IJABR, VOL.9 (1) 2019: 43-47 ISSN 2250 – 3579

INTERNATIONAL JOURNAL OF ADVANCED BIOLOGICAL RESEARCH

www.scienceandnature.org

# EFFECTS OF IRRIGATION WITH TREATED WASTEWATER BY BINARY IRRIGATION ON HEAVY METALS UPTAKE IN CORN CROP IN A CALCAREOUS SOIL IN SOUTHERN BAGHDAD

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## ABSTRACT
A field experiment was conducted to determine some of the soil's chemical characteristics by cultivating yellow corn crop for the fall season of in the field of (Zafaraniyah Station –Ministry of Agriculture, Department of Horticulture, 30km south of Baghdad. The field's soil texture was classified as Silty Loam. The experiment was designed according to randomized complete block design (RCBD) with three replicates, and treatments distributed randomly on experimental plots. The experiment consisted into five treatments, irrigation treatments: $T_1$ (100 wastewater), $T_2$ (75% wastewater +25% river water), $T_3$ (50% waste water + 50% river water), $T_4$ (25% wastewater + 75% river water) and $T_5$ (100% river water). Results showed that was a direct correlation between the percentage of mixing with treated wastewater by binary irrigation and heavy metals concentrations with high significant correlation coefficient, heavy metals concentrations increased with increasing percentage of mixture of treated wastewater and binary irrigation. Result also revealed that Fe and Cd concentrations exceed permissible limits of Fe and Cd concentrations in leaves while Fe and Cd not exceed permissible limits in grain for all treatments, while Pb exceed permissible limits in both leaves and grain for all treatments.

**KEYWORDS:** treated wastewater, binary irrigation, heavy metals uptake.

## INTRODUCTION
Water is considered the basic driving force of agriculture development in the dry areas and semi dry areas, the efficiency of using irrigate water in the last years became a significant issue because of the lack of water resources available and working on using the available water sources rationally in some areas which became a serious issue for the finite availability of fresh waters which made the search process for alternative resources an important matter (FAO, 1992).

The various household and commercial mixed wastewater is considered one of the alternative utilities and consists of 99% water and 1% impurities and contaminants (Bansode, 2002), as it is used and recycled alone or another water source for irrigation and agriculture considered one of the significant strategies within the conservation of non-renewable water resources and utilize the unconventional water resources given what this type of water represent an additional and renewable source for irrigation water (Hussien *et al*., 2010), as this type of waters used for irrigation to minimize the water shortage in the dry and semi dry areas (Galavi *et al.*, 2009). On the other hand these waters contain useful nutrients for plant growth, therefore good management methods must be applied to deal with this water to guarantee it will be used in the best manner without damaging the environment, and recycling treated wastewater has multi-factor problems related to social, spatial, economic and environmental criteria, each of them includes a number of sub-criteria, with the increase of water consumption by using low quality water resources (treated wastewater) considered a solution to the agricultural water necessities which pointed at as the largest water consumer for irrigation, despite of the growing agricultural products it is still a threat for both human health and the environment (Brace *et al*., 1995, Garcia *et al.*, 1981).

Chemically wastewater contain organic compounds (carbohydrates, proteins, fat, grease, oils, pesticide and phenol), and non-organic (heavy metals, nitrogen, phosphorus, sulfur and chlorides), as well as gases (hydrogen sulfide, methane gas, ammonia, oxygen, $CO_2$ and nitrogen), therefore it is a rich source of essential elements for plant growth, treated wastewaters needs special management (Chauhan and Chauhan, 2014). This is due to the health and environmental problems; soil contamination with heavy metal is the most dangerous environmental threat with serious effects on human health (Dang *et al.*, 2002, Krishna and Govil, 2007). Possibly the used water grants a positive outcome on the soil and plant growth, given it has rich with organic and nutrient materials (Obiajunwa *et al.*, 2002). Karatas *et al.* (2006) and Shadma and Pandey (2010) found an increase absorption and accumulation of heavy elements during the crop growth with the raise of the treated wastewater used for irrigation, this study was performed to evaluate the effect of different procedures for irrigation with treated wastewater on up taking and accumulate the selected heavy metals and the possible contaminations in the soil and corn crops.

