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EFFECT OF IRRIGATION WITH URBAN SEWAGE AND AQUEDUCT WATER ON HEAVY METALS ACCUMULATION AND NUTRITIONAL VALUE OF BEAN (*Phaseolus vulgaris* L)

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ABSTRACT

This research was conducted to study heavy metals accumulation and nutritional value of bean in three areas of Tehran's south based on completely randomized block design in the form of split plot with 3 replications in 2007. The main factor was included in three levels as sewage canals in Salehabad, Talebabad and Dehkheir areas; sub factor in two levels was involved sewage and aqueduct water (control). Use of Talebabad's sewage increased heavy metals assembling in different parts of bean, especially in root compared to sewages of Salehabad and Dehkheir. In three areas, irrigation with sewage in comparison with aqueduct water had no high effects on heavy metals except of Fe and Cr. In bean's pod and seed, only Fe and Cr were higher than standard limit and most of the other metals accumulated like aqueduct water. Heavy metals accumulation in bean's root and leaves were almost high, but high control of bean's pod and seed caused lower quantities of transported heavy metals ratio to grain than root and leaves. So, in respect of heavy metals assembling, using of bean's green pod and grain will not be resulted in problem.

Keyword: bean, heavy metals, sewage, irrigation, pollution.

INTRODUCTION

Using sewage irrigation for many countries specially those who are located in warm and dry regions has been prevailed. Around 80% of Iran's land is located in dry region and economizing in water resources by re-using of sewage can be useful for overcoming the water limitation problem. Evaluation of increasing urban sewage according to the annually growth population can be considered as an important issue for optimum use of wastewater. Excessive use of waste water will be resulted in heavy metal accumulation in soil (Hoodji, 2001).

Heavy elements in the soil tended to increase with wastewater use in agricultural land and therefore, significantly increase such elements in plants.

Urban wastewater irrigation can be used as a nutritional element for plants, as well as fertilizers for the plants and also it will be resulted in water saving (Ramirez-Fuente *et al*., 2002; Melli *et al*., and 2002 Ratton *et al*., 2005).

It was reported that application of wastewater irrigation increased soil nutrient elements and thus improved soil fertility and convenient access to high concentration of nutrients which resulted in increment of growth and biomass of plants (Gardiner *et al*., 1995; Soumlnmez and Bozkurt., 2006; Yang *et al*., 2010 and Keller *et al*., 2002). Wastewater application as plant irrigation should be done based on proper management and consistent control (Bozkur and 0 Yarilga, 2003).

Nutritional elements in wastewater makes higher yield in crops. Transmitted heavy metals to the soil are a function of the clay, organic matter, and cationic exchange capacity (Azimi *et al*., 2006; Cobb *et al*., 2000; Taha *et al*., 2004 and Walker *et al*., 2003). Using wastewater for plant irrigation as a source of substantial needed elements for plants has been used long-terms in various countries (Aghabarati, 2006). It was reported that sewage irrigation caused cadmium adsorption for plant and animal as toxic rates. Also significant relationship between heavy metal concentration in sewage and its absorption in plant and fruit was observed (AL Enezi *et al*., 2006). This fact should not be ignored that wastewater irrigation can play a role as a factor for ecosystem disrupting in order to its high elements concentration (Yadav *et al*., 2002; Brar *et al*., 2000). Hence plants as first cycle of food chain have considerable influence on living things organisms, so influent agent of metal pollutants to food chain should be considered more than another food levels. In lands under wastewater irrigation in various countries, with heavy metal concentration in the assembly plant, average cadmium concentration was reported of heavy elements 0.07, chrome 0.16, lead 0.43 and zinc 39.2 milligrams per kilogram in brown rice (McGrath *et al*., 1997; Ngole *et al*., 2009 and Zheng *et al*., 2007). Nowadays, local research into non-conventional water resources such as wastewater in irrigated lands has become very important. Relying only on instructions provided in other regions of the world were proven wrong and resulted in irreparable long term damage to soil and water resources. Results in a research about industrial wastewater showed that none of the concentrations of elements Ni, Cd, and Pb were above the limit, but the limitations were noted for wastewater salinity, pH and high concentrations of some positively-charged ions (known as cations), and negatively-charged ions (known as anions) (Ramulu and Sree., 2002 and Zavadil, 2009).

