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Assessment of Heavy Metals Contamination and the Risk of Target Hazard Quotient in Some Vegetables in Isfahan

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ABSTRACT: The main objective of this study is to evaluate heavy metals contamination of highly consumed vegetables and hazardous effects of consuming these vegetables. The study was conducted in vegetable fields in three different regions according to the level of environmental pollutions, including "Isfahan", "Flavarjan" and "Faridan, Golpayegan and Natanz". Six types of vegetables in each field with three replicates in each region were selected in the summer of 2017 by the random sampling method from vegetable fields. The level of heavy metals (Pb, Cu, Co, Cd and Cr) in vegetables has been measured for each sample. The result showed that in the Isfahan region, the highest daily intake of Pb, Cu, Co, Cd and Cr for the consumption of all the vegetables was obtained in the recipients. The highest target hazard quotient for non-cancerous diseases of contaminated vegetables was 28.9 and 21.1 in "Isfahan" for children and adults, respectively. The target hazard quotient for vegetable consumption was greater than one and at high hazard for both age groups. The principal component analysis showed that the contamination by the heavy metals in the "Isfahan" and "Falavarjan" regions overlapped and the risk of contamination of heavy metals in urban vegetables in both regions increased the hazard of non-cancerous diseases. It is highly recommended that the quality standards of foods that are imposed on the production of food crops.

Keywords: Heavy metals, Vegetable consumption, Urban pollution, Health risk.

INTRODUCTION

The absorption of heavy metals (HMs) by the plant on contaminated agricultural land is one of the main and indirect routes of entry of HMs to human food chains (McBride et al., 2014; Ali et al., 2019; Amiri et al., 2019). In recent years, farmers have used contaminated resources to produce their agricultural crops in the suburbs and rural areas to supply their necessary products that threaten the food health of society (Wu et al., 2019; Asgharipour et al., 2019). Informing society first, makes all members of society aware of the hazards of consuming unhealthy vegetables and not only pay attention to the price and appearance of them; second, it moves society to a path that, in turn, separates the value of healthy and unhealthy products, since unhealthy products are not bought in the markets;

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third, producers know how to use contaminated resources (Jafari et al., 2018; Sandeep et al., 2019; Esmaeilzadeh et al., 2019) for production and the hazards caused by the use of unhealthy products in society and try to produce more healthy products and more income (Moradi et al., 2016; Srinivas et al., 2009). In cold region of Harbin, China resulted that the content of soil heavy metals of Cd, Pb, Cu and Cr were 0.2±0.2, 26.5±8.4, 29.1±8.6 and 56.5±6.3 respectively (Lv et al., 2019).

The first step to assess the extent of HMs contamination in suspected areas is to determine the concentration of HMs, and the analysis of the state of the contaminated area using indices such as the health hazard index (HI) (Gupta et al., 2013). In one investigation, the daily absorption of Pb, Cd, Cu and Cr for adults was 0.28, 0.06, 3.14 and 0.14 mg.kg of the individual weight, respectively (Bo et al., 2009). The target hazard quotient (THQ) of greenhouse product consumption in Isfahan was estimated for children, adolescents and adult age groups as 2.03, 0.67 and 0.45, respectively (Aghili et al., 2009). In another investigation, health risk for men and women was obtained 2.6 and 2.9, respectively, which shows the negative effects of the resulting non-cancerous diseases by consuming the products (Salehipour et al., 2015). In addition, Cr, Pb and Cd showed the highest hazards to get the non-cancerous diseases (Cherfi et al., 2016).

Given the variety and diversity of data, research in these fields involves not only modern analytical methods with sensitivity, specificity and high accuracy to achieve valid results on HMs content in vegetable but also complex statistical methods that provide the big view in what they are concerned (Pop et al., 2009). The principal components analysis (PCA) estimates the correlation structure of the variables by finding new hypothetical variables (principal components-PC) that account for the variance (or correlation) as much as possible in a multidimensional data. These new variables are linear combinations of the original variables (Hammer et al., 2001). This methodology is used to reduce the dimensions of the data with many relevant variables without losing data and, however, to protect the maximum changes between the data (Gergen & Harmanescu, 2012).