## MATERIALS AND METHODS
This field experiment was performed within the fall season to cultivate the Grain Synthetic Category 5018 for yellow corn crop, Generated and registered in the General

Authority for Agricultural Research, in the field of (Zafaraniyah Station– Ministry of Agriculture, Department of Horticulture, 30 km south of Baghdad, 44.4˚ longitude, 33.14 latitude and 34 m elevation of sea level). The field's soil was classified as sedimentary and mixed Greenwich (Silty Loam). The soil samples were taken from depths (0-15, 15-30, 30-60)cm from several locations in the field. The soil samples for each depth were mixed separately and taken an ideal sample, the soil samples were dried up by air, grinded and sifted with a sieve of 2mm diameter holes. These samples were used to estimate the physical and chemical characteristics of the field's soil pre-cultivation, soil samples from the field of depths (0-15,15-30,30-60)cm were taken and for each duplicate of the experimental parameters also taken as well after the experiment's duration was done. Tables 1 and 2 showed some of the field's soil pre-cultivation physical and chemical characteristics and table 3 shows some of the chemical characteristics of the irrigation water. And the methods described were followed by Page *et al.* (1982) and Klute (1986).

**TABLE 1.** Some of the physical properties of the field's soil pre-cultivate

| Property | | Depth (cm) | | |
|---|---|---|---|---|
| | | 0 –30 | 30 –60 | 0 –30 |
| sand | $g.kg^{-1}$ | 142,0 | 91,3 | 142,0 |
| Silt | | 601,2 | 652,6 | 601,2 |
| Clay | | 256,7 | 256,1 | 256,7 |
| Texture | | Silty loam | | |
| Virtual density | Mega $gram.m^{-3}$ | 1.35 | 1.42 | 1.35 |
| Real density | Mega $gram.m^{-3}$ | 2.66 | 2.65 | 2.66 |
| porosity | $Cm^3.cm^{-3}$ | 0.49 | 0.46 | 0.49 |

The chemical properties of the soil were estimated as followed:

- Electrical conductivity was measured ($EC_e$) for the extracted saturated paste $EC_e$ in the soil extract by using the electrical conductivity device.
- Soil pH was measured in the extracted-saturated paste by using the pH-meter device.
- The organic matter was estimated in the soil by using humid oxidation method with potassium dichromate according to the method described by Black and Wikelly and received in Jackson (1958).
- Some of the dissolved positive and negative ions in the extracted and saturated paste according to the methods in Richards (1954).
  - Calcium and magnesium were estimated in titration process with EDTA 0.01 *N*
  - Sodium and potassium were measured by using the Flame photometer
  - Chloride was estimated by titration with silver nitrate 0.03*N*
  - As for sulfates was estimated by barium chloride deposition as received in Black (1965)
  - Bicarbonate were estimated by titration with sulfuric acid 0.01*N*

**TABLE 2.** Some of chemical characteristic of the field's soil pre-cultivate

| Property | Unit | Depth (cm) | | |
|---|---|---|---|---|
| | | 0-15 | 15 –30 | 30-60 |
| EC | $dS.m^{-1}$ | 2.11 | 1.35 | 1.26 |
| T.D.S | $mg.l^{-1}$ | 997 | 853 | 760 |
| pH | | 7.66 | 7.62 | 7.57 |
| $Ca^{+2}$ | milli mol. $Liter^{-1}$ | 14.25 | 7.15 | 7.9 |
| $Mg^{+2}$ | | 13.83 | 9.0 | 6.08 |
| $Na^{+1}$ | | 20.86 | 13.30 | 11.30 |
| $K^{+1}$ | | 0.174 | 0.136 | 0.123 |
| $SO_4^{-2}$ | | 5.89 | 3.375 | 3.312 |
| $HCO_3^{-1}$ | | 4.52 | 3.34 | 2.36 |
| EC | | 11.15 | 7.32 | 6.82 |
| SAR | millimoze charge . $liter^{-1})^{1/2}$ | 5.56 | 4.679 | 4.27 |
| O.M. | $g.kg^{-1}$ | 0.904 | | 0.806 |

The experiment included five irrigation procedures and added by binary irrigation method:

$T_1$: 100% wastewater
$T_2$: 75% wastewater + 25% river water
$T_3$: 50% wastewater + 50% river water
$T_4$: 25% wastewater + 75% river water
$T_5$: 100% river water

The experiment was designed according to the Randomized Complete Block Design (RCBD) with three repetitive; the procedures were distributed on experimental boards randomly, dividing the field according to statistical design to experimental units.

