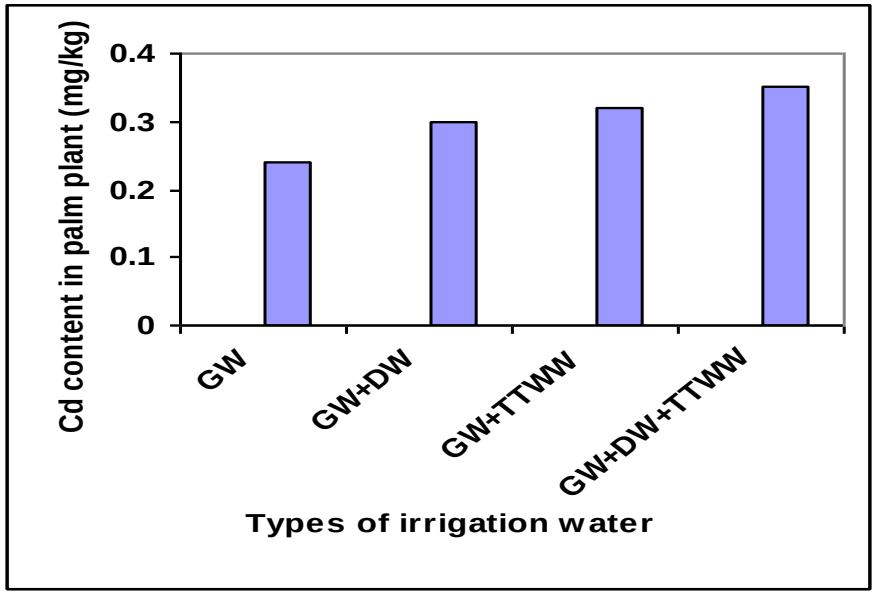
Water quality parameters

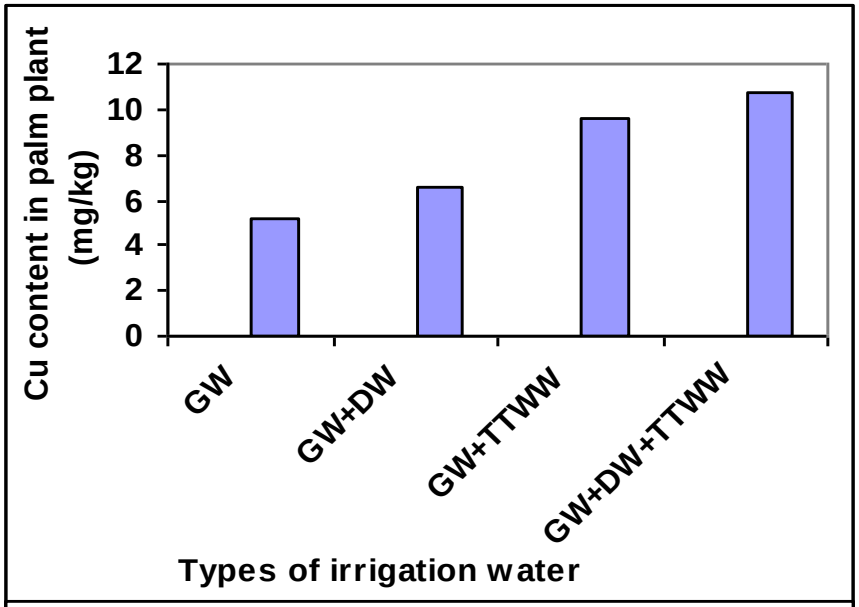
Irrigation water	EC_w dS/m	SAR	SSP %	Mg Hazard %	RSC me/L	Potential salinity me/L	Cl^- me/L	B mg/L	NO^-_3 mg/L
GW	2.24	4.43	46.61	42	-7.47	13.33	8.12	0.23	3.43
GW+DW	2.85	6.22	54.93	38	-7.36	17.11	11.61	0.42	6.90
GW+TTWW	3.84	6.67	52.25	32	-14.72	29.58	25.00	0.33	13.13
GW+DW+TTWW	4.24	9.08	60.78	40	-9.77	28.40	21.11	0.41	11.21
Critical level	3dS/m	10	60	50		5			45

