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EFFECT OF TREATED IRRIGATION WATER ON THE HEAVY METAL ACCUMULATION IN TOMATO PLANT TISSUE AND YIELD UNDER GREENHOUSE CONDITION

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ABSTRACT

This study was aiming for the determination of heavy metals (Co, Se, Cu, Mn, Fe, Zn, Pb, and Cd) of tomato plant tissue and tomato yield. Plants were cultivated in pots under greenhouse condition for two consecutive seasons using different mixed of tri-treated, di-treated and ground water. Using (75% ground water (G) + 25% ditreated water (D)) treatment, significantly increased Co, Se, Cu, Mn, Fe, and Pb in plants tissue compared with other treatments in plants tissue were (2.966, 1.014, 0.583, 43.86, 187.9, 1.373 mg/kg) respectively. While the highest value for Zn (47.40 mg/kg), Cd (1.730 mg/kg) were obtained after irrigation with (75% ground water (G)+ 25% tri-treated water (T) treatments compared with other irrigation treatments. On other the hand, the lowest concentration for heavy metal (Co 2.873 mg/kg, Se 1.002 mg/kg, Cu 0.423 mg/kg, Mn 32.06 mg/kg, Fe 172.7 mg/kg Pb 1.306 mg/kg, and Cd 1.490 mg/kg), in plants tissue were obtained after irrigation with control (G), while Zn (40.36) was the lowest value with (100% T) treatment. However, high value for dry/fresh weight plant (19.87 %) was observed when (75% G + 25% D) treatment was used. The highest value for tomato yield (2.22 kg/plant) was obtained after irrigation with (G) control, the second rank (1.870 kg/plant with 100% (D). The lowest value for dry/fresh weight/plant (16.26%), and tomato yield (1.320 kg/plant) was observed when irrigated with (75% G + 25% D) treatment**.**

Finally, it is possibly suggested that the use of tri ,ditreated water could be utilizated for irrigating tomato plants without hazardous heavy metal concentration in plant tissue.

INTRODUCTION

Tri-treated and ditreated water often contain discrete amount of heavy metals as impurities, especially (Pb, Cd, Co, Se, Fe, Mn, Zn and Cu). The determination of heavy metal in tissue tomato plants irrigatied by treated water is very important. The metals accumulated in soil after irrigation with treated water can become available for plant uptake, leading to an increase of the heavy metal concentration in plant tissue. Some of these elements, such as Pd, Cd, Co, Se, are phytotoxic and could enter into the human food chain.

Previous investigations showed that different irrigation treatment with tri-treated, di-treated and ground water positively or negatively affect the heavy metal contents in the tomato plant, tissue, dry/fresh weight per plant % and fruit yield. Johns and Mc Conchie (1994) showed that irrigation of bananas with secondary treated sewage gave positive results of crops. Zekri and Koo (1991) found that irrigation with well water and treated, reclaimed municipal waste water on citrus trees gave different results of the fruit crops. Results, showed that higher accumulation of nitrogen, potassium, calcium and magnesium in soils irrigated with reclimed water were not significantly reflected in leaf mineral status. Also leaf sodium, chloride and boron concentration were noticeably higher in reclaimed water treatments than in those of well water, they are still far below the toxicity levels.

Barneda *et al.* (1993) mentioned that possible using of tomato seedling to detect bensulfuron and quinchorac residues. El-Madini *et al.* (1995) mentioned that the treated sewage water from University Campus utilities significantly increased the Na, K and Cu and reduce Co in leaves and Zn in fruits of date palms. But no significant effect was observed on the K, Ca, Mg, and Na contents in fruits of the same palms. The same investigators mentioned that, leaves of date palms irrigated with desalinized and well water contained higher Ca and Zn, but lower K, Mg, Na, Cu, Fe and Pb contents than those of palms irrigated with treated sewage water. Desalinized water reduced the K, Ca, Na and Zn contents, but it increased the Mg, Fe, Cu, and Pb content of leaves, compared to well water. Neilsen *et al.* (1991) mentioned that the tomato plants irrigated either well water or secondary effluent; yield with effluent irrigation were greater than or similar to yield obtained with well water. Also, effluent irrigation decreased Zn, increased P, and variable results for other nutrients in plant tissues.

Csizinszky *et al.* (1990) suggested that the treated water used for tomato irrigation had a greater effect than the experimental variables.

Ambujam *et al.* (1993) reported that the yield of Eleusine Coracana yield was generally increased by waste water treatments, compared with ground water. Also, this investigator found that the yield was increased by treated waste water or diluted untreated water, but decreased by untreated undiluted waste water. Heavy metal did not accumulate significantly in the plants.

