The Effect of Irrigation With Raw and Treated Sewage Water on Balady Orange Plants Grown in Clay and Sandy Soil

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Abstract: A pot experiment was conducted during 2009 and 2010 seasons in Horticulture Research Sation in Alexandria, Egypt to study the effect of irrigation with raw and treated sewage water on the vegetative growth and leaf mineral composition of Balady orange plants grown in clay and sandy soils, as well as, the effect on soil chemical characteristics. The obtained data showed that growth rate, fresh and dry weight of top and, root of plants were increased with raw and treated sewage water treatments. Leaf and root minerals contents (N, P, K, Na, Fe, Mn, Zn, Cu, Pb, Cd, Ni and Cr) increased by irrigating with raw and treated sewage water for plants grown in both clay and sandy soils. Also, leaf and root proteins contents showed a marked increase as a result of the different treatments. Values of EC, pH, soluble ions, total N available P, K, Fe, Zn, Mn, Pb, Ni, Cd, and Cr were increased in both soils type irrigated with raw and treated sewage water. The clay soil indicated more positively trends than the sandy one.

Key words: Balady Orange raw- treated sewage water, clay, sandy soil.

Introduction

Recently, the Egyptian government has focused attention on water conservation issues and the use of alternate irrigation water sources. One of these sources is using municipal water or reclaimed sewage water. Irrigation with sewage water may be recommended, as a sheep water source, as well as nutrients and organic matter provider. It could also be a soil characteristics amendment. However, analysis of such kind of water, its use regularity and the plant growth stage, especially for fruit tree should be put in consideration before using that water. Excessive concentrations of heavy metals in plant tissue may cause phytotoxicity or inhibition of plant growth or toxicity towards man or animal nourished with these plants (Badawy, 1987). Therefore, using sewage and treated waste water to irrigate citrus, grapevines, olive , pistachio, and guava was investigated (Shehata ,1983; Zaid and Asker, 1987; Tester , 1990; Khalifa and Hassan, 1993; and Salama and Khalifa, 1993). They confirmed that applying this water by drip irrigation method was possible without risk to consumers . Nevertheless, the waste water discharge from Alexandria governorate was estimated to reach one million m^3 per day by the year 2000 (Fahmy and El- Zaher , 1986), which might have reached more than that in this recent years. Therefore, the present study was carried out to investigate the impact of using raw and treated sewage water for irrigation of balady orange seedlings grown in two soil types.

Materials and methods

Plant material and experimental design

A pot experiment was conducted in Horticulture Research Station in Alexandria, starting at the beginning of July 2009 until the end of December 2009 ,then from June 2010 until the end of December 2010 on two years Balady orange plants (*C. sinensis*) budded on sour orange rootstock grown in 50 x40 cm pots filled with either sandy or clay soil . The clay soil was obtained from the experimental station of the faculty of agriculture, Alexandria

University and sandy soil from El-Bostan region, Behera governorate. The sewage water was taken from the East Alexandria Purification Station, Alexandria governorate and used before treating (raw sewage water) or after primary precipitation of the solid contents (treated sewage water). Water and soil analysis is presented in Table (1). Plants were irrigated twice weekly (two liters for each pot) and were subjected to the following irrigation treatments:

1. Control (tap water only).
2. 75 % tap water + 25 % raw water.
3. 25 % tap water + 75 % raw water.
4. 0 % tap water +100 % raw water.
5. 75 % tap water + 25% treated sewage water.
6. 25 % tap water + 75 % sewage water.
7. 0 % tap water + 100 % treated sewage water

Table (1) Soil and water analysis.

	Irrigation water				**Soil type**	
Parameters	**Tap water**	**RawSewage water**	**Treated Sewage water**	**Parameters**	**Clay**	**Sandy**
pH	7.8	7.34	6.8	pH	7.1	7
EC**dSm-1**	0.81	2.2	2.01	EC**dSm-1**	0.68	0.21
(meq /L) HCO^{-}_{3}	1.13	2.1	1.98	(meq /L) HCO^{-}_{3}	3.69	.81
Cl (meq/L)	4.86	10.89	7.29	Cl (meq/L)	2.16	0.045
(meq /L) SO^{-}_{4}	1.91	7.25	5.99	(meq /L) SO^{-}_{4}	0.68	0.45
$^{+}$(meq /l) Na	4.05	12.15	9.45	$^{+}$(meq /l) Na	3.42	0.99
$^{+}$(meq /L) K	0.081	3.24	1.44	K $^{+}$(meq /L)	0.27	0.9
Fe (mg/l)	0.429	1.683	0.858	Fe (mg /kg)	1.46	0.729
Mn (mg/l)	0.324	1.17	0.659	Mn (mg/ kg)	8.67	0.702
Zn(mg/l)	0.045	0.292	0.153	Zn(mg/ kg)	2.93	0.576
Cu(mg/l)	0.062	0.127	0.94	Cu(mg/ kg)	2.52	0.9
Pb (mg/l)	0.031	0.235	0.109	Pb (mg kg)	1.36	1.28
Ni (mg/l)	0.028	0.279	0.113	Ni (mg/ kg)	0.50	0.162
Cd (mg/l)	0.0027	0.0144	0.005	Cd (mg/ kg)	0.072	0.0621
Cr (mg/l)	0.002	0.11	0.066	Cr (mg/ kg)	0.198	0.036