The increase in environmental pollution in waterborne, soil and air requires the determination and evaluation of the health hazards of vegetable products (Nasrabadi et al., 2015; Baghaie et al., 2019; Liu et al. 2013) because the use of contaminated vegetables to HMs will increase the risk of unwanted and unknown hazards and diseases of members throughout society (Sandeep et al., 2019). There is an assumption of pollutions that can enter and accumulate HMs in the food chains due to the presence of important and diverse contaminated resources in the province of Isfahan (Moradi et al., 2016). This research was carried out to determine the contamination of HMs and to evaluate the health risk of highly consumed vegetable crops (Pop et al., 2009) in three regions of Isfahan province. For this purpose, many PCA models were constructed and calculated with different markers (Abad-Garcia et al., 2012; Ghahremanzadeh et al., 2018). Two types of markers were used as main markers for pollution: simple markers, represented by contaminations of HM in vegetables (Bordean et al., 2011) consumed by people in Isfahan. A complex marker was also used, namely Target Hazard Quotients (THQ) which links the contamination by heavy metals in vegetables with its toxicity, quantity and quality of vegetable consumption and the body mass of consumers (FAO/WHO, 2011).

MATERIALS AND METHODS

This study was conducted in the summer of 2017 in Isfahan (51.64481° and 32.68339°). Samples of vegetable fields were taken in three different regions according to environmental contamination;

including (Fig 1), first region (Isfahan), second region (Falavarjan) and third region (Feridan, Golpayegan and Natanz) (Figure 1). Contamination in this research means the presence of industries and the resources of producers of industrial pollution and the use of urban waste to produce vegetables in various areas (Singh et al., 2010; Li et al., 2006). The vegetables sampled for research included; 1- Leafy vegetables (basil and lettuce), 2- Fruity vegetables (cucumber and tomato) and 3-Tuber vegetables (potato and onion).

Six types of vegetable in each field with three replications in each region were selected (one kilogram samples) by the random sampling method (a total of 270 samples) that were stored in paper bags and transferred to the Water and Soil research Laboratory, Isfahan Agricultural and Natural Resources Research. Samples were taken from the edible parts and washed with distilled water three times and placed at 75 °C for 48 h to reach a constant weight. The samples were ground after drying and stored in paper bags until the time of extraction. For the extraction, a wet digestion technique with 65% nitric acid and 30% hydrogen peroxide was used. The concentrations of HMs (Pb, Cu, Co, Cd and Cr) of the digested plant samples were measured by flame atomic absorption spectrometer (Konik Won M300, Barcelona, Spain) (Cui et al., 2005).

Equation 1 calculates the daily intake of HMs by ingesting vegetables, including basil, lettuce, cucumber, tomato, onion and potatoes per kilogram of body weight per day for two age groups of children (under 18) and adults (over 18) (Salehipour et al., 2015):

$$EDI = (CF \times IR \times FI \times EF \times ED)/(BW \times AT) \quad (1)$$

In which, EDI: estimated daily intake (mg/kg/day), CF: contaminator factor in vegetables (mg.kg), IR: ingestion rate (gr- the average daily consumption of vegetable for adults and children is 325 and 235 gr, respectively), FI: the fraction ingested of the concentration of HMs that is absorbed in the plants (this coefficient was considered 0.4 in this investigation), EF: exposure frequency (day in year, in this investigation it was considered 365 days), ED: exposure duration (number of years that vegetable are used, of non-cancerous diseases for adults and children are considered 30 and 13 years old), BW: body weight (kg) in this investigation the average body weight of adults and children was considered to be 70.0 and 35.7 kg (Gupta et al., 2013) and AT: average time, obtained by multiplying the number of years by the number of days (Pop et al., 2009).

Target Hazard Quotients (THQ) is a complex parameter used to estimate the potential health risks associated with long term exposure to different pollutants or heavy metals, as in our case. For its calculation, in addition to metal contamination of vegetables, other parameters were also involved and refer to the metals toxicity (Orisakwe et al., 2012; Harmanescu et al., 2011). Therefore, THQ is a complex parameter used in the evaluation of risks for the health of heavy metals that provides a better image related to the content of metals in vegetables than the use of a simple parameter (Gergen & Harmanescu, 2012). Equation 2 was used to calculate the THQ of non-cancerous diseases for adults and children that were developed by the Environmental Protection Agency (EPA) in the United States (Moradi et al., 2016; USEPA, 2005; USEPA, 2010):

$$THQ = EDI/RfD \quad (2)$$

In which, RfD is an oral reference dose and is defined for each metal (mg/kg/day). This amount by animal tests shows the maximum concentration of metals that cannot represent a hazard to live animals (USEPA, 2005). The RfD values were 0.004, 0.04, 0.043, 0.001 and 1.5 for Pb, Cu, Co, Cd and Cr, respectively (USEPA, 2005).The numerical values obtained after measuring the concentration of HMs were calculated and the data were statistically analyzed by SAS and PAST software (Gergen & Harmanescu, 2012; Hammer et al., 2001).

