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UTILIZATION OF TREATED WASTEWATER IN IRRIGATION AND GROWTH OF JATROPHA PLANT TO PROTECT THE ENVIRONMENT FROM POLLUTION AND COMBATING DESERTIFICATION

Luma Abdalalah Sagban Alabadi[1]*, Wafaa Sahib Abbood Alawsy[2], Hussein M. Khaeim[3] and Azam H. AL-Hadithy[4]

[1,3]Department of Horticulture and Garden Engineering, College of Agriculture, University of Al-Qadisiyah, Iraq.
[2]Department of Soil Science and Water, College of Agriculture, University of Al-Qadisiyah, Iraq.
[4]Department of Research and Technology of Environment and Water, Ministry of Science of Technology, Iraq.

Abstract

This study was conducted to determine the possibility of using couple treated wastewater sources of Baghdad Company for Soft Drinks and Al-Rustamiya sewage water system for irrigation and growth of Jatropha plants and their effect on some soil characteristics and the content of microelements in both soil and plants. Jatropha's seeds were planted in the wooden canopy of the Environment and Water Research and Technology, Department in Baghdad. Five treatments of wastewater were used as a fellow: control treatment of fresh river water, the second and the third were irrigated with Baghdad Company, wastewater, the fourth and the fifth were irrigated with sewage water of the Rustamiya by 50% and 100% of total irrigation county, respectively. Wastewater irrigation to Jatropha seedlings continued for 180 days. Randomized Complete Block Design (RCBD) with five replicates was used. The results showed significant increase in both plant height and diameter growth of the jatropha plants with all levels of wastewater as compared to the control treatment. 50% of wastewater treatments level presents significant increase in the measured growth indicators than the level of 100% for both wastewater sources. Plants that irrigated with sewage water of the Rustamiya had more plant growth as compared to those irrigated with wastewater of Baghdad Company for Soft Drinks. There were significant increases in the values of the electrical conductivity (EC) of saturated soil paste extract due to the usage of wastewater compared to the control. The high level of used wastewater shows significant increases in the values of electrical conductivity compared with the low level of wastewater usage. Soil PH values were increased significantly at 100% levels of Baghdad Company wastewater treatments, while its values remained close to equivalence point with the treatment of sewage water of the Rustamiya. The results also present significant increases in the content of all studied microelements in both soil and plant for all treatments as compared to the treatment of comparison. This increase continued with increasing the level of uses of wastewater. However, all these elements were within the normal allowed limits and did not reach the critical limits or toxicity that cause soil and plant pollution by these elements.

Key words : Sewage water, wastewater, microelements, jatropha.

Introduction

Water resources are important means of narrowing the food gap, which is still growing as a result of population growth. Therefore, it is necessary to carry out extensive researches and studies to optimize the use of water, rationalize its consumption and find non-conventional water resources such as reuse of treated wastewater for agricultural purposes to meet the expected shortage of water resources in the coming years. This use is also considered the main outlet to dispose this type of water. Wastewater forms a high percentage of this water and can be an important source of water that can be used for agricultural purposes. Desertification is the process of destroying the vital energy of the earth, which can eventually lead to conditions that are similar to desert conditions. It is a manifestation of the widespread degradation of ecosystems that leads to shrink vital energy of the land that are represented in plant and animal production and thus the impact on the maintenance of human existence. There are many stages in the process of desertification, but whatever its shape, the final stage will be the complete desert with zero productivity, Nima

