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Impact of wastewater irrigation on concentration and absorption of nutrients and heavy metals in barley in calcareous soils

Solmaz Ahmadifard*

Department of Soil Science, College of Agriculture, Islamic Azad University, Khorasgan Branch, Isfahan, Iran

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Key words: Heavy metals, Wastewater, Nutrients, Calcareous soils, barley.

Abstract

In arid and semiarid regions such as Iran, wastewater reuse can be a means to compensate for the lack of water. The use of refined wastewater in agriculture will reduce the use of agriculture water that it can be used for other purpose such as drinking. A study was carried out to investigate the effect irrigation with wastewater effluent on concentration and absorption of nutrients and heavy metals in barley grown in the calcareous soils. Surface soil samples (0-30 cm) were collected from Najafabad, Khatoonabad and Lenjan areas in Isfahan province, Iran.A pot experiment consisted of 2 irrigation treatments including irrigation with tap water and with wastewater and 3 soils was conducted in the green house. Plants were grown in pots and they were irrigated with urban water effluent for 70 days. Plant samples were analyzed after barley harvest. Selected nutrients and heavy metals concentration and absorption were also determined in barley. Irrigation with waste water increase concentration and absorption of phosphorus (P), iron (Fe) and zinc (Zn) in barley.

***Corresponding Author:** SolmazAhmadifard ✉ ahmadifard_s@yahoo.com

Introduction

Nowadays with the increasing population and industrial development, water isn't available abundant and readily for human. In addition the massive industrial developments in every society depend on being and abundance of water (Hosseinian, 2002. Gholamalizadeh, 2007).In many countries, poor water quality and which ones are good and bad in the boundary waters, are used. These waters are often the only source and while the plant may not be the maximum yield, have economic efficiency.Iran's average annual rain fall is 250 mm that is in the arid region of the world. If sewage effluent into the water cycle, on the other hand, were reduced removal from aquifers and were revived and again could be improved by adding some elements and the characteristics of the soil.

Effluent is the liquid part of the sewage treatment that it has passed wastewater processes but it is pollution and reuse depend on the quantity and quality of raw wastewater, treatment level and environment standards (Takdastan and Pazouki, 2007).Reuse of wastewater for irrigation can be a real way to prevent the loss of water resources. Therefore due to the water shortage and the need to exploitation of non-conventional water resources, optimal utilization of the effluent wastewater from urban areas is one of the most important research topics. The use of wastewater, on the one hand, prevent the discharge of sewage into the environment and on the other hands, due to reduction and cessation of use of chemical and organic fertilizers prevent of harmful effects of this material on the environment. Thus, in areas with limited water resources treatment effluent use for agriculture and industry (Asano and Mails, 1990).

The first scientific report on wastewater reuse was published in 1921 by doctor Emamoff. According to the theories of this scientist, the wastewater and effluent can be transformed by treatment so that can be used in urban or rural typical applications and reuse it continued as long as the limitation are not of elements concentration.

The most important reuse of wastewater effluent and polluted water to be considered, as follows:Agriculture uses, industrial uses, artificial recharge groundwater, recreational and urban uses (Hosseinian, 2002).Among the use for wastewater, using in agriculture may be more important (Hosseinian, 2002).

Irrigation with wastewater for more using of water in agriculture is taken into consideration. Irrigation with wastewater management should be done and the positive and negative effects of such operation on soils and plants and environmental quality be recognized as well as (Glogen and Forti, 2006).Wastewaters often contain significant concentrations of organic and inorganic nutrients for example nitrogen, phosphate, micronutrients and heavy metals (Mojiri *et al.*, 2013). Municipal wastewater treatment may be contaminating the soil and the accumulation of potentially toxic elements in soils and plants (Ebrahimizadeh *et al.*, 2006).These adverse effects can be included accumulation of metals such as Cr, Ni, Cd that primarily infect the soil and sometimes wastewater limits can be related to the salinity, pH and high concentrations of cations and anions (Rahmani, 2005).Sewage effluent is a source of nutrients for plants. The use of sewage will increase soil fertility and crop (Behrouz and Liaghat).Harmful of variety metals can be found at the factories wastewater are not same copper losses in plant is double of zinc and nickel losses is eight times the zinc (Borognot *et al.*, 1992).