RESULTS AND DISCUSSION

The results indicated that contamination of the vegetables with the heavy metals differed significantly between the three regions of this study when using LSD test ($p < 0.05$) (Figure 2). In the first and second regions, contaminations of Pb and Cr were higher compared with corresponding permissible limits (0.2 mg.kg for Pb and 0.1 mg/kg for Cd) established by the Institute of Standards and Industrial Research of Iran (Food & Feed-Maximum limit of heavy metals, 2010) for human consumption in vegetables, and also the standard values (0.1 mg/kg for Pb and 0.09 mg/kg for Cd) recommended by WHO and FAO (FAO/WHO, 2011). The highest contamination of Pb was detected in basil and tomato 0.78 and 0.75 mg/kg, respectively, while cucumber contained the highest contamination of Cu 2.69 mg/kg, and contaminations of Cd (0.50 mg/kg) and Cr (1.41 mg/kg) were uppermost in onions (Table 1). Unfortunately, no permissible limits have been established for Cu, Co and Cr showing a lack of attention to the problems of HMs contamination standards at the scientific and top-level planning of the country (Salehipour et al., 2015; Moradi et al., 2016).

Table 1. Multivariate analysis of variance, mean comparisons using LSD test, P value 5% and standard deviation (Sd) for heavy metals contamination in all regions (Pb, Cu, Co, Cd and Cr) in six vegetable (Cucomber, Tomato, Basil, Lettuce, Onion and Potato) (mg/kg)

Vegetable	Heavy metals									
	Pb		Cu		Co		Cd		Cr	
	Mean	Sd	Mean	Sd	Mean	Sd	Mean	Sd	Mean	Sd
Cucomber	0.71ab	0.59	2.69a	1.44	0.62c	0.47	0.44a	0.42	0.44d	0.31
Tomato	0.75a	0.59	2.31b	1.35	0.75b	0.48	0.26bc	0.33	0.91c	0.67
Basil	0.78a	0.68	1.10d	0.64	0.53c	0.41	0.32b	0.31	1.21ab	0.94
Lettuce	0.72ab	0.61	0.62e	0.51	0.40d	0.25	0.18c	0.19	0.44d	0.26
Onion	0.61cb	0.52	1.04d	0.72	0.53c	0.35	0.50a	0.41	1.41a	0.81
Potato	0.53c	0.45	1.87c	1.21	0.88a	0.62	0.33b	0.31	1.14b	0.76

Means followed by the same letter in columns are not significantly different; using LSD test (P value 5%).

Result of mean compared using LSD test at the 5% level showed, the highest contamination of Pb in basil and tomato 0.78 and 0.75 mg/kg respectively, Cd (0.50 mg/kg) and Cr (1.41 mg/kg) in onion, Co (0.88 mg/kg) in potatoes and Cu and Cd were 2.69 and 0.44 mg/kg respectively in cucumber (Table 1). Except for Cu in this study, the other two HMs were higher than the recommended standard values, hence, the consumption of these contaminated vegetables possibly threatens human health. The greater HMs contamination in urban vegetables could be related to some characteristics of the resources used because the absorption and translocation of metals in plants depend on the agrochemical characteristics of the water and soil (Wu et al., 2019; Aghili et al., 2009).

PCA was constructed to characterize the results of HMs contamination in vegetables using a PCA1-vegetable model (Figures 3 and 4). The analytical data of HMs in the vegetables were standardized logarithmically and processed with the PAST software. As can be seen in this model, the first and two PCs explain only 92.9% of the variance. Graphical representation of PCA1-vegetable model and biplot of PC1 and PC2 (Figure 3) clearly separates regions (H and M) with anthropogenic pollution of vegetables in the low pollution region (L region). The model, built on the HM-contaminated vegetables, compares the pollution disposition in the biplot area, and cannot make a clear differentiation between the two regions (H and M) with anthropogenic pollution. The contamination of HMs in the first and second pollution regions is overlapped, and the probability of HMs contamination in the urban vegetables in these closely related regions supports the idea that the pollution does not remain in a single clear region. PCA indicated overlapped HMs contamination in Isfahan and Falavarjan, both of which suggest the probability of contamination with some HMs. PC1 and PC2 and their components are the factors that differentiate the regions (H, M, and L) from each other (Figure 3).

