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ORIGINAL ARTICLE

EFFECT OF SEWAGE WATER IRRIGATION ON GROWTH PERFORMANCE, BIOMASS AND NUTRIENT ACCUMULATION IN MAIZE AND BARLEY

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Abstract : The effects of different concentrations of sewage water (0, 25, 50, 75 and 100%) on soil chemical properties and growth performance, biomass and nutrient accumulation of maize (*Zea mays*) and barley (*Hordeum vulgare*) crops grown under nursery conditions were examined for couple successive seasons. The study conducted according to the Randomized Complete Block Design (RCBD) with three replicates. Maximum growth was observed in the 50, 75 and 100% concentration of sewage water application. Biomass (g/plant) and plant height (cm) and dry weight (g/plant) of the maize and barley seedlings treated with sewage water (50%) showed a significant increase over the control. The electrical conductivity of soil increases with an increase in the concentration of sewage for both seasons. It increased significantly at the concentration of 100% as compared to the control treatment. Soil interaction value remains close to the equivalence point and does not significantly affected. At the 75 and 100% concentration of sewage water, the accumulation of heavy metals increases. However, all these metals are within the permitted natural limits and do not reach the critical or toxic limits that cause soil and plant pollution.

Key words : Sewage water, Growth performance, Nutrient concentration, Randomized Complete Block Design

1. Introduction

Poor quality water is used for irrigation purposes in the dry and semi-dry areas, either because of water deficiency or for disposing of it. In both cases, this water uses either by direct application to the soil or indirectly by adding it to the rivers and streams. Sewage water is a very high percentage of this poor quality water and can be an important source of water that can be used for irrigating agricultural crops [Al-Hadithy *et al.* (2011), FAOUN (2000)]. Most of the studies confirm its various nature and content depends on their sources. The researchers pointed to the need to identify sewage water contents before irrigation usage because they may contain high concentrations of some elements beyond its natural limits. It may also contain toxic substances and pathogens that are likely to cause, directly or indirectly, a significant environmental hazard to plants and the consuming organisms [Abdul *et al.* (2001), FAOUN (2000)]. Most of the studies [Gilani (1993), Al-Hadithy *et al.* (2002), Abou-Seeda *et al.* (1997)] indicate the possibility of using sewage water in the agricultural soil to gain economic and environmental benefits such as:

1. Mitigating or eliminating the problem of pooling this water in the places of storage and the potential pollution of the environment.
2. Agricultural irrigation.
3. Utilization it as a fertilizer because it contains the necessary nutrients for plant growth.

Most developed countries and some Arab and developing countries use irrigation water extensively. This water is transported by means of pipes or irrigation canals directly into agricultural land. In Iraq, the use of sewage water goes in an indirect way, as this water runs under triple treatment and headed to the Tigris and Euphrates rivers and then used in irrigation [Al-Hadithy (2002)]. The studies indicate the importance