Bogoescu *et al.* (1997) found that the irrigation of cabbage with magnetic treated water (MTW) lead to significant increase in marketable yield compared with cabbage irrigated with magnetic untreated water. Use of magnetic indicator such as: soluble dry water (7.5%), titratable acidity (0.33%), soluble sugar (3.3%), ascorbic acid (33.3) mg/100 g and mineral salts contents (1.14%).

Waly *et al.* (1987) mentioned that citrus trees irrigated by using treated water gave good yield, also found very little heavy metal concentration in fruits. Abdel-Sabour *et al.* (1998) found that sesame seeds showed higher affinity to accumulate trace elements (Fe, Zn, Co, Cr, Se and Hg) than maize grains in most tested elements. Moreover, municipal solid waste (MSW) addition enhanced the accumulation of tested metals in seeds more than sewage sludge (BS) compost.

This investigation wase carried out to compare the effect of three irrigation sources (tri-treated, di-treated and ground water) on tomato plants. It also aims to determine the optimum water mixed on tomato plants grown in pots under greenhouse condition to give best vegetative growth, yield, and to determine heavy metal contents in the tomato plants.

MATERIALS AND METHODS

This study was carried out during the winter and spring seasons of 2000, under greenhouse condition at the Agricultural and Veterinary Training and Research Station, King Faisal University, Al-Hassa, Kingdom of Saudi Arabia. The main properties of the used soil are listed in the Table (1) including the salinity (EC), pH, $CaCO_3$ concentration and particle size distribution. The soil analysis was done following the methods outlined in Rowell (1994). pH was determined in a 1 : 2 : 5 soil-distilled water suspention while EC was determined in 1:2.5 soil : water extraction.

Table(1): Main properties of the used soil.

Salinity(E.C) dsm –1	pH	$CaCO_3$ (%)	Particle size distribution (%)		Textural class
			Sand	Silt and clay	
1.60	7.80	7.00	96	4	Sandy

In the current study, nine different concentrations of tri-treated, di-treated and ground water were used. The irrigations were: 1- Zero G + 100% T, 2- 25% G + 75% T, 3- 50% G + 50% T, 4- 75% G + 25% T, 5- Zero G + 100 D, 6- 25% G + 75% D, 7- 50% G + 50% D, 8- 75% G + 25% D, 9- Control 100% ground water. (G = Ground water, T = Tritreated, D = Ditreated water). The mixed irrigation water was completed on a daily basis. The pot experiment consisted of nine treatments in complete randomized block with four replicates.

Data of Table (2) are summary of tritreated, ditreated and ground water chemical analysis. An aged of 40 days tomato seedings (Carmelo cultivar) were transplanted on 7^{th} of November 2000. All other common greenhouse practices for tomato were also performed. At the end of expeiments, heavy metal (Pb, Cd, Co, Se, Fe, Mn, Zn and Cu) fresh/dry weight/plant % and tomato yield (kg) in the tomato plants were measured in the pot plants.

The plant tissue was dried in a forced-air at 50 ºC. The heavy metal concentration in the plant tissue was determined after nitric-perchloric digestion using the atomic absorption spectro meter of Perkin Elmer 3030 equipped with the background corrector (Petruzzelli *et al.,* 1985). All data obtained were subjected to the proper statistical analysis (Gomez and Gomez 1984). The least significant differences at the 5% level (L.S.D. 5%) were also calculated.

Table (2): Summary of tri-treated, di-treated and ground water chemical analysis.

Chemical analysis	EC dsm^{-1}	pH	(meq/L)							
			Na	K	Ca	Mg	CO_3	HCO_3	Cl	SO_4
Tri-treated Water	2.60	7.70	21.3	0.79	7.8	9.2	0	12	15	12.09
Di-treated Water	2.67	6.93	26.52	0.90	5.8	7.2	0	3.0	28	9.42
Ground water	1.9	6.60	13.04	0.36	4.2	10.5	0	6.4	23	0

RESULTS AND DISCUSSION

Table (3) includes the Co, Se, Cu and Mn concentration of tomato plants tissue affected by the irrigation with tri-treated, di-treated and ground water. The obtained data show that irrigation with 75% G (Ground water)+ 25% D treatment (Ditreated water) gave the highest concentration for heavy metals (Co,Se, Cu and Mn) in the tomato plants tissue) the second rank was 75% G (Ground water) 25%+ T (Tri-treated water) treatment.

