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RISK-ASSESSMENT OF HEAVY METAL BY CONSUMPTION OF VEGETABLES

JITENDER PAL[1], KAMLESH[2]

[1]Department of Environmental Science & Engineering, Guru Jambheshwar University of Science & Technology, Hisar-125001 (Haryana), j_pal2k1@yahoo.com

[2]Ex-M.Tech student, Department of Environmental Science & Engineering, Guru Jambheshwar University of Science & Technology, Hisar-125001 (Haryana)

ABSTRACT

The present study was carried out to assess heavy metals (Pb, Cu,Cd, Ni, Zn and Cr) from cauliflower (Brassica oleracea), cabbage (Linna caita), bottle gourd (Lagenaria vulgaris), chilly (Capsicum annuum), spinach (Beta vulgaris), radish (Raphanus sativus) and brinjal (Solanum melongena). The vegetable samples were collected from three locations having different type of irrigation regime (DWI samples were collected from Hisar, CWI from Hansi and GWI from Raipur village). Concentrations of studied heavy metals were noticed maximum in roots of selected vegetables at all three locations. The maximum uptake of Zn was noticed in roots, stems, leave and fruit of selected vegetable at pre-identified locations. The result indicates that there is no potential hazard by consumption of studied vegetables by adults. Therefore, the health risks from the heavy metals exposure through vegetables was of no significance effect and it is generally assumed to be safe.

Key words: *Heavy Metals, Daily Intake, Vegetables, Food chain*

INTRODUCTION

Rapid urbanization and industrialization generates large amounts of wastewater which is utilized as a valuable resource for irrigation in urban and peri urban agriculture [1]. Disposal of domestic water and industrial wastes is a big challenge for municipalities and discharge to the agricultural fields without any treatment for irrigation to vegetables crops. This domestic water is not only a rich source of organic matter and other nutrients but also contains heavy metals in soil [2]. As a result, vegetables absorb heavy metals from the soil and wastewater [3], which contributes to contamination of the food chain [2] [4] and it depends on soil pH, types of species and soil condition [5] [6]. Several species may accumulate specific type of heavy metals from the soil, which causing a serious health risk to human health when plants based food crops are consumed [7]. Heavy metal bioaccumulation in the food chain can be especially highly dangerous to human health. Heavy metals enter the human body mainly through two routes namely: inhalation and ingestion. Furthermore, a number of factors including, nature of soil and maturity level of the plant at the time of harvesting also influence the concentration of heavy metals within plants [8]. Excessive accumulation of heavy metals in agricultural soils through wastewater irrigation may not only result in soil contamination but also affect food quality and safety [9]. Heavy metals easily accumulate in the edible parts of leafy vegetables as compared to grain or fruit crops [3]. Intake of heavy metals through the food chain by human populations has been widely reported throughout the world [9]. Due to the non-biodegradable heavy metals are accumulated in vital organs in the human body such as the kidneys, bones and liver and are associated with numerous serious health disorders [10]. Individual metals exhibit specific signs of their toxicity [11]. In the present study, the concentrations of heavy metals in locally produced vegetables were quantified throughout a year at a suburban area of Hisar City of Haryana. The aim of study was to quantification of heavy metal in vegetables and identification of risk-assessment by consumption of vegetables.

MATERIALS AND METHODS

Study site

The study was conducted around Hisar city is located at 29.09°N 75.43°E in western Haryana. Three locations were selected for present study namely Hisar, Hansi and Raipur village. These study locations were categorized on the basis of past irrigation practices with ground water irrigated (GWI), canal water irrigated (CWI) and domestic wastewater irrigated (DWI).

Collection of samples

Total nine samples were collected from the pre-identified locations, three samples from each location. DWI samples were collected from Hisar, CWI from Hansi and GWI from Raipur village. Total 21 soil samples (7 from each site) were collected from three selected locations irrigated with GWI, CWI and DWI. The eight vegetables (Cauliflower, Cabbage, Bottle gourd, Chilly, Spinach, Radish, and Bringal) samples were collected and washed with tap water to remove the soil particles. All soils and vegetables samples were oven dried, grinded and kept in polythene bags for further analysis.

Digestion samples

Take one gm of soil and vegetable samples. The soil and vegetable ash samples were digested with perchloric acid and nitric acid (1:4) solution. The samples were

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cooled, filtered and make up final volume of 50 ml with distilled water. Concentration of each heavy metal was analyzed by atomic absorption spectrophotometer (ASS: model AA6300, Shimadzu).