The experiment was designed as a randomized complete block design with two factors (the water levels {7 levels)} comprised the first factor and soil types {2 types} is the second one). Treatments were obtained with 3 replicate for each treatment and 5 plants for each replicate for each soil {210 plants for the experiment}. At the end of the experiment, a soil sample from the pots of each treatment was taken to measure the effect of the different irrigation treatments on soil properties. Also, all plants were taken for obtaining the following measurements:

Growth rate

Growth rate was calculated as the differences between the intial and final plant as follow:

Growth rate = A – B / B

Where; A=Final plant length and B=Initial plant length (cm).

Plant fresh and dry weight

Weight (g) of shoot and root of each plant was recorded before (fresh weight) and after drying to a constant weight in air drying oven at 70°C (dry weight).

Leaf and root mineral content

A leaf sample in December 2009 and 2010 and root sample of each dried replicate in the end of the experiment was taken, grounded and digested with H_2O_2 and H_2S0_4 according to the method of Evenhauis and Dewaard (1980). Total nitrogen was determined colorimetrically according to Evenhuis (1976). Phosphorus was determined colorimetrically by ascorbic acid method according to Murphy and Riley(1962) . Potassium content was determined by a flame photometer. Pb, Cd, Ca, Mg, Fe, Zn, Mn and Cu contents were measured using an atomic absorption spectrophotometer 305B. The concentrations of N, P, K, Ca and Mg were expressed as percent, while Pd, Cd, Fe, Mn, Zn, and Cu were expressed as ml/l on dry weight basis.

Leaf and root carbohydrate and protein content

Total carbohydrate in leaves and root was determined calorimetrically according to(Mailk and Singh, 1980) and proteins were determined by multiplying nitrogen content by 6.25.

Statistical analysis:

All data were tested for treatments effects on analyzed parameters by analysis of variance ANOVA according to Snedecor and Cochran(1989) and using Statistical Analysis System (SAS Institute, 1988).

Results and Discussion

Soil properties

The effect of the different irrigation treatments on the chemical characteristics of the clay and sandy soil is presented in Table (2). The Data obtained indicated that irrigation with raw and treated sewage water increased the pH and EC values of both clay and sandy soils as compared with irrigation with tap water (control). However, the pH and EC values of clay soil irrigated with raw and treated sewage water were higher than those of sandy soil. High concentrations of HCO^{-}_{3} and SO^{-}_{4} were obtained in both soil types under irrigation with either raw or treated sewage water as compared to the control. These results are in agreement with those obtained by Dennis and Fresquez (1989) and Khalifa and Hassan (1993) With regard to mineral concentration, the obtained data showed that Na and K content in both soil types increased as a result of increasing raw and treated sewage water levels in irrigation water as compared with the control, with the highest values obtained in the clay soil. These results are in line with those reported by (Header ,1987 and Hinsely and Jones,1990). Further, concerning the micronutrients and heavy metals content in both soil types, the data showed that Fe, Zn, Cu, Mn , pb, Ni , Cr , and Cd

concentrations were increased by the different irrigation treatments in comparison with the control (irrigation with tap water only). These results are similar to those obtained by (Badawy, 1987 and Abdel –Sabour et al ,1995). They found that heavy metal amounts in soil increased with utilization of sewage effluent irrigation water.

Fresh and dry weight

The effect of the different irrigation treatments, as well as soil type on fresh and dry weight is presented in Table (3).

With regard to the irrigation treatments, shoot and root fresh weight was not affected by any treatment . Balady orange plants treated with75% raw water and 100% treated sewage water had significantly higher shoot dry weight as compared with the control. In addition, root dry weight in plants irrigated with 100% raw water and 75% treated sewage water increased significantly as compared with the control.

As for the soil type effect, it was found that plants grown in clay soil had significantly higher shoot and root dry weight as compared with those grown in sandy soil. However, shoot and root fresh weight did not differ in both soil types.

Growth rate:

The effect of the different irrigation treatments as well as soil type on plant growth rate is presented in Table (3).

