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Effect of irrigation with municipal wastewater effluent on selected chemical properties of three calcareous soils and heavy metals concentration in corn

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Abstract

Water is a vital resource but a severely limited one in most countries, due to water restrictions and increased water consumption using wastewater is considered as a solution to resolve agricultural water requirement. A study was carried out to investigate the effect irrigation with municipal wastewater effluent on selected chemical properties of three calcareous soils and heavy metals concentration in corn grown in the soils and irrigated with the wastewater. 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. Wastewater was collected weekly from Shahinshahr water treatment facilities. Soil and plant samples were analyzed after corn harvest. Soil pH, electrical conductivity (EC) and selected soil properties including total nitrogen and selected heavy metals were determined in soil extracts. Selected heavy metals and micronutrients concentration were also determined in corn .Results indicated that soil irrigated with wastewater had a larger EC, organic matter (OM), total nitrogen (TN), available potassium (K), and nickel (Ni) content but lower pH. Irrigation with waste water did not increase concentration of heavy metals in corn.

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Introduction

In most arid and semiarid regions of the world, including Iran, scarcity of water is considered as one of the main problems on the path to sustainable agriculture. Due to water restrictions and increased water consumption using low quality water resources including wastewater is considered a solution to decrease agricultural water requirement (Galavi *et al.*, 2010).

Municipal wastewater is a combination of the water and carried wastes removed from residential, institutional and commercial establishments together with infiltration of water, surface water and runoff water (Rusan *et al.*, 2007).

Since wastewater is an uncommon source of water, its application in agriculture requires especial management to benefit advantages and to prevent its disadvantages in regard to the soil and underground water pollution and plant contamination (Asgari *et al.*, 2007).

Using large-scale wastewater irrigation on agricultural lands can be a synergistic management practice .The wastewater will have a different fate than being pumped into a river, agricultural crops can make use of the extra water and nutrients and ground water recharge is yet another positive outcome of wastewater irrigation (Walker and Lin, 2008).

Recently, the amounts of wastewater are sharply increasing and the kinds of pollutants are also varied as the world wide industry is being developed recently. With respect to both the quantity and composition, the textile processing wastewater is recorded as the most polluted sources among all industrial sectors (Chang *et al.*, 2009).

Rusan *et al.* (2007) investigated long term effect of wastewater irrigation of forage crops on soil and plant quality parameters .Their results showed plant Cu, Zn, Fe and Mn content increased with 2 years of wastewater irrigation, then reduced with longer period. Plant Pb and Cd content increased with wastewater irrigation and their levels were higher the longer the period of wastewater irrigation .Based on these results, it can be concluded that proper management of wastewater irrigation and periodic monitoring of soil and plant quality parameters are required to ensure successful, safe, long-term wastewater irrigation.

Al-Lahham *et al.* (2007) studied translocation of heavy metals from soil to tomato (Solanumlycopersicom L.) fruit irrigated with treated wastewater.

Results of tomato fruit analysis showed an increased concentration of Fe, Cu, Ni, Mn and Zn in the cultivar "RS589956", whereas, an increased concentration of Mn and Zn were detected in the cultivar "GS12", but no accumulation of Cd and Pb in either cultivars .The accumulation of heavy metals in fruit was below the Jordanian standard limits, thus, the use of treated wastewater in irrigation might be feasible.

Pérez *et al.* (2007) studied composted municipal waste effects on chemical properties of a Brazilian soil .The evidences provided by this experiment indicated that heavy metals are less likely to cause problems for the estimation of CMW (composted municipal waste) loadings to Brazilian agricultural land.

Tamoutsidis *et al.* (2009) investigated the effect of treated urban wastewater on soil properties, plant tissue composition and biomass productivity in beseem clover and corn .The results showed that the treated urban wastewater was suitable for irrigation of corn and clover, as the accumulation of the nutritive and toxic elements in the soil and in the species biomass varied in low level and didn't cause any nutrient deficit or toxicity in the plants.

