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# محتوى بعض النباتات المروية بالمياه العادمة من المغذيات والفلزات الثقيلة

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## الملخص العربي

أجريت دراسة لتقييم مستويات الفلزات الثقيلة الغير حيوية (كادميوم، كوبلت، نيكل ورصاص) والحيوية (حديد ، زنك ، نحاس و منجنيز) وايضا المغذيات الكبرى (نيتروجين ، فوسفور وبوتاسيوم) فى النباتات المروية بمياه صرف صحى معالج ومياه صرف صناعى من مصادر مختلفة. وقد جمعت العينات المختلفة للمياه المستخدمة فى الرى والنباتات المنزرعة فى الفترة من شهر يوليوعام ٢٠٠٧ حتى شهر يناير عام ٢٠٠٩ وذلك من ثلاث مواقع. الموقع الاول مزرعة الجبل الاصفر ، الموقع الثانى مزرعة ابو رواش والموقع الثالث منطقة العاشر من رمضان. تستخدم مياه الصرف الصحى المعالج للرى فى منطقتى الجبل الاصفر وأبو رواش بينما تستخدم مياه الصرف الصناعى للرى فى منطقة العاشر من رمضان والتى تضم العديد من المصانع.

وقد اوضحت تحليلات مياه الرى ان المحتوى من المغذيات الكبرى والفلزات الثقيلة الحيوية والغير حيوية فى مياه الصرف الصناعى اكثرمن مياه الصرف الصحى المعالج . كما أظهرت النتائج زيادة الفلزات الثقيلة الحيوية والغير حيوية زيادة معنوية فى جميع النباتات المروية بالمياه العادمة المستخدمة وذلك عند مقارنتها بالحدود المسموح بها دوليا طبقا للمنظمة العالمية لحماية البيئة

National Environmental Protection Agency of China (1995) and Turkdogan *et al*., 2003

وأيضا فان اقصى زيادة فى المحتوى من كل من الفلزات الثقيلة الحيوية والغير حيوية وجد فى نباتات الذرة ، القمح والبرسيم المروية بمياه الصرف الصناعى بالمقارنة بمثيلاتها المروية بمياه صرف صحى معالج .

# NUTRIENTS AND HEAVY METALS CONTENT OF SOME PLANTS IRRIGATED BY WASTEWATER

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**ABSTRACT:** *The present study was carried out to assess levels of macronutrients (N, P and K), biogenic heavy metals ( Fe, Zn, Cu and Mn) and non biogenic heavy metals ( Cd, Co, Ni and Pb) in plants irrigated with treated sewage effluent (TSE) and industrial effluent (IE) from different sources. Different samples of irrigation water and cultivated plants were collected seasonally during the period from July 2007 to January 2009 from three sites. The first site was El- Gabal El- Asfar Farm ( EGAF), the second was Abu- Rawash Farm ( ARF) and El-Ashir of Ramadan area (EAR). Both two Farms (EGAF and ARF) irrigated with TSE, meanwhile EAR ( El- Ashir of Ramadan area) irrigated with IE. This location adjacent to many factories which dump their wastes near this location. Analysis of irrigation water has indicated the maximum concentrations of macronutrients and bio and non biogenic heavy metals in industrial effluent compared with the corresponding values in treated sewage effluent. The results indicated a substantial build- up of bio and non biogenic heavy metals in plants irrigated with wastewater compared with the maximum permit limits proposed by National Environmental Protection Agency of China 1995 and Turkdogan et al., 2003. . The maximum increase in the content of both bio and non biogenic heavy metals was observed in corn, wheat and clover plants that irrigated with IE compared with those grown in soil irrigated with TSE.*

***Key words**: Wastewater, Bio and non biogenic heavy metals, Plant chemical compositions, Macronutrients and Maximum permit limit*

## INTRODUCTION

When wastewater is used continuously as the sole source of irrigation water for field crops in arid regions, excessive amounts of nutrients are simultaneously applied and their accumulation in the soil may cause unfavorable effects on productivity and quality of crops, and soil as well as ground water by leaching in coarse textured soils. Consequently, management of irrigation with wastewater should consider the nutrient content in relation to the specific crop requirement and the concentrations of plant nutrients in the soil, and other soil fertility parameters (Kiziloglu *et al.,* 2008 ) .

Vegetables accumulate heavy metals in their edible and non edible parts. Although some of the heavy metals such as Zn, Mn, Ni and Cu act as micro-nutrients at lower concentrations, they become toxic at higher concentrations. Health risk due to heavy metal contamination of soil has been widely reported (Eriyamremu *et al*., 2005; Muchuweti *et al*., 2006 and Satarug *et al*., 2000). Crops and vegetables grown in soils contaminated with heavy metals have greater accumulation of heavy metals than those grown in uncontaminated soil (Marshall *et al*., 2007 and Sharma *et al*., 2007). Intake of vegetables is an important path of heavy metal toxicity to human being (Singh *et al*., 2010). Heavy metal accumulation in plants depends upon plant species, and the efficiency of different plants in absorbing metals is evaluated by either plant uptake or soil-to-plant transfer factors of the metals (Rattan *et al*., 2005). Kiziloglu *et al*. (2008) recorded that irrigation with wastewater increased plant available phosphorus and microelements and increased the yield as well as N, P, K, Ca, Mg, Na, Fe, Mn, Zn, Cu, Pb, Ni and Cd contents of cauliflower and red cabbage plants. The highest yield, macro- and micronutrients uptake of cauliflower and red cabbage plants were obtained with the untreated wastewater. Undesirable side effect such as heavy metal contamination in soil and plant. Plant and salinity were not observed with the application of wastewater.

There are two basic strategies by which higher plants can tolerate high heavy metals concentrations in soil. The first is exclusion whereby transport of metals is restricted and the amount of metals in shoots is maintained over a wide range of soil concentration. The second is accumulation whereby metals are accumulated in the upper plant parts at both high and low concentrations (Mc Grath *et al*., 2001). It has been suggested that this accumulation might be a self- defence against pathogens and herbivores (Poschenrieder *et al*., 2006).

Normally four criteria have been used to identify plants that accumulate large amounts of metals. First, the amount of the element reaches large concentration in the plant shoots. Second, the concentration of the element in the shoots is 10-500× larger than normally found in plants. Third, the concentration of the element in the shoots is larger than in the roots or the shoots/roots quotient > 1. Fourth, the concentration of the element in the shoots is larger than in the soil or the extraction coefficient, metal concentration in plant shoot/ metal concentration in soil and is used to evalulate the ability of a plant to accumulate the heavy metals (Chen *et al*., 2004), or the shoot/soil quotient > 1 (Franco-Hernandez *et al*., 2010).