Table (3): Effect of tri-treated and di-treated water irrigation on Co, Se, Cu and Mn contents of tomato plants average of two seasons (2000-2001).

Treatments	Heavy metals in plant tissue (mg/ kg)			
	Co	**Se**	**Cu**	**Mn**
G T				
T1- zero 100%	2.878	1.003	0.473	37.43
T2- 25% 75%	2.893	1.004	0.523	38.56
T3- 50% 50%	2.898	1.009	0.520	41.06
T4- 75% 25%	2.926	1.014	0.556	43.16
G D				
T-5 zero 100%	2.883	1.003	0.486	38.13
T-6 25% 75%	2.888	1.005	0.543	39.26
T-7 50% 50%	2.916	1.012	0.550	41.46
T-8 75% 25%	2.966	1.014	0.583	43.86
T-9 Control	2.873	1.002	0.423	32.07
L.S.D. at 5%	0.002	0.004	0.036	0.82

The same Table showed that there are significant variances between all treatments and control. The lowest concentration of all heavy metals in the tomato tissue was obtained after irrigation with ground water. On the contrary, the used ditreated and tritreated water at mixed (75% G + 25% with T and or D) caused accumulation of Co, Se, Cu and Mn in the pot soil resulted in an increase of Co, Se, Cu and Mn uptake by the plants. These results are in correspondence with the findings of other researchers (Zekri and Koo (1991), El-Madini *et al.* (1995), Waly *et al.* (1987), and Abdel-Sabour *et al.* (1998).

The summary of the heavy metals is given in Table (4) which includes the Fe, Zn, Pb and Cd concentration in the tomato plants tissue. Table (4) shows that all irrigation treatments resulted in significant differences in the heavy metal contents compared to the control; also Table (4) shows hat the increases in the Fe and Pb concentrations were greater using (75% G + 25% D) and the second rank was (50% G + 50% D), while the highest value for Zn and Cd were obtained after using (75% G + 25% T),. Moreover the second rank was (75% G + 25% D). On the other hand, the increased accumulation of Fe, Zn, Pb and Cd in the soil after continues the irrigation resulted in an increase of Fe, Zn, Pb and Cd uptake by the plants. The increase in the availablity of heavy metal enhanced the tomato growth processes positively or negatively affecting the tomato yield. In our experiment the increas in heavy metals of the soil could have positive effect on dry/fresh weight per plant %, while the high concentration of heavy metal gave negative effect on tomato yields. The results of this study agree with those obtained by other investigators (Abdel-Sabour *et al.*1998, Waly *et al.*, 1987, and Neilsen *et al.*, 1991).

Table (4): Effect of tri-treated, di-treated water irrigation on Fe, Zn, Pb and Cd contents of tomato plants average of two seasons (2000-2001)

Treatments	Fe	Heavy metal in plant tissue (mg/ kg)		
		Zn	Pb	Cd
G T				
T1- zero 100%	180.7	40.36	1.310	1.543
T2- 25% 75%	183.8	40.66	1.320	1.566
T3- 50% 50%	185.6	42.76	1.336	1.573
T4- 75% 25%	186.3	47.40	1.323	1.730
G D				
T-5 zero 100%	181.2	40.80	1.343	1.550
T-6 25% 75%	183.6	43.16	1.360	1.576
T-7 50% 50%	186.9	45.40	1.366	1.603
T-8 75% 25%	187.9	47.20	1.373	1.620
T-9 Control	172.7	42.26	1.306	1.490
L.S.D. at 5%	3.440	3.333	0.023	0.141

Table (5) shows that the increase in the dry/fresh weight/plant % was greater using (75% G + 25% D) treatments. This treatment gave the highest concentration for all heavy metal except Zn and Cd. The second value by using (50% G + 50% D) treatments, while the highest tomato yield was obtained after using control (ground water only, the second value for yield was obtained with zero G + 100% D) treatment, moreover the third rank was (zero G + 100% T) treatment. This table showed that all treated water irrigation treatments caused a significant increase in the dry/fresh weight/plant % and tomato yield as compared to control (ground water). The lowest value for dry/fresh weight and tomato yield was obtained after using (75% G + 25% T) treatments, this treatment gave the highest value for Zn and Cd. Similar results are observed by other investigators. Johns and Mc Conchie (1994), Zekri and Koo (1991), Barneda *et al.* (1993), Neilsen *et al.* (1991).

Table (5): Effect of tri-treated, di-treated water irrigation on dry/fresh weight plant %, yield kg/plant of tomato plants, average of two seasons (2000-2001).