Wastewater may contain large amount of micronutrients and heavy metals as well. When applied to soil, plants may take up large quantities of these metals and may contaminate human and animal food (Nazari *et al.*, 2006).

Research work on the impact of wastewater use in irrigation of plants particularly plants used as food or feed is very limited in Iran. This is the case while wastewater use for irrigation is widespread and increasing.

Since wastewater composition and soil properties are different in various parts of the world and even in different areas of one country, and the results obtained in one country or area could not directly be applied to another country or area, a study with the following objectives was necessary. i) to investigate the effect of irrigation with municipal wastewater as compared with tap water on the selected chemical properties of 3 calcareous soils and, ii) to study the concentration of selected heavy metals in corn grown in these soils.

Materials and methods

Site description

The experiment was carried out in green house, Faculty of Agriculture, Islamic Azad University, Khorasgan Branch in 2010. Three Surface soil samples (0-30 cm) were collected from Najafabad, Khatoonabad and Lenjan areas in Isfahan province in center of Iran.

Soil and plant sample preparation

Soils were air-dried, passed 4-mm sieve and were transferred into 3 Kg pots.Corn 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. Corn seeds (single cross 704) were soaked in water for 24 hours and planted in pots. Corn seedlings were reduced to 2 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. Corn dry yield determined and plants and soil samples from each pot were taken for chemical analysis.

Laboratory analysis

Soil pH, electrical conductivity (EC) and soluble cations were measured in 1:2 (soil: water) extract. 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). Heavy metals were extracted by DTPA and measured by AAS using the Standard Methods (APHA, 1998).

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

Effect of wastewater on soil properties

Analysis of tap and wastewater are shown in Table1.Effect of irrigation with sewage effluents on soil electrical conductivity, total nitrogen, available potassium and Ni are shown in figures 1-4.

Table 1. Analysis of tap and waste water.

	pH	EC (dS m^{-1})	N (%)	K (mg L^{-1})	Fe (mg L^{-1})	Cd (mg L^{-1})	Cr (mg L^{-1})	Ni (mg L^{-1})	Cu (mg L^{-1})	Zn (mg L^{-1})	Mn (mg L^{-1})
Tap water											
	7.3	0.38	0	0.01	0.002	0	0	0	0	0.001	0
Waste water											
	6.90	1.0	28.0	25.6	0.20	0.07	0.01	0.01	0.031	0.04	0.051

Electrical conductivity (EC)

Electrical conductivity of soils irrigated with wastewater increased (Fig.1) apparently because of higher EC of wastewater as compared to tap water (Table 1). Irrigation with wastewater has increased salinity of soils significantly. The highest increase was in Lenjan and the lowest was in Najafabad soil. This is in line with findings of Boroojeni *et al.* (2007).

Increasing the electrical conductivity of soil irrigated with wastewater is attributed to soluble salts in the wastewater (Mojiriet *al.*, 2011).

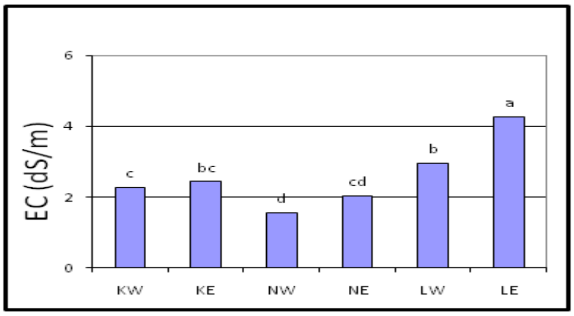

Fig. 1. Effect of wastewater irrigation on soil electrical conductivity. K=Khatoonabad, N=Najafabad, L=Lenjan, W=Tap water, E=Effluent.

Total nitrogen (TN)

According to Fig. 2, total N content of soils irrigated with wastewater was higher compared to soils irrigated whit tap water. This was due to the higher concentration of N in wastewater as compared to the tap water (Table 1). The differences were significant in all 3 soils. The highest increase was in Khatoonabad soil and the lowest was in Lenjan soil. This is in line with findings of Debosz *et al.* (2002).