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of soil and river water that receive waste water in protecting the environment from pollution since the huge river water quantity works by reducing the concentration of sewage water. Soil acts as a filter. Both river water and soil have a potential for the biological purification of waste water [Al-Hadithy (2001)]. Salts content is an important indicator to be considered when using this water for irrigation. The Food and Agriculture Organization of the United Nations (FAO) has developed standards for agricultural water salinity diagnosis [FAOUN (2000)]. However, many countries have used irrigation water, which has more than 2000 mg/l of dissolved salts, but has followed proper management to avoid accumulation of salts. The addition of waste water to agricultural land may result in a rise or decrease in the value of soil reaction depending on the source of the nature of its components. The low pH of the soil resulted not only from the melting of calcium carbonate, but also from the presence of free organic acids as well as increases the biological effectiveness of the soil. High pH soil is due to the increase in calcium carbonate and the amount of applied sulfur during irrigation and the presence of gypsum that reacts with sodium carbonate and deposited in the form of calcium carbonate [Pearson (2003)]. The ability of waste water to supply the soil with its nutrients can be a positive factor in crop growth. It may contain more than the crops needs of the nutritional metals. This may lead to some problems related to vegetative growth increases, maturity delayed or irregularity, and decreases yield quality. Therefore, this should be considered before fertilizers application, [Abou-Seeda *et al*. (1997), Aboukhaled (1991)]. The sewage water content of heavy metals is a source of concern due to their effect on the properties of soil, vegetation, groundwater and the environment in general. This situation becomes more important and dangerous if sewage is mixed with industrial waste water [Al-Hadithy *et al*. (2001)]. It is necessary to measure the concentrations of heavy metals in this water and rely mainly on determining the suitability of their use for agricultural purposes. Since they congregate close torhizosphere area, heavy metals may contaminate root edible parts of the plant. However, these elements may not below their natural concentration limits, does not have a risk when applied to the agricultural soils. These elements sometimes interact with soil compounds to form organic and inorganic complexes. Toxicity may occur when applying sewage water with high concentrations of these metals in soil with a low pH [Hamdy (1999), Asano *et al.* (2006)]. The impact of sewage on plant growth is determined by several factors, including its chemical composition, type of applied treatment to this water, the level of application, type of the growing crop, soil conditions and climatic conditions of the agricultural season [Abdullrzzakmani (2011); Patsios and Karabelas (2007)]. Most of the researchers indicated a low probability of contamination of soil and plants with heavy elements and pathogens, especially when appropriate soil and water management methods are used [Ioukopoulos and Kalavrouziotis (2008), Angelakis and Bontoux (2003)]. This study was conducted to investigate the effect of sewage that discharged from the water treatment plant of Diwaniyah city for agricultural use. This effect either on the growth of crops or on some soil properties and the possibility of contamination by heavy elements.

2. Materials and Methods

The study was carried out in the wooden canopy of the Environment and Water Department of the Ministry of Science and Technology in Al-Jadriya area. 10 kg of plastic bags filled with a non-saline soil that goes into a 4 mm diameter sieve. Table 1 shows soil's physical and chemical properties. The Ministry of Science and Technology and the Department of Science and Technology of Diwaniya of the Department of Non-Provincial Affairs in the Ministry of Science and Technology took part in the required analysis. Quantities of treated sewage water from the water treatment plant located 11 kilometers south of the city of Diwaniyah in tanks was brought and samples of it were taken for required analysis. Five different concentrations of sewage were used as a percentage of river water (0, 25, 50, 75 and 100%). Zero concentration is the control treatment, which is river water only. This means that 25% is mixed water with 75% river water and so on to the other levels; the last level is sewage water itself. The experiment was designed according to the design of Randomized Complete Block Design (RCBD) with three replicates. Corn seeds of spring variety were planted and irrigated by raising the moisture to the field capacity level. Container weight was recorded of each with its contents to compensate for the lost water and maintain the moisture level for the same level. The plants were harvested after 70 days of planting by cutting the vegetation directly from the surface of the soil. Soil

Table 1 : Physical and chemical properties of soil.

Texture	Particle Size Analysis ($g.kg^{-1}$)			Total Nitrogen	O.M.	$CaCO_3$	pH	EC($ds.m^{-1}$)
	Clay	Silt	Sand	$g.kg^{-1}$				
Clay loam	360	390	250	0.043	10.2	22.53	7.44	3.9
Macro nutrients ($mg.kg^{-1}$)			Micronutrients extracted by DTPA($mg.kg^{-1}$)					
N	P	K	Fe	Mn	Zn	Cu	Cd	Pb
47	8.9	179	16.5	12.8	10.3	4.8	0.185	2.7

samples were taken for the necessary chemical analysis. The same containers with their contents of the soil of the previous agricultural season using the same levels of sewage application were prepared. The barley seeds were planted on 1-12-2015 and harvested after 90 days of the planting date. They dried after taking the required growth measurements. Soil samples at the end of the second season, two were taken for required analyzes. pH and EC were measured though soil saturated soil extract. The micro metals were estimated according to Lindsay and Norvell (1978) method by shaking 10 ml soil extract in 20 ml of Diethylene Triamine Penta Acetic Acid (DHTA) solution with 7.3 pH for 2 hours and filtered. After that, iron, manganese, zinc, copper, cadmium and lead were estimated in the solution using the atomic absorption spectrometer device. The microelements in the plant were estimated to Walsh (1971) method by using nitric acid and pyrochloric acid to digest plant samples and using the atomic absorption spectrometer device measure iron, manganese, zinc, copper, cadmium, and lead. Water analyzes were conducted according to the methods listed in APHA (1998).