With regard to the irrigation treatments only, the obtained data indicated that, plant growth rate increased significantly with 100% raw sewage water and 100% treated sewage water as compared with the control.

As for the soil type effect, it was found that plants grown in clay soil had significantly higher growth rate than those grown in sandy soil. The obtained results are in harmony with those previously reported (Saavedra *et al* ,1987; on olive, Tattini *et al*,1991; on olive and peach , Davies and Maurer ,1993; on citrus, Salama and khalifa ,1993; working on guava and Salama and Saleh ,1993; on sour orange). They all reported that sewage water and sewage sludge applications enhanced plant growth.

Carbohydrate and protein contents

The effect of the different irrigation treatments, as well as soil type on leaf and root protein and carbohydrates content is presented in Table (4).

With regard to the different irrigation treatments, the obtained data showed that all raw sewage and treated sewage water treatments except 25% treated sewage water caused a significant increase in leaf protein content as compared with the control in 2009. Also, all raw sewage and treated sewage water treatments caused a significant increase in leaf protein content as compared with the control in 2010 .Whereas, root protein content tended to increase significantly with 75% and 100% raw sewage water treatments as compared with the control. In addition leaf carbohydrate did not show any significant differences by all treatments in 2009 however, plants treated with 25% treated sewage water had significantly higher leaf carbohydrates than all other treatments.Moreover, plants treated with 25% raw sewage water and

75% treated sewage water had significantly higher root carbohydrates content as compared with the control (water tap).

With regard to the soil type effect, plants grown in clay soil did not had any significant differences in leaf in 2009 and root protein content when they compared with those grown in sandy soil whereas, plants grown in clay soil had significantly higher leaf protein in 2010. Also leaf carbohydrates showed a significant increase in plants grown sandy soil as compared with those grown in clay soil However , root carbohydrates content was increased significantly in plants grown in clay soil as compared with those in sandy soil. Similarly (Pandya et al. ,1989 and 1991) found that reported an increase in protein content by sewage sludge application. Also, Gadallah (1994) working on sunflower plants found that waste water increased root soluble sugars , hydrolysable carbohydrates and root soluble protein content.

Macro and Micro nutrients and heavy metals content

The effect of the different irrigation treatments, as well as soil type on leaf and root macro and micro nutrients and heavy metals content is presented in Tables (5 to 8) .The obtained results showed that plants grown in clay soil had significantly higher leaf manganese, zinc, copper, lead, chromium and cadmium content in 2009 and 2010 and leaf nitrogen, phosphorus and iron in 2010 as compared with those in sandy soil. .Also ,root potassium, manganese, copper, lead, chromium ,cadmium and nickel content increased in plants grown in clay soil as compared with those in sandy soil.

With regard to the irrigation treatments, the obtained data showed that all sewage and treated sewage water treatments significantly increased leaf manganese, iron potassium, copper and zinc in 2009 and leaf nitrogen ,phosphorus, manganese, iron potassium, copper and zinc ,lead , chromium cadmium and nickel in 2010 and root phosphorous content as compared with control. In addition, Balady orange plants treated with100% raw sewage water had significantly greater leaf nitrogen, sodium, potassium, manganese, copper ,zinc and lead in 2010 as compared with all other treatments. Balady orange plants treated with all treatments except 25% treated sewage water had significantly higher leaf phosphorus and root copper content as compared with control .All treatments except 25% raw sewage and 25% treated sewage water caused a significant increase in root potassium and root zinc content as compared with control .100% raw sewage water treatment gave significantly higher leaf sodium , leaf iron , root nitrogen and root sodium content as compared with control .Also plants treated 75% raw sewage water had significantly higher root sodium content as compared with control. As for soil type effect, plants in clay soil had significantly higher leaf zinc, manganese, copper and root potassium, manganese, and copper as compared with control. Moreover, All raw sewage and treated sewage water treatments led to a significant increase in leaf chromium and cadmium also in root lead , chromium , cadmium, and nickel content as compared with control. Balady orange plants treated with all treatments except 25% treated sewage water treatment had a significant increase in leaf lead content as compared with control .Also 100% treated sewage water and 75% , 100% raw sewage water treatments gave significantly increase in leaf nickel content as compared with control. These results were in similar with those found by (Whitton. and Well,1978; on carrot ;

Berry *et al.* ,1979; on vegetables, Kirkhan ,1983; on wheat and grain, ,Shehata ,1983; on orange , olive , guava and grapes ,Furie *et al.* ,1984; on grapevines ,Basiony ,1986; on peach ,Aboulroos *et al.* ,1988; on orange, Neilson *et al.* ,1989; on apple ,Trefz – Malcher *et al* ,1987; on beach, Chakrabarti and Chakrabarti ,1988; on wheat, Salama and Khalifa ,1993; on guava, Salama and Saleh ,1993; on sour orange nursling, El- Mardi *et al.* ,1995; on date palm, Lepenae *et al.* ,1995; on oranges ,Agular *et al.* ,2005; on olive trees and Angin *et al.* , 2012; on sour cherry). They found that mineral composition increased by raw sewage water and sewage sludge applications.