The Daily Intake of Metal (DIM)

Daily Intake of Metal (DIM) was estimated according to Arora et al., [12]:

Daily Intake of Metal (DIM) = M_c . C_f . D_i / B_w (i)

Where mc is the metal concentration in plants (mg/kg) on dry weight basis, C_f the fresh to dry weight conversion factor (0.085), Di the daily intake of green vegetable (kg) and the body weight (Bw) for adult (55 kg) and children (25kg). Daily intake of green vegetable was considered for adult (250) gm/person/day.

Hazard quotient (HQ)

Risk to human health by the intake of metal-contaminated vegetables was characterized using a hazard Quotient (HQ). HQ is the ratio of Daily intake of metal (DIM) to the reference dose (Rd) is defined as the maximum tolerable daily intake of a particular metal that does not result in any harmful effects [13]. If the value of HQ < 1, the exposed population is safe and if HQ > 1, it indicates that there is a potential risk related to that metal and was calculated by equation:

Hazards Quotient (HQ) = DIM / Rd (ii)

Where, the R_d is the reference dose. The values of R_d for Cd, Ni, Zn, Cr, Pb and Cu are taken as 0.001, 0.02, 0.3, 1.5, 0.0035 and 0.04 mg/kg body weight/day respectively [14].

RESULTS AND DISCUSSION

The following parameters (pH, EC, alkalinity) from water, wastewater and soils were estimated from the pre-identified locations. The water, wastewater and soils pH was found alkaline (more than 7) in nature in all the three studied locations. The maximum average pH (8.30±0.20) and EC (2.81±2.52 µs) was observed in DWI. The maximum alkalinity was noticed in CWI and GWI. In case of soil, the maximum average alkalinity (147.0±37 mg/l) and TOC (117.0±17 mg/l) was observed in Hansi. The maximum average EC (227.0±72 (µs) was observed in Raipur village.

Back Ground Heavy Metal Concentration

Water and wastewater

The average heavy metals concentration was in order of (Cr>Zn>Pb>Cu>Cd>Ni) in water and wastewater samples in all the three locations. The average maximum Cr (mg/l) concentration was observed high at all the studied locations. The results of the present study showed that concentrations of heavy metals in DWI location (Hisar) are higher than CWI (Hansi) and GWI location (Raipur village). Greater concentration of heavy metals in Hisar city was noticed and it may be due to long irrigation practices with DWI which contains sufficient amount of heavy metals. In case of soil, The results indicate the concentration of Zn and Cr (mg/kg) were found at higher side in all locations and other metal concentration were noticed in order of Zn>Cr>Cu>Ni>Pb>Cd at all three locations viz, Hisar, Hansi and Raipur village location. The details of back ground concentration of heavy metals in water, wastewater and soil are shown in table 1.

Table 1: Back ground concentration of heavy metal in soil, water and wastewater

Parameter	Heavy metals(mg/kg)					
	Pb	Cu	Cd	Ni	Zn	Cr
Soil						
Hisar	09.26±2.00	16.06±3.30	1.38±0.30	15.44±3.5	53.98±1.6	18.15±2.30
Hansi	10.54±2.40	13.50±1.30	2.07±0.70	16.31±3.0	51.01±0.7	17.80±1.30
Raipur Village	08.17±0.70	15.47±3.00	2.42±0.30	13.34±1.8	52.73±1.3	18.07±2.10
Water and Wastewater						
DWI (Hisar)	10.37±0.31	9.50±0.20	1.50±0.20	1.43±0.21	14.50±0.26	20.95±0.21
CWI (Hansi)	07.40±0.15	6.30±0.20	1.27±0.21	0.56±0.21	10.13±0.25	19.00±0.42
GWI (Raipur Village)	06.50±0.20	5.50±0.26	1.37±0.31	0.53±0.25	08.70±0.30	18.35±0.35

Note: *DWI= Domestic Wastewater Irrigated, CWI= Canal Water Irrigated, GWI= Ground Water Irrigated*