The first two PCs explain 92.9% of the model variance and can make a relatively good separation between some vegetable species (Figure 4). In the negative area of PC1, Cu is the metal found at high concentrations in cucumber and tomato in the first and second regions (cities of Isfahan and Falavarjan). With regard to basil and onion, Cr and Pb have the highest concentrations in the regions with anthropogenic pollution (H). Also the potato presents the highest concentrations of Co in the two contaminated regions (H and M) (Sandeep et al., 2019).

Significant differences were found between the concentrations of all HMs in some vegetables in the contaminated regions (H and M) and those grown in the low pollution region. This can be explained by the homeostasis of vegetables, which, by specific-specific mechanisms each, limits excessive accumulation of HMs in their bodies in response to polluted sources (water, soil, and air) (Matyssek et al., 2006; Ghahremanzadeh et al., 2018). In PC1, Pb in basil has the highest distribution and effect compared to those of Cu and Cr in cucumber and onion in PC2 with some correlations together. The samples of tomato (H4), basil (M3), and onion (M5) are located on the positive side of PC2 dominated by a lower content of HMs. With the exception of tomato (M4), samples of all vegetables grown in low-polluted regions are on the negative side of PC1 characterized by a low HMs content (Table 1). The results indicated a very easy transfer of HMs from the polluted regions to the plants due to their absorption through the root and leaves this rendering them unhealthy for daily human consumption. Besides, the health risk index shows the potential hygienic risk of these HMs in relation to the polluted consumption of vegetables in daily human diet (Ali et al., 2019; Moradi et al., 2016).

The highest daily intake rates of Pb, Cu, Co, Cd, and Cr for children (under 18 years of old) in the first region (city of Isfahan) for the consumption of all types of vegetables were 0.1, 0.25, 0.12, 0.05, and 0.13 mg/kg of body weight per day, respectively (Table 2). The maximum daily intake rates of Pb, Cu, Co, Cd, and Cr for adults (over 18 years of old) in the first region for total vegetable consumption were 0.07, 0.18, 0.08, 0.03, and 0.09 mg/kg of body weight per day, respectively. The average daily intake rates of Pb, Cu, Co, Cd, and Cr for recipients under 18 years old were 0.03, 0.07, 0.03, 0.01, and 0.05 mg/kg per day, respectively. The average daily intake rates of Pb, Cu, Co, Cd, and Cr for adults were 0.02, 0.05, 0.02, 0.01, and 0.03 mg/kg per day for the vegetables studied (Table 2). The daily intake of HMs by people depends on the concentrations of HMs and the amounts of food consumption (Lv et al., 2019; Baghaie et al., 2019).

The maximum daily intake of Pb was 0.04 mg/kg in leafy vegetables, and 0.1, 0.05, 0.02, and 0.08 mg/kg per day per body weight for Cu, Co, Cd, and Cr in tuber vegetables, respectively (Table 2). The provisional tolerable daily intake of Pb and Cd was determined at 0.0036 and 0.001 mg/kg, respectively (Anonymous, 2010; FAO/WHO, 2011). It is unfortunate that no reference value for the provisional tolerable daily intake has been determined for Cu, Co, and Cr, which needs paying attention to the contamination problems of HMs in daily foods necessitating to obtain details of the study (Moradi et al., 2016). It was reported that daily intake rates of Pb, Cd, Cu, and Cr in vegetables for adults were 0.28, 0.06, 3.14, and 0.14 mg/kg of body weight, respectively (Bo et al., 2009). In the first (Isfahan) and the second (Falavarjan) regions, all the receptors cause pollution. The sources of urbanization and industrial activities have many problems with respect to HMs contamination (Gupta et al., 2013; Nasrabadi et al., 2015).