The culture of the millet corn, sorghum of forage plants and sunflower of oil plants in sandy soils and irrigation with wastewater and fresh water along the commercial fertilizer it is shown that amount of harvesting of farmlands irrigated with wastewater treatment compared to irrigated farmlands with fresh water and fertilizer are more (Monte and Isusa, 1992).Nazari *et al.* (2006) reported that effluent application increased nitrogen concentration in plant as for wheat and barley provide the plant nitrogen required in comparison with presented critical limit but in the case of corn, the plant needs more fertilizer to us with this material is considered. Wastewater application didn't have effect on the concentration of phosphorus and potassium but the concentration of Fe, Zn, Mn, Cu, Ni, Pb, Co and also increase the yield of plant's dry weight. In this study be considered the Impact of wastewater irrigation on concentration and absorption of nutrients and heavy metals in barley in calcareous soils**.**

Materials and methods

Site description

The experiment was carried out in green house, Faculty of Agriculture, Islamic Azad University, Khorasgan Branch in 2010. Surface (0-30) soil samples were collected from Najaf abad, Khatoon abad and Lenjan regions in Isfahan province in central of Iran. Then the samples were transferred to the university green house.

Plant sample preparation

Soils were air-dried, passed 4-mm sieve and were transferred into 3 Kg pots.barley seeds were planted in each pot and pots were irrigated with either tap water (control treatment) or wastewater collected weekly from Shahinshar sewage treatment facilities. Barley seeds (Ghods) were soaked in water for 24 hours and planted in pots. Barley seedlings were reduced to 4 in each pot and were irrigated with 250-400 mL of either tap water or wastewater every other day.

Aerial parts of plants were harvested after 70 days. Barley dry yield determined and plants and soil samples from each pot were taken for chemical analysis.

Laboratory analysis

Available potassium was extracted by ammonium acetate and was measured by Flame photometer (Zarinkafsh, 1993). Total nitrogen concentration was measured by Kjeldahl method (ASA, 1982). Plants heavy metals content were determined after dry ashing and acid extraction using AAS (Ganj and Page, 1974). Data were analyzed using SAS and graphs were prepared using Excel.

Results and discussion

Analysis of tap and wastewater are shown in Table 1. Effect of irrigation with sewage effluents on concentration and absorption of nutrients and heavy metals in barley are shown in figs. 1-14.

Table 1. Analysis of tap and waste water.

	pH	P (mg L^{-1})	N (%)	K (mg L^{-1})	Fe (mg L^{-1})	Cu (mg L^{-1})	Zn (mg L^{-1})	Mn (mg L^{-1})
Tap water	7.3	0	0	0.01	0.002	0	0.001	0
Waste water	6.90	17.3	28.0	25.6	0.20	0.031	0.04	0.051

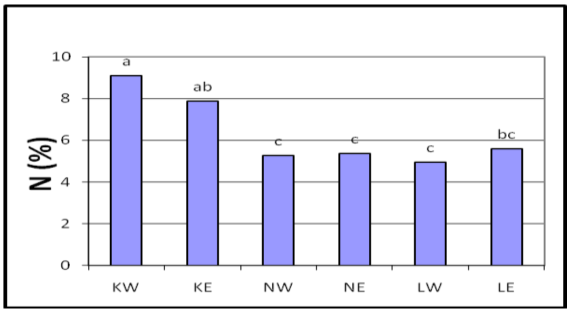

Fig. 1. Effect of wastewater irrigation on N concentration in barley.

K=Khatoonabad, N=Najafabad, L=Lenjan, W=Tap water, E=Effluent.

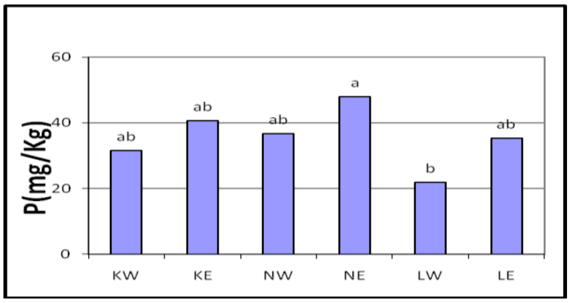

Fig. 2. Effect of wastewater irrigation on P concentration in barley.
K=Khatoonabad, N=Najafabad, L=Lenjan, W=Tap water, E=Effluent.

