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EFFECT OF DRAINAGE AND TREATED IRRIGATION WATERS ON SOME HEAVY METAL ACCUMULATION IN SOIL AND CUCUMBER PLANT TISSUE

Eed .Al.,M.A and F.N.Assubaie

Chemistry and Botany Department, College of Agri. and Food Sci., King Faisal University, Al-Hassa, Saudi Arabia.

ABSTRACT

This study was aiming for the determination of some heavy metals (Co, , , Pb, Cd and Co) of soil and cucumber plant tissue. Plants were cultivated in pots under greenhouse condition for two consecutive seasons using different mixed of drainage, tri-treated, di-treated and ground water. Using (100% Tri-treated water) treatment, significantly increased Pb and Cd in soil and plants tissue compared with other treatments in soil and plants tissue were (2.90,2.81,1.92 and 2,01 mg/kg) respectively. While the highest value for Co (3.29 mg/kg) in soil was obtained after irrigation(100% drainage water) treatment compared with other irrigation treatments .while the highest Co value in plant tissue(2.42 mg/kg) was obtained after using 100% di-treated water . On other the hand, the lowest concentration for heavy metal (Pb,Cd and Co in soil and plant (0.93.0.91,1.08 ,0.93,o.90 and 1.09 mg/kg)respectively were obtained after using ground water only . However, high value for dry/fresh weight plant (19.66 %) was observed when (100% ground water (G) treatment was used. The highest value for cucumber yield (1.60 kg/plant) was obtained after irrigation with ground water (G) control, the second rank (0.79 kg/plant with 75% (G) + 25% drainage water(R. The lowest value for dry/fresh weight/plant (15.66%), and cucumber yield (0.40 kg/plant) was observed when irrigated with (25% G + 75% D) treatment. The highest Pb ,Cd and Co concentrations(3.80,3.27 and 3.95 mg/kg) respectively were obtained of tri-treated water compared with others waters (drainage .di-treated water and ground water)

Finally, it is possibly suggested that the use of drainage, tri .ditreated water could be utilizated for irrigating cucumber plants without hazardous some heavy metal (Pb. Cd and Co) concentration in soil and plant tissue.

INTRODUCTION

Drainage, tri-treated and ditreated water often contain discrete amount of heavy metals as impurities, especially (Pb, Cd,and Co,). The determination of heavy metals in soil and cucumber plant tissues irrigated with drainage and treated water is very important. The metals accumulated in soil after irrigation with drainage and treated water can become available for plant uptake, leading to an increase of the heavy metal concentrations in plant tissues. Some of these elements, such as Pb, Cd and Co are phytotoxic and could enter into the human food chain.

Previous investigations showed that different irrigation treatments with drainage and tri-treated, di-treated and ground waters positively or negatively affected the heavy metal contents in the soil and cucumber plant, tissues, dry/fresh weight per plant % and fruit yield. Buran *et al.* (1995) showed that the tow cyclic drainage-water reuse practices were tested in a 3 year-rotation of processing tomato and cotton .In both practices drainage water (Eci =7.4

dsm $^{-1}$ and 0.74 mmoil^{-1}B was applied to processing tomato after first bloom to take advantage of salt-induced enhancement of fruit quality and increased crop salt tolerance at later developmental stages .In one practice .drainage water was also applied to the following cotton crop after thinning .Non saline water was used for irrigation at all other times and throughout for the control. When saline water was applied once every 3 year, yield of both crops were unaffected. Tomato yields were generally lowest when saline water was applied 2-3 years, but saline water improved tomato fruit quality by increasing Brix in most years. Changes in soil chemical and physical quality may limit long -term reuse. Both B and salts accumulated in the soil over time particularly depth (60-40 cm), whereas Se was more readily leached and showed greater fluctuations in the root zone with irrigation treatment. Calculation using reclamation formulae estimated that for low drainage water, the amount of drainage water ,the amount of drainage water used exceeded that of non-saline water needed to return soil. Ece to control levels.

Al-Harbi (1995) found that seedling growth of cucumber was generally reduced with increasing salinity level. Cucumber was more salt sensitive than other vegetable plants. Shoot and root dry weight of cucumber was increased by decreasing Na/Ca ratio at 4.0 ms/cm salinity. AL-Eed and Hamaiel (2002) found that using (75% ground water +25% ditreated water treatment significantly increased Pb and Co in tomato plant tissue. While the highest value for Cd (1.730 mg/kg) was obtained after irrigation with (75% ground water +25% tri-treated water.