Table 2. Average, max, min, average of vegetable groups and average of regions for estimated daily intake (EDI) of heavy metals in vegetable regime for children (under 18 years) and adults (over 18 years) (mg/kg)

Groups	Index	Estimated daily intake (EDI)				
		Pb	**Cu**	**Co**	**Cd**	**Cr**
Children	Average	0.033	0.075	0.032	0.017	0.052
	Max	0.106	0.259	0.122	0.053	0.134
	Min	0.001	0.005	0.002	0.001	0.003
	Fruit vegetable	0.021	0.068	0.019	0.009	0.019
	Leafy vegetable	0.040	0.051	0.026	0.015	0.052
	Tuber vegetable	0.037	0.106	0.051	0.026	0.084
	First region (H)	0.056	0.109	0.048	0.029	0.069
	Second region (M)	0.040	0.087	0.034	0.018	0.061
	Third region (L)	0.003	0.029	0.014	0.003	0.025
Adults	Average	0.024	0.055	0.023	0.012	0.038
	Max	0.077	0.189	0.089	0.038	0.098
	Min	0.001	0.004	0.001	0.001	0.003
	Fruit vegetable	0.015	0.050	0.014	0.007	0.014
	Leafy vegetable	0.029	0.037	0.019	0.011	0.038
	Tuber vegetable	0.027	0.077	0.037	0.019	0.061
	First region (H)	0.040	0.080	0.035	0.021	0.050
	Second region (M)	0.029	0.064	0.025	0.013	0.045
	Third region (L)	0.002	0.021	0.010	0.002	0.019

The THQ of non-cancerous diseases of individual HMs through the consumption of vegetables should be less than one in order not to have the explicit hazards for the presence of these metals in of the whole life of an area through the consumption of vegetables (Cherfi et al., 2016). The average THQ values of people who consumed vegetables contaminated to Pb, Cu, Co, Cd, and Cr were 8.1, 1.8, 0.74, 16.5 and 0.03 for children, and 5.9, 1.3, 0.54, 0.12 and 0.02 for adults, respectively (Table 3). These results show that HMs account for a high amount of daily absorption resulting from the consumption of all types of vegetables to have a high hazard and increased THQ of non-cancerous diseases (McBride et al., 2014). In the research regions, maximum Cd-THQ amounts of 52.6 and 38.4 were obtained for children and adults, respectively (Table 3). Therefore, it can be affirmed that the THQ of HMs intake in the human body, except for Co and Cr, is the result of using vegetables in recipients less than 18 years old due to the lower weight and bioaccumulation of HMs. This problem shows that the age group of children has the highest vulnerability to HMs (Lv et al., 2019; Sandeep et al., 2019). Aghili et al., (2009) estimated THQs of 2.03, 0.67, and 0.45 in children, adolescents, and adult age groups, respectively, for the consumption of cucumber, tomato, and pepper in the greenhouse.

Table 3. Average, max, min, average of vegetable groups and average of regions for target hazard quotient (THQ) of heavy metals in vegetable regime for children (under 18 years) and adults (over 18 years)

Groups	Index	Target hazard quotient (THQ)				
		Pb	Cu	Co	Cd	Cr
Children	Average	8.19	1.88	0.74	16.55	0.03
	Max	26.39	6.47	2.84	52.67	0.08
	Min	0.26	0.13	0.04	0.87	0.002
	Fruit vegetable	5.21	1.70	0.44	9.44	0.01
	Leafy vegetable	10.11	1.28	0.60	14.70	0.03
	Tuber vegetable	9.25	2.65	1.19	25.50	0.05
	First region (H)	13.88	2.72	1.11	28.98	0.04
	Second region (M)	9.96	2.18	0.79	17.79	0.04
	Third region (L)	0.74	0.73	0.32	2.88	0.01
Adults	Average	5.97	1.37	0.54	12.06	0.02
	Max	19.24	4.72	2.07	38.42	0.07
	Min	0.20	0.10	0.03	0.64	0.002
	Fruit vegetable	3.80	1.24	0.32	6.89	0.009
	Leafy vegetable	7.37	0.93	0.44	10.72	0.02
	Tuber vegetable	6.75	1.93	0.86	18.59	0.04
	First region (H)	10.11	1.98	0.81	21.13	0.03
	Second region (M)	7.26	1.59	0.58	12.97	0.03
	Third region (L)	0.54	0.53	0.23	2.10	0.01

Analytical data of THQs for non-cancerous diseases were standardized in vegetable samples by PCA2-THQ model based on eigenvalue analysis of the covariance or correlation matrix. Each variable (HMs) with a load shows how well the HMs are taken into account by the components of the THQ model. They reflect how much each HMs contributes to the significant variation (or correlation) in the data to interpret HMs relationship. Each sample has a score along the component of the THQ model that shows the location of the samples (Figure 5), which is used to detect sample patterns, grouping, similarities or differences. The effects of HMs variable were studied (Figure 5 a-b) after indicating the variance and loading of principle components such as PC1 (95%) and PC2 (4.5%). The process of principle components and eigenvalue percentage are shown in the scree plot (Figure 5c). In addition, these figures show that Cd in PC1 and Pb in PC2 are the most effective variables to determine THQs for non-cancerous diseases with no correlations (Wu et al., 2019).