The mechanisms of metal toxicity induction are not fully understood for crop plants. Metals may directly or indirectly interfere with the metabolic activities by altering the conformation of proteins for example enzymes, transporters or regulatory proteins by their strong affinities as ligands to sulfhydryl and carboxylic groups (Chandara *et al*., 2009).

## Cadmium

Cadmium is one of the most dangerous heavy metals due to its high mobility and the small concentration at which its effects on plants begin to show. The high concentration of Cd in plants affects adversely various metabolic processes in plants such as synthesis of chlorophyll, protein, carbohydrate, free amino acids, and RNA. Cadmium and lead are reported to have inhibitory effect on photosynthesis, transpiration, carbohydrate metabolism and other metabolic activities (Chandara *et al*., 2009). Cadmium reduced the concentration of ATP and chlorophyll in many species, and decreased oxygen production.

## Cobalt

In excess concentration, the ill effects of Co on plants indirectly lower the concentration of essential nutrients, decrease photosynthesis, reduce intercellular spaces, and disturb the structural integrity of chloroplast metabolism and carbohydrates metabolism. The activity of several enzymes, including Fe-containing enzymes, is disturbed by excessive amounts of Co within the plants (Chatterjee and Chatterjee, 2003).

## Nickel

Nickel is considered an essential micronutrient for plants, but is strongly phytotoxic at higher concentrations and has a destructive effect on growth, mineral nutrition, photosynthesis and membrane function (Madhava *et al*., 2000).

## Lead

Lead has been shown to accumulate in plants from several sources including soil but the reports on accumulation of the metal with in plants are variable. Nagajyoti *et al*. (2008) have concluded that Pb is partially deposited on the surface and partially incorporated into the tissue because the total Pb content showed a correlation with the leaf area. Large differences in Pb deposition have been reported in different plant species (Chatterjee *et al*., 2004 ).

## Iron

Excessive concentration of Fe have also been reported to be toxic to the plants.

## Zinc

Zn is an essential nutrient for plant growth, although elevated concentrations resulted in growth inhibition and toxicity symptoms. It does not affected seed germination but helps in plumule and radical development. Nagajyoti *et al*., (2008) reported that the seeds silene maritime were germinated better and rapidly on calcium nitrate solutions containing different concentration of zinc, at higher concentrations inhibiting root growth.

## Copper

A number of studies have reported that oxidative stresses of increasing copper affect miotic activity and cell division of roots, with subsequent decrease in growth or cellular death by necrosis. Copper toxicity induces leaf chlorosis through degradation of photosynthetic components (Nagajyoti *et al*., 2008).

## Manganese

Manganese is an essential microelement for most living organisms, and plays an important role in oxygen photosynthesis (Marschner, 1995). The tolerance to excess of this component varies characteristically with plant species and with cultivars within these species.

FAO (1992) noted that, the potential accumulation of certain toxic metals in plants and their intake through eating of crops irrigated with contaminated water must be carefully assessed. Plants can take up high levels of heavy metals until the levels become injurious.

The study aimed to assess the impact of irrigation with wastewaters on physicochemical characteristics, as well as on the accumulation of heavy metals, macronutrients and micronutrients in the different plant parts.

## MATERIALS AND METHODS

During the period of 2007/ 2009, triplicate plant samples of corn, wheat and clover irrigated by some wastewater ( sewage and industrial) resources were collected separately. These samples were collected from three different locations, the first location was El- Gabal El- Asfar Farm (EGAF), Qalubiya Governorate representing the soil irrigated by treated sewage effluent (TSE). The second one was Abu- Rawash Farm (ARF), Giza Governorate which also representing the soil irrigated by treated sewage effluent (TSE). The third location was El- Ashir of Ramadan (EAR), El-Sharkiya Governorate representing the soil irrigated by industrial effluent (IE). In all investigated locations, corn, wheat and clover were commonly dominant. The collected plant samples from different locations were brought back to the laboratory, separation take place, Corn plants were separated into roots, shoots and grains, Wheat plants were separated into roots, shoots and spikes, while clover plants were separated into shoots and roots. The separated plant parts washed with clean tap water to remove the soil particles adhered to the surface samples and to remove airborne pollutants. After removing the extra water from the surface samples with blotting paper. Then the samples air – dried, placed into separate bags, and oven- dried at 70°C until constant weight was achieved. The dry weight of each separated part was recorded, ground and kept for chemical analysis. A 1.0 g of each dried sample was digested by mixture of conc. sulphuric acid $H_2SO_4$ and perchloric acid $HClO_4$ according to the method of Sommer and Nelson (1972). The plant samples content of some macro-nutrients (N, P and K ) was determined in the obtained clear digestion according to Chapman and Pratt (1961). Also, in the digestion the contents of some non biogenic heavy metals (Pb, Co, Ni and Cd ) and some biogenic heavy metals (Fe, Mn, Zn and Cu ) were determined using atomic absorption spectrophotometer (Parkin Elmer 3300) according to Cottenie *et al*. (1982) and determined using Inductively Couped Plasma (ICP) Spectrometry model 400, as described by Soltanpour and Schwab (1977).

Water samples were taken seasonally from the the sources of irrigation water from each location. Each water sample was placed in clear and dried glass bottle. A few drops of tolween were added to each glass to prevent the biological activity and good stooped. All glasses were kept in the freezer. Water samples contents of some macronutrients (N, P and K), biogenic heavy metals (Fe, Mn, Zn and Cu ), non biogenic heavy metals ( Pb, Co, Ni and Cd ) and sodium ( Na) were determined according to the methods described by Cottenie *et al*. (1982). Also, water EC values (dS/m) and the content of soluble cations and anions were measured as described by Cottenie *et al*. (1985).

Water and plant samples were collected from each site of the study area to be used for analyses. The statistical analyses of data were done according to the method described by Sndecor and Cochran (1989).

## RESULTS AND DISCUSSION

### Irrigation Water:

Three sources of irrigation water were used in the present study namely, control (River Nile water, Mansouria canal and Ismailia canal from EGAF, ARF and EAR, respectively), treated sewage effluent (TSE) from both EGAF, ARF and industrial effluent (IE) from EAR . Irrigation water samples were collected every season during the period of investigation from the different sources according to the method described by by APHA (1985).