Johns and McConchie (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 on citrus trees gave different results of the fruit crops. Results, showed that higher accumulations of nitrogen, potassium, calcium and magnesium in soils irrigated with reclaimed water were not significantly reflected in leaf mineral status. Also leaf sodium, chloride and boron concentrations were noticeably higher in reclaimed water treatments than in those of well water, they are still far below the toxicity levels. Knapp(1992) found that drainage water irrigation gave good results of some crops .while heavy metal concentrations were lower than other treatments

Barneda *et al.* (1993) mentioned that possible using of tomato seedlings 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 waters 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 with well water or secondary effluent; yield with effluent irrigation was 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.

Ambujam *et al.* (1993) reported that the yield of Eleusine Coracana 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 metals 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 treated water gave good yield and 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 was carried out to compare the effect of four irrigation sources (drainage, tri-treated, di-treated and ground waters) on for cucumber plants. It also aims to find the optimum water mixture on cucumber plants grown in pots under greenhouse conditions to give best vegetative growth and yield. The pollution of soils and plants by Pb, Cd and Co was also investigated.

MATERIALS AND METHODS

This study was carried out during the winter and spring seasons of 2000/2001 respectively, 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 suspension 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, 13 different concentrations of drainage and tri-treated, di-treated and ground waters were used. The irrigation treatments were: 1- Zero G+100%R, 2- 25%G+75%R, 3- 50%G+50%R, 4- 75%G +52%R, 5- Zero G + 100% T, 6- 25% G + 75% T, 7- 50% G + 50% T, 8- 75%

G + 25% T, 9- Zero G + 100 D, 10- 25% G + 75% D, 11- 50% G + 50% D, 12- 75% G + 25% D, 13-Control 100% ground water. (G = Ground water, R= Drainage water T = Tritreated water , D = Ditreated water). The mixed irrigation water was completed on a daily basis. The pot experiment consisted of 13 treatments designed in complete randomized blocks with four replicates.

Data of Table (2) are summary of drainage, tritreated, ditreated and ground water chemical analysis. An aged of 15 days cucumber seedlings (Erigon cultivar) were transplanted on 9 and 5th of October 2000 and 2001 respectively. All other common greenhouse practices for cucumber were also performed. At the end of experiments, fresh/dry weight/plant % and cucumber yield (kg) and heavy metal (Pb, Cd and Co) in the cucumber plants and soil were measured in the pot plants.

EC and pH of the soil were analyzed following the methods described by Page *et al.* (1982). The plant tissue was dried in a forced-air at 50 °C. The heavy metal concentrations in the plant tissue and soil were determined after nitric-perchloric digestion using the atomic absorption spectrometer 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 chemical analysis of drainage, tri-treated, di-treated and ground waters. (By atomic absorption spectrometer)

Chemical analysis	EC dsm^{-1}	pH	Pb mg/liter	Cd mg/liter	Co mg/liter
Drainage water	2.66	7.80	3.60	3.05	3.80
Tri-treated water	2.60	7.70	3.80	3.27	3.95
Di-treated water	2.67	6.93	3.75	3.10	3.15
Ground water	1.9	6.60	0.65	0.09	0.16

RESULTS AND DISCUSSION

Table (3) includes the Pb (Lead), Cd (Cadmium) and Co (Cobalt) concentrations of soil and cucumber plant tissues affected by the irrigation with drainage, tri-treated, di-treated and ground waters. The obtained data show that rrigation with zero G (Ground water)+ 100% Tri-treatment (Tri-treated water) gave the highest concentration for heavy metals (Pb and Cd) in the soil and cucumber plant tissues) the second rank was 25% G (Ground water)+ 75% T (Tri-treated water) treatment. While the highest value for Co in the soil was obtained after using 100% drainage water. On the other hand the highest concentration of Co in the cucumber plant was obtained after using 100% di-treated water.

Table (3): Effect of drainage, tri-treated and di-treated irrigation waters on Pb, Cd and Co, contents in soil and cucumber plants (average of two seasons 2000-2001).