Cottenie and Camerlnck (1976) reported that phytotoxic of raygrass was 60 ppm for lead, >80ppm for nickel,>100ppm for cadmium. Alloway (1990) indicated that the critical level was 30-300 ppm for lead, 10-100 ppm for nickel, 5-30ppm for cadmium and chromium. Therefore nonflowering Balady orange plants grown in sandy soil can be irrigated with 25% treated sewage water .Such concentration cause the least visual symptoms of toxicity.

Conclusions

Growth rate, fresh and dry weight shoot and root of plants increased with raw sewage and treated sewage water treatments. Leaf and root minerals contents (N, P, K, Na, Fe, Mn, Zn, Cu, Pb, Cd, Ni and Cr) increased by irrigating with raw sewage and treated sewage water applications for plants grown in both clay and sandy soils. Also, leaf and root proteins contents showed a marked increase as a result of the different treatments. Values of EC, pH, soluble ions, total N available P, K, Fe, Zn, Mn, Pb, Ni, Cd, and Cr were increased in clay and sandy soils treated with raw sewage and treated sewage water as compared with un- treated ones. The clay soil indicated more positively trends than the sandy soil. In conclusions, nonflowering Balady orange plants grown in sandy soil can be irrigated with 25% treated sewage water .Such concentration cause the least visual symptoms of toxicity.

Table (2) Chemical properties of clay and sandy soil as affected by sewage & treated sewage water applications

	Control (tap water)		100%raw sewage water		75%raw sewage water		25%raw sewage water		100% treated sewage water		75% treated sewage water		25% treated sewage water	
	clay	sandy	clay	sandy	clay	Sandy	clay	sandy	clay	sandy	clay	sandy	clay	sandy
pH	7.02	6.94	7.32	7.21	7.39	7.31	7.37	7.34	7.38	7.00	7.38	7.22	7.3	7.22
EC dSm-1	0.75	0.23	0.86	0.23	1.2	0.31	2.52	0.32	0.60	0.23	1.08	0.25	1.17	0.261
Cl(meq/L)	4.06	0.89	4.68	1.08	5.94	1.26	9.45	1.35	3.78	0.81	4.77	1.08	5.49	1.26
SO^{-}_{4}(meq/L)	2.38	0.055	3.06	0.18	6.03	0.81	15.08	0.86	2.61	0.14	3.33	0.36	4.6	0.68
HCO^{-}_{3} (meq/)	0.73	0.49	0.9	0.68	2.03	1.13	2.25	2.03	0.9	0.68	1.13	1.13	2.25	1.8
Na^{-}(meq/L)	3.74	1.09	4.4	1.2	5.67	1.53	13.1	1.62	3.78	1.08	5.04	1.26	5.22	1.26
K^{-}(meq/L)	0.297	0.99	0.81	0.09	1.08	0.18	1.13	0.27	0.45	0.09	0.99	0.18	1.08	0.18
Fe (mg/kg)	1.61	0803	5.06	1.37	5.67	1.62	6.12	1.62	4.71	1.22	5.2	1.4	5.54	1.46
Mn mg/kg)	9.54	0.77	12.22	3.55	14.96	3.80	17.33	4.86	10.42	2.61	13.16	3.55	14.08	3.76
Zn mg/kg)	3.22	0.99	3.55	0.252	3.80	0.65	4.86	0.68	2.61	0.216	3.55	0.32	3.76	0.58
Cu mg/kg)	2.77	0.58	2.99	0.74	3.94	1.39	5.26	1.40	2.99	0.67	3.46	0.76	3.71	0.79
Pb mg/kg)	1.26	0.18	2.68	0.378	2.65	0.47	2.68	0.63	1.75	0.25	2.48	0.43	2.5	0.43
Ni (mg/kg)	0.50	0.16	0.72	0.08	0.81	0.31	0.81	0.38	0.67	0.16	0.72	0.20	0.79	0.29
Cd mg/kg)	0.07	0.02	0.21	0.11	0.371	0.25	0.425	0.309	0.124	0.062	0.333	0.167	0.369	0.185
Cr (mg/kg)	0.2	0.04	0.38	0.22	0.45	0.27	0.47	0.32	0.34	0.22	0.396	0.234	0.414	0.25

Table (3) Effect of raw and treated sewage water on shoot and root fresh and dry weight and growth rate of Balady orange plants