This study, taking into account the cases discussed above, focuses on the effects of minerals' accumulation on the nutritional value of bean plants irrigated with wastewater in three regions of southern Tehran.

MATERIALS AND METHODS

For evaluation the effects of irrigation with sewage water and pure water, the experiment was conducted on the area south of Tehran (Rey) in 2007. A split-plot design based on randomized complete blocks with three replicates was used.

The main factor in three levels of sewage canals in Tehran were monitored for different soil and climates including: **1 -** Shoor river wastewater in the lands of Salehabad region (Agro-Industry Jamaran), **2 -** Firoozabad sewage canal (in agricultural lands of Dehkheir village), **3 -** Sorkheh Hesar canal (in agricultural lands of Talebabad village). The type of irrigation method was selected as sub factor and was monitored at two levels: 1 - Wastewater, 2 - aqueduct water. One liter sample of wastewater was taken to measure the amount and concentration of heavy metals, Ec, PH and other cases and then submitted to the laboratory. Irrigation water requirements of plants were based on irrigation with wastewater combined (the three canals) with aqueduct water. Also entrance channels for the combined irrigation adjusted equally with adjustable valves. Soil samples from a sampling depth of 30 centimeters, transferred to the laboratory in air-dried and then crushed-in porcelain mortar, and were sieved to a thickness of two millimeters. To prepare extracts of minerals extracted from soil, a mixture was used of two acid including normal HCL 0.05 and sulfuric acid 0.025. For the study of dry-weather soil, five grams of air-dried soil was weighted exactly with the lab scale 0.01 grams and purred in a 100-ml glass jar, and mixed with 20 ml solution extractor for 15 minutes. The material was then filtered using filter paper 42 and was collected in a 50-ml beaker and then brought to the amount of 50 ml by mixing with solution extractor. Then, using the atomic absorption model B1100, the minerals were measured. Water samples were filtered by filter paper 42, and the suspended particles separated, as the minerals were measured with atomic absorption equipment. Samples of the plants were looked over for chemical analysis. Furthermore, samples were observed for one hour at normal temperatures and then in a 70°C oven for 72 hours to remove the plant's moisture completely. Finally, one gram of plant powder was placed in an urn, and positioned into an electric furnace for an entire day at temperatures of 500°C. Afterwards, ash was dissolved in five milliliters of 20-percent hydrochloric acid solution and filtered using filter paper 42. Extracts of the minerals were collected in a 50ml beaker, and filled with distilled water to 50ml to check their atomic absorption. The mix was measured in samples of soil and plant dry powder, respectively 10 and 50 times of read numbers base of milligram element per kg. Densitometer apparatus was used to calculate the elements in water samples, according to mg per liter. The raw data was then compared with LSD test, after being run through the SAS software for statistical analysis.

RESULTS AND DISCUSSIONS

The impact of sewage water irrigation on mineral accumulation in bean

The accumulation of minerals in bean's root in different areas using wastewater for irrigation: The results showed accumulation of minerals such as Fe, Cr, Mn and Cadmium (Cd) in bean's underground parts was affected by wastewater irrigation in different areas (Table-1). The highest rate of Cr and Cd was attained in Salehabad region (Tables 1 and 5) meanwhile highest rate of Fe and Mn was found in the region near Talababd. Furthermore it was noticed that means of total accumulated elements in the region near Talababd was more than Dehkheir and Salehabad regions (Table-5). Sing *et al*., (2008) by using wastewater irrigation for plants reported decrement in stem length, root length and leaf area. The present results are not in agreement with results of Azimi *et al*., (2006), which noted not significant increment of cadmium in radish roots by using wastewater irrigation.

Accumulations of minerals in bean's shoot under different areas and wastewater irrigation

Nutrient accumulation in bean root was affected by using wastewater and aqueduct but they were not impacted by different areas. Also significant accumulation of Cr was founded on bean shoot for control and wastewater treatments. Interaction effects of different area and aqueduct and wastewater on accumulation of Fe and Cr was significant on bean shoot (Table-2). It seems that accumulated nutrients in been root has been scarcely transmitted to shoot and according to the more higher dry matter of shoot than root, a significant difference about accumulated nutrients in shoot and root can't be observed. So the highest rate of Cr accumulated was related to control treatment (aqueduct water). Also it was noticed that mean of Cr accumulated rate in root was twice than shoot (Tables 2 and 5).