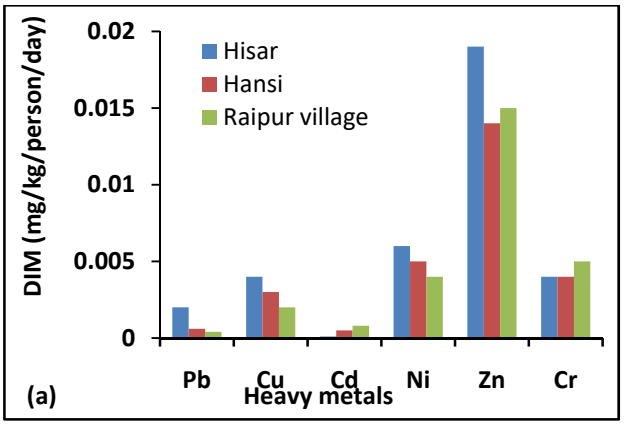
ISSN (O): 2348-4098
ISSN (P): 2395-4752

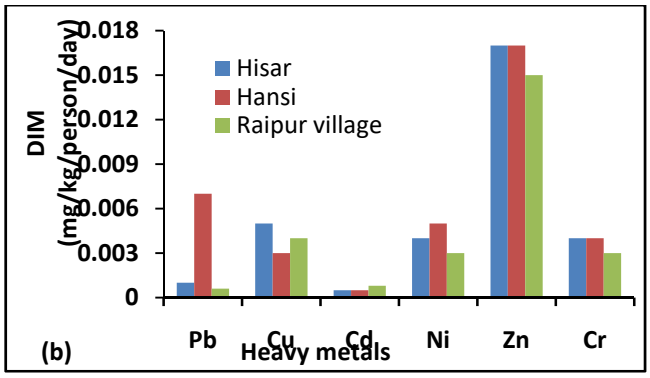
Heavy Metal Concentrations in Vegetables

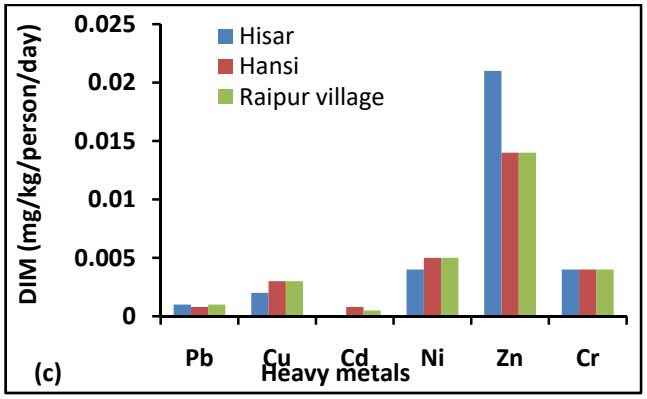
The metal concentration (mg/kg) was estimated in roots, stems, leave and fruit of selected vegetables grown at location [Hisar (L1), Hansi (L2) and Raipur village (L3)]. No fixed patterns of uptake of heavy metals have been observed in different parts of studied vegetables. The maximum uptake of Zn was noticed in roots, stems, leave and fruit of selected vegetable at pre-identified locations. The maximum uptake of Zn metal was noticed in cauliflower root (52.0mg/l) and cauliflower steam (48.6mg/l) at Hisar. Maximum amount of Zn metal was noticed in bottle ground roots (51.1mg/l) at Hisar. The minimum uptake of Cd was observed in radish leaves (0.5mg/l) at Hisar, brinjal steam (0.5mg/l) at Hansi, cauliflower fruit (0.3mg/l) at Hisar. Concentrations of all the heavy metals were noticed maximum in roots of selected vegetables for study at all three locations. The concentrations of heavy metals are higher in soils than vegetables grown on the same soils. This indicates that only a small portion of soil heavy metals is transferred to the vegetables and the root acts as a barrier to the translocation of heavy metals within plant [15] [16]. The details of results of study are shown in Table 2.

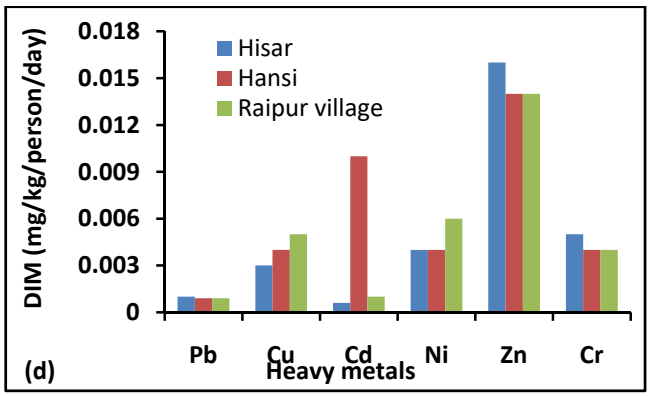
Daily Intake of Metal (DIM)