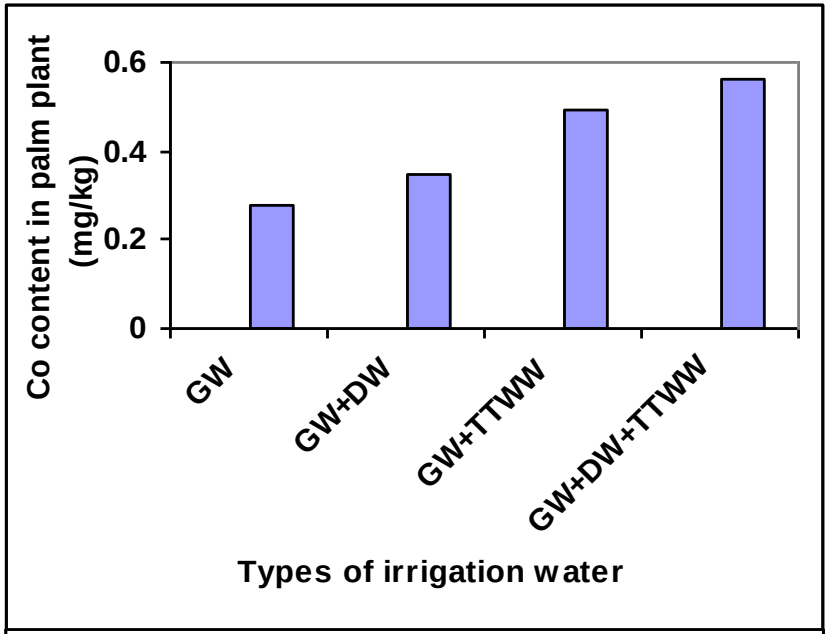

Fe content in palm plant(mg/kg)
400
300
200
100
0
GW
GW+DW
GW+TTWW
GW+DW+TTWW
Types of irrigation water

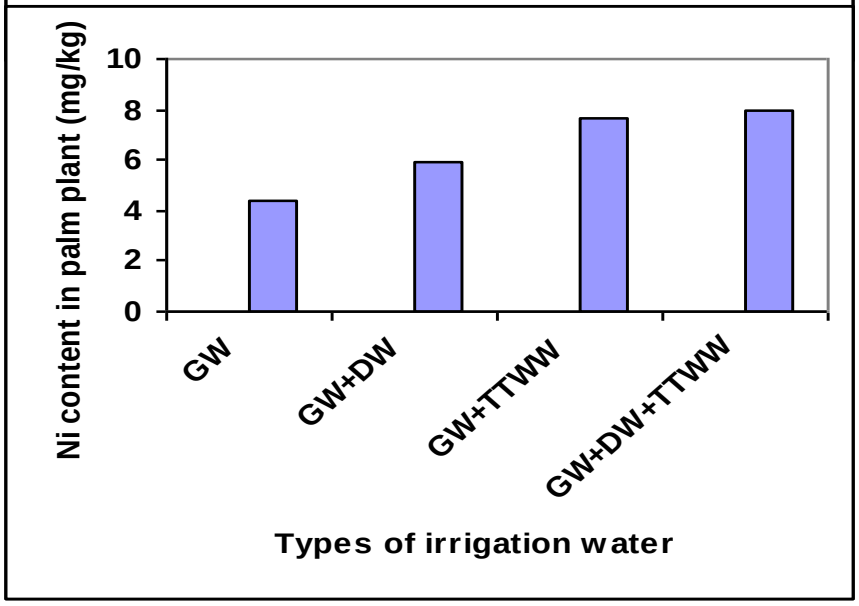

Zn content in palm plant (mg/kg)
20
16
12
8
4
0
GW
GW+DW
GW+TTWW
GW+DW+TTWW
Types of irrigation water