3, Results and Discussion

The results in Table 3 indicate an increase in all studied growth indicators of maize and barley crops for all treatments compared to the control for both seasons. This increase was significant at (50, 75, 100%) sewage water concentration compared. These results are consistent with the results of the researchers who obtained an increase in the growth of growing crops in treating soils with different levels of waste water [Al-Hadithy *et al*. (2011), Capra & Scicolone (2007)]. It is clear from the above results that the sewage water contains the most important quantities of necessary nutrients for the need of the plant, so it is recommended to irrigate and to fertilizer crops. The absorbed micronutrients (Fe, Mn, Zn, Cu, Cd, Pb) by the maize and barley crops is increased for all the treatments compared to the control for both seasons. The more the concentration of sewage water, the more is the absorbed micronutrients. It was a significant increase in both 75 and 100% treatment. This is due to the good containment of sewage quantities of microelements and thus increase the absorbed quantities with increasing their level. However, the amount of these elements did not reach the toxic limits in maize and barley plants for the first and second agricultural seasons. These results are consistent with the results of most researchers [Al-Hadithy *et al*. (2002), Gilani (1993), York *et al*. (2008)],

Table 2 : Physical and chemical properties of water.

Property		Wastewater	River water
EC ($ds.m^{-1}$)		1.92	0.88
pH		7.51	7.64
TDS ($mg.L^{-1}$)		1228	561
Dissolved ions ($mg.L^{-1}$)	Ca	205	89
	Mg	98	41
	Na	285	113
	K	8.5	1.6
	So_4	196	90
	Cl	290	115
	Hco_3	94	41
	Po_4	0.42	0.31
	No_3	6.8	1.8
Macro nutrients ($mg.L^{-1}$)	N	78	0
	P	2.3	0.26
	K	18	0.54
Micronutrients extracted by DTPA ($mg.L^{-1}$)	Cu	1.51	0.058
	Zn	3.50	0.088
	Mn	5.76	0.022
	Fe	9.23	0.045
	Pb	0.110	0.010
	Cd	0.210	0.015

Table 3 : The effect of different concentrations of sewage waterapplication on crop growth and plant content from the microelements of both seasons.

Treatment	Season 1		Season 2		Micro nutrients Season 1(mg.L^{-1})						Micro nutrients Season 2(mg.L^{-1})					
	Length (cm)	Dry weight (gm)	Length (cm)	Dry weight (gm)	Fe	Mn	Zn	Pb	Cu	Cd	Fe	Mn	Zn	Pb	Cu	Cd
0 %	73	25.0	34	2.0	170	53	26	2.4	7.3	0.091	159	46	23	3.0	8.2	0.960
25 %	98	32.0	51	4.1	196	68	38	2.9	9.9	0.120	210	72	37	3.5	11.0	0.122
50 %	110	40.0	56	4.9	215	91	51	3.6	12.0	0.158	232	95	54	4.1	14.3	0.165
75 %	121	44.0	49	5.4	231	106	63	4.3	12.0	0.176	246	116	69	4.8	17.8	0.181
100 %	115	41.0	49	5.8	248	118	72	4.9	16.3	0.193	262	131	85	5.4	19.6	0.209
LSD0.05	33.5	13.7	14.7	2.5	56	45	30	1.6	5.4	0.079	83	65	41	1.5	8.2	0.081

Table 4 : The effect of different concentrations of sewage waterapplication on chemical properties of soil for both of the successive seasons.