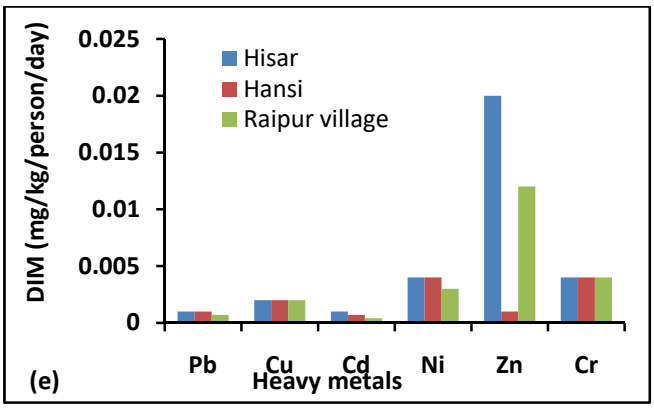
To determine the health risk from heavy metals and the food chain is the most important pathway to exposure of heavy metals. The daily intake of metals (Pb, Cu, Cd, Ni, Zn and Cr) was estimated according to the average vegetable consumption by the adults. The higher values of DIM was observed in cauliflower (Zn=0.019 mg/kg/person/day) at Hisar, in cabbage (Zn =0.017 mg/kg/person/day) at Hansi, in chilly (Zn=0.016 mg/kg/person/day) at Hisar, in spinach (Zn=0.020mg/kg/person/day) at Hisar, in Radish (Zn=0.023 mg/kg/person/day) at Hisar, in Brijal (Zn=0.018 mg/kg/person/day) at Hisar. The results of the study revealed that DIM suggest that the consumption of vegetables grown in pre-identified location is high but is free from any risk as the exposure of Pb, Cu, Cd, Ni, Zn and Cr in adults is below than the permissible limits [17].











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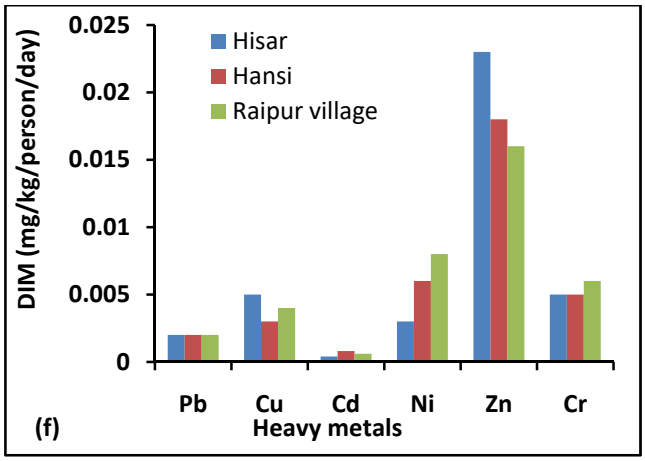