****Author for correspondence :*** Luma Abdalalah Sagban Alabadi

(1994). There are preparations on the possibility of cultivating and investing in jatropha plants, which is a substitute for fuel and energy, and the possibility of benefiting from the reduction of desertification, which does not need fertile soil or fresh water. Preparations are being made to cultivate this plant in Iraq after success attempts of planting it in neighboring countries that are similar to the Iraqi territory in agricultural composition Gargoli (2008). Jatropha plant is a tree with 3-5 meter high. India is the origin of it. Its importance comes from the fact that its seeds produce biofuels. In recent years, the plant has begun to be regarded as one of the green gold trees as a clean source of energy. It is used as an alternative to conventional fuel because of its oil characteristics that distinguishes it from diesel, including less polluted emissions. It is a clean source of energy because it contains little counties of sulphur dioxide and carbon monoxide. Jatropha grows in marginal soils along with economic crops and does not require big quantity of fertilizers. Treated wastewater can be used to irrigate this trees, which uses to protect soils from erosion and sand dunes stabilization (Bader, 2009). Wastewater refers to water that has already been used, or to the sewage water or discharged water from the plants (industrial water), containing dissolved and suspended substances. It contains 99.9% water and the remaining 0.01% suspended materials such as organic, industrial, household and heavy metals (Al-Hadithy, 2001 and FAO, 2000). Most of the studies that have been conducted on the use of wastewater confirmed the different nature and content of these water depends on their resources. They pointed out the need to identify their contents before using them in irrigation process because some have high concentrations of some elements beyond its natural limits in some cases they cause contamination. Wastewater may contain other toxic substances and potential pathogens that may directly or indirectly cause environmental hazards to plants and their habitats (Abozeid, 1997; Abu Khaled, 1991; Sugar, 1978 and Hamdi, 1999). The salt content of wastewater is an important indicator to be taken into consideration, when using this water for irrigation. The Food and Agriculture Organization of the United Nations (FAO) has set standards for the assessment of salinity of water for agriculture. However, many countries have used irrigation water that has more than 2000 mg/L dissolved salts but has followed by proper management system to avoid accumulation of salts. Soil salinity can be controlled by controlling the movement of water inside the soil and then washing the salts from it (Aziz, 1995 and Al-Hadithi, 2009). The effect of wastewater on the growth of plants is determined by several factors including: chemical composition of the water, type of used treatment, uses level, type of growing plant, soil conditions and climatic conditions of the agricultural season. Most studies indicated that there were no negative effects on the growth and yield of irrigated plants (Modern, 2002 and Aziz, 1995).

The experiment aims to study the possibility of using treated wastewater of both Al-Rustamiya sewage water station and Baghdad Company for soft drinks in irrigation and their effect on the growth of Jatropha plant and some soil characteristics and the content of micro elements in soil and plants.

Materials and Methods

Jatropha curcus seeds were planted in black perforated bags that were filled with loamy sand soil (rough texture) representing desert soils. Quantities of two sources of wastewater were brought, which are the sewage water of Rustamiya and industrial water of the Baghdad Soft Drinks Company. Samples of this water were taken for examination. Table 1 shows the properties of the soil, wastewater and river water used in the experiment. The experiment was carried out in the wooden canopy belonging to the Department of Water Reuse Research in the Department of Environmental and Water Research and Technology. Five wastewater treatments (S2, S1, W2, W1 and S0W0) were used. S0W0 is the control treatment that was irrigated with fresh river water. W2, W1 are treatments that irrigated with wastewater of the Baghdad Company in couple levels of 50% and 100%, respectively. S2, S1 W1 are treatments that irrigated with sewage water of Rustamiya in 2 levels of 50% and 100%, respectively. Irrigation operations started according to these treatments and lasted for six months.

The experiment was done according to the Randomized Complete Block Design (RCBD) with five replicates for each. Plants were being irrigated by these kinds of water to reach 2/3 of water availability at field capacity point.

The seedling growth measurements, which included the plant height and growth of the jatropha plants, were taken. Soil samples were taken for all treatments to conduct the necessary chemical analyzes. Saturated soil paste extract was used to measure each of soil pH and electric conductivity (EC) by using PH meter and EC meter. Microelements were estimated according to method of Lindsay (1978) by preparing soil extract by shaking (10 ml) of it in (20 ml) of Diethylen Triamin Penta Acetic (DHTA) solution with PH of 7.3 for 2 hours then

Table 1 : Characteristics of soil, wastewater and fresh river water that were used in the study.

Characteristic		**Soil**	**Sewage water**	**Wastewater of Baghdad Company**	
Soil texture			-	-	-
Clay		88	-	-	-
Silt		140	-	-	-
Sand		772	-	-	-
EC (dc.m)		2.4	2.3	1.7	0.91
PH		7.35	7.56	9.77	8.15
Lime (g. kg^{-1})		250	-	—	-
O.M. (g. kg^{-1})		3.0	-	—	-
Total N (g. kg^{-1})		0.18	0.077	0.050	-
Available K (mg. kg^{1})		200	19	11.0	0.56
Available P (mg. kg^{1})		6.0	2.5	2.6	0.29
Nitrate- N (mg. kg^{1})		13.0	18.9	13.0	0.45
Ammonium- N (mg. kg^{1})		10.0	21.5	19.9	0.36
Extracted microelements by DTPA (mg. kg^{-1})	Cu	6	1.7	1.2	0.05
	Zn	9.3	6.5	8.5	0.08
	Mn	0.11	3.5	5.0	0.02
	Fe	0. 2	6.4	6.2	0.45
	Pb	-0.98	0.09	0.08	0.01
	Cd	-0.20	0.22	0.09	0.08

filtration it and assessing each of iron, manganese, zinc, copper, cadmium and lead in the solution using an atomic absorption device.