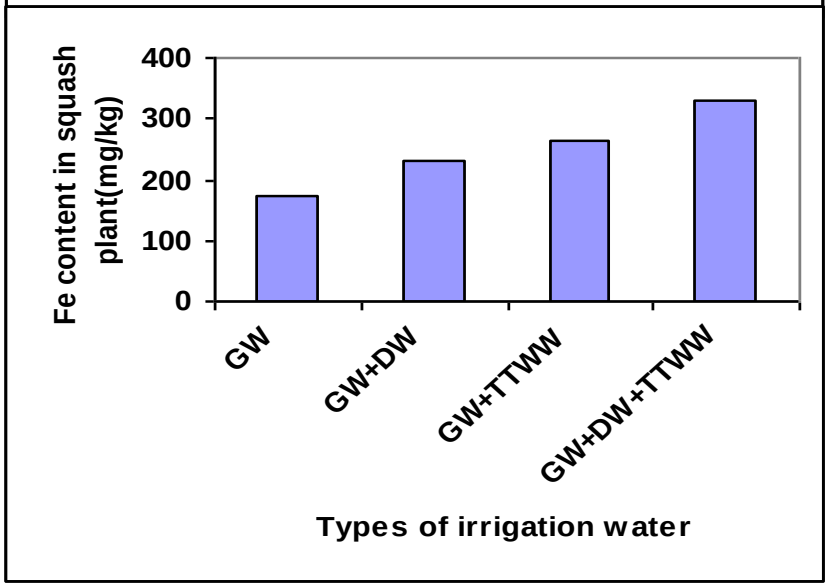
Mn content in palm plant (mg/kg)
50
40
30
20
10
0
GW
GW+DW
GW+TTWW
GW+DW+TTWW
Types of irrigation water

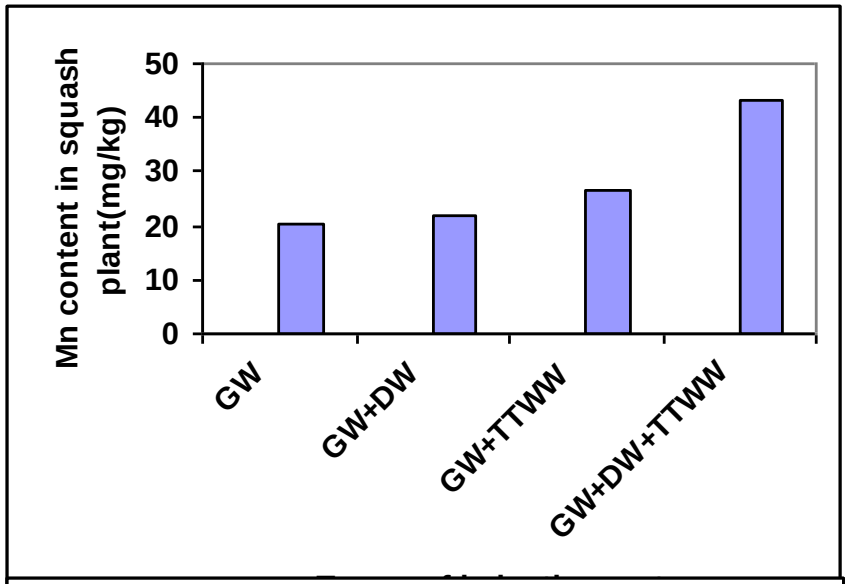

Cd content in palm plant (mg/kg)
0.4
0.3
0.2
0.1
0
GW
GW+DW
GW+TTWW
GW+DW+TTWW
Types of irrigation water