Treatments	Fresh weight(g)						Dry weight(g)						Growth Rate		
	Shoot			Root			Shoot			Root					
	Clay	Sandy	Means	Clay	Sandy	Means	Clay	Sandy	Means	Clay	Sandy	Means	Clay	Sandy	Means
Control (tap water)	56.35	52.2	54.28	40.1	36.58	38.33	34.25	20.23	27.24	32.63	23.28	27.6	0.188	0.205	0.196
100% Raw sewage wate	62.77	70.97	66.87	64.97	49.53	57.25	33.7	29.00	31.35	42.2	37.2	39.69	0.327	0.227	0.277
75% Raw sewage wate	60.3	58.1	59.2	60.93	63.15	62.041	38.08	34.25	36.04	33.63	29.3	31.46	0.314	0.233	0.274
25% Raw sewage waste	50.97	46.55	48.76	68.93	55.85	62.40	37.60	23.48	30.54	30.90	29.28	30.09	0.238	0.217	0.227
100% Treated sewage water	58.03	46.46	52.44	67.63	66.59	67.11	41.40	36.40	38.90	29.60	28.25	28.93	0.325	0.231	0.278
75% Treated sewage water	52.36	56.75	54.55	65.57	72.80	69.18	30.70	38.03	34.36	36.85	34.58	35.72	0.309	0.236	0.272
25% Treated sewage water	48.53	51.25	49.89	63.00	52.85	57.98	34.38	23.98	29.18	29.58	25.63	27.6	0.210	0.216	0.213
Means	55.61	54.61		61.60	56.76		35.73	29.3		33.63	29.64		0.273	0.224	
L.S.D Treatments			13.82			14.83			6.27			4.86			0.079
L.S.D Soil types	7.39			7.79			3.35			2.60			0.042		

Table (4) Effect of raw and treated sewage water on leaf and root protein and carbohydrate content (%on dry weight basis) of Balady orange plants

Treatments	Protein(%)									Carbohydrate (%)								
	Leaf (2009)			Leaf (2010)			Root (2010)			Leaf (2009)			Leaf (2010)			Root (2010)		
	Clay	Sandy	Mean	Clay	Sandy	Mean	Clay	Sandy	Mean	Clay	Sandy	Mean	Clay	Sandy	Mean	Clay	Sandy	Mean
Control (tap water)	14.80	13.97	14.39	17.02	16.07	16.55	14.31	13.51	13.91	9.37	27.54	18.46	10.27	30.29	20.28	10.94	9.77	10.35
100% Raw sewage water	20.89	19.83	20.36	24.02	22.47	22.40	17.40	16.63	14.91	10.94	9.53	10.25	12.03	10.48	11.26	11.20	11.13	11.17
75% Raw sewage water	19.43	18.72	19.07	22.34	21.53	21.94	16.63	15.56	16.10	11.46	10.16	10.81	12.61	11.18	11.9	12.50	10.55	11.52
25% Raw sewage water	16.73	16.15	16.44	19.24	18.57	18.91	15.26	14.56	17.02	10.69	9.90	10.29	11.73	10.89	11.30	12.76	11.72	12.24
100%Treated sewage water	19.13	18.38	18.75	21.67	21.14	21.40	16.16	15.14	15.65	11.46	10.55	11.00	12.61	11.61	12.11	10.94	10.42	1237
75%Treated sewage water	18.19	17.73	17.96	20.92	20.39	20.66	15.47	14.75	15.11	12.50	11.46	11.98	13.75	12.63	13.19	12.50	12.24	12.37
25% Treated sewage water	15.35	14.57	14.96	17.65	16.76	17.21	14.65	14.28	14.47	10.01	8.59	9.30	11.01	9.45	10.23	12.50	10.94	11.72
Means	17.79	17.07		20.41	19.56		15.70	14.98		10.92	12.53		13.79	12		11.90	10.97	
L.S.D Treatments			1.75			0.713			2.32			10.61			0.81			1.58
L.S.D Soil types	0.149			0381			0.240			0.014			0.430			0.842		

Table (5) Effect of raw and treated sewage water on leaf and root nitrogen and phosphorous contents (%on dry weight basis) of Balady orange plants