By contrast, Wahid and Ghani (2008) in their study concluded the use of soil containing Cd and other heavy metals in the planting of vetch bean reduced the absorption of essential nutrients for plant growth, due to interference. So, the amount of dry weight, the leaf number and leaf area of vetch bean besides other biological factors reduced significantly.

Moreover Aiman *et al*., (2009) reported that sewage with heavy metals decreased shoot mass, root length and leaf area. They concluded that heavy metals such as Cd could potentially poison plants and cause growth retardation and interference enzyme activity, due to absorption, transport and deposition in the plant stem.

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Table-1. Variance analysis of heavy metals in bean's root.

		Mean square						
SOV	**Degree of freedom**	**Cd**	**Mn**	**Cr**	**Pb**	**Ni**	**Zn**	**Fe**
Replication block	2	0.208^{ns}	5.428^{ns}	4.863^{ns}	199.293^{ns}	3.028^{ns}	251.929^{ns}	46016.477^{ns}
Main factor (a)	2	12.278^{**}	108.2036^{*}	24.896^{*}	331.366^{ns}	18.117^{ns}	147.842^{ns}	363363.003^{*}
Error (a)	4	0.461	158.933	2.472	379.013	3.543	460.570	28957.881
Sub factor (b)	1	0.785^{ns}	34.917^{ns}	81.494^{*}	1294.048^{ns}	13.313^{ns}	3230.740^{*}	60790.029^{ns}
Interaction a*b	1	3.647^{*}	949.863^{*}	259.955^{**}	2186.994^{ns}	10.131^{ns}	1674.151^{ns}	53583.632^{ns}
Error (b)	6	0.428	127.936	3.123	319.106	5.307	460.865	30192.087
Variance coefficients		24.87	27.27	20.40	26.83	28.95	23.60	27.98

*, **: Respectively significant at 5% and 1%
Ns: not significant

Table-2. Variance analysis of heavy metals in bean's shoots.

SOV	**Degree of freedom**	**Cd**	**Mn**	**Cr**	**Pb**	**Ni**	**Zn**	**Fe**
Replication block	2	0.393^{ns}	80.054^{ns}	0.752^{ns}	17.315^{ns}	3.458^{ns}	186.123^{ns}	5912.237^{ns}
Main factor (a)	2	0.238^{ns}	1105.996^{ns}	0.705^{ns}	3.446^{ns}	1.355^{ns}	244.247^{ns}	14046.961^{ns}
Error (a)	4	0.260	533.338	2.879	11.890	5.282	763.385	3664.999
Sub factor (b)	1	1.130^{ns}	938.311^{ns}	19.365^{*}	1.356^{ns}	7.258^{ns}	40.320^{ns}	7535.006^{ns}
Interaction a*b	2	0.414^{ns}	577.742^{ns}	19.002^{*}	10.519^{ns}	2.555^{ns}	418.566^{ns}	53921.715^{*}
Error (b)	6	0.304	536.685	1.671	17.739	6.265	373.713	4280.112
Variance coefficients		22.49	25.96	20.46	23.05	24.04	21.02	21.43

*, **: Respectively significant at 5 % and 1 %
Ns: not significant

Accumulated heavy metals in bean pod under different areas and sewage irrigation

Accumulated amounts of Pb, Mn and Cd found in bean in different planting areas affected by sewage (Table-3).

The highest accumulation of Pb, Mn and Cd in beans pod were observed in Dehkheir, Salehabad and Talebabad regions, respectively (Table-5).

The means of heavy metals accumulated rate in beans root was higher about 20 times more than beans pod (Table-5). It seems less dynamic of heavy metals properties has decreased its transfer from root to shoot. Zn, Ni and Cd accumulation rate were affected by aqueduct and sewage irrigation. Accumulated rate of Zn, Ni and Cd from sewage was higher than aqueduct irrigation rate. Means of accumulated elements in beans pod under sewage irrigation was 2 times higher than accumulate elements.

The means of accumulated rate of nutrient in beans pod under sewage irrigation was 2 times higher than beans pod properties under aqueduct irrigation.

Interaction effects of different area with aqueduct and wastewater on accumulation of Zn and Cd was significant (Table-5).