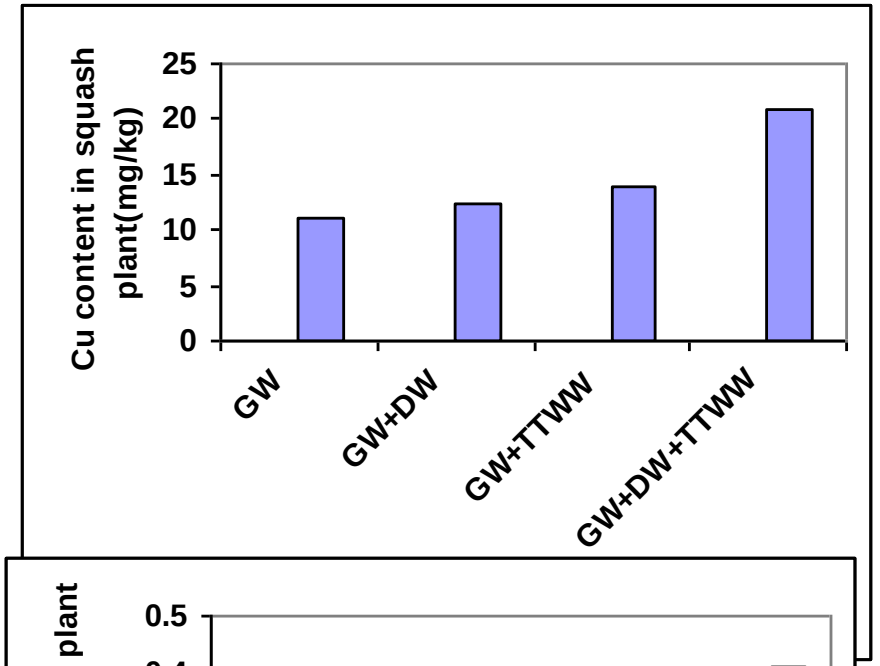

Cu content in palm plant (mg/kg)
12
10
8
6
4
2
0
GW
GW+DW
GW+TTWW
GW+DW+TTWW
Types of irrigation water

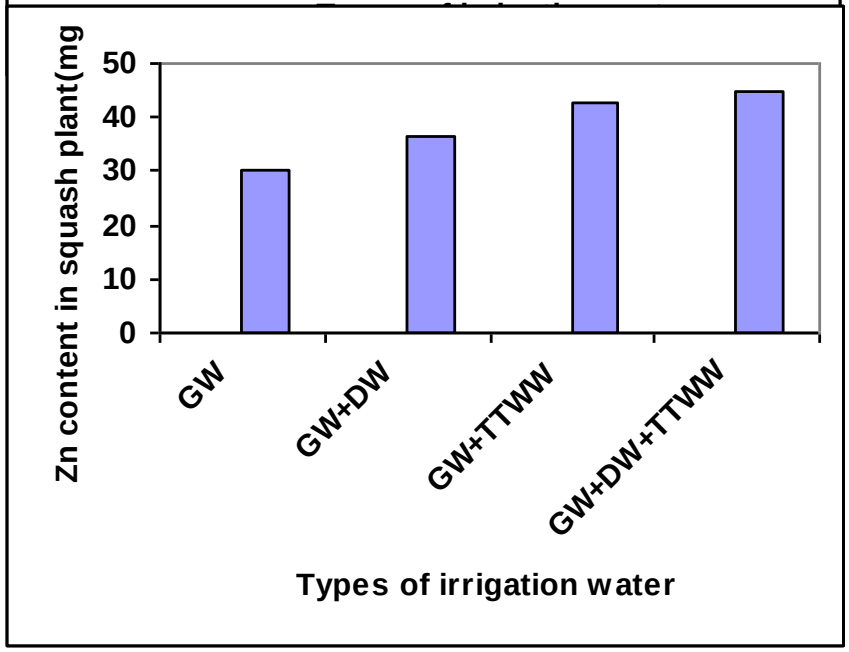

Co content in palm plant (mg/kg)
0.6
0.4
0.2
0
GW
GW+DW
GW+TTWW
GW+DW+TTWW
Types of irrigation water