Treatments	Nitrogen (%)									Phosphorous (%)								
	Leaf (2009)			Leaf (2010)			Root (2010)			Leaf (2009)			Leaf (2010)			Root (2010)		
	Clay	Sandy	Mean				Clay	Sandy	Mean	Clay	Sandy	Mean				Clay	Sandy	Mean
Control (tap water)	2.37	2.24	2.30	2.73	2.58	2.66	2.29	2.16	2.23	0.113	0.106	0.109	0136	0.126	0.131	0.095	0.069	0.823
100% Raw sewage water	3.34	3.17	3.26	3.84	3.65	3.75	2.78	2.66	2.72	0.176	00172	0.174	0.211	0.206	0.209	0.163	0.159	0.161
75% Raw sewage water	3.11	2.30	3.05	3.58	2.65	3.12	2.66	2.55	2.61	0.191	0.188	0.189	0.229	0.226	0.228	0.180	0.164	0.172
25% Raw sewage water	2.68	2.58	2.63	3.08	2.97	3.03	2.44	2.33	2.39	0.145	0.137	0.141	0.174	0.164	0169	0.136	0.136	0.136
100%Treated sewage water	3.06	2.94	3.00	2.52	3.38	3.45	2.59	2.42	2.50	0.169	0.164	0.166	0.203	0.197	0.200	0.162	0.147	0.154
75%Treated sewage water	2.91	2.84	2.87	3.35	3.27	3.31	2.47	2.36	2.42	0.155	0.140	0.148	0.186	0.168	0.177	0.148	0.139	0.146
25% Treated sewage water	2.46	2.33	2.39	2.83	2.68	2.76	2.34	2.29	2.32	0.137	0.124	0.131	0.164	0.149	0.157	0.133	0.120	0.127
Means	2.85	2.73		3.28	3.03		2.51	2.40		0.155	0.147		0.186	0.177		0.145	0.134	
L.S.D Treatments			0.280			0.106			0.372			0.026			0.007			0.027
L.S.D Soil types	0.149			0.057			0.199			0.014			0.004			0.015		

Table (6) Effect of raw and treated sewage water on leaf and root sodium and potassium content (% on dry weight basis) of Balady orange plants

Treatments	Sodium (%)									Potassium (%)								
	Leaf (2009)			Leaf (2010)			Root (2010)			Leaf (2009)			Leaf (2010)			Root (2010)		
	Clay	Sandy	Mean	Clay	Sandy	Mean	Clay	Sandy	Mean	Clay	Sandy	Mean	Clay	Sandy	Mean	Clay	Sandy	Mean
Control (tap water)	0.413	0 392	0.402	0.437	0.412	0.425	0.451	0.407	0.429	1.2	1.32	1.26	1.32	1.55	1.44	1.28	1.26	1.27
100% Raw sewage water	0.589	0.567	0.578	0 618	0.618	0.618	0.637	0.613	0.625	2.12	1.76	1 94	2.33	1.94	2.14	1.93	1.66	1.80
75% Raw sewage water	0.494	0.484	0.489	0.516	0.508	0.512	0.555	0.541	0.545	1.93	1.69	1.81	2.12	1.86	1.99	1.88	1.59	1.73
25% Raw sewage water	0 470	0.433	0.452	0.494	0.455	0.475	0.491	0.475	0.483	1.56	1.57	1.56	1.72	1.73	1.73	1.57	1.38	1.48
100%Treated sewage water	0.484	0.469	0.477	0.508	0.492	0.500	0.518	0.496	0.507	1.69	1.64	1.66	1.86	1.80	1.83	1.78	1.61	1.69
75%Treated sewage water	0.502	0.486	0.494	0.527	0.510	0.519	0.502	0.487	0.494	1.63	1.61	1.62	1.79	1.77	1.78	1.66	1.48	1.57
25% Treated sewage water	0.446	0.420	0.433	0.468	0.441	0.455	0.479	0.462	0.470	1.58	1.55	1.57	1.74	1.71	1.73	1.45	1.57	1.51
Means	0.485	0.464		0.510	0.491		0.519	0.497		1.67	1.59		1.84	1.77		1.65	1.51	
L.S.D Treatments			0.0946			0.037			0.112			0.24			0.122			0.26
L.S.D Soil types	0.051			0.02			0.059			0.127			0.07			0.139		

Table (7) Effect of raw and treated sewage water on leaf and root manganese and iron((mg/l) on dry weight basis) of Balady orange plants