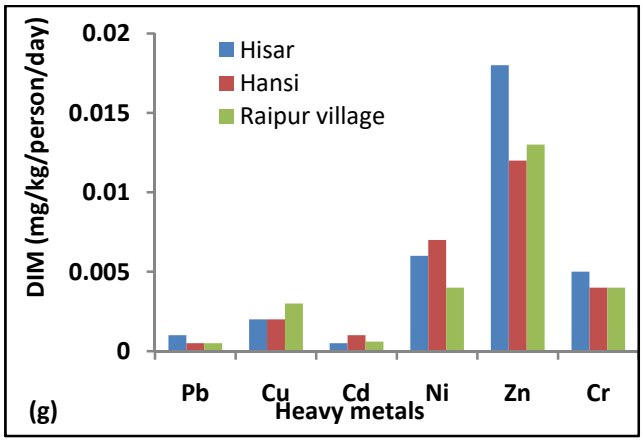
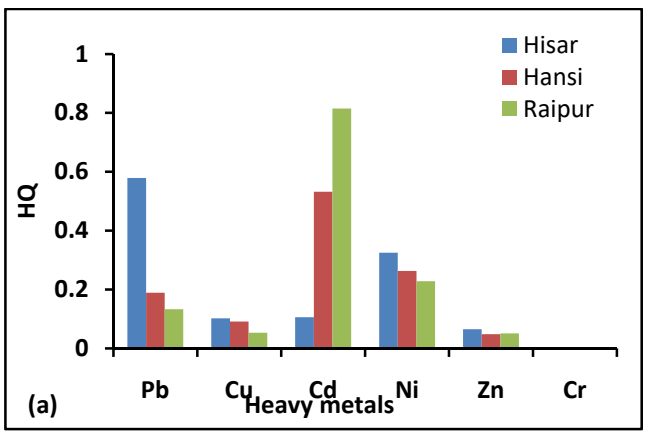
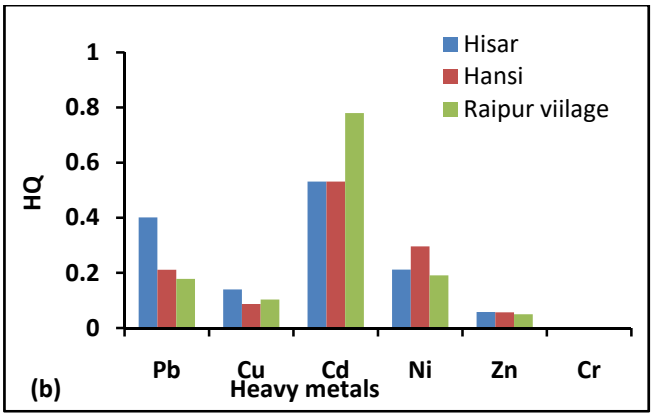


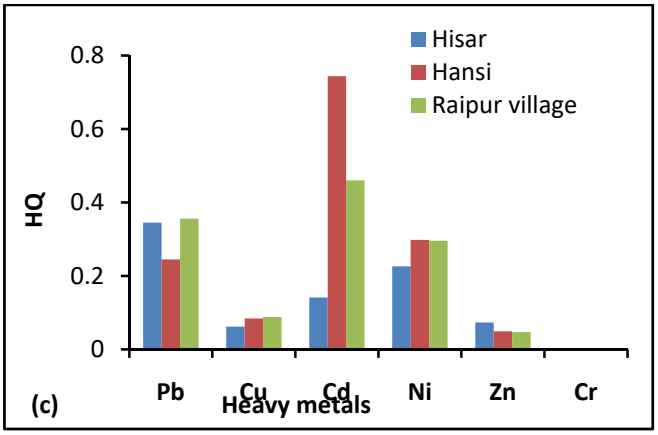
Fig. 1: DIM through (a) Cauliflower, (b) Cabbage, (c) Bottle gourd, (d) Chilly, (e) Spinach, (f) Radish, (g) Brinjal

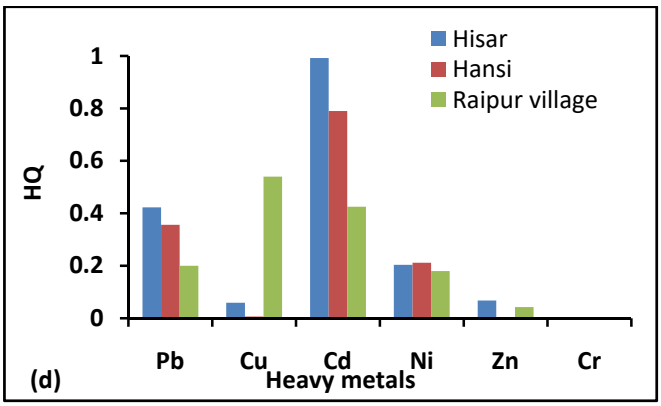
Hazard quotient (HQ)