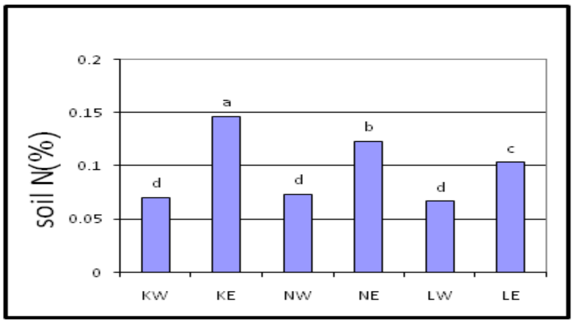

Fig. 2. Effect of wastewater irrigation on soiltotal nitrogen.

Available potassium (K)

According to Fig. 3, soil irrigated with wastewater showed an increase in available potassium compared to soils irrigated with tap water. This is likely due to the higher K content of waste water as compared to the tap water (Table 1). Changes in available potassium in Khatoonabad and Najafabad soils were not significant and showed only a small increase. This may be due to the higher K fixation capacity of these soils compared to the Lenjan soil. Glavi, *et al* (2010) found similar results.

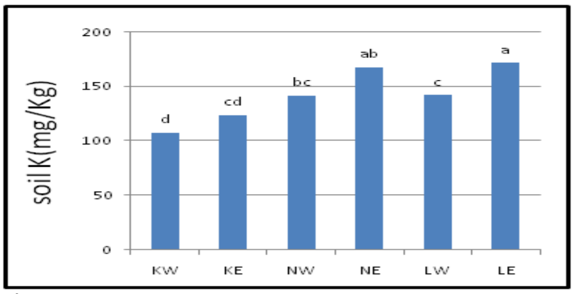

Fig. 3. Effect of wastewater irrigation on soilavailable potassium. K=Khatoonabad, N=Najafabad, L=Lenjan, W=Tap water, E=Effluent.

Nickel (Ni)

Wastewater contained higher concentrations of N, K, Fe, Cd, Cr and Ni compared to the tap water. Effect of irrigation with sewage effluents on heavy metals concentration of corn are shown in figures 5-8.

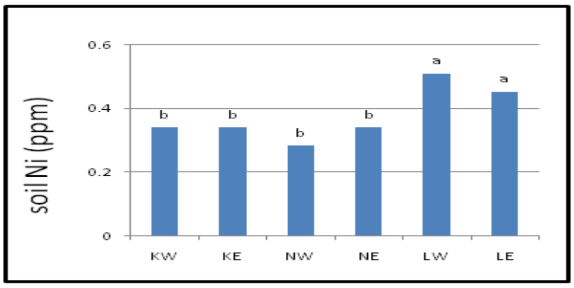

Fig. 4. Effect of wastewater irrigation on soil nickel. K=Khatoonabad, N=Najafabad, L=Lenjan, W=Tap water, E=Effluent.

Soil irrigated with wastewater showed a slight increase of nickel content especially in Lenjan soil (Fig.4). The increases were not, however, significant in any of soils. This is likely due to the higher concentration of Ni in waste water as compared to the tap water (Table 1).This is also in line with findings of Vaseghi *et al.*(2005).

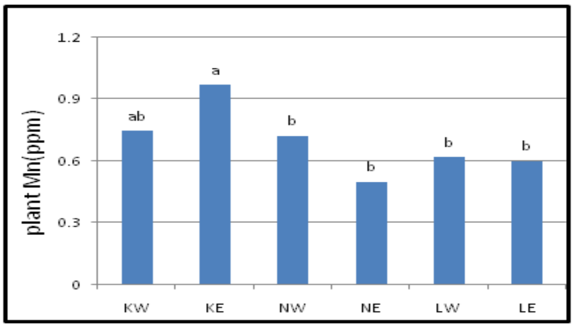

Fig. 5. Effect of wastewater irrigation on Mn concentration of corn. K=Khatoonabad, N=Najafabad, L=Lenjan, W=Tap water, E=Effluent.