Three compound plant samples were taken in each treatment for leaves and seeds at harvest time and boron, iron, copper, cadmium and lead were analyzed according to standard and follow-up methods by APHA (1998).

**TABLE 3.** The physical and biological characteristics of irrigate water

| Property | Unit | Wastewater | River water |
|---|---|---|---|
| EC | $dS.m^{-1}$ | 2.79 | 0.96 |
| pH | | 7.23 | 7.33 |
| Ca | milli mol charge.liter$^{-1}$ | 10.9 | 3.93 |
| Mg | | 8.2 | 3.66 |
| Na | | 10 | 2.85 |
| K | | 0.743 | 0.33 |
| $CO_3$ | | 0.0 | 0.0 |
| $HCO_3$ | | 1.770 | 0.885 |
| Cl | | 9.01 | 2.8 |
| $SO_4$ | | 4.396 | 1.531 |
| $NO_3$ | | 1.12 | 0.0316 |
| T.D.S | ppm | 1150 | 492 |
| SAR | (milli mol charge.liter$^{-1}$)$^{1/2}$ | 3.24 | 0.75 |
| Fe | $\mu g.g^{-1}$ | 4,2 | 0,12 |
| Cu | | 1.9 | - |
| Cd | | 0.16 | - |
| B | | 0.62 | 0,41 |
| Pb | | 0.11 | - |
| Water type | | $S_1$-$C_3$ | $S_1$-$C_2$ |

The statistical analyses program GenStat (2012) was used in analyzing the data statically with under the probability of 0.05 to compare among the average procedures.
The land was tilled by a mold board plough perpendicularly, the soil was smoothed by rotary reaper then the field was settled, the specified area was divided into tablets with intervals of (3x2) $m^2$. The yellow corn seeds type 5018 was planted in 23/7 on lines by putting 2-3 seeds inside every furrow and lessened into one plant after two weeks of emergence, the distance between each line was 0.75 m and between each furrow 0.020m, a distance of 2m was given between each main sectors and 2 m interval between each tablet to control the flow of water and salts and to prevent the interception among the irrigation parameters and by leaving 4 guarding lines surrounding the field by its four sides, the number of experimental unites became fifteen unites and table 1 shows the distribution in the parameters within the field. Superphosphate fertilizer was added by a rate of 400 kg. hectare$^{-1}$ in one batch pre- cultivation. Urea fertilizer was added by 400 kg. hectare$^{-1}$ on two batches, the first was 200 kg. hectare$^{-1}$ one batch pre-cultivation and the second after five weeks of cultivation. Corn stem Borer control was initiated by Diazinon pesticide (10% effective matter) by 6 kg.hectare$^{-1}$ within the core of the plant after 20 days post cultivation, the weeding process was performed manually and periodically for all procedures.

## RESULTS

Results indicates that Boron concentrations were about 6.39-11.83 mg.liter$^{-1}$ and a significant effect for dual irrigation with treated wastewater in Boron element absorption, for the highest concentration of the element was found in the first procedure, however it was the lowest in the fifth procedure, the difference in concentrations in Boron varies with the water type in a incorporeal degree, the largest was in procedure $T_1$, however, the lowest concentration at irrigation was in $T_5$, the results showed that there is a positive relation *r=0.983 between the irrigation water treatment and Boron concentrations in the leaves (figure 1).
The results also indicated that the Iron concentrations were about 133.33-161.67 mg.liter$^{-1}$, and significan effect for dual irrigation with treated wastewater in Iron absorption, the highest concentration was in the first procedure, while the lost was in the fifth procedure, the Iron concentrations differ by the water type in a incorporeal degree. The highest Iron concentration effect was in $T_1$ parameter, while the lowest Iron concentration effect in irrigation was in $T_5$ parameter, the results revealed there is a direct correlation *r=0.961 between the irrigation water treatment and Iron concentrations in the leaves (figure 1).
The results revealed that the Copper concentrations were about 4.27-8.80 mg.liter$^{-1}$ and a significant effect for dual irrigation treated wastewater in Copper absorption, the highest concentrations for Copper was in first procedure, while the lowest concentration was in fifth procedure, the results showed a direct correlation *r=0.995 between the irrigation water treatment and Copper concentration in the leaves (figure 1). The results indicated that the highest Cadmium concentrations was in the first parameter with 0.43 mg.liter$^{-1}$, while the lowest concentration was in the fifth parameter 0.0137 mg.liter$^{-1}$ , the Cadmium concentrations varied with the variation of water type in an incorporeal degree, the highest concentration effect of Cadmium was at $T_1$ parameter, while the lowest effect for Cadmium concentration in irrigation was in $T_5$, the results showed a direct correlation *r=0.981 between the irrigation water treatment and Cadmium concentration in the leaves (figure 1).
The results indicated the Lead concentrations were about 2.32-3.64 mg.liter$^{-1}$ and a significant effect for dual irrigation with treated wastewater in Lead absorption; the highest Lead concentration was in the first parameter, while the lowest concentration was in the fifth parameter. The difference in the Lead concentration varied with the difference of water type in incorporeal degree. The largest concentration of Lead was in parameter $T_1$ while the lowest concentration of Lead was in $T_5$ parameter, the