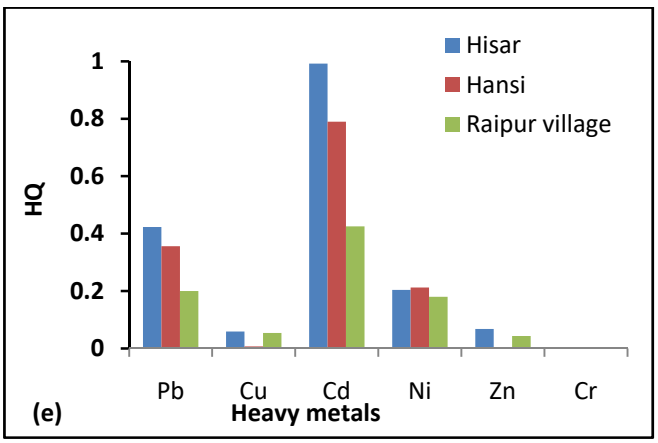
Hazard quotient (HQ) has been recognized by US EPA as a useful tool for evaluation of risk associated with consumption of metal contaminated vegetable. Calculated values of HQ were found to be less than one in all the three locations. It indicates that there is no potential hazard by consumption of studied vegetables by adults. Therefore, the health risks from the heavy metals such Pb, Cu, Cd, Ni, Zn and Cr exposure through vegetables was of no significance effect and it is generally assumed to be safe.











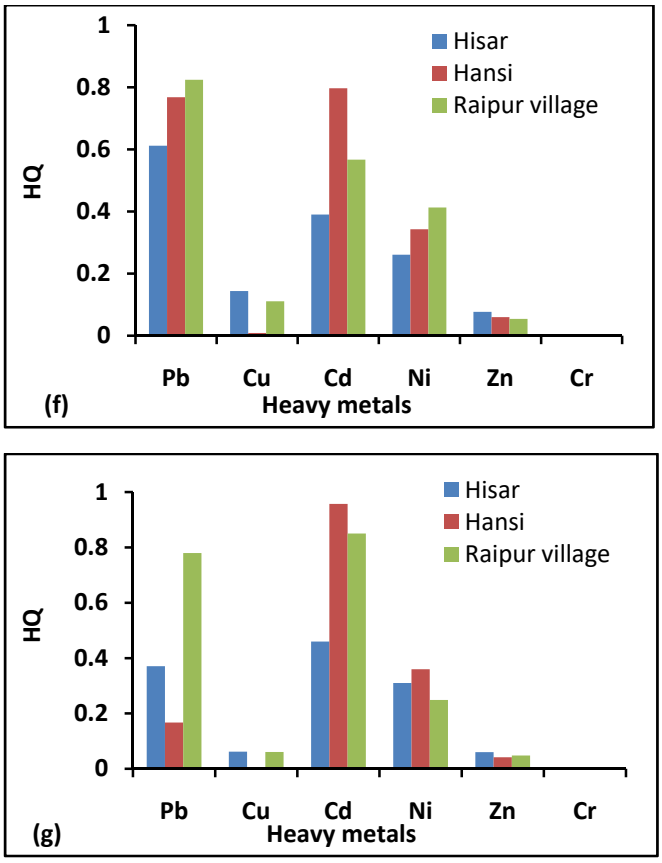


Fig. 2: Hazard Quotient (HQ) for (a) Cauliflower, (b) Cabbage, (c) Bottle gourd, (d) Chilly, (e) Spinach, (f) Radish, (g) Brinjal

CONCLUSION

This study was deign to investigate the heavy metals (Pb, Cu,Cd, Ni, Zn and Cr) concentration in soils, vegetable crops and estimate the potential health risk of metals to adults via consumption of contaminated vegetable crops grown at three locations namely Hisar, Hansi and Raipur village. The experimental results showed that soils, water & wastewater, vegetables at Hisar, Hansi and Raipur village were contaminated by heavy metals (Pb, Cu, Cd, Ni, Zn and Cr). Heavy metal concentrations were varied among the selected vegetables, which reflect the difference in their uptake capabilities and their further translocation to edible portion of the plants. Accumulation of Zn in all vegetables roots, stems, leaves and fruits is more. The daily intake of Zn metal (mg/kg/person/day) was found in maximum vegetables. Estimated values of HQ were also found less than one. It indicates that there is no potential hazard by consumption of studied vegetables.

REFERENCE

[1] Marshall, F.M., J. Holden, C. Ghose, B. Chisala, E. Kapungwe, J. Volk, M. Agrawal, R. Agrawal, R.K. Sharma & R.P. Singh. 2007. Contaminated Irrigation Water and Food Safety for the Urban and Periurban Poor: Appropriate Measures for Monitoring and Control from Field Research in India and Zambia. Incpetion Report DFID Enkar R8160, SPRU, University of Sussex. www.pollutionandfood. net 2007.

[2] Singh, K.P., D. Mohon, Sinha, S., Dalwani, R., (2004). Impact assessment of treated and untreated waste water toxicants discharge by sewage treatment plants on health, agricultural and environmental quality in waste water disposal area. Chemosphere, 55, 227- 255.