The presented data in Tables 1 and 2 show that, the mean values of all the studied parameters (EC, $Ca^{++}$, $Mg^{++}$, $Na^{+}$, $K^{+}$, $HCO^{-}$, $Cl^{-}$, $SO_4^{=}$ and SAR) of industrial effluent ( IE) used in irrigation in EAR recorded higher values in IE than in the control for both summer and winter seasons.

Comparing the present results of irrigation water (Treated sewage effluent) used in EGAF with those used in EAR (Industrial effluent) the data reveal that, the mean values of EC (dS/m), and the content (meq/l) of $Mg^{++}$, $Na^{+}$, $HCO_3^{-}$, $Cl^{-}$, $SO_4^{=}$ and SAR increased by 2.1 folds, 1.4 folds, 3.9 folds, 1.4 folds, 3.8 folds, 1.1 folds and 3.8 folds in IE as compared with the corresponding ones in TSE used in irrigation at EGAF, respectively. Meanwhile the water content of $Ca^{++}$, $K^{+}$ increased in TSE used in EGAF when compared with those used in EAR (Table, 1).

The results of chemical characteristics (EC, $Ca^{++}$, $Mg^{++}$, $Na^{+}$, $K^{+}$, $HCO^{-}$, $Cl^{-}$, $SO_4^{=}$ and SAR) of TSE used in ARF indicated that the mean contents of $Ca^{++}$, $Mg^{++}$ increased significantly in TSE used in ARF as compared with those used in EAR, meanwhile the mean values of EC, $Na^{+}$, $K^{+}$, $Cl^{-}$ and SAR recorded the highest values in IE as compared with those used in TSE used in ARF. From the recorded results, it can be noted that all the studied parameters recorded higher values in IE than those recorded in TSE which used in irrigation in both two farms. The obtained results are in accordance with those obtained by Khafagi *et al*. (2010).

Generally, the mean values of the determined chemical parameters for the evaluated irrigation water resources during summer season were higher than those measured during winter season. This trend may be attributed to the high evaporation rate of water from canals in summer season than that in winter season.

In this concern, Nazif *et al*. (2006) stated that waters having electrical conductivity of $1.5 dSm^{-1}$ were safe for irrigation, but those having up to 1.5 to 3.0 $dSm^{-1}$ were marginal and waters having EC values more than 3.0 $dSm^{-1}$ were unsafe.

Results in Table (2) show the content (meq/l) of N, P and K in irrigation water used in the studied sites during the period of investigation. The irrigation water contents of (N, P and K) increased significantly in TSE in both EGAF and ARF and IE in EAR during the period of investigation in both (summer and winter seasons) as compared with the control, where the obtained increases in the contents of these macronutrients in the summer season were higher than measured during winter season. This trend was found with the studied irrigation water resources in the three sites. With except of the concentration of P in irrigation water collected from EGAF during winter seasons which increased insignificantly as compared with the control. With respect to the IE content of macronutrients the results indicated that the mean content of N, P and K increased significantly in IE as compared with TSE used in both ARF and EGAF.

Considering the irrigation water used during winter season the data showed that the nitrogen content of TSE used in EGAF increased significantly as compared with those used in ARF. On the other hand, the mean values of P and K recorded the reverse trend. Generally, the mean content of N, P and K of IE used in EAR during winter seasons recorded the highest values than that recorded in TSE which used in irrigation in both EGAF and ARF. Generally the concentration of macronutrients (N, P and K) in IE in EAR increased significantly as compared with the corresponding ones in TSE used in both of EGAF and ARF (Khafagi *et al*., 2001). In this respect Rusan *et al*. (2007) reported that, the wastewater contains considerable amount of nitrate, phosphate and potassium which are considered essential nutrients for improving plant growth and soil fertility and productivity levels.

**Table (1): Chemical characteristics of irrigation water used in the studied locations (mean values).**

| Site | Type of water | Season | EC dS/m | Soluble cation (meq/l) | | | | Soluble anion (meq/l) | | | | SAR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | $Ca^{++}$ | $Mg^{++}$ | $Na^{+}$ | $K^{+}$ | $CO_3^{=}$ | $HCO_3^{-}$ | $Cl^{-}$ | $SO_4^{=}$ | |
| EGAF | Control | Summer seasons | 0.72 | 2.49 | 2.20 | 2.28 | 0.25 | 0.00 | 3.24 | 1.60 | 2.38 | 1.49 |
| | TSE | | 1.22 | 4.70 | 2.90 | 4.19 | 0.35 | 0.00 | 3.66 | 3.12 | 5.36 | 2.14 |
| | LSD at 0.05 | | 0.13 | 0.21 | 0.30 | 0.37 | 0.07 | | 0.99 | 0.39 | 0.85 | 0.27 |
| | Control | Winter seasons | 0.59 | 1.69 | 1.46 | 2.51 | 0.24 | 0.00 | 2.13 | 1.99 | 1.78 | 2.09 |
| | TSE | | 1.12 | 4.27 | 2.29 | 4.05 | 0.42 | 0.00 | 2.09 | 3.70 | 5.23 | 2.23 |
| | LSD at 0.05 | | 0.11 | 0.97 | 0.16 | 0.41 | 0.16 | | 0.39 | 0.66 | 0.72 | 0.60 |
| ARF | Control | summer seasons | 0.78 | 2.73 | 2.25 | 2.52 | 0.24 | 0.00 | 2.92 | 1.81 | 3.00 | 1.59 |
| | TSE | | 1.45 | 5.05 | 4.44 | 3.58 | 0.33 | 0.00 | 3.73 | 3.75 | 5.91 | 1.64 |
| | LSD at 0.05 | | 0.23 | 0.14 | 0.30 | 0.23 | 0.09 | | 0.54 | 0.34 | 0.74 | 0.13 |
| | Control | winter seasons | 0.58 | 1.78 | 1.61 | 1.80 | 0.34 | 0.00 | 1.82 | 1.55 | 2.16 | 1.43 |
| | TSE | | 1.24 | 4.34 | 4.32 | 3.27 | 0.26 | 0.00 | 2.57 | 2.67 | 6.98 | 1.57 |
| | LSD at 0.05 | | 0.07 | 0.38 | 0.77 | 0.49 | 0.11 | | 0.59 | 0.65 | 1.19 | 0.47 |
| EAR | Control | summer seasons | 0.60 | 1.86 | 1.56 | 2.25 | 0.27 | 0.00 | 1.85 | 1.69 | 2.40 | 1.77 |
| | IE | | 2.51 | 4.17 | 3.79 | 16.64 | 0.43 | 0.00 | 3.65 | 15.71 | 5.68 | 8.37 |
| | LSD at 0.05 | | 0.15 | 0.58 | 0.56 | 1.03 | 0.09 | | 0.55 | 0.32 | 0.50 | 0.90 |
| | Control | winter seasons | 0.57 | 2.08 | 1.90 | 1.49 | 0.18 | 0.00 | 2.41 | 1.37 | 1.88 | 1.05 |
| | IE | | 2.36 | 3.86 | 3.26 | 16.06 | 0.36 | 0.00 | 3.07 | 14.37 | 6.10 | 8.53 |
| | LSD at 0.05 | | 0.17 | 0.29 | 0.27 | 1.28 | 0.06 | | 0.28 | 0.84 | 0.32 | 0.92 |
| Summer seasons | | | | | | | | | | | | |
| LSD at 0.05 | | | | | | | | | | | | |
| EGAF & ARF | | | 0.24 | 0.17* | 0.31* | 0.30* | 0.08 | | 0.51 | 0.44* | 0.62 | 0.15* |
| EGAF & EAR | | | 0.12* | 0.50* | 0.17* | 1.03* | 0.09 | | 0.47 | 0.47* | 0.44 | 0.83* |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| ARF & EAR | 0.25* | 0.50* | 0.31* | 1.03* | 0.10* | | 0.69 | 0.36* | 0.76 | 0.83* |
| Winter seasons | | | | | | | | | | |
| LSD at 0.05 | | | | | | | | | | |
| EGAF & ARF | 0.08* | 0.40 | 0.57* | 0.30* | 0.16* | | 0.49 | 0.64* | 1.19* | 0.16* |
| EGAF & EAR | 0.13* | 0.38* | 0.15* | 1.27* | 0.16 | | 0.28* | 0.84* | 0.48* | 0.91* |
| ARF & EAR | 0.12* | 0.42* | 0.58* | 1.29* | 0.07* | | 0.55 | 1.05* | 1.16 | 0.92* |