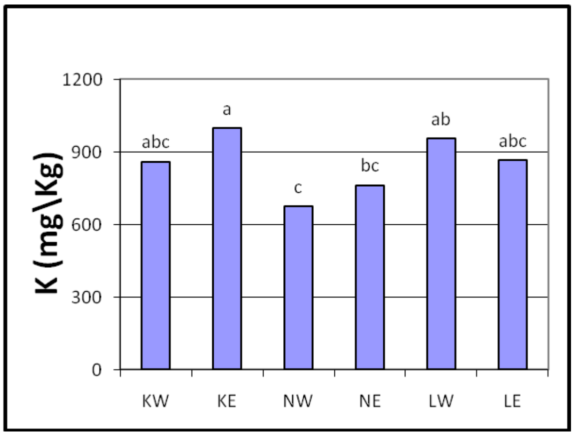

Fig. 3. Effect of wastewater irrigation on K concentration in barley.
K=Khatoonabad, N=Najafabad, L=Lenjan, W=Tap water, E=Effluent.

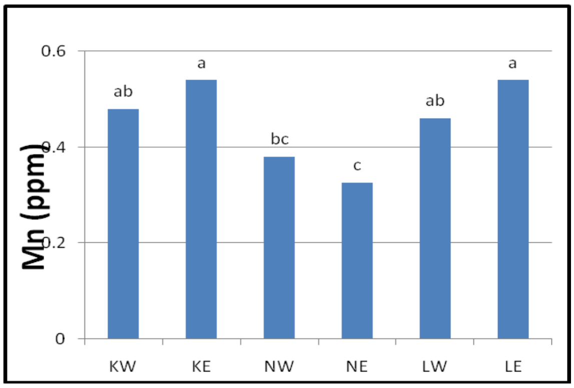

Fig. 4. Effect of wastewater irrigation on Mn concentration in barley.
K=Khatoonabad, N=Najafabad, L=Lenjan, W=Tap water, E=Effluent.

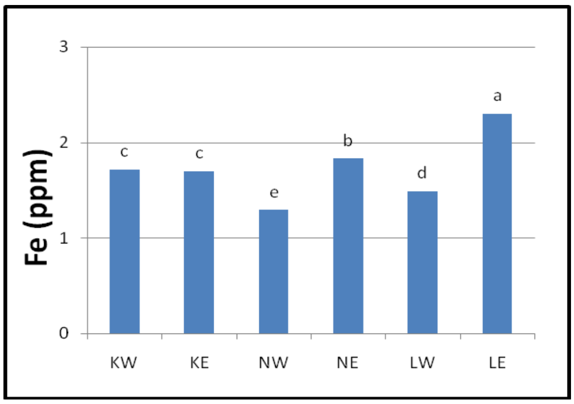

Fig. 5. Effect of wastewater irrigation on Fe concentration in barley.
K=Khatoonabad, N=Najafabad, L=Lenjan, W=Tap water, E=Effluent.

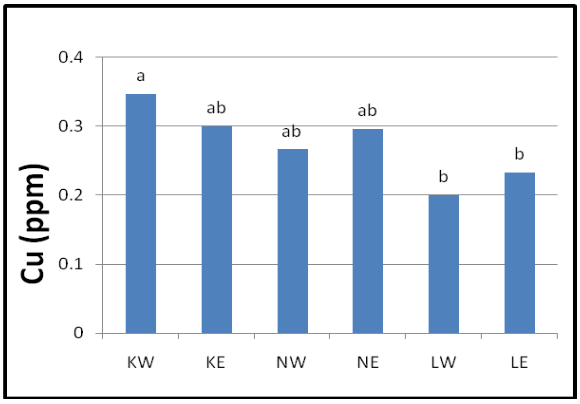

Fig. 6. Effect of wastewater irrigation on Cu concentration in barley.
K=Khatoonabad, N=Najafabad, L=Lenjan, W=Tap water, E=Effluent.

