Effects of Urban Wastewater on Heavy Metal Uptake by Corn in a Calcareous Soil of Southern Iran

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***Abstract*—** The reuse of the treated municipal wastewater is a multifactor problem, related to social, spatial, economic and environmental criteria, each of these including a number of sub-criteria. In most arid and semiarid regions of the world, including southern Iran water crisis is considered as one of the main problems on the path of sustainable agriculture. Due to water restrictions and increased water consumption using low quality water resources is considered as a solution to resolve agricultural water requirements which is pointed out as the largest consumption of water recently. The use of municipal wastewater for irrigation needs special management. This is due to the environmental and health hazards. This study was conducted to evaluate the effect of different treatments of irrigation with wastewater on absorption and accumulation of selected heavy metals and their possible contaminations in corn and soil. The location of the study was in a research farm with a semi-arid climate with annual mean precipitation and temperature of 330mm and 17ºC in Kohgilouye Province. The irrigation treatments were well water (I_1), the first half of plant growth with waste water and the second period with well water (I_2), the first half of plant growth with well water and the second part with waste water (I_3), alternating irrigation with well water and waste water (I_4), and irrigation with waste water (I_5). The results have indicated that irrigation with wastewater lead to significant increase in N, P, K, EC, O.C% and CEC than control treatment ($p<0.05$). Analysis of variance showed the significant effect of irrigation with wastewater treatments on accumulation rate of Fe, Zn and Pb in soil. No significant change was noticed in Cu concentration of soil and Pb concentration of plants. Concentration of Fe, Zn and Cu in corn forage was affected by irrigation treatments and increased significantly**.**

***Keywords*—** Corn, Heavy metals, Iran, Wastewater

I. Introduction

The reuse of the treated municipal wastewater is a multifactor problem, related to social, spatial, economic and environmental criteria, each of these including a number of sub criteria. In most arid and semiarid regions of the world, including the lands of Iran water crisis is considered as one of the main problems on the path of sustainable agriculture. Due to water restrictions and increased water consumption using low quality water resources (wastewater) is considered as a solution to resolve agricultural water requirements which is pointed out as the largest consumption of water recently. This source of irrigation, although increases agricultural products but threats environment and human health [1] and [2]. Therefore, the most of countries have limited been using the urban wastewater for agricultural production [3] and [4]. Wastewater is very rich source of macro and micro elements which is necessary for plant growth [5]. Amount of organic matter, nitrogen and phosphorus in sewage sludge is five, three and three times more than animal manure, respectively [6]. The use of municipal wastewater for irrigation needs special management. This is due to the environmental and health hazards. Contamination of soils by heavy metals is the most serious environmental problem and has significant implications for human health process [7] and [8]. Wastewater can have a positive effect on soil and eventually plant growth, due to being rich of organic matter and nutrients such as nitrogen, potassium and phosphorus [9]. Zhang et al. [10] have reported the significant increase in percentage of organic matter and improvement in soil structure as a result of irrigation with wastewater. A six years experiment on maize plants irrigated with wastewater showed that, the highest accumulation of Cd, Cr, Cu, Ni, Pb and Zn were related to 20 cm depth in soil and these heavy metals were traced in all parts of the maize [5]. Also the results showed that, Cu, Zn and Pb accumulation were more than control treatment in the first year while Cr accumulation was initiated in second year. Moreover, Pb accumulation was three times more than control treatment and this increase was recorded two times for other elements compared with control treatment [9]. Therefore, this study was conducted to evaluate the effect of different treatments of irrigation with wastewater on absorption and accumulation of selected heavy metals and their possible contaminations in corn crop and soil.