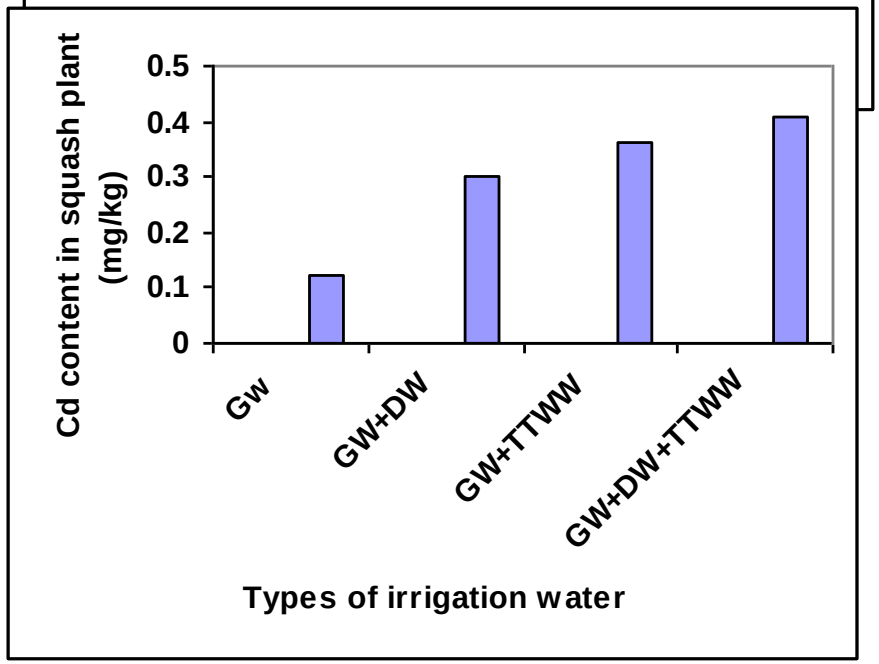

Ni content in palm plant (mg/kg)
10
8
6
4
2
0
GW
GW+DW
GW+TTWW
GW+DW+TTWW
Types of irrigation water

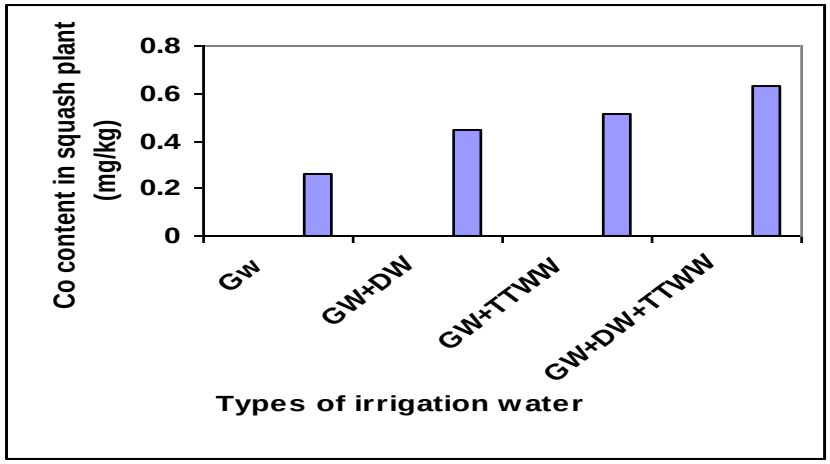

Fe content in squash plant(mg/kg)
400
300
200
100
0
GW
GW+DW
GW+TTWW
GW+DW+TTWW
Types of irrigation water