Treatments	Manganese (mg/l)									Iron (mg/l)								
	Leaf (2009)			Leaf (2010)			Root (2010)			Leaf (2009)			Leaf (2010)			Root (2010)		
	Clay	Sandy	Mean	Clay	Sandy	Mean	Clay	Sandy	Mean	Clay	Sandy	Mean	Clay	Sandy	Mean	Clay	Sandy	Mean
Control (tap water)	72.02	53.41	62.72	79.22	58.8	68.9	91.67	79.55	85.61	349	310.4	329.4	346.3	325.5	335.9	545.1	528.5	536.8
100% Raw sewage water	157.3	131.5	144.4	172.7	144.7	158.7	187.1	150.3	168.7	697	580.6	638.7	731.9	609	670.4	649.5	684.9	723.1
75% Raw sewage water	127.8	114.5	121.1	140.6	125.9	133.3	133.3	123.3	128.3	627	549.4	588.3	658.4	576.9	617.6	610.6	630.6	646.8
25% Raw sewage water	113	95	104.0	124.3	104.5	114.4	124.2	117.8	121.0	558	509.4	533.9	585.9	540.9	563.4	567.5	558.3	569.4
100% Treated sewage water	125.4	105.6	115.5	137.9	116.5	127.2	172.1	145.5	158.8	594	538.7	566.2	623.7	565.6	594.7	761.2	609.5	629.5
75% Treated sewage water	123.3	100	111.7	135.6	110	122.8	174.7	150.1	162.4	563	547.8	555.5	591.2	575.2	583.2	663.1	597	603.9
25% Treated sewage water	107.2	89.84	98.52	117.9	98.8	108.4	203.9	112	157.9	523	502.7	512.7	549.2	530.8	540	580.6	550.1	558.8
Means	118	98.54		129.8	108.4		155.3	125.5		559	505.6		583.8	531.9		625.3	594.2	
L.S.D Treatments			19.44			5.03			27.39			12.27			21.23			152.2
L.S.D Soil types	10.39			2.69			14.64			65.56			11.35			81.38		

Table (8) Effect of raw and treated sewage water on leaf and root copper and zinc content ((mg/l) on dry weight basis) of Balady orange plants

Treatments	Copper (mg/l)									Zinc (mg/l)								
	Leaf (2009)			Leaf (2010)			Root (2010)			Leaf (2009)			Leaf (2010)			Root (2010)		
	Clay	Sandy	Mean	Clay	Sandy	Mean	Clay	Sandy	Mean	Clay	Sandy	Mean	Clay	Sandy	Mean	Clay	Sandy	Mean
Control (tap water)	27.5	20	23.8	31.5	23.0	27.3	57.3	46.67	52.01	42.78	38.15	40.47	45.9	43.9	44.9	75.34	62.33	68.84
100% Raw sewage water	64.5	58.35	61.4	74.2	63.1	68.6	222	184.7	203.3	116.7	113.7	115.2	134.2	130.8	132.5	163.4	146.2	154.8
75% Raw sewage water	55	51.67	53.3	63.3	59.4	61.3	205	174.2	189.5	104	103.2	103.2	119.6	118.7	119.1	152.2	140	146.1
25% Raw sewage water	41.7	36.66	39.2	47.9	42.2	45.1	185	150.8	70.33	76.89	66.67	71.78	89.7	76.7	83.2	97.66	98.56	93.61
100% Treated sewage water	48.9	46.11	47.5	56.2	53.03	54.6	432	405.7	419	97.67	91.47	94.57	112.3	105.2	108.8	137.9	124.2	131.1
75% Treated sewage water	46.7	39.45	43.1	53.7	45.37	49.5	202	168.7	185.2	68.34	65.45	66.89	78.6	75.3	76.9	118	110	114
25% Treated sewage water	37.2	33	35.1	42.8	37.9	40.4	84	56.7	167.9	71.67	63.5	67.59	82.4	73.0	77.7	93.34	88.66	91
Means	45.9	40.75		52.81	46.29		198	169.6		82.58	77.44		94.68	89.07		119.7	108.7	
L.S.D Treatments			8.18			4.22			23.99			8.07			6.66			25.16
L.S.D Soil types	4.37			2.26			12.83			4.31			3.56			13.45		

Table (9) Effect of raw and treated sewage water on leaf and root lead and chromium content ((mg/l) on dry weight basis) of Balady orange plants

Treatments	Lead (mg/l)									Chromium (mg/l)								
	Leaf (2009)			Leaf (2010)			Root (2010)			Leaf (2009)			Leaf (2010)			Root (2010)		
	Clay	Sandy	Mean	Clay	Sandy	Mean	Clay	Sandy	Mean	Clay	Sandy	Mean	Clay	Sandy	Mean	Clay	Sandy	Mean
Control(tap water)	39.3	32.69	36	34.4	29.3	39.6	40	34.48	37.2	28.67	24.4	26.55	9.17	7.34	31.8	32.5	28.33	30.41
100% Raw sewage water	89.6	82.05	85.8	86.0	77.3	94.5	103.9	95.28	94.6	71.67	64.45	68.06	39.1	34.83	81.7	77.5	72.92	75.21
75% Raw sewage water	85.3	73.72	79.5	106	75.0	90.8	85.18	73.88	79.5	86.34	62.5	65.42	36.7	31.24	90.5	71.67	68.34	70
25% Raw sewage water	69	61.67	65.3	68.9	57.6	73.4	64.96	62.18	63.6	57.49	48	53.15	25.0	22.68	63.3	61.67	50	55.83
100%Treated sewage water	84.6	70.94	77.8	78.0	65.9	85.5	71.79	68.59	70.2	65	54.99	59.99	33.9	29.81	71.9	69.44	66.11	67.78
75% Treated sewage water	72.4	62.17	67.3	65.0	64.0	74.02	67.31	65.8	66.6	54.17	53.34	56.26	28.9	26.3	64.5	67.5	56.17	63.34
25% Treated sewage water	44.9	39.75	42.3	63.9	48	46.6	52.94	41.02	47	53.33	40	46.67	17.8	17.14	55.9	52.5	43.67	48.09
Means	69.3	60.43		76.2	67.9		69.44	63.06		57.67	49.8		71.8	59.6		61.83	55.5	
L.S.D Treatments			8.4			10.2			8.25			7.96			9.6			8.27
L.S.D Soil types	4.4			5.44			4.39			4.256			5.12			4.4		