II. Materials and Methods

This study was conducted in a research farm with a semi-arid climate with annual mean precipitation and temperature of 330mm and 17ºC in Fars Province, southern Iran, during the 2014 growing season. The experiment was conducted out in a randomized complete block design with three replications. The irrigation treatments were well water (I_1), the first half of plant growth with waste water and the second period with well water (I_2), the first half of plant growth with well water and the second part with waste water (I_3), alternating irrigation with well water and waste water (I_4), and irrigation with waste water (I_5). Corn seeds were planted manually using three seeds per hole in May 2014. Single cross 704 was used in this study because this hybrid is cultivated in this area commonly. In this study EC, pH, organic carbon, texture, calcium carbonate equivalent, cation exchangeable capacity, total nitrogen, available P, available K and concentration of heavy metals (Pb, Fe, Zn and Cu) were

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measured in soil and plant samples by routine methods. Finally, for statistical analysis includes analysis of variance, comparison of means and drawing of graphs statistical software MSTATC, SAS and EXCEL were used, respectively.

III. RESULTS AND DISCUSSION

Comparison of means showed that EC, CEC, OC and the concentration of N, P and K were significantly affected by irrigation treatments, so that the highest and lowest value of EC, CEC, OC, total nitrogen, available K and were obtained by irrigation with wastewater in whole growing season and control treatments respectively ($p < 0.05$) (Table 1).

TABLE I: COMPARING THE AVERAGES FOR SOIL CHEMICAL CHARACTERISTIC BEFORE AND AFTER IRRIGATING WITH WASTEWATER.

Parameters	Before	I1	I2	I3	I4	I5
pH	7.94	8.08^{ab}	7.81^{c}	8.00^{b}	8.27^{a}	8.19^{ab}
EC	0.90	0.70^{d}	0.80^{c}	1.82^{c}	1.40^{b}	2.52^{a}
CEC	10.3	10.16^{b}	11.1^{ab}	11.20^{ab}	11.08^{ab}	11.40^{a}
CCE (%)	64.2	62.3^{ab}	63.3^{ab}	64.1^{a}	61.3^{b}	62.9^{ab}
OC (%)	0.36	0.40^{c}	0.46^{b}	0.48^{ab}	0.502^{a}	0.503^{a}
TN (%)	0.056	0.06^{d}	0.06^{c}	0.061^{c}	0.072^{b}	0.078^{a}
K (ppm)	210	211^{d}	212^{dc}	214^{c}	217^{b}	219^{a}
P(ppm)	5.8	5.9^{e}	8.3^{d}	9.1^{c}	12.6^{b}	13.9^{a}

Difference between wastewater treatments in first half and second half of plant growth showed that irrigation by well water in second half reduced nitrogen concentration in soil due to leaching.

TABLE II: COMPARING THE AVERAGE OF EFFECT OF WASTEWATER ON SOME HEAVY METALS CONCENTRATION IN SOIL AND CORN FORAGE.[1]

Parameters		I1	I2	I3	I4	I5
Soil ($mgkg^{1-}$)	Pb	1.055^{c}	1.072^{a}	1.067^{ab}	1.06^{b}	1.074^{a}
	Fe	1.21^{b}	1.52^{a}	1.54^{a}	1.56^{a}	1.59^{a}
	Zn	3.56^{c}	3.74^{b}	3.61^{b}	3.95^{a}	2.86^{a}
	Cu	0.84^{a}	0.86^{a}	0.87^{a}	0.89^{a}	0.87^{a}
Corn forage ($mgkg^{1-}$)	Pb	1.11^{a}	1.14^{a}	1.13a	1.12a	1.15^{a}
	Fe	216.1^{b}	216.7^{b}	230.9^{ab}	236.2^{a}	248.3^{a}
	Zn	30.0^{b}	32.2a	32.4^{a}	33.7^{a}	33.5^{a}
	Cu	15.0^{b}	16.2a	16.4^{ab}	18.5^{a}	18.6^{a}

Analysis of variance showed the significant effect of irrigation with wastewater treatments on accumulation rate of Fe, Zn and Pb in soil (Table 2).

No significant change was noticed in Cu concentration of soil. Concentration of Fe, Zn and Cu in corn forage was affected by irrigation treatments and increased significantly (Table 2). Total amount of heavy metals in soil is not enough to predict their absorption by the plant, because in the study on complex systems like soil and plant pollution several factors should be taken into account such as soil, metals, plant species and type of vegetation.

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