[3] Mapanda, F., Mangwayana, E.N., Nyamangara, J. K., Giller E., (2005). The effect of long term irrigation using waste water on heavy metal content of soil under vegetables in Harere, Zimbabwe. Agriculture, Ecosystem and Environment, 107, 151-165.

[4] Sharma, R.K., Agrawala, M., Fiona, M., (2007). Heavy metal contamination of soil and vegetables in suburban areas of Varanasi, India. Ecotoxicology and Environmental Safety, 66, 258–266.

[5] Sharma, R.K., Agrawal, M., Marshall, F.M., (2006). Heavy metals contamination in vegetables grown in wastewater irrigated areas of Varanasi, India. Bull. Environ. Contam. Toxicol., 77, 311-318.

[6] Ismail, B.S., Farihah, K., Khairiah, J., (2005). Bioaccumulation of heavy metals in vegetables from selected agricultural areas. B. Environ. Contam. Tox., 74, 320-327.

[7] Wenzel, W., Jackwer., F., (1999). Accumulation of heavy metals in plants grown on mineralized solids of the Austrian Alps. *Environ. Poll.,* 104, 145-155.

[8] Voutsa, D., Grimanis, A., Samara, C., (1996). Trace elements in vegetables grown in an industrial area in relation to soil and air particulate matter. Environ. Pollut., 94, 325-335.

[9] Muchuweti, M., Birkett, J.W., Chinyanga, E., Zvauya, R., Scrimshaw, M.D., Lester, J.N., (2006). Heavy metal content of vegetables irrigated with mixture of waste water and sewage sludge in Zimbabwe: implications for human health. Agriculture, Ecosystem and Environment, 112, 41-48.

[10] Duruibe, J.O., Ogwuegbu, M.D.C., Egwurugwu, J.N., (2007). Heavy metal pollution and human biotoxic effects. International Journal of Physical Sciences, 2, 112-118.

[11] McCluggage, D., (1991) Heavy Metal Poisoning, NCS Magazine, Published by The Bird Hospital, CO, U.S.A.

[12] Arora, M., Kiran, B., Rani, S., Rani, A., Kaur, B., Mittal, N., (2008). Heavy metal accumulation in vegetables irrigated with water from different sources. Food Chemistry, 111, 811-815.

[13] U. S. Environmental Protection Agency (1989). Risk Assessment Guidance for Superfund: Human Health Evaluation Manual [part A]: Interim Final. Washington, DC, USA: U.S. Environmental Protection agency.

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ISSN (O): 2348-4098
ISSN (P): 2395-4752

[14] U.S. Environmental Protection Agency (US EPA). 2010. Integrated risk information system. Available at: http://cfpub.epa.gov/ ncea/iris/compare.cfm.

[15] Ghosh, M., Singh, S.P., (2005). A comparative study of cadmium phytoextraction by accumulator and weed species. Environment Pollution, 133: 365-371.

[16] Davies, B.E., H.M., White, H.M., (1981). Trace elements in vegetables grown on soils contaminated by base metal mining. J. Plant. Nutr., 3: 387-396.

[17] FAO/WHO, Codex Alimentarius Commission (2001). Food additives and contaminates, FAO/WHO Food Standards Programme.

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Table 2: Heavy metal concentrations (mg/kg) in in Roots, Stems, Leave and fruits of vegetables at Hisar (L1), Hansi (L2) and Raipur Village (L3)