Treatments		Heavy metals in soil and plant tissue (mg/kg)					
		Soil			Plant tissue		
		Pb	Cd	Co	Pb	Cd	Co
G	R						
T1-zero	100%	2.51 2.49	1.66 1.66	3.29 3.27	1.50	1.06 1.06	2.11
T2-25%	75%	2.47 2.46	1.65 1.65	3.26 3.21	1.50	1.06 1.05	2.10
T3-50%	50%				1.46		2.10
T4-75%	25%				1.45		2.09
G	T						
T5-zero	100%	2.90 2.86	2.81 2.70	2.94	1.92 1.90	2.01 1.96	2.17
T6- 25%	75%	2.85 2.80	2.65 2.60	2.90	1.86 1.82	1.91 1.88	2.17
T7- 50%	50%			2.89			2.16
T8- 75%	25%			2.84			2.16
G	D						
T9-zero	100%	2.82 2.78	2.56 2.49	2.94	1.71 1.70	1.61 1.56	2.42
T10-25%	75%	2.75 2.73	2.43 2.42	2.93	1.70 1.64	1.43 1.42	2.34
T11-50%	50%	0.93	0.91	2.88	0.93	0.90	2.32
T12-75%	25%			2.87			2.26
T13- Control				1.08			1.09
L.S.D. at 5%		0.03	0.06	0.05	0.04	0.06	0.03

The same Table showed that there are significant variances between all treatments and control. The lowest concentration of Pb.Cd and Co in soil and in the cucumber tissue was obtained after irrigation with ground water only. On the contrary, the used tri treated water at 100% T and or 25% G+27%T) caused accumulation of Pb and Cd in the pot soil resulted in an increase of Pb and Cd uptake by the plants. These results are in correspondence with the findings of other researchers EL-Eed and Hamaiel (2002), Zekri and Koo (1991), El-Madini *et al.* (1995), Waly *et al.* (1987), and Abdel-Sabour *et al.* (1998).

On the other hand, the increased accumulation of Co in the soil was obtained after continuous irrigation with drainage, while the highest concentration of Cobalt in plant tissue was obtained after irrigation with 100% di -treated water. The increase in the availability of heavy metal enhanced the cucumber growth processes positively or negatively affecting the cucumber yield. In our experiment the increase in heavy metals of the soil could have negative effect on dry/fresh weight per plant %, while the high concentration of heavy metal in plant tissue gave negative effect on cucumber yields.

Table (4) shows that the increase in the dry/fresh weight/plant % was greater using (100% G) treatments. This treatment gave the lowest concentration for Pb, Cd and Co in soil and plant. The second value by using (50% G + 50%T) treatments, while the highest cucumber yield was obtained after using control (ground water only, the second value for yield was obtained with 75%G + 25%R) treatment, moreover the third rank was (75%G

+ 25% T) treatment. This table showed that all drainage, treated water and ground water irrigation treatments caused a significant differences in the dry/fresh weight/plant % and cucumber yield. The lowest value for dry/fresh weight was obtained after using (25% G + 75%R) treatments, while the lowest value for cucumber yield was obtained after using (25% G +75% D) treatment gave. Similar results are observed by other investigators. Johns and Mc Conchie (1994), Zekri and Koo (1991), Barneda *et al.* (1993), Neilsen *et al.* (1991) and AL-Eed and Hamaiel (2002).

Table (4): Effect of Drainage, tri-treated, di-treated water irrigation on dry/fresh weight plant %, yield kg/plant of cucumber plants, average of two seasons (2000-2001).

Treatments		Dry/fresh weight plant (%)	Yield (kg/plant)
G	R		
T1-zero	100%	18.66	0.38
T2-25%	75%	15.66	0.62
T3-50%	50%	15.66	0.71
T4-75%	25%	17.33	0.79
G	R		
T1-zero	100%	18.66	0.50
T2-25%	75%	18.33	0.64
T3-50%	50%	19.33	0.65
T4-75%	25%	18.33	0.75
G	D		
T9-zero	100%	17.00	0.60
T10-25%	75%	17.66	0.40
T11-50%	50%	18.00	0.50
T12-75%	25%	16.66	0.60
T13- Control		19.66	1.60
LS.D. at 5%		**1.41**	**0.12**

Fig. (1) Showed, lead concentration in different type water (drainage, tri-treated, di-treated and ground water) and Pb concentration in soil, plant after irrigation, data showed that the highest Pb concentration in soil, plant and water was obtained after using tri -treated water, while the lowest Pb concentration in plant was obtained after using ground water (control).

Fig. (2) Showed Cadmium concentration in different type water (drainage. tri-treated. di-treated and ground water) and Cd concentration in

soil, plant after irrigation data showed that the highest Cd concentration in soil, plant and water was obtained after using tri-treated water, while the lowest Pb concentration was obtained after using ground water (control).

Fig. (3) showed Co concentration in different type water (drainage, tri, di, and ground water) and concentration in soil, plant after irrigation, data showed that the highest Co concentration in soil was obtained after using drainage water, while the highest Co concentration in plant was obtained after using di-treated water. On the other hand the highest Co concentration in water was obtained after using tri-treated water, while the ground water (control) treatment gave the lowest Co concentration for soil, plant and water after irrigation. Similar results were obtained by AL-Eed and Hamaiel (2002).