Treatment	EC		pH		Micro nutrients Season 1(mg.L^{-1})						Micro nutrients Season 2(mg.L^{-1})					
	Season 1	Season 2	Season 1	Season 2	Fe	Mn	Zn	Pb	Cu	Cd	Fe	Mn	Zn	Pb	Cu	Cd
0 %	4.10	4.30	7.49	7.52	13.30	36.40	11.50	2.50	4.30	0.168	11.80	33.00	10.2	2.0	3.60	0.159
25 %	5.50	6.00	7.45	7.47	24.50	39.50	12.30	2.90	5.50	0.189	27.00	38.40	12.6	2.8	5.21	0.189
50 %	6.30	7.50	7.48	7.50	31.70	44.80	14.00	3.50	7.20	0.201	34.20	46.80	15.3	3.8	8.57	0.200
75 %	7.50	7.45	7.42	7.45	36.30	49.30	16.20	3.80	10.60	0.223	40.70	51.50	18.6	4.0	11.35	0.230
100 %	9.70	7.40	7.38	7.40	40.00	53.00	18.70	4.20	12.00	0.240	47.10	57.30	20.0	4.2	14.13	0.250
LSD0.05	4.30	4.30	0.13	0.14	20.15	9.62	3.89	1.12	5.76	0.048	25.63	16.22	7.19	1.80	6.08	0.059

who indicated that the toxic limits of zinc, copper, cobalt, lead, nickel, cadmium and chromium in crops are 200, 19, 6, 35, 11, 15 and 10 mg/kg, respectively. However, the use of sewage water should be a caution to irrigate other crops that are freshly eaten, taking into consideration all experimental conditions, in order to avoid the problem of increasing the absorption of these nutrients. Table 2 presents sewage water effect on the values of the electrical conductivity of the saturated soil paste. EC values increase as the applied concentration of sewage water increases. This increase was significant at 100% concentration level as compared to the control. It is mainly due to the containment of this water on large quantities of dissolved salts. This finding is consistent with the results of other researchers who pointed out the salinity increase in the soil irrigated with sewage water [Al-Hadithy *et al*. (2011), Al-Hadithy *et al*. (2002), Iglesias (2008)]. EC values that measured at the end of the seasons are classified under the saline soils limit that is specified by the US Salinity Laboratory [Richards (1954)]. The results showed that the waste water affects as values of the saturated soil paste extract and increased twice at the end of the first season and more than three times at the end of the second season. This can have a greater impact when continuing to treat the soil with sewage water, especially with a poor drainage system.

Tables 1 and 3 present that the soil pH values before and after the experiment are between 7.38-7.52. Analysis of variance indicates that pH values are close to equalization and are not affected by sewage water concentration for both seasons. This result is consistent with the results of the researchers [Al-Hadithy *et al.* (2002), Abdul Majid and Bedour (2001), Hamdy (1999)], who confirmed that there are no significant differences in pH values of the irrigated soil with different levels of waste water.

Table 4 shows the effective concentrations of sewage water on soil content of heavy elements (iron, manganese, zinc, copper, cadmium, and lead). There is an increase in concentrations of these metals with an increase in the concentration of the sewage water application. It is clear that there is a significant increase in 75 and 100% sewage water concentration as compared to the comparison treatment. It is due to the containment of sewage quantities of these metals and thus increases the absorbed quantities. However, the concentrations of all the studied microelements in both seasons were within the allowed natural limits and did not reach the critical limits or toxicity that cause soil contamination. This is consistent with the results of the researchers [Al-Hadithy *et al.* (1987), Abou-Seeda *et al*. (1997), Aziz (1995)], who presented microelements increase with increasing the concentration of sewage. They also indicated that the critical or toxic limits of copper, zinc, cobalt, lead, nickel, cadmium and chromium in the soil are 100, 300, 50, 100, 100, 5, 100 mg/kg, respectively.

4. Conclusion

Sewage water can be used for irrigation purposes, taking into account the control of soil salinity and the amount of metals in the soil at the end of the season, especially in the long-term use of this water.

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