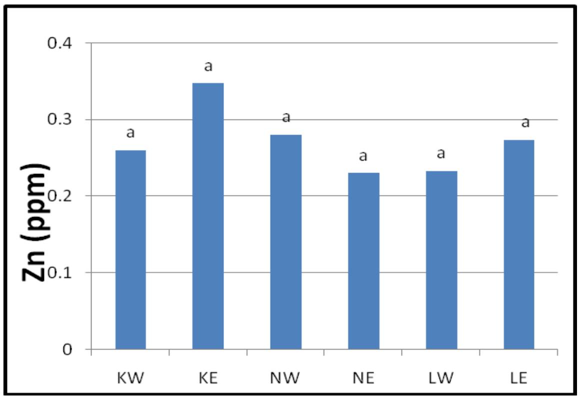

Fig. 7. Effect of wastewater irrigation on Zn concentration in barley.
K=Khatoonabad, N=Najafabad, L=Lenjan, W=Tap water, E=Effluent.

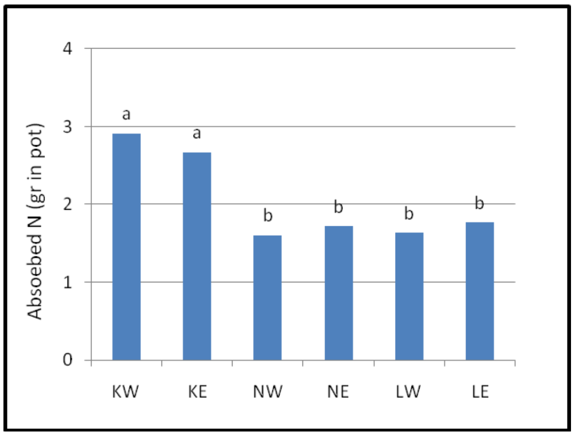

Fig. 8. Effect of wastewater irrigation on absorbed N in barley.

K=Khatoonabad, N=Najafabad, L=Lenjan, W=Tap water, E=Effluent.

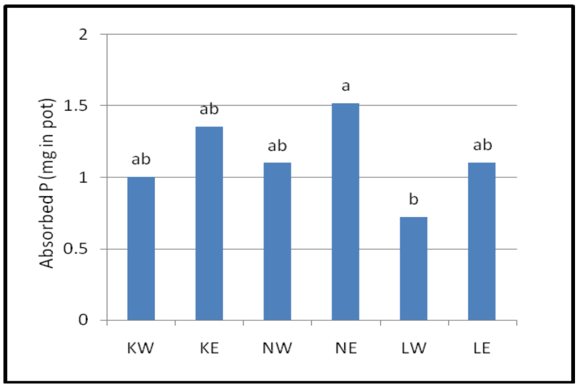

Fig. 9. Effect of wastewater irrigation on absorbed P in barley.

K=Khatoonabad, N=Najafabad, L=Lenjan, W=Tap water, E=Effluent.

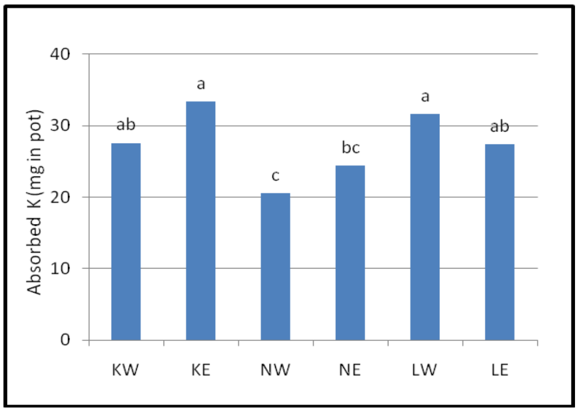

Fig. 10. Effect of wastewater irrigation on absorbed K in barley.

K=Khatoonabad, N=Najafabad, L=Lenjan, W=Tap water, E=Effluent.

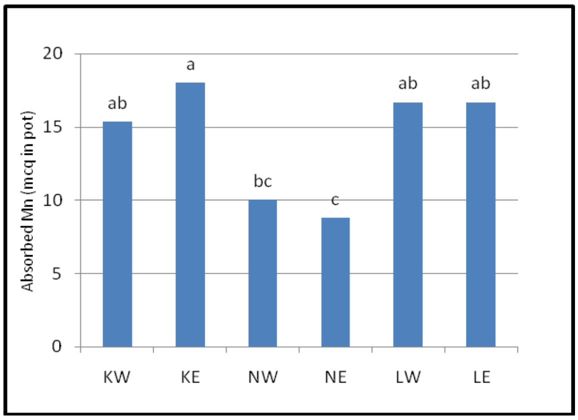

Fig. 11. Effect of wastewater irrigation on absorbed Mn in barley.