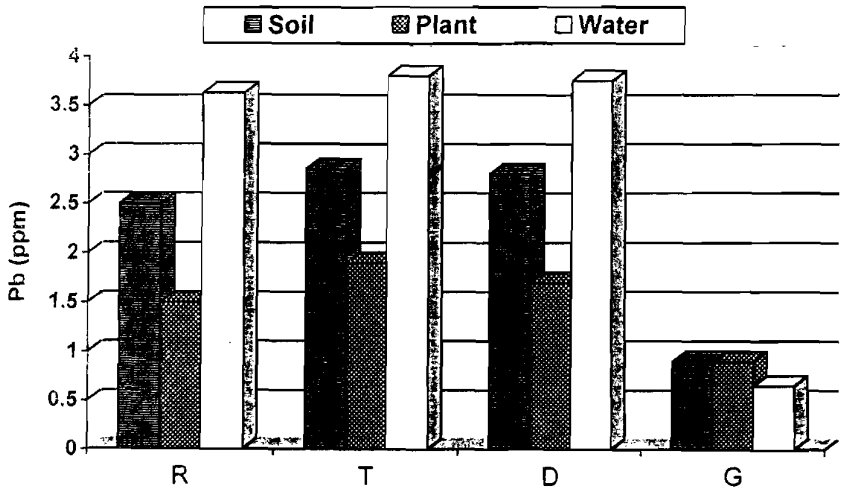

Fig. 1: Lead concentration (Pb) in treated water: drainage (R), tri (T), di (D) and ground water (G), soil and plant after irrigation.

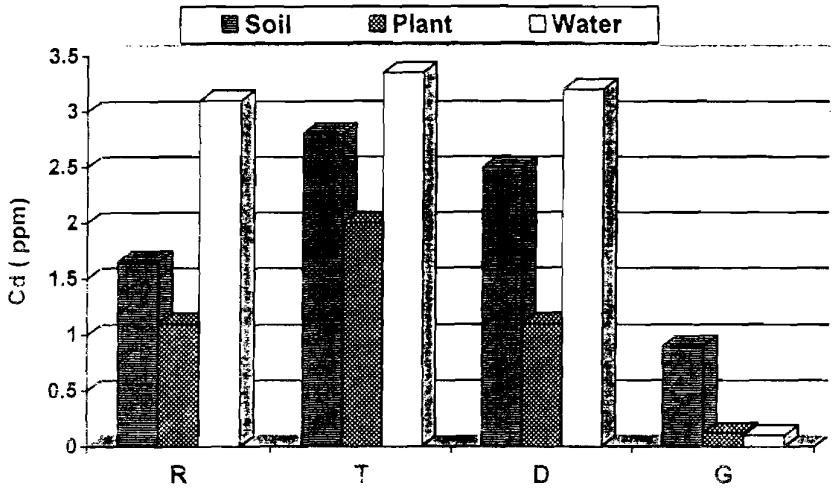

Fig. 2: Cadmium concentration (Cd) in treated water: drainage (R), tri (T), di (D) and ground water (G), soil and plant after irrigation.

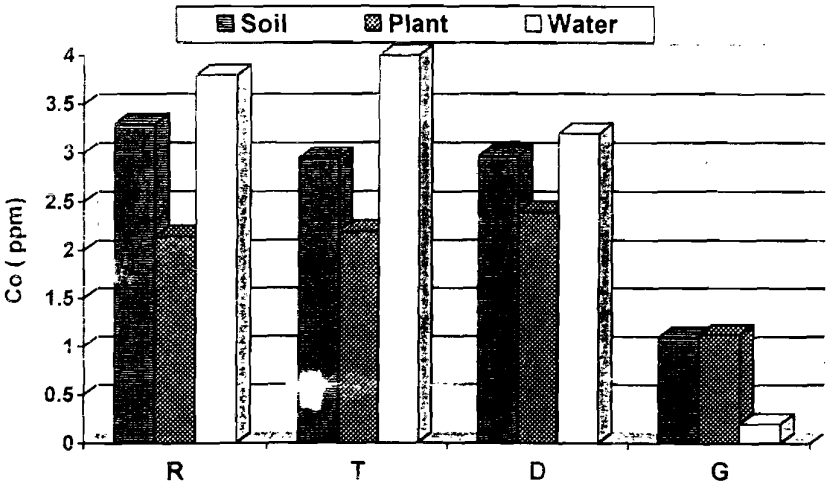

Fig. 3: Cobalt concentration (Co) in treated water: drainage (R), tri (T), di (D) and ground water (G), soil and plant after irrigation.