results showed a direct correlation *r=0.998 between the irrigation water treatment and Lead concentration in the leaves (figure 1).

The results indicates that the Boron concentrations were about 5.95 – 9.24 mg.liter$^{-1}$ ,and a significant effect of dual irrigation with treated wastewater in Boron absorption ,the highest Boron concentration appears in the first parameter, while the lowest concentration is in the fifth parameter, the concentration of Boron varies with different water qualities in an incorporeal degree. Most effective concentration of Boron was in parameter $T_1$ while the least effective concentration was in parameter $T_5$, although results revealed a direct correlation *r= 0.954 between the irrigation water treatment and Boron concentrations in the seeds (figure 1).

The results indicates that Iron concentrations were about 30.00–45.67 mg.liter$^{-1}$ and a significant effect of dual irrigation with treated wastewater in Iron absorption , the highest Iron concentration appears in the first parameter, while the lowest concentration appears in the fifth parameter, the concentration of Iron varies with different water qualities in an incorporeal degree, Most effective concentration of Iron was in parameter $T_1$ while the least effective concentration was in parameter $T_5$, although results showed a positive relation *r= 0.989 between the irrigation water treatment and concentration of Iron in the seeds (figure 1).

Seeds Leaves

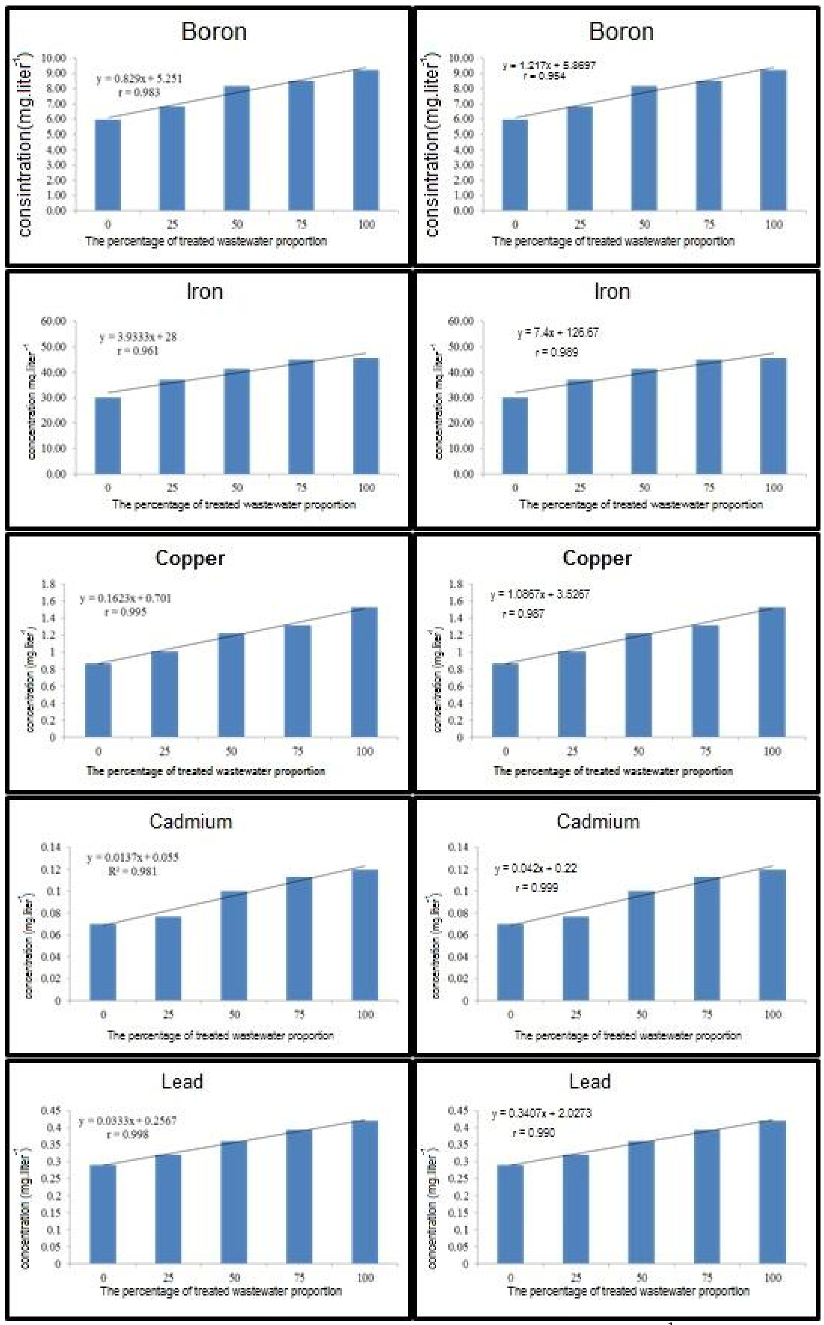


**FIGURE 1.** Concentrations of heavy elements in corn crop seeds and leaves (mg.liter$^{-1}$) for every experimental parameter

The results revealed that Copper concentrations were about 0.87 – 1.53 $mg.liter^{-1}$ and a significant effect of dual irrigation with treated wastewater in Copper absorption, the highest Copper concentration appears in the first parameter while the lowest concentration was in the fifth parameter, results indicates that a positive relation *r = 0.987 between the irrigation water treatment and concentration of Copper in the seeds (figure 1).