Table-3. variance Analysis of heavy metals in bean's pod.

		Mean square						
SOV	**Degree of freedom**	**Cd**	**Mn**	**Cr**	**Pb**	**Ni**	**Zn**	**Fe**
Replication block	2	0.0001 ns	4.803ns	14.259 ns	8.860 ns	0.950 ns	343.123 ns	56705.472 ns
Main factor (a)	2	0.067**	252.696**	68.312ns	54.457**	2.752 ns	1678.856 ns	79619.785 ns
Error (a)	4	0.01	4.775	12.241	6.326	1.834	368.430	67238.109
Sub factor (b)	1	0.028**	25.442*	61.790 ns	0.159 ns	26.791 ns	6776.420**	975545.027 ns
Interaction a*b	2	0.570**	53.533*	39.161 ns	1.968 ns	0.898 ns	335.932**	35593.841 ns
Error (b)	6	0.001	8.069	12.909	7.669	1.539	14.868	63425.562
Variance coefficients		3.87	14.40	18.71	23.78	21.26	5.85	22.95

*, **: Respectively significant at 5 % and 1 %
Ns: not significant

Table-4. Variance analysis of heavy metals in bean's grain.

		Mean square						
SOV	**Degree of freedom**	**Cd**	**Mn**	**Cr**	**Pb**	**Ni**	**Zn**	**Fe**
Replication block	2	0.137 ns	233.583**	2.447 ns	97.862 ns	0.110 ns	145.936 ns	253.063 ns
Main factor (a)	2	0.551 ns	200.877**	1.575 ns	98.544 ns	4.895 ns	545.989 ns	833.365 ns
Error (a)	4	0.332	8.235	4.129	118.530	3.387	869.972	1434.624
Sub factor (b)	1	0.748 ns	2434.159**	14.383 ns	15.512 ns	2.457 ns	5.667 ns	452.203 ns
Interaction a*b	2	0.475 ns	418.001 ns	0.165 ns	73.241 ns	1.332 ns	204.844 ns	3748.432 ns
Error (b)	6	0.323	70.375	3.271	137.891	3.165	619.543	964.554
Variance coefficients		22.91	26.22	25.65	24.15	28.67	26.18	29.63

*, **: Respectively significant at 5% and 1%
Ns: not significant

Accumulated heavy metals in beans grain under different areas and sewage irrigation

It was observed that just Mn accumulation among elements was affected by Different areas, irrigation types (sewage and aqueduct) and its interactions (Table-4).

The highest and lowest accumulated Mn in beans grain was related to Talebabd region by using sewage irrigation and Dehkheir area by using of aqueduct irrigation (Table-5).

Accumulation rate of heavy metals in different parts of bean plants under sewage and aqueduct irrigation compared to standard Table (Table-6) displayed more fluctuations as below:

- Ni, Mn, Zn and Cd accumulated rates in different areas and different parts of shoot, grain and pod were less than permission level. So bean plant was not affected by these elements (Table-5 and Figure-1).
- Pb, Cr and Cd accumulated rates in all organs and different areas in beans root were higher 1-4, 2-10 and 1-1.5 times than permission level which can be resulted in serious damages. Accumulated elements via irrigation with sewage were 1-5 times higher than accumulated element from aqueduct water irrigation (Table-5 and Figure-1).
- Heavy metal accumulated in different parts of bean was less or maximum at permission level for livestock feed compared to standard table and determined for livestock irrigation (Table-5 and Figure-1).

ARPN Journal of Agricultural and Biological Science

Table-5. Means of heavy metals in different planting areas.