Treatments	Dry/fresh weight plant (%)	Yield (kg/plant)
G T		
T1- zero 100%	18.09	1.830
T2- 25% 75%	18.51	1.643
T3- 50% 50%	17.20	1.536
T4- 75% 25%	16.26	1.320
G D		
T-5 zero 100%	19.22	1.870
T-6 25% 75%	19.35	1.533
T-7 50% 50%	19.66	1.353
T-8 75% 25%	19.87	1.540
T-9 Control	17.28	2.220
L.S.D. at 5%	1.445	0.05

CONCLUSION

The addition of ground water + ditreated water at 75% + 25%, respectively on tomato gave the highest concentration for Co, Se, Cu, Mn, Fe, Pb, and dry/fresh weight/plant %, while the highest value for Zn, Cd gave with using (75% G + 25% T) treatments, on other hand, the highest yield was obtained after irrigation with ground water only (control).

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تأثير الرى بالماء المعالج على تراكم المعادن الثقيلة فى انسجة نباتات الطماطم والمحصول تحت ظروف البيوت المحمية

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تهدف هذه الدراسة الى تحديد المعادن الثقيلة (كوبالت-سلنيوم-نحاس-منجنيز-حديد-زنك-رصاص-كادميوم) فى أنسجة النبات وتأثيرها على محصول نبات الطماطم

تم زراعة نباتات الطماطم فى أصص تحت ظروف البيوت المحمية لمدة موسمين متتابعين باستخدام معاملات مختلفة من الماء المعالج ثلاثيا والماء المعالج ثنائيا مع الماء الأرضي

أشارت النتائج أن استخدام المعاملة المكونة من ٧٥%ماء أرضى +٢٥% ماء معالج ثنائيا أعطت زيادة معنوية فى كلا من محتوى الكوبالت وسلينيوم –نحاس –منجنيز – حديد- رصاص-فى أنسجة النبات بالمقارنة بالمعاملات الأخرى كما أوضحت هذه النتائج ان محتوى الكوبالت –السلينيوم –نحاس-منجنيز-حديد ورصاص فى أنسجة النبات كانت (٢,٩٦٦-١,٠١٤-٥٨٣و٠-٨٦و٤٣-٩٠و١٨٧-١,٣٧٣ ملجم/كجم) على التوالى بينما كانت أعلى قيمة لكلا من الزنك (٤٠و٤٧ ملجم/كجم) والكادميوم (٧٣٠و١ ملجم/كجم) تم الحصول عليها بعد الرى بالمعاملة (٧٥%ماء أرضى +٢٥%ماء معالج ثلاثيا بالمقارنة ببقية المعاملات الأخرى ومن ناحية أخرى كان اقل تركيز بالنسبة للمعادن الثقيلة –كوبالت (٢,٨٧٣ ملجم/كجم) وسلينيوم (١,٠٠٢ ملجم/كجم) ونحاس(٤٢٣ز٠ ملجم/كجم) منجنيز٠٦و٣٢ ملجم/كجم) وحديد (٧و١٧٢ ملجم/كجم) ورصاص ١,٣٠٦ ملجم /كجم) والكادميوم (٤٩٠و١ملجم /كجم) فى أنسجة النبات تم الحصول عليها بعد الرى بمعاملة الكنترول (الماء الارضى) بينما اظهر الزنك اقل قيم عند المعاملة (١٠٠%ماء ثلاثى) واكثر من ذلك كانت أعلى قيمة بالنسبة للوزن الجاف/الطازج للنبات (٨٧و١٩%) وكانت عند المعاملة ٧٥% ماء أرضى +٢٥%ماء معالج ثنائيا) بينما كانت أعلى قيمة فى المحصول بالنسبة للطماطم (٢٢٠و٢كجم/للنبات) تم الحصول عليها بعد الرى بمعاملة الكنترول (الماء الأرضي) وتأتى فى المرتبة الثانية (٨٧٠و١كجم/للنبات) مع استخدام ١٠٠% من الماء المعالج ثنائيا

اقل فيم فى كلا من الوزن الجاف/الطازج للنبات (٢٦و١٦%) ومحصول الطماطم (٣٢٠و١كجم/للنبات) كانت بعد الرى باستخدام المعاملة ٧٥%ماء أرضى +٢٥%ماء معالج ثنائيا

وأخيرا يمكن القول بأنه يمكن الاستفادة من الماء المعالج ثلاثيا وتنائيا فى رى نباتات الطماطم بدون مخاطر من مستوى تركيز العناصر الثقيلة فى أنسجة النبات