EGAF: El- Gabal EL- Asfar Farm, ARF: Abu- Rawash Farm, EAR: El- Ashir of Ramadan,
TSE: Treated sewage effluent IE: Industrial effluent * : significant at LSD 0.05%

**Table (2): Nitrogen, phosphorus and potassium content (mg/l) of irrigation water used in the studied locations (mean values)**

| Site | Type of water | Season | Macronutrients (mg/l) | | |
|---|---|---|---|---|---|
| | | | N | P | K |
| EGAF | Control | summer seasons | 2.31 | 0.71 | 7.15 |
| | TSE | | 3.74 | 1.15 | 11.73 |
| | LSD at 0.05 | | 0.86 | 0.22 | 0.73 |
| | Control | winter seasons | 3.62 | 0.66 | 6.43 |
| | TSE | | 5.46 | 0.83 | 8.95 |
| | LSD at 0.05 | | 0.55 | 0.22 | 0.60 |
| ARF | Control | summer seasons | 2.04 | 0.75 | 6.93 |
| | TSE | | 3.51 | 1.27 | 12.33 |
| | LSD at 0.05 | | 0.70 | 0.28 | 0.54 |
| | Control | winter seasons | 2.64 | 0.81 | 7.35 |
| | TSE | | 4.53 | 1.14 | 11.75 |
| | LSD at 0.05 | | 0.69 | 0.27 | 1.20 |
| EAR | Control | summer seasons | 1.55 | 0.55 | 6.85 |
| | IE | | 9.54 | 3.61 | 15.15 |
| | LSD at 0.05 | | 2.35 | 0.51 | 0.76 |
| | Control | winter seasons | 1.79 | 0.55 | 5.89 |
| | IE | | 12.16 | 2.50 | 12.94 |
| | LSD at 0.05 | | 2.98 | 0.39 | 0.61 |
| Summer seasons | | | | | |
| LSD at 0.05 | | | | | |
| EGAF & ARF | | | 0.73 | 0.27 | 0.38* |
| EGAF & EAR | | | 2.41* | 0.49* | 0.61* |
| ARF & EAR | | | 2.35* | 0.50* | 0.62* |
| Winter seasons | | | | | |
| LSD at 0.05 | | | | | |
| EGAF & ARF | | | 0.53* | 0.30* | 1.05* |
| EGAF & EAR | | | 2.95* | 0.39* | 0.43* |
| ARF & EAR | | | 2.97* | 0.43* | 1.03* |

EGAF: El- Gabal EL- Asfar Farm, ARF: Abu- Rawash Farm, EAR: El- Ashir of Ramadan,
TSE: Treated sewage effluent IE: Industrial effluent * : significant at LSD 0.05%

The contents of irrigation water resources under study either of biogenic (Fe, Mn, Zn and Cu) or non biogenic ( Pb, Co, Cd and Ni) heavy metals increased significantly in all samples of TSE and IE than in the control except in some cases which increase insignificantly (Table, 3). From the recorded results it can be observe that all the irrigation water samples collected from different sources under the present investigation contained high levels of both biogenic and non biogenic heavy metals which affected on the concentrations of these metals in the soil and the cultivated plants. El –Gendi (2003) showed that the contents of Zn, Fe, Ni and Cd in Nile water were ( 0.012, 0.02, 0.001 and 0.001 mg/l), respectively, which located within the critical levels reported for these metals in waters for irrigation use. Meanwhile, the sewage effluent water contains measurable quantities of Zn, Fe, Ni and Cd were 0.70, 1.05, 0.40 and 0.12 mg/l, respectively.

**Table (3): The mean values of biogenic and non biogenic heavy metals content (mg/l) of irrigation water used in the studied locations compared with permissible limits**