Tested plant part	Region	Irrigation type	Fe	Zn	Cd	Cr	Mn	Pb	Ni
Shoots	TALEBABAD	Aqueduct water	220.67	66.35	0.64	1.12	8.33	5.93	3.85
		Sewage water	257.37	102.08	1.60	17.95	80.13	29.65	3.04
	SALEHABAD	Aqueduct water	344.71	88.94	0.96	3.85	88.46	13.46	3.85
		Sewage water	251.20	73.32	0.96	4.09	52.40	9.86	3.85
	DEHKHEIR	Aqueduct water	453.37	88.46	0.48	4.81	40.87	7.69	3.37
		Sewage water	602.08	94.71	1.43	5.53	69.23	11.06	3.41
Roots	TALEBABAD	Aqueduct water	840.8	114.1	0.72	0.1	85.1	8.6	4.8
		Sewage water	850.6	74	0.96	20	2.64	21.6	6.5
	SALEHABAD	Aqueduct water	217.7	124	4.8	19.2	39.9	-	0.48
		Sewage water	439.4	77.4	1.9	3.6	22.3	0.96	5.7
	DEHKHEIR	Aqueduct water	231.7	81.7	1.2	10.1	17.7	26.44	5.7
		Sewage water	558.1	88.8	1	4.1	46.9	21.8	5.1
Grains	TALEBABAD	Aqueduct water	123.3	88	0.77	2.9	19	8.4	4.2
		Sewage water	97.6	100.9	1.6	1.4	57.6	10.1	4.8
	SALEHABAD	Aqueduct water	81.01	100	0.31	1.4	16.8	1.2	4.3
		Sewage water	137.5	94.9	0.48	0.96	18	11.3	5.7
	DEHKHEIR	Aqueduct water	87.2	85.3	0.48	2.8	18.5	5.5	2.4
		Sewage water	116.3	85.5	1.9	4.48	36	48	2.4
Pods	TALEBABAD	Aqueduct water	84.8	65.7	0.96	0.96	1.4	5.7	2.4
		Sewage Water	88.9	69.3	0.48	1.9	13.5	1.4	5
	SALEHABAD	Aqueduct water	108.1	38	0.24	Trace	21.9	0.63	2
		Sewage water	126.9	90.8	0.96	1.9	29.3	3.8	5.2
	DEHKHEIR	Aqueduct water	49.6	23.7	0.16	0.8	7.6	3.3	0.32
		Sewage water	643.6	50.7	0.5	9.4	7.9	12.6	3.2

Effect of planting in different area and wastewater influence on vegetative and reproductive characteristics of bean

Grain weight and pod weight were affected by aqueduct water and wastewater.

Individual plant dry weight by using control treatment was higher about 4 times more than grain and pod weight by applying sewage treatment (Table-6). Interaction effects of different area with aqueduct and sewage treatment just influenced grain weight. The highest grain weight was found from Dehkheir region by using aqueduct water irrigation.

Vegetative characteristics of bean as root weight, shoot weight and root/shoot weight and reproductive traits as grain weight and pod weight were not affected by different areas (Table-6). Rhizobium activity throughout the root was impacted by sewage irrigation at different areas and in this way it was resulted in changing on vegetative and reproductive characteristics but mentioned bacteria were not affected by these kind of effects probably and yield and dry weight were not changed. Vegetative traits of bean were firmed in three different areas by using sewage water and aqueduct water irrigation meanwhile variance analysis of reproductive components such as grain weight and pod weight was completely significant.

It seems that mineral and microelements of sewage has been accumulated largely in roots and because of that a big deal of assimilate has been allocated to vegetative components and finally resulted in improvement of yield and yield components. So sewage irrigation has provided needed minerals for bean and in this way grain weight and pod weight has been increased. According to the severe decreased of heavy metal accumulation in grain and pod of bean so human feed cannot makes problem.

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Table-6. Variance analysis of vegetative and reproductive traits of bean.

SOV	Degree of freedom	Root weight	Shoot weight	Grain weight	Pod weight	R/S weight
Replication (Block)	2	43.43^{ns}	15.73^{ns}	33.42^{ns}	30.46^{ns}	0.22^{ns}
Main factor (a)	2	36.98^{ns}	81.27^{ns}	7.75^{ns}	0.14^{ns}	0.1^{ns}
Error (a)	4	28.91	60.89	19.28	39.71	0.36
Sub factor (b)	1	26.89^{ns}	24.73^{ns}	289.48^{**}	352.01^{**}	0.01^{ns}
Interaction a*b	2	85.22^{ns}	57.87^{ns}	94.56^{*}	65.24^{ns}	0.87^{ns}
Error (b)	6	36.11	94.91	20.10	20.91	0.35
Variance coefficients		20.4	25.4	29.04	22.89	23.24