Results found that the highest Cadmium concentration in the first parameter 0.12 $mg.liter^{-1}$, while the lowest concentration was 0.07 $mg.liter^{-1}$ in the fifth parameter, the concentration of Cadmium varied with different water treatment in an incorporeal level. The most effective concentration of Cadmium was in parameter $T_1$ while the least effective concentration was in parameter $T_5$, results showed a positive relation *r=0.999 between the irrigation water treatment and concentration of Cadmium in the seeds (figure 1).

Results also showed the concentration of Lead were about 0.29–0.42 $mg.liter^{-1}$, and a significant effect in dual irrigation with treated wastewater in Lead absorption. The highest concentration of Lead was found in the first parameter while the lowest concentration was in the fifth parameter; the concentration of Lead varies with different water treatment in an incorporeal degree. The most effective concentration of Lead was in $T_1$ parameter, while the least effective concentration was in $T_5$ parameter, results revealed a positive relation *r=0.990 between the irrigation water treatment in Lead element concentration in seeds (figure 1).

Figure 1 shows the difference in concentrations among the measured heavy elements in leaves and seeds, Iron had a significant effect on seeds and leaves and exceeded the limit in the leaves but did not surpass it in the seeds (48 $mg.kg^{-1}$ dry substance ($mg.liter^{-1}$) and for all parameters by the difference in mixing with wastewaters according to WHO (1996).

Copper concentrations in leaves and seeds were within the natural limits of Copper concentration in plants as put by WHO (1996), Copper concentration in plant (30 $mg.kg^{-1}$ dry substance) and for all experiment parameters which was significant under probability level of 0.05.

Cadmium concentration didn't exceed the limit put by WHO (1996) (0.2 $mg.kg^{-1}$ dry substance) in seeds but surpass the limit of it in leaves and for all experiment parameter, although the Lead concentration in leaves differed of it in seeds as the concentration of leaves was higher than in seeds and surpassed the limit put by WHO (1996) (2 $mg.kg^{-1}$ dry substance) in both leaves and seeds and for all parameters.

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