Table (10) Effect of raw and treated sewage water on leaf and root cadmium and nickel content ((mg/l)on dry weight basis) of Balady orange plants

Treatments	Cadmium (mg/l)									Nickel (mg/l)								
	Leaf (2009)			Leaf (2010)			Root (2010)			Leaf (2009)			Leaf (2010)			Root (2010)		
	Clay	Sandy	Mean	Clay	Sandy	Mean	Clay	Sandy	Mean	Clay	Sandy	Mean	Clay	Sandy	Mean	Clay	Sandy	Mean
Control (tap water)	8.34	6.67	7.5	9.17	7.34	8.3	6.12	5	5.56	11.67	29.79	20.73	13.11	20.63	16.9	15.53	13.54	14.69
100% Raw sewage Water	35.58	31.66	33.62	39.14	34.83	36.9	35.01	30	32.51	45.45	42.59	44.02	49.9	46.85	48.4	47.33	41.86	44.59
75% Raw sewage Water	33.4	28.4	30.9	36.74	31.24	33.9	33.31	27.54	30.42	41.67	37.14	39.41	45.84	40.85	43.4	45	39.17	42.08
25% Raw sewage Water	22.73	20.62	21.68	25.0	22.68	23.8	20.07	16.87	18.47	30	25.84	27.92	33.00	28.42	30.7	33.34	28.89	31.11
100% Treated sewage water	30.84	27.1	28.97	33.92	29.81	31.9	30	28.75	29.38	39.17	33.84	36.5	43.09	37.22	40.2	41.79	34.59	38.19
75% Treated sewage water	26.34	23.91	25.13	28.97	26.3	27.6	22.84	19.47	21.15	35.29	29.51	32.4	38.82	32.46	35.6	38.89	30.84	34.86
25% Treated Sewage water	16.16	15.58	15.87	17.78	17.14	17.5	15	13.33	14.17	22.5	18.75	20.63	24.75	22.77	23.8	23.33	21.11	22.22
Means	24.77	21.99		27.25	24.19		23.19	20.147		32.25	31.06		35.51	32.74		35.07	29.99	
L.S.D Treatments			3.22			4.23			4.58			11.75			6.23			5.56
L.S.D Soil types	1.72			2.26			2.45			6.28			3.33			2.97		

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الملخص العربي

تاثير الري بماء الصرف الصحي المعالج و غير المعالج علي شتلات البرتقال البلدي النامية فى ارض طينية ورملية

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مركز البحوث الزراعية –معهد البساتين

اجريت الدراسة خلال سنتى الدراسة 2009 و2010 بمحطة بحوث البساتين في الاسكندرية – مصر لدراسة تاثير الري بماء الصرف الصحي المعالج و غير المعالج علي النمو الخضري والمحتوي المعدني لشتلات البرتقال البلدي النامية فى تربة طينية او رملية و تايثرذلك علي صفات التربةالطبيعية والكميائية و قد اظهرت النتائج زيادة معدل النمو والوزن الجاف والرطب للنباتات المعاملة بماء الصرف الصحي المعالج و غير المعالج وزيادة عناصر N,P,K,Na,Fe,Mn,Zn,Cu,Pb,Cd,Ni,Cr في جذور واوراق النباتات المعاملة بماء الصرف الصحي المعالج و غير المعالج في كل من التربة الطينية والرملية ايضا اظهرت مختلف المعاملات زيادة ملحوظة فى محتوى البروتين وادت المعاملات لزيادة PH,EC والايونات الذائبة والنيتروجين المتاح وزيادة عناصر N,P,K,Na,Fe,Mn,Zn,Cu,Pb,Cd,Ni,Cr فى التربة و خاصة الطينية عن الرملية.