Microelements in the plant were estimated in the manner described in Walsh (1971) using nitric acid and pyrophoric acid to digest the samples of the plant and using the atomic absorption device in the estimation of iron, manganese, zinc, copper, cadmium and lead.

Results and Discussion

This study used wastewater that is classified as moderate saline water (2-10.ds.m) according to the FAO classification of 1992 for saline water. Electrical conductivity of sewage and wastewater of Baghdad Company were (1.7-2.2 ds.m), respectively. Nitrogen, phosphorus and potassium content in these water (50-79, 2.6-2.7, 11-16 mg.l), respectively. It has a great importance in providing plants with nutrients, so this water can be used for irrigation in all soils, especially those of light texture, which have high permeability and good drainage. The used soils in the study are calcic soils that have high regulatory potential, which lead to deposition of a large part of the nutrients and converting them into non-plant formulas or being unavailable to plants so there is no expectation of environmental problems.

1. Effect of using wastewater on the growth of Jatropha plants and their content of microelements

Results in table 2 shows the effect of the using levels of sewage water and wastewater of Baghdad Company on plant growth using both parameters of plant height and diameter growth of the plant of Jatropha. It presents also some chemical properties of the used soil including soil EC and PH. ANOVA showed significant increase in plant height and diameter growth of plants at all levels of the used wastewater compared to the control. The low level of 50% of both wastewater resources presents significant increase in the studied growth indicators compared to the control treatment at significant level of 1%. Using 5% significant level, this level of wastewater shows significant increase as compared to the level of 100% for both wastewater resources (sewage water, wastewater of Baghdad Company). This result is consistent with the results of other researchers, who present an increase in the growth of maize crop that is treated with different levels of wastewater (Al-Hadithi, 2002 and Aziz, 1995). Plants that were treated with sewage water had more plant growth as compared to those treated with wastewater of Baghdad Company for soft drinks. This is due to its content of nutrients (K, P, N) that are necessary for the growth of plants than the content in the water of Baghdad Company (table 1).

It is clear that it is necessary to mix the sewage and water of the Baghdad Company with river fresh water at a ratio of 1: 1 before using it agricultural in agricultural purposes in order to reduce the negative impact of this water, especially the content of dissolved salts. There is a significant increase in the quantity of the microelements (Fe, Zn, Mn, Cu, Cd, Pb) that were absorbed by the plants for all the treatments compared to its comparative treatment. Absorbed quantity of these elements increased with increasing the level of additive of wastewater water (for both resources). Plants absorbed more elements at the treatment of 100% of wastewater compared to the lower level of 50%. These increases are attributed to the content of this water of these elements and thus increase the absorbed quantities as wastewater usage level

Table 2 : Effect of using wastewater on growth of Jatropha plant and its content of microelements.

Treatment	Plant height (cm)	Diameter growth (mm)	Plant content of microelements (mg.kg^{-1})					
			Fe	Mn	Zn	Cu	Cd	Pb
S_0W_0	35.2	1.2	82.5	31	21	4.9	0.09	1.50
W_1 (50%)	46.4	1.7	96.0	47	38	6.0	0.14	1.68
W_2 (100%)	40.4	1.4	120.2	63	59	7.2	0.23	1.87
S_1 (50%)	50.8	2.0	103.6	42	34	6.5	0.19	1.72
S_2 (100%)	45.5	1.6	131.2	57	50	7.6	0.28	1.94
LSD 0.05	5.2	0.2	7.27	5.64	6.48	0.81	0.027	0.098
LSD 0.01	9.6	0.5	13.45	10.86	12.59	1.094	0.050	0.180

W_0-S_0: Control treatment that was irrigated with fresh river water

W_2-W_1: Baghdad Company for Soft Drinks wastewater treatments of 50% and100%, respectively (50% mixed with fresh river water 1: 1)

S_2-W_1: Al-Rustamiyah sewage water treatments of 50% and100%, respectively.

increased. However, the quantity of these elements did not reach the toxic limits in the Jatropha plant. Hadith (1987) pointed out that the toxic limits of zinc, copper, cobalt, lead, nickel, cadmium and chromium in crops are (10, 15, 11, 35, 6, 19 and 200 mg/kg), respectively. However, caution should be taken when using wastewater to irrigate other crops especially those are freshly eaten, and taking into consideration the comparison with all experimental conditions. This should be done in order to avoid problems of increasing the absorption of those elements by agricultural crops, especially lead metal. Plants need it by very small quantities, and it is very toxic when increasing its concentration to plants or animals consumed it. This is consistent with what most researchers have found like, Hadith (1987) and Hadith (2011).