CONCLUSION

The irrigation of cucumber plants with tri-treated water 100% gave the highest concentration of Pb and Cd in soil and cucumber plant .while the highest value for Co in soil resulted with using 100% drainage water treatment , the highest Co value in plant with using 100% di-treated water. On other hand, the highest dry/fresh weight plant % and cucumber yield was obtained after irrigation with ground water only (control).

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تأثير الرى بمياه الصرف الزراعى والماء المعالج على تراكم بعض المعادن الثقيلة فى التربة وأنسجة نباتات الخيار

محمد بن عبد الرحمن العيد ــ فهد بن ناصر السبيعى

قسم الكيمياء والنبات ــ كلية العلوم الزراعية والأغذية ــ جامعة الملك فيصل

تهدف هذه الدراسة إلى تحديد بعض المعادن الثقيلة (رصاص ــ كادميوم ــ كوبالت) فى التربة أنسجة النبات وتأثيرها على محصول نبات الخيار تم زراعة نباتات الخيار فى أصص تحت ظروف البيوت المحمية لمدة موسمين متتابعين باستخدام معاملات مختلفة من مياه الصرف الزراعى والماء المعالج ثلاثيا والماء المعالج ثنائيا مع الماء الأرضى.

أشارت النتائج أن استخدام المعاملة المكونة من ١٠٠ % ماء معالج ثلاثيا أعطت زيادة معنوية فى كل من محتوى الرصاص والكاديوم فى كلا من التربة وفى أنسجة النبات بالمقارنة بالمعاملات الأخرى كما أوضحت هذه النتائج أن محتوى الرصاص والكاديوم فى التربة وأنسجة النبات كانت (٢,٩٠ ــ ٢,٨١ ــ ١,٩٢ ــ ٢,٠١ ملجم / كجم) على التوالى بينما كانت أعلى قيمة للكوبالت فى التربة (٣,٢٩ ملجم / كجم) تم الحصول عليها بعد الرى بالمعاملة (١٠٠ % من مياه الصرف الزراعى) بالمقارنة ببقية المعاملات الأخرى بينما أعلى قيمة للكوبالت فى أنسجة النبات (٢,٤٢ ملجم / كجم) تم الحصول عليها بعد الرى بـ ١٠٠ % بالماء المعالج ثنائيا ومن ناحية أخرى كان أقل تركيز بالنسبة لكلا من الرصاص ، الكاديوم والكوبالت فى كلا من التربة والنبات (٠,٩٣ ــ ٠,٩١ ــ ١,٠٨ ــ ٠,٩٣ ــ ٠,٩٠ ــ ١,٠٩ ملجم / كجم) على التوالى. وأعلى قيمة للوزن الجاف / الطازج للنبات (١٩,٦٦ %) تم الحصول عليها بعد الرى بـ ١٠٠ % من الماء الجوفى وأعطت المعاملة باستخدام الرى بالماء الجوفى ١٠٠ % أعلى قيم بالنسبة لمحصول الخيار (١,٦ كجم للنبات) بينما احتلت المعاملة باستخدام ٧٥ % من الماء الجوفى + ٢٥ % من مياه الصرف الزراعى المرتبة الثانية من حيث المحصول (٠,٧٩ كجم للنبات) فى حين أن المعاملة باستخدام الرى بمعدل ٢٥ % من الماء الجوفى + ٧٥ % من الماء المعامل ثنائيا أعطت أقل قيم بالنسبة للوزن الجاف / الطازج للنبات % وأيضا بالنسبة للمحصول الثمرى للخيار. ومن ناحية أخرى أعطت المعاملة باستخدام الماء المعالج ثلاثيا ١٠٠ % أعلى تركيز بالنسبة لكلا من الرصاص والكاديوم والكوبالت (٣,٨٠ ــ ٣,٢٧ ــ ٣,٩٥ ملجم / كجم) بالمقارنة ببقية أنواع المياه الأخرى.

وأخيرا يمكن القول بأن استخدام كلا من مياه الصرف الزراعى والمياه المعالجة ثنائيا وثلاثيا يمكن استخدامها فى رى نباتات الخيار بدون حدوث مخاطر من وجود بعض المعادن الثقيلة (رصاص ــ كاديوم ــ كوبالت) بتركيزات منخفضة وأنسجة النبات.