| Site | Type of water | Season | Non biogenic heavy metals (mg/l) | | | | Biogenic heavy metals (mg/l) | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Cd | Co | Ni | Pb | Fe | Zn | Cu | Mn |
| EGAF | Control | Summer seasons | 0.005 | 0.015 | 0.050 | 0.290 | 0.792 | 0.300 | 0.035 | 0.012 |
| | TSE | | 0.020 | 0.300 | 0.250 | 0.495 | 1.275 | 0.745 | 0.165 | 0.265 |
| | LSD at 0.05 | | 0.010 | 0.120 | 0.070 | 0.110 | 0.250 | 0.130 | 0.060 | 0.080 |
| | Control | Winter seasons | 0.004 | 0.035 | 0.025 | 0.290 | 0.650 | 0.380 | 0.035 | 0.005 |
| | TSE | | 0.015 | 0.365 | 0.110 | 0.425 | 1.215 | 0.710 | 0.125 | 0.280 |
| | LSD at 0.05 | | 0.010 | 0.130 | 0.11 | 0.140 | 0.320 | 0.290 | 0.050 | 0.110 |
| ARF | Control | Summer seasons | 0.002 | 0.003 | 0.014 | 0.105 | 0.860 | 0.310 | 0.115 | 0.070 |
| | TSE | | 0.030 | 0.135 | 0.245 | 0.290 | 1.310 | 0.900 | 0.785 | 0.145 |
| | LSD at 0.05 | | 0.01 | 0.04 | 0.07 | 0.10 | 0.25 | 0.17 | 0.10 | 0.05 |
| | Control | Winter seasons | 0.003 | 0.002 | 0.019 | 0.140 | 0.922 | 0.340 | 0.480 | 0.075 |
| | TSE | | 0.027 | 0.070 | 0.235 | 0.415 | 1.355 | 0.780 | 0.670 | 0.165 |
| | LSD at 0.05 | | 0.01 | 0.01 | 0.07 | 0.10 | 0.16 | 0.17 | 0.23 | 0.07 |
| EAR | Control | Summer seasons | 0.001 | 0.035 | 0.140 | 0.055 | 0.195 | 0.775 | 0.060 | 0.015 |
| | IE | | 0.065 | 0.890 | 0.660 | 0.880 | 2.380 | 2.510 | 1.360 | 0.395 |
| | LSD at 0.05 | | 0.02 | 0.13 | 0.10 | 0.07 | 0.21 | 0.27 | 0.10 | 0.09 |
| | Control | Winter seasons | 0.002 | 0.055 | 0.185 | 0.055 | 0.275 | 0.650 | 0.120 | 0.025 |
| | IE | | 0.065 | 0.785 | 0.635 | 0.750 | 2.515 | 2.590 | 0.735 | 0.380 |
| | LSD at 0.05 | | 0.03 | 0.19 | 0.17 | 0.20 | 0.42 | 0.15 | 0.52 | 0.15 |
| Permissible limits | | | 0.010 | 0.050 | 0.200 | 5.000 | 5.000 | 5.000 | 0.200 | 0.200 |
| Summer seasons | | | | | | | | | | |
| EGAF | TSE | | 0.020 | 0.300 | 0.250 | 0.495 | 1.275 | 0.745 | 0.165 | 0.265 |
| ARF | | | 0.030 | 0.135 | 0.245 | 0.290 | 1.310 | 0.900 | 0.785 | 0.145 |
| EAR | IE | | 0.065 | 0.890 | 0.660 | 0.880 | 2.380 | 2.510 | 1.360 | 0.395 |
| LSD at 0.05 | | | | | | | | | | |
| EGAF & ARF | | | 0.02 | 0.13* | 0.10 | 0.13* | 0.28 | 0.17 | 0.11* | 0.09* |
| EGAF & EAR | | | 0.02* | 0.18* | 0.12* | 0.12* | 0.27* | 0.26* | 0.12* | 0.12* |
| ARF & EAR | | | 0.02* | 0.14* | 0.12* | 0.11* | 0.29* | 0.28* | 0.14* | 0.10* |
| Winter seasons | | | | | | | | | | |
| EGAF | TSE | | 0.015 | 0.365 | 0.110 | 0.425 | 1.215 | 0.710 | 0.125 | 0.280 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| ARF | | 0.027 | 0.070 | 0.235 | 0.415 | 1.355 | 0.780 | 0.670 | 0.165 |
| EAR | IE | 0.065 | 0.785 | 0.635 | 0.750 | 2.515 | 2.590 | 0.735 | 0.380 |
| LSD at 0.05 | | | | | | | | | |
| EGAF & ARF | | 0.01 | 0.13* | 0.13 | 0.14 | 0.260 | 0.240 | 0.10* | 0.13 |
| EGAF & EAR | | 0.03* | 0.23* | 0.19* | 0.23* | 0.47* | 0.26* | 0.52* | 0.18 |
| ARF & EAR | | 0.03* | 0.19* | 0.17* | 0.22* | 0.43* | 0.16* | 0.52 | 0.16* |

EGAF: El- Gabal EL- Asfar Farm, ARF: Abu- Rawash Farm, EAR: El- Ashir of Ramadan,
TSE: Treated sewage effluent IE: Industrial effluent * : significant at LSD 0.05%
Permissible limit according to FAO (1992) and Egyptian code 2004 (ppm)

## Plant Analysis

### Effect of wastewater irrigation on plant content(%) of macronutrients:

Data in Table (4) show the mean plant values of NPK content in corn, wheat and clover plants grown on the studied three sites during two successive years (from summer 2007 to winter 2009). In view of nitrogen concentration, the results showed that irrigation with IE caused significantly increment in the content of N in both roots and shoots of corn plants, while the grains content of N increased significantly in corn grown in EGAF followed by that grown in EAR then that grown in ARF. Also, the results indicated that, the mean values of P concentrations increased in root and shoot of corn plants grown in soil irrigated with IE. With respect to the grains content of P it can be observe that, the concentration of P increased significantly in grains grown in soil irrigated with IE from that grown in soil irrigated with TSE. With regard to K concentration, data in Table (4) declared that, the mean content of K increased significantly in both root, shoot and grains of corn plants grown in soil receiving IE irrigation compared to soil irrigated with TSE in ARF and EGAF. It is obvious that P and K concentrations tended to attain higher contents in root, shoot and grains of corn plants grown in EAR than that grown in soil irrigated with IE. Considering the concentration of macronutrients in clover plant, the results indicated that, the mean concentration of N, P and K increased significantly in the root and shoot of clover plants grown in soil receiving IE compared with those irrigated with TSE. Additionally there was insignificantly increase in the concentration of P and K in root and shoot of plants irrigated with TSE in EGAF compared with those grown in ARF. Kiziloglu *et al*. (2008) recorded that wastewater irrigation affected significantly plant nutrient content after harvest. They added that application of wastewater increased plant available phosphorus and microelements.