K=Khatoonabad, N=Najafabad, L=Lenjan, W=Tap water, E=Effluent.

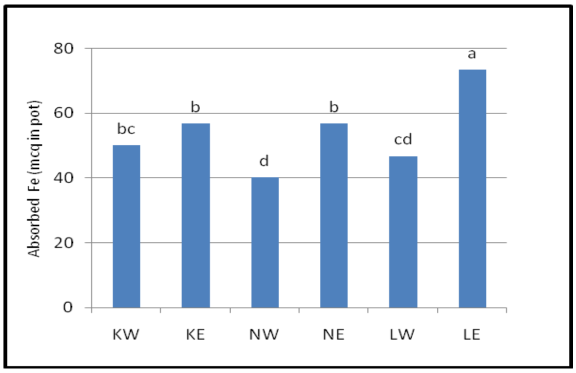

Fig.12. Effect of wastewater irrigation on absorbed Fe in barley.

K=Khatoonabad, N=Najafabad, L=Lenjan, W=Tap water, E=Effluent.

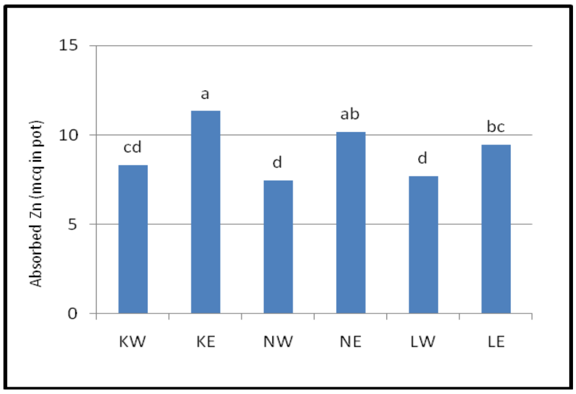

Fig.13. Effect of wastewater irrigation on absorbed Zn in barley.

K=Khatoonabad, N=Najafabad, L=Lenjan, W=Tap water, E=Effluent.

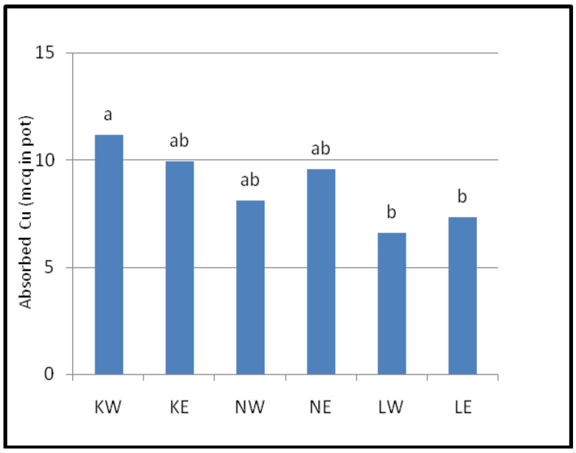

Fig.14. Effect of wastewater irrigation on absorbed Cu in barley.
K=Khatoonabad, N=Najafabad, L=Lenjan, W=Tap water, E=Effluent.

Effect of wastewater on nutrients and heavy metals concentration in barley

Nitrogen (T)

Effect of wastewater irrigation on N concentration of barley plant is shown in Fig. 1. N concentration in barley irrigated with wastewater in the Khatoonabad soil decreased slightly and in Najafabad soil remained unchanged and in Lenjan soil increased slightly and the changes were not significant in any soil. Highest N concentration was in barley grown in Khatoonabad soil irrigated with tap water and the lowest was in barley grown in Lenjan soil irrigated with tap water.

Phosphorus (P)

Effect of irrigation with effluent on phosphorus concentration in barley grown in three soils is shown in Fig. 2. P concentration of barley grown on every three soils due to use wastewater increased. However this increase was not significant in any of the soils. The highest concentration of P in barley plant related to Najafabad soil and in Lenjan soil is the lowest.

Potassium (K)

The effect of irrigation with wastewater on potassium concentration in three soils is shown in Fig. 3. Irrigation with wastewater increased slightly in K concentration in barley in Khatoonabad and Najafabad soils and decreased slightly in Lenjan soil. None of the increases and decreases is not significant. The highest concentration of K involved plants grown in Khatoonabad soil irrigated with wastewater and the lowest concentration of K involved plants grown in Najafabad soil irrigated with tap water that show significant difference.