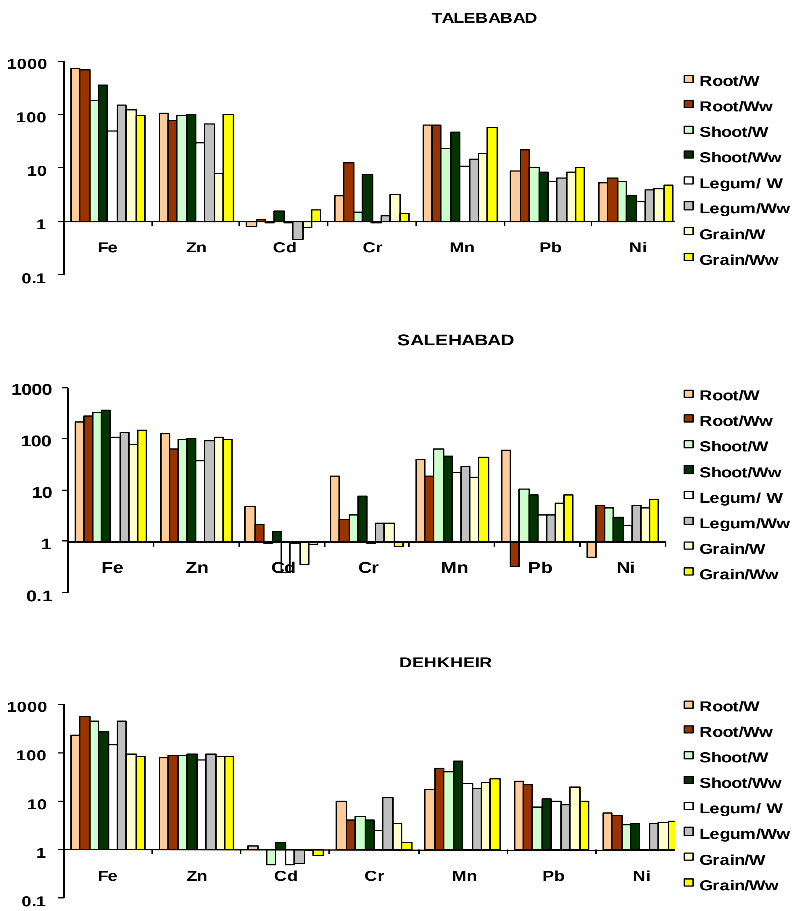

Figure-1. Natural rate of some elements in soil and plants free of contamination with sewage irrigation and other contaminant agents (mg/kg) (PPM). W = Water, Ww = Waste water.

CONCLUSIONS

Heavy metals assembling in bean's root and leaves were almost high, but high control of bean's pod and seed caused transported heavy metals ratio to grain became much less than quantities of them in root and leaves. So, in respect of heavy metals assembling, use of bean's green pod and grain have no problem.

So harvesting of green pod instead of grain because of lower time using of sewage water is suggested.

REFERENCES

Aghabarati A. 2006. Effect of irrigation with sewage sludge on chemical characteristics of soil and growth of olive in urban green space. M.Sc. Thesis, Tarbiat Modarres University, Natural Resources and Marine Science Faculty. p. 100.

Aiman Hasan S., Fariduddin Q., Ali B., Hayat S. and Ahmad A. 2009. Cadmium toxicity and tolerance in plants. Journal of Environmental Biology. 30(2): 165-174.

AL Enzi G., Hamoda M. F. and Fawzi N. 2004. Heavy metals content of municipal wastewater and sludge in Kuwait. Journal of Environmental Science and Health. 39(2): 397-407.

Azimi A., Navab Daneshmand T. and Pardakhti A. 2006. Cadmium absorption and accumulation in different parts of kidney beans, radishes and pumpkins. International Journal of Environmental Science and Technology. 3(2): 177-180.

Bozkurt M. A. and Yarilga T. 2003. The effects of sewage sludge applications on the yield, growth, nutrition and heavy metal accumulation in apple trees growing in dry conditions. Turk J. Agric. 27: 285-292.

Brar M. S., Mahli S. S., Singh A. P., Arora C. L. and Gill K. S. 2000. Effects of sewer water irrigation on some potentially toxic trace elements in soil and potato plants in northwest India. Can. J. Soil Sci. 80: 465-471.

Cob B., George P., Kristin S., Melissa W., Bobby G., Wixson E. and Dorward K. 2000. Accumulation of heavy metals by vegetables grown in mine wastes. Environmental Toxicology and Chemistry. 19(3): 600-607.