The results in Table (4) also, indicated that, the mean concentration of N, P and K increased significantly in both root, shoot and grains of wheat plants grown in EAR compared to the corresponding ones grown in soil irrigated with TSE. On the other hand, the mean concentration of P in shoot of wheat plants grown in EGAF did not differ significantly compared with that grown in ARF. The same trend was observed for the mean values of P and K in shoot of wheat plants grown in EGAF compared with those grown in ARF. Additionally P concentration in grains of wheat plants in EGAF show the same results as compared with that grown in EAR. In this respect, Rusan *et al*. (2007) demonstrated that long term wastewater irrigation increased plant nutrients in the soil. Plant essential nutrients (Total- N, $NO_3$, P, and K) were higher in plants grown in soils irrigated with wastewater. They also recorded that phosphorus concentration in barley shoot increased significantly 10 years of wastewater irrigation increased. It increased from 0.18 % in the control treatment to 0.28 % in the 10 years irrigated with wastewater. There was no significant difference in phosphorus concentration between the control and 2 years irrigated with wastewater. Also, Emongor and Ramolemana (2004) recorded that the use of sewage effluent for irrigation of horticultural crops will supply some of the P and K needed by plants. Therefore, the amount of fertilizer applied as part of the effluent will be a plus factor and must be accounted for when considering the fertilizer requirements of horticultural crops.

## Effect of wastewater irrigation on plant content of the biogenic and non biogenic heavy metals

Data in Table (5) show non biogenic (Cd, Co, Ni and Pb), and biogenic heavy metals ( Fe, Zn, Cu and Mn) concentration (mg/kg) in corn, wheat and clover plants grown under treated sewage effluent (TSE) and industrial effluent ( IE) used as irrigation water in the studied locations. From these data, the following conclusion could be elucidated.

**Table (4): Nitrogen, phosphorus and potassium content (%) of plants grown in the studied locations ( mean values)**

| Plant | Site | Plant parts | Macronutrients (%) | | |
|---|---|---|---|---|---|
| | | | N | P | K |
| Corn | EGAF | Root | 1.245 | 0.735 | 0.860 |
| | ARF | | 0.810 | 0.240 | 0.525 |
| | EAR | | 1.448 | 0.870 | 1.285 |
| | | | LSD at 0.05 | | |
| | EGAF& ARF | | 0.24* | 0.14* | 0.17* |
| | EGAF& EAR | | 0.18* | 0.14 | 0.15* |
| | ARF & EAR | | 0.22* | 0.06* | 0.16* |
| | EGAF | Shoot | 1.805 | 0.700 | 0.773 |
| | ARF | | 1.400 | 0.507 | 0.593 |
| | EAR | | 2.235 | 0.900 | 1.185 |
| | | | LSD at 0.05 | | |
| | EGAF& ARF | | 0.33* | 0.07* | 0.19 |
| | EGAF& EAR | | 0.22* | 0.12* | 0.10* |
| | ARF & EAR | | 0.28* | 0.11* | 0.17* |
| | EGAF | Grains | 2.055 | 0.195 | 0.370 |
| | ARF | | 0.790 | 0.335 | 0.325 |
| | EAR | | 1.497 | 0.325 | 1.265 |
| | | | LSD at 0.05 | | |
| | EGAF& ARF | | 0.28* | 0.09* | 0.15 |
| | EGAF& EAR | | 0.34* | 0.14* | 0.18* |
| | ARF & EAR | | 0.27* | 0.13 | 0.11* |
| Clover | EGAF | Root | 0.595 | 0.275 | 0.420 |
| | ARF | | 0.753 | 0.360 | 0.470 |
| | EAR | | 1.680 | 0.595 | 1.283 |

| | | | | | |
|---|---|---|---|---|---|
| | | | LSD at 0.05 | | |
| | EGAF& ARF | | 0.11* | 0.10 | 0.14 |
| | EGAF& EAR | | 0.15* | 0.18* | 0.09* |
| | ARF & EAR | | 0.15* | 0.19* | 0.15* |

**Table (4): Continued**

| Plant | Site | Plant parts | Macronutrients (%) | | |
|---|---|---|---|---|---|
| | | | N | P | K |
| Clover | EGAF | Shoot | 0.710 | 0.225 | 0.488 |
| | ARF | | 1.230 | 0.255 | 0.557 |
| | EAR | | 1.655 | 0.798 | 1.465 |
| | | | LSD at 0.05 | | |
| | EGAF& ARF | | 0.36* | 0.05 | 0.12 |
| | EGAF& EAR | | 0.27* | 0.18* | 0.17* |
| | ARF & EAR | | 0.41* | 0.18* | 0.16* |
| Wheat | EGAF | Root | 1.680 | 0.290 | 0.895 |
| | ARF | | 0.585 | 0.362 | 0.605 |
| | EAR | | 1.935 | 0.960 | 1.705 |
| | | | LSD at 0.05 | | |
| | EGAF& ARF | | 0.12* | 0.11 | 0.12* |
| | EGAF& EAR | | 0.10* | 0.18* | 0.11* |
| | ARF & EAR | | 0.11* | 0.20* | 0.12* |
| | EGAF | Shoot | 0.485 | 0.295 | 0.695 |
| | ARF | | 1.090 | 0.255 | 0.755 |
| | EAR | | 2.902 | 0.885 | 1.875 |
| | | | LSD at 0.05 | | |
| | EGAF& ARF | | 0.19* | 0.11 | 0.18 |
| | EGAF& EAR | | 0.22* | 0.15* | 0.13* |
| | ARF & EAR | | 0.26* | 0.16* | 0.16* |
| | EGAF | Spike | 1.195 | 0.340 | 0.405 |
| | ARF | | 0.420 | 0.180 | 0.215 |

| | | | | | |
|---|---|---|---|---|---|
| | EAR | | 1.570 | 0.295 | 1.330 |
| | | | LSD at 0.05 | | |
| | EGAF& ARF | | 0.10* | 0.06* | 0.10* |
| | EGAF& EAR | | 0.21* | 0.10 | 0.14* |
| | ARF & EAR | | 0.21* | 0.10* | 0.14* |

EGAF: El- Gabal EL- Asfar Farm, ARF: Abu- Rawash Farm, EAR: El- Ashir of Ramadan,
TSE: Treated sewage effluent IE: Industrial effluent * : significant at LSD 0.05%