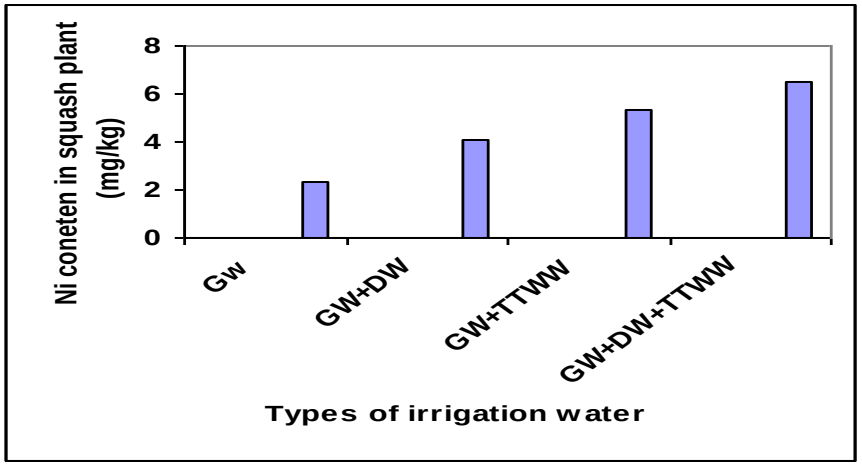

Mn content in squash plant(mg/kg)
50
40
30
20
10
0
GW
GW+DW
GW+TTWW
GW+DW+TTWW

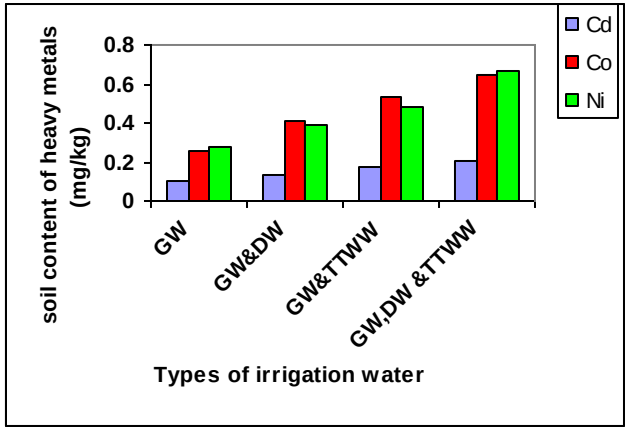

Cu content in squash plant(mg/kg)
25
20
15
10
5
0
GW
GW+DW
GW+TTWW
GW+DW+TTWW

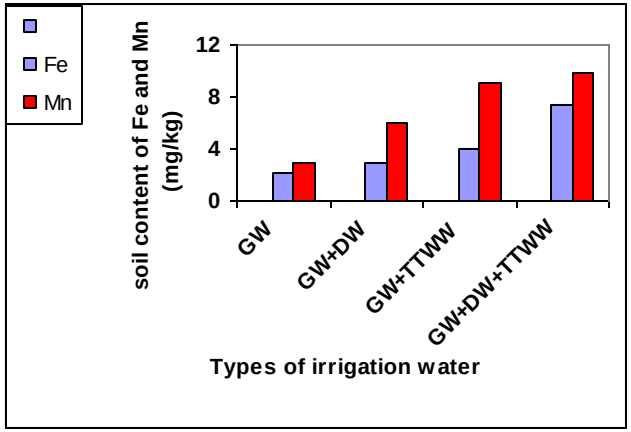

Zn content in squash plant(mg
50
40
30
20
10
0
GW
GW+DW
GW+TTWW
GW+DW+TTWW
Types of irrigation water

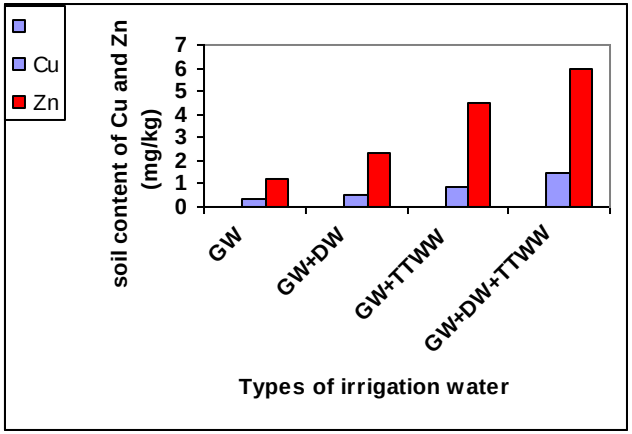

Cd content in squash plant (mg/kg)
0.5
0.4
0.3
0.2
0.1
0
Gw
GW+DW
GW+TTWW
GW+DW+TTWW
Types of irrigation water


Co content in squash plant (mg/kg)
0.8
0.6
0.4
0.2
0
Gw
GW+DW
GW+TTWW
GW+DW+TTWW
Types of irrigation water


Ni coneten in squash plant (mg/kg)
8
6
4
2
0
Gw
GW+DW
GW+TTWW
GW+DW+TTWW
Types of irrigation water







Effect of different types of irrigation water on Fe, Mn, Cu, Zn, Cd, Co and Ni contents of of soil

CONCLUSION

From this research project, it can be concluded that

- The water types used in this 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 remarkable 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.
- (GW+DW +TTWW) have the highest effect on elemental composition of plants and soil followed by (GW+TTWW), (GW+DW) and then (GW).
- Heavy metals in the studied soil and plants were in acceptable range (of the uncontaminated area).