Locations	HM (mg/kg)	Cauliflower				Cabbage				Bottle ground				Chilly				Spinach				Radish				Brinjal			
		R	S	L	F	R	S	L	F	R	S	L	F	R	S	L	F	R	S	L	F	R	S	L	F	R	S	L	F
L1	Pb	6.10	4.10	3.90	3.20	5.90	-	2.50	3.60	5.60	2.20	2.60	3.10	7.10	2.80	3.20	3.40	5.50	-	3.8	-	5.50	-	4.70	-	6.10	3.30	4.60	3.40
	Cu	11.4	7.60	5.40	4.60	11.2	-	8.40	9.40	11.1	9.60	9.30	6.40	11.4	6.80	8.60	9.80	10.1	-	6.1	-	14.8	-	9.60	-	10.1	8.00	9.30	6.40
	Cd	1.00	0.87	0.50	0.30	0.80	-	0.60	0.64	0.90	0.70	0.60	0.40	1.10	0.60	0.82	0.99	2.70	-	2.1	-	0.60	-	0.50	-	1.10	0.80	0.90	0.99
	Ni	10.7	10.1	8.30	6.70	11.3	-	10.1	10.9	12.5	10.8	11.3	11.6	11.3	10.4	9.30	10.8	11.9	-	10.5	-	13.4	-	11.2	-	12.5	11.0	10.3	11.9
	Zn	52.0	48.6	42.8	40.1	52.1	-	44.8	45.1	51.1	42.2	45.8	42.3	47.4	46.8	44.6	42.1	51.8	-	50.7	-	50.7	-	48.3	-	46.7	44.4	42.3	44.5
	Cr	14.6	10.4	9.20	7.60	12.8	-	10.6	10.8	11.2	10.0	10.7	10.3	15.7	14.1	14.8	14.1	14.4	-	12.2	-	14.3	-	11.6	-	13.9	12.8	13.4	13.5
L2	Pb	6.80	1.40	1.10	1.10	6.40	-	3.20	1.90	6.50	1.80	2.10	1.20	7.10	2.60	2.30	1.50	6.50	-	3.2	-	6.90	-	4.70	-	7.30	1.50	1.70	1.50
	Cu	10.5	8.60	6.90	6.30	10.6	-	9.60	9.10	11.5	6.10	6.90	8.70	12.6	11.8	11.9	11.4	11.5	-	7.4	-	9.40	-	8.60	-	9.10	5.40	6.10	6.80
	Cd	1.00	0.80	0.60	0.50	0.90	-	0.60	0.78	1.30	0.70	0.90	1.09	1.73	0.90	1.50	1.70	1.50	-	1.3	-	1.87	-	1.60	-	1.00	0.50	0.70	0.94
	Ni	14.1	13.2	11.5	13.1	11.3	-	9.90	9.20	9.60	7.60	7.30	7.50	12.0	10.7	11.6	12.1	11.6	-	10.9	-	14.8	-	12.8	-	12.0	10.3	11.0	11.5
	Zn	41.9	35.8	33.5	32.6	46.1	-	43.8	44.1	43.6	37.1	37.6	38.4	44.5	43.6	36.2	36.6	47.7	-	33.2	-	46.4	-	34.7	-	37.1	30.6	31.7	32.8
	Cr	14.3	10.8	9.80	7.20	11.4	-	10.1	10.4	10.9	10.5	10.2	10.5	12.1	10.6	11.1	11.5	14.5	-	12.8	-	13.9	-	12.2	-	11.3	10.8	9.30	10.6
L3	Pb	6.30	4.90	4.00	1.20	6.60	-	4.40	3.60	6.40	1.70	2.40	3.20	7.10	1.30	1.60	2.40	7.60	-	4.8	-	7.40	-	4.60	-	5.70	1.80	1.20	1.50
	Cu	11.4	10.4	9.60	5.50	14.7	-	10.1	10.6	11.0	8.30	8.50	9.10	11.1	10.6	8.40	9.60	12.9	-	5.6	-	11.4	-	5.80	-	10.1	8.60	8.90	9.20
	Cd	2.00	1.50	1.32	1.20	1.90	-	1.50	1.70	2.00	1.50	1.80	1.30	2.50	1.70	1.90	2.10	1.65	-	1.2	-	1.60	-	1.30	-	1.80	1.10	1.30	1.70
	Ni	14.0	13.8	12.5	11.7	11.5	-	5.20	9.80	10.6	7.80	8.90	9.20	11.1	9.30	9.80	10.5	12.2	-	10.3	-	11.2	-	10.8	-	12.7	11.6	12.1	11.4
	Zn	47.6	39.4	37.7	35.7	44.6	-	37.1	39.1	40.8	35.4	36.1	36.4	43.3	37.1	36.6	37.1	37.4	-	33.1	-	41.6	-	35.3	-	39.3	34.6	33.6	34.8
	Cr	16.1	14.3	11.9	11.1	12.7	-	9.30	9.70	14.8	10.5	12.2	12.8	13.0	11.0	11.6	12.0	14.3	-	10.1	-	14.9	-	12.5	-	11.4	10.3	10.6	10.7

Note: R=Roots, S=Stems, L=Leaves and F=Fruits