Table (5): Non biogenic and biogenic heavy metals concentrations (mg/kg) of plants grown in the studied locations

| Plant | Site | Plant parts | Non biogenic heavy metals (mg/kg) | | | | Biogenic heavy metals (mg/kg) | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Cd | Co | Ni | Pb | Fe | Zn | Cu | Mn |
| Corn | EGAF | Root | 5.65 | 6.97 | 70.92 | 96.55 | 179.95 | 125.84 | 62.25 | 138.42 |
| | ABF | | 2.41 | 5.00 | 61.13 | 94.71 | 114.67 | 126.14 | 56.35 | 138.08 |
| | EAR | | 4.77 | 9.39 | 146.12 | 189.45 | 252.79 | 196.71 | 121.48 | 234.31 |
| | | | LSD at 0.05 | | | | | | | |
| | EGAF& ARF | | 0.65* | 1.04* | 3.81* | 2.06 | 12.44* | 11.72 | 2.88* | 11.55 |
| | EGAF& EAR | | 0.62* | 1.01* | 13.50* | 4.06* | 12.58* | 11.39* | 3.33* | 5.06* |
| | ARF & EAR | | 0.68* | 0.84* | 13.01* | 4.07* | 2.05* | 3.79* | 3.07* | 10.42* |
| | EGAF | Shoot | 3.05 | 6.52 | 61.81 | 91.82 | 169.42 | 126.51 | 32.33 | 118.49 |
| | ABF | | 2.09 | 4.68 | 69.35 | 83.17 | 187.77 | 107.92 | 27.82 | 114.99 |
| | EAR | | 4.33 | 10.46 | 159.85 | 184.03 | 233.50 | 191.64 | 122.34 | 168.16 |
| | | | LSD at 0.05 | | | | | | | |
| | EGAF& ARF | | 0.54* | 1.35* | 1.59* | 1.75* | 16.17* | 5.18* | 5.13 | 5.77 |
| | EGAF& EAR | | 0.67* | 1.29* | 4.71* | 3.19* | 12.37* | 3.56* | 3.26* | 50.13 |
| | ARF & EAR | | 0.62* | 0.89* | 4.47* | 3.34* | 11.09* | 3.95* | 4.48* | 49.94* |
| | EGAF | Grains | 3.14 | 6.26 | 54.13 | 81.49 | 100.62 | 95.14 | 24.50 | 113.36 |
| | ABF | | 2.07 | 4.36 | 62.87 | 63.59 | 153.79 | 94.67 | 24.77 | 112.47 |
| | EAR | | 3.96 | 9.41 | 155.49 | 71.55 | 228.34 | 185.07 | 126.28 | 104.79 |
| | | | LSD at 0.05 | | | | | | | |
| | EGAF& ARF | | 0.55* | 1.00* | 5.04* | 1.78* | 11.05* | 7.92 | 2.68 | 1.28 |
| | EGAF& EAR | | 0.46* | 0.92* | 3.02* | 2.65* | 11.25* | 7.12* | 2.33* | 7.52* |
| | ARF & EAR | | 0.59* | 1.04* | 4.57* | 2.88* | 3.72* | 3.93* | 1.45* | 7.44* |
| Clover | EGAF | Root | 3.25 | 9.57 | 99.90 | 61.50 | 158.86 | 64.69 | 20.90 | 144.62 |
| | ABF | | 3.64 | 3.73 | 116.12 | 191.39 | 379.92 | 92.89 | 44.55 | 133.56 |
| | EAR | | 6.57 | 12.43 | 257.51 | 214.18 | 266.78 | 154.25 | 103.97 | 215.11 |
| | | | LSD at 0.05 | | | | | | | |
| | EGAF& ARF | | 0.72 | 1.64* | 2.83* | 6.40* | 25.37* | 8.81* | 9.57* | 33.27 |
| | EGAF& EAR | | 0.90* | 1.99* | 4.22* | 23.32* | 23.95* | 39.71* | 9.96* | 32.90* |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | ARF & EAR | | 0.97* | 1.81* | 3.76* | 22.86* | 225.98 | 38.82* | 13.42* | 5.80* |
| | EGAF | Shoot | 2.37 | 7.84 | 85.20 | 46.41 | 112.89 | 54.09 | 7.37 | 80.28 |
| | ABF | | 2.72 | 4.36 | 94.52 | 162.35 | 350.38 | 82.86 | 20.23 | 125.50 |
| | EAR | | 4.11 | 9.83 | 247.55 | 208.88 | 218.40 | 108.30 | 103.33 | 234.82 |
| | | | LSD at 0.05 | | | | | | | |
| | EGAF& ARF | | 0.86 | 1.33* | 8.81* | 4.97* | 80.54* | 3.42* | 1.26* | 3.24* |
| | EGAF& EAR | | 1.17* | 1.82* | 18.05* | 22* | 12.87* | 5.43* | 8.30* | 21.50* |
| | ARF & EAR | | 1.11* | 2.02* | 16.02* | 22.57* | 13.08* | 5.74* | 8.36* | 21.72* |

Table (5): Continued

| Plant | Site | Plant parts | Non biogenic heavy metals (mg/kg) | | | | Biogenic heavy metals (mg/kg) | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Cd | Co | Ni | Pb | Fe | Zn | Cu | Mn |
| Wheat | EGAF | Root | 3.14 | 6.81 | 90.72 | 52.15 | 111.16 | 88.31 | 17.76 | 141.24 |
| | ABF | | 2.64 | 6.99 | 91.32 | 81.46 | 142.70 | 76.74 | 15.26 | 135.74 |
| | EAR | | 5.73 | 14.64 | 116.22 | 119.77 | 258.01 | 195.59 | 104.32 | 287.77 |
| | | | LSD at 0.05 | | | | | | | |
| | EGAF& ARF | | 1.27 | 1.2 | 3.98 | 5.30* | 2.53* | 7.40* | 4.78 | 3.61* |
| | EGAF& EAR | | 1.81* | 1.64* | 8.43* | 5.27* | 41.27* | 7.75* | 8.43* | 5.09* |
| | ARF & EAR | | 1.54* | 1.85* | 7.67* | 2.00* | 41.24* | 1.69* | 7.11* | 4.24* |
| | EGAF | Shoot | 2.45 | 6.33 | 80.10 | 43.21 | 147.17 | 83.24 | 8.65 | 120.71 |
| | ABF | | 2.82 | 5.29 | 83.50 | 84.90 | 153.04 | 71.31 | 18.15 | 120.39 |
| | EAR | | 4.56 | 13.83 | 92.54 | 112.60 | 290.00 | 131.55 | 78.01 | 220.13 |
| | | | LSD at 0.05 | | | | | | | |
| | EGAF& ARF | | 0.81 | 0.84* | 2.40* | 3.10* | 20.01 | 13.29 | 1.41* | 16.74 |
| | EGAF& EAR | | 0.97* | 1.35* | 1.78* | 3.08* | 20.44* | 14.45* | 1.24* | 17.31* |
| | ARF & EAR | | 1.05* | 1.40* | 2.62* | 1.70* | 4.76* | 5.87* | 1.74* | 4.81* |
| | EGAF | Spike | 1.34 | 4.30 | 79.08 | 49.65 | 169.79 | 83.32 | 12.49 | 121.71 |
| | ABF | | 2.83 | 4.65 | 79.62 | 65.56 | 132.15 | 22.83 | 19.32 | 9.89 |
| | EAR | | 3.18 | 9.64 | 99.85 | 85.01 | 208.16 | 138.23 | 89.37 | 127.94 |
| | | | LSD at 0.05 | | | | | | | |
| | EGAF& ARF | | 0.68* | 1.10 | 6.66 | 3.12* | 28.81* | 15.32* | 1.65* | 3.10* |
| | EGAF& EAR | | 1.17* | 1.36* | 6.21* | 3.42* | 31.79* | 15.32* | 2.33* | 57.22 |
| | ARF & EAR | | 1.16 | 1.26* | 2.83* | 2.43* | 13.70* | 2.37* | 2.42* | 57.23* |
| | Maximum permit limit | | 0.50 | 0.50 | 10.00 | 9.00 | | 100.00 | 20.00 | |