2. Effect of using wastewater on some chemical characteristics of soil and its content of microelements

Table 3 shows wastewater effect on electrical conductivity of saturated soil paste extract. Results showed that EC values increase as levels of used wastewater increase of both sources of wastewater compared to comparison treatment. Both wastewater resources present significant increase in EC values compared with the comparison treatment at 5% significant level. Using high level of wastewater shows high significance increase in EC values at 1% significant level as compared to the control. Treatments of 100% wastewater of both resources show significant increase in EC values at 5% significant level compared to the lower level of 50%. It is also noted that sewage water increases electrical conductivity values of soil compared to wastewater Baghdad Company, significantly. This is due to the higher content of soluble salts and the value of electrical conductivity of sewage water than in the wastewater of Baghdad Company for soft drinks (table 1).

Table 2 shows pH values of the used soil before and after the experiment, which ranged between (7.35 and 7.84). Results indicate that sewage water has led to slight statistical decrease in pH values. There are non-significant differences in pH values of soils that were irrigated with sewage water and fresh water. This result is consistent with the results of Ahmed (2006) and Saadi (2002), who confirmed that pH values remain close to the equivalent point and do not affected by different levels of sewage water. On the other hand, wastewater of Baghdad Company for soft drinks has made significant increase in the values of soil pH with 100% treatment level. The reason for this increase is due to the high pH value of wastewater of Baghdad Company for soft drinks and considered it as alkaline water (pH = 9.77) (table 1). Previous research has shown that using wastewater in agricultural purposes may result in increase or decrease in soil pH value depends on the source and nature of its components. Soil pH reduction is not only caused by dissolving of calcium carbonate, but also by the presence of free organic acids as well as by increased the biological activity of soils (Hinesly, 1979; Schauer, 1980). pH value of soil increases due to the increase in calcium carbonate content in the soil as well as the increase in the amount of sulphur throughout irrigation process, and the presence of gypsum, which reacts with sodium carbonate and sedimentation it as calcium carbonate (Pettygrov, 1988).

Table 3 shows the effect of wastewater in the concentrations of microelements (iron, manganese, zinc, copper, cadmium and lead). Wastewater significantly increases soil content of these elements. 100% wastewater treatment level increased soil content of these

Table 3 : Effect of using wastewater on some soil characteristics and its content of microelements.

Treatment	EC (dc.m)	PH	Heavy metals that extracted from soil (mg.kg^{-1})					
			Fe	Mn	Zn	Cu	Cd	Pb
S_0W_0	2.5	7.78	12.00	10.6	8.2	5.2	0.250	1.05
W_1 (50%)	2.8	7.81	15.40	4.3	12.7	7.8	0.27	1.20
W_2 (100%)	3.3	7.84	18.90	17.9	16.0	10.3	0.293	1.42
S_1 (50%)	3.2	7.76	15.80	13.6	12.3	8.3	0.273	1.26
S_2 (100%)	4.0	7.74	20.00	17.5	15.6	10.9	0.295	1.49
LSD 0.05	0.3	0.06	1.98	1.37	2.51	1.28	0.013	0.08
LSD 0.01	0.9	0.12	3.38	2.98	3.27	2.57	0.020	0.15

elements significantly compared to 50% usage level. This is due to the content of these kinds of water of microelements. However, the concentration of all the studied microelements in the extracted soil was within the permitted natural limits and did not reach the critical limits or toxicity that cause soil pollution. The critical or toxic limits of copper, zinc, cobalt, lead, nickel and cadmium in the soil are (100, 300, 50, 100, 5, 100 mg/kg), respectively (Modern, 1987 and 2011). From this, it is concluded as the following; treated wastewater can be used for irrigation of jatropha plants in light texture soils to dispose it and utilize it without any environmental or economic damage. Action of monitoring and controlling soil salinity and the amount of microelements in the soil and plant for long-term use of this water should be considered. Preferably, this water is recommended to be mixed with fresh river waster by 1: 1 ratio to reduce the amount of dissolved salts.

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