Gardiner D. T., Miller R. W., Badamchian B., Azzari A. S. and Sisson D. R. 1995. Effects of repeated sewage sludge applications on plant accumulation of heavy metals. Agriculture, Ecosystems and Environment. 55(1): 1-6.

Ghani A. and Wahid A. 2008. Varietal differences in mungbean (*Vigna radiata*) for growth, yield, toxicity symptoms and cadmium accumulation. Annals of Applied Biology. 152(1): 59-69.

Hoodji M. 2001. The movement of three heavy metals Cadmium, Cobalt and Chromium in treated soil with sewage and absorption of them by plant, Ph.D. thesis for soil science, Islamic Azad University. Science and Research Branch.

Keller C., McGrath S.P. and Dunham S. J. 2002. Trace metal leaching through a soil grassland system after sewage sludge application. J. Environ. Qual. 31: 1550-1560.

McGrath S. P., Shen Z. G. and Zhao F. J. 1997. Heavy metal uptake and chemical changes in the rhizosphere of *Thlaspi caerulescens* and *Thlaspi ochroleucum* grown in contaminated soils, Plant and Soil. 188(1): 153-159.

Ngole V. M. and Ekosse G. E. 2009. Zinc uptake by vegetables: Effects of soil type and sewage sludge. African Journal of Biotechnology. 8(22): 6258-6266, 16.

Porto M., Belligno A., Bufo S. A., Mazzatura A. and Scopa A. 2002. Influence of irrigation with lagooned urban wastewater on chemical and microbiological soil parameters in a citrus orchard under Mediterranean condition. The science of the total environment. 285: 69-77.

Ramirez-Fuentes E., Lucho-Constantino C., Escamilla-Silva E. and Dendooven L. 2002. Characteristics and carbon and nitrogen dynamics in soil irrigated with wastewater for different lengths of time. Bioresource Technology. 85: 179-187.

Ramulu U. and Sree S. 2002. Reuse of municipal sewage and sludge in agriculture. Scientific Publishers, Jodhpur, India.

Rattan R. K., Datta S. P., Chhonkar P. K., Suribabu K. and Singh A. K. 2005. Long-term impact of irrigation with sewage effluents on heavy metal content in soils, crops and groundwater a case study. Agriculture, Ecosystems and Environment. 109: 310-322.

Singh A., Sharma R. K., Agrawal M. and Fiona M. 2010. Risk assessment of heavy metal toxicity through contaminated vegetables from waste water irrigated area of Varanasi, India, Tropical Ecology. 51(2S): 375-387.

Soumlnmez F. and Bozkurt M. A. 2006. Lettuce grown on calcareous soils benefit from sewage sludge. Journal Acta Agriculturae Scandinavica, Section B - Plant Soil Science. 56(1): 17-24.

Taha A. A., EL-Tantawy I. M. and AbuElatta A. A. 2004. Effect of cadmium on the growth and uptake of some nutrients by lettuce and spinach. Journal of the Saudi Society of Agricultural Science. 3(2).

Walker D. J., Rafael C., Asuncion R. and Pilar B. M. 2003. The effects of soil amendments on heavy metal bioavailability in two contaminated Mediterranean soils. Environmental Pollution. 122(2): 303-312.

Yadav R. K., Goyal B., Sharma R. K., Dubey S.K. and Minhas P. S. 2002. Post-irrigation impact of domestic sewage effluent on composition of soils, crops and ground water-a case study. Environ. Int. 28: 481-486.

ARPN Journal of Agricultural and Biological Science

Yang J., Haitao G., Yibing Ma., Liqun W., Dongpu W. and Luo H. 2010. Genotypic variations in the accumulation of Cd exhibited by different vegetables. Journal of Environmental Sciences. 22(8): 1246-1252.

Zavadil J. 2009. The Effect of Municipal Wastewater Irrigation on the Yield and Quality of Vegetables and Crops. Soil and Water Res. 4(3): 91-103.

Zheng N., Wang Q. and. Zheng D. 2007. Health risk of Hg, Pb, Cd, Zn, and Cu to the inhabitants around Huludan Zinc Plant in China via consumption of vegetables. Sci. Total. Environ. 383(1-3): 81-89.