Manganese (Mn)

Fig. 4 shows that irrigation with wastewater caused a reduction of Mn concentration in barley grown in Najafabad a mild increase in barley grown in Khatoonabad soil. Neither increase nor decreases were significant. Mn concentration in barley grown in Khatoonabad soil was higher than the other two soils.

Iron (Fe)

Effect of irrigation with wastewater on barley iron concentration is shown in Fig. 5. Irrigation with wastewater increased Fe concentration significantly in barley only in Lenjan soil. This is in line with findings of Kiayee (2013). In other 2 soils no effects was observed in barley Fe concentration.

Copper (Cu)

Effect of wastewater irrigation on Cu concentration of barley plant is shown in Fig. 6. Cu concentration in barley irrigated with wastewater in the Khatoonabad soil decreased slightly and in Lenjan and Najafabad increased. Highest Cu concentration was in barley grown in Khatoonabad soil irrigated with tap water and the lowest was in barley grown in Lenjan soil irrigated with tap water.

Zinc (Zn)

Effect of wastewater irrigation on the concentration of zinc in three soils is shown in Fig. 7. Irrigation with wastewater caused to increase Zn concentration in barley in Khatoonabad and Lenjan soils. The highest concentration of Zn related to barley grown in Khatoonabad soil and the lowest one related to barley grown in Lenjan and Najafabad soils. Difference between plants grown in these three soils was not significantly.

Effect of wastewater on nutrients and heavy metals absorption in barley

Nitrogen (T)

Fig. 8 shows that irrigation with wastewater caused a slight reduction of absorbed N concentration in barley grown in Khatooabad soil and a mild increase in barley grown in Najafabad and Lenjan soils. Neither increase nor decreases were significant. Absorbed N concentration in barley grown in Khatoonabad soil was higher than the other two soils.

Phosphorus (P)

The effect of irrigation with wastewater on absorbed phosphorus by barley is shown in Fig. 9. Absorbed P in barley grown on three soils increased due to use of wastewater however, this increase was not significant in any soils. The highest levels of P uptake were in the Najafabad soil irrigated with wastewater and the lowest was in Lenjan soil irrigated with tap water.

Potassium (K)

Fig.10 shows that irrigation with wastewater increased uptake of potassium in Khatoonabad and Najafabad soils and in Lenjan soil is reduced. None of the increases and decreases are not significant. The highest K uptake related to plants grown in Khatoonabad soil irrigated with wastewater and the lowest was in plant grown in Najafabad soil irrigated with tap water.

Manganese (Mn)

The effect of irrigation with wastewater on manganese uptake by barley is shown in Fig.11. Irrigation with wastewater increased Mn uptake by barley grown in Khatoonabad and Lenjan soils and decrease in the Najafabad soil. These increases and decreases are not significant in any soils. Mn absorption in barley grown in Najafabad soil was lower than two other soils.

Iron (Fe)

Effect of irrigation with effluent on iron uptake in barley grown in three soils is shown in Fig. 12. Fe uptake in barley grown on every three soils due to use wastewater increased. This increase was significant in Najafabad and Lenjan soils and in Khatoonabad was not significant. The highest concentration of Fe in barley plant related to Lenjan soil and in Najafabad soil is the lowest.

Zinc (Zn)

Fig. 13 shows that Zn uptake in barley grown on every three soils due to use wastewater increased. This increase was significant in every three soils. Zn absorption in barley grown in Khatoonabad soil was higher than the other two soils.

Copper (Cu)

Effect of wastewater irrigation on copper uptake in barley plant is shown in Fig. 14. Cu absorption in barley irrigated with wastewater in the Khatoonabad soil decreased slightly and in Lenjan and Najafabad soils increased slightly and the changes were not significant in any soil. Highest Cu uptake was in barley grown in Khatoonabad soil irrigated with tap water and the lowest was in barley grown in Lenjan soil irrigated with tap water.

Conclusion

Irrigation with wastewater effluents had not effect on concentration and absorption of nitrogen, manganese and copper by barley. Although the concentration and absorption of phosphorus, iron and zinc showed a slight increase in the effect of irrigation with wastewater.

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