Effect of wastewater on heavy metals concentration in corn

Manganese (Mn)

Fig. 5 shows that irrigation with wastewater caused a slight reduction of Mn concentration in corn grown in Najafabad and Lenjan and a mild increase in corn grown in Khatoonabad soil. Neither increase. nor decrease were significant. Mn concentration in corn grown in Khatoonabad soil was higher than the other two soils.

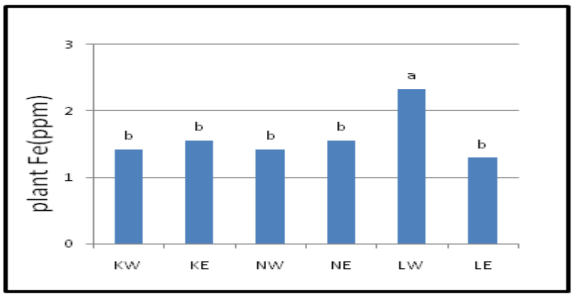

Fig. 6. Effect of wastewater irrigation on Fe concentration of corn. K=Khatoonabad, N=Najafabad, L=Lenjan, W=Tap water, E=Effluent.

Iron (Fe)

Effect of irrigation with wastewater on corn iron concentration is shown in Fig. 6. Irrigation with wastewater increased Fe concentration significantly in corn only in Lenjan soil. In other 2 soils no effects was observed in corn Fe concentration.

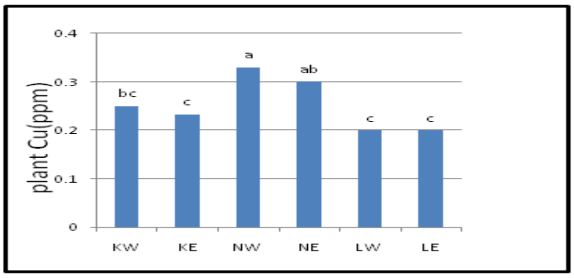

Fig. 7. Effect of wastewater irrigation on Cu concentration of corn. K=Khatoonabad, N=Najafabad, L=Lenjan, W=Tap water, E=Effluent.

Copper (Cu)

Effect of wastewater irrigation on Cu concentration of corn plant is shown in Fig. 7. Cu concentration in corn irrigated with wastewater in the Najafabad and Khatoonabad soils decreased slightly and in Lenjan soil remained unchanged and the changes were not significant in any soil. Highest Cu concentration was in corn grown in Najafabad soil irrigated with wastewater and the lowest was in corn grown in Lenjan soil irrigated with both waters.

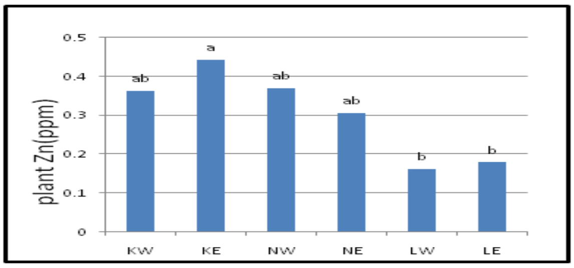

Fig. 8. Effect of wastewater irrigation on Zn concentration of corn. K=Khatoonabad, N=Najafabad, L=Lenjan, W=Tap water, E=Effluent.

Zinc (Zn)

Effect of wastewater irrigation on the concentration of zinc in three soils is shown in Fig. 8. Irrigation with wastewater caused no significant changes in corn Zn concentration in any soils. The highest concentration of Zn related to corn grown in Khatoonabad soil and the lowest one related to corn grown in Lenjan soil that shows a significant difference at 5% level.

Conclusion

Irrigation with wastewater increased EC, TN, K and Ni in soils as compared to the pots irrigated with tap water. Irrigation with sewage effluents did not change concentration of heavy metals concentration in corn except for Fe in corn grown in Lenjan soils.

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