*: significant at 0.05 LSD
ARF: Abu- Rawash Farm
EGAF: El- Gabal El- Asfar Farm
EAR: El- Ashir of Ramadan region

Maximum permit limit of elements (mg/kg) in vegtables and fruits according to National Environmental protection Agency of China, Turkdogan *et al*., 2003 .

The concentration of biogenic and non biogenic heavy metals increased significantly in the studied plant parts grown in soil receiving IE compared with that receiving TSE (except in some cases). For example the mean concentrations of non biogenic heavy metals ( Cd, Co, Ni and Pb) were 4.77, 9.39, 146.12 and 189.45 mg/kg, respectively in root of corn plant grown in soil receiving IE, meanwhile the mean concentrations of these metals were 2,41, 5.00, 61.13 and 94.71 mg/kg, respectively in corn root plant grown in soil irrigated with TSE in ARF. Data also revealed that, the concentrations of biogenic and non biogenic heavy metals were significantly higher in plant parts grown under TSE for long period about 100 year in EGAF than those of plants grown under shorter period for about 50 year in ARF, for the exception in some cases. Considering the concentrations of tested heavy metals within the different parts of the studied plants, it is obvious that these heavy metals (bio and non biogenic) tended to accumulate generally in the roots rather than in shoots then grains or spikes in the most cases. In this concern, Singh *et al*. (2010) mentioned that using wastewater irrigation led to accumulation of heavy metals in soil and consequently into the vegetables. Heavy metals concentrations varied among the vegetables, which reflect the differences in their uptake capabilities and their further translocation to edible portion of the plants. Arora *et al*. (2008) recorded that, the difference of the metal contents in vegetables depend on the physical and chemical nature of the soil and absorption capacity of each metal by the plant, which is altered by various factors like environmental and human interference, and the nature of the plant.

Comparing the concentration of bio and non biogenic heavy metals of the different parts of the studied plant parts in summer and winter seasons with those obtained by National Environmental Protection Agency of China (1995) and Turkdogan *et al*. (2003). According to these references the safe limits for the determined heavy metals were 0.50, 0.50, 10.00, 9.00, 100.00 and 20.00 (mg/kg) for Cd, Co, Ni, Pb, Zn and Cu, respectively. The results indicated that all the values of the tested bio and non biogenic heavy metals in the studied plants under the present investigation exceeded the maximum permit limits except in a few cases. Khan *et al*. (2008) recorded that heavy metal concentrations in plants grown in wastewater-irrigated soils were significantly higher ($p \leq 0.001$) than in plants grown in the reference soil, and exceeded the permissible limits set by the State Environmental Protection Administration (SEPA) in China and the World Health Organization (WHO).

## Conclusion and recommendation

It can be concluded, based on these results that proper management of wastewater irrigation and periodic monitoring of soil fertility and quality parameters are required to ensure successsful and safe long term reuse of wastewater for irrigation. The long term wastewater irrigation has led to contamination of soils and food crops in the study area. The author strongly recommended that it must be do not use the industrial effluent in irrigation the crops that eaten by human or animals because these lead to bioaccumulation of heavy metals that cause risks to the consumers, scince dietary of food results in long- term low body accumulation of heavy metals and detrimental impact becomes apparent only after several years of consumed these food.

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# محتوى بعض النباتات المروية بالمياه العادمة من المغذيات والفلزات الثقيلة

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## الملخص العربي

أجريت دراسة لتقييم مستويات الفلزات الثقيلة الغير حيوية (كادميوم، كوبلت، نيكل ورصاص) والحيوية (حديد ، زنك ، نحاس و منجنيز) وايضا المغذيات الكبرى (نيتروجين ، فوسفور وبوتاسيوم) فى النباتات المروية بمياه صرف صحى معالج ومياه صرف صناعى من مصادر مختلفة. وقد جمعت العينات المختلفة للمياه المستخدمة فى الرى والنباتات المنزرعة فى الفترة من شهر يوليوعام ٢٠٠٧ حتى شهر يناير عام ٢٠٠٩ وذلك من ثلاث مواقع. الموقع الاول مزرعة الجبل الاصفر ، الموقع الثانى مزرعة ابو رواش والموقع الثالث منطقة العاشر من رمضان. تستخدم مياه الصرف الصحى المعالج للرى فى منطقتى الجبل الاصفر وأبو رواش بينما تستخدم مياه الصرف الصناعى للرى فى منطقة العاشر من رمضان والتى تضم العديد من المصانع.

وقد اوضحت تحليلات مياه الرى ان المحتوى من المغذيات الكبرى والفلزات الثقيلة الحيوية والغير حيوية فى مياه الصرف الصناعى اكثرمن مياه الصرف الصحى المعالج . كما أظهرت النتائج زيادة الفلزات الثقيلة الحيوية والغير حيوية زيادة معنوية فى جميع النباتات المروية بالمياه العادمة المستخدمة وذلك عند مقارنتها بالحدود المسموح بها دوليا طبقا للمنظمة العالمية لحماية البيئة

National Environmental Protection Agency of China (1995) and Turkdogan *et al*., 2003

وأيضا فان اقصى زيادة فى المحتوى من كل من الفلزات الثقيلة الحيوية والغير حيوية وجد فى نباتات الذرة ، القمح والبرسيم المروية بمياه الصرف الصناعى بالمقارنة بمثيلاتها المروية بمياه صرف صحى معالج .