The results of the biplot investigation were plotted according to the PCA in Figure 6. PC1 and PC2 reflect a part of the THQ distribution of HMs in vegetables in the three research regions. PC1 shows maximum percentage of variance (95%) in the longitudinal diameter; hence, the maximum distribution and the variance of THQ in the positive quartet shows the greater effects of Cd and Pb. Better grouping of basil leaves was observed in the positive quarter of PC1 and PC2 in the first and second regions (Figure 6). Potato (M6 and H6), onion (M5 and H5), cucumber (H1), and tomato (H2) are shown in the positive quarter of PC1 and in the negative side of PC2. This means that vegetables from these regions have the greatest amount of health risk affected by HMs contamination, which were well separated from other vegetable species. PC2 shows a distribution in the transverse diameter, and Cu, Co, and Cr have maximum correlations and minimum effects on THQ values. Tomato (M2), cucumber, and lettuce (M4 and H4) in the positive quartet of PC2 and the negative side of PC1 show the lowest THQ hazards in the regions (Orisakwe et al., 2012).

The other vegetables are not segregated satisfactorily, merging them in the negative sides of PC1 and PC2. Vegetables grown in contaminated H and M regions are associated with greater THQ hazards, particularly for toxic metals such as Cd and Pb, which means that their consumption represents a significant risk to human health. In the third region (L), vegetables are associated with a lower health risk of their consumption (Bordean et al., 2011). Considering the results of this study, it seems that the vegetables grown in urban farming and near the industrial centers, urban roads, traffic areas, and other soil and water pollutants have greater contaminations of some metals. Therefore, their long-time daily consumption causes unwanted and unknown hazards and diseases of people throughout the society (Sandeep et al., 2019; Aghili et al., 2009). Also, only some not all of the vegetables were studied herein, so fruits and or others food materials may also be contaminated with HMs or other pollutants. The wide range of aspects related to the presence of HMs in vegetables and their implications for human health require future research on this important problem in a joint approach to environmental health that humanity is part of that.

CONCLUSION

The conclusion of this study has been summarized in 5 main sections. The highest contamination of all HMs (Pb, Cu, Co, Cd and Cr) was obtained in the first region (Isfahan), followed by the second and third regions. The results showed that the highest contamination of Pb was in basil and tomato, the highest contamination of Cu was in cucumber and the highest contamination of Cd and Cr was in onion. With attention to the result of this study, with the exception of Cu, all the other HMs were higher than the recommended standard values and the consumption of these vegetables can increase the risk to the health of people in a long time.

The highest daily intake of Pb, Cu, Co, Cd and Cr for recipients under 18 in the first region was 0.10, 0.25, 0.12, 0.05 and 0.13 mg/kg of body weight per day for the consumption of all vegetables, respectively. The highest daily intake of Pb, Cu, Co, Cd and Cr for adults (over 18 years old) in the first region was 0.07, 0.18, 0.08, 0.03 and 0.09 mg/kg per day, respectively. The THQ of non-cancerous diseases resulting from vegetable consumption was obtained from 18.3 and 13.3 in the first region for children and adults, respectively.

The risks of consumption by both age groups were greater than the index one with high hazard. The analysis of the principal components showed that the contamination of the HMs in the first and second regions overlapped with the probability of contamination of the HMs in the urban vegetables in the second region, which increased the THQ to non-cancerous diseases.

It is suggested to consider food safety and quality standards as the basis for communicating with the community and producing food products. Farming with the contaminated air and maximum usage of the chemical inputs and urban wastewaters will make unhealthy product that the gradual consumption of these vegetables can threaten as the human health hazard and will have unrepairable consequences especially in the future.

Controlling the maximum tolerance of HMs in food products is one of the issues that food consumers should mention to protect their health and achieve food safety. The purification of contaminants in agricultural products helps improve the safety and quality of food products and reduces THQ in human health and the environment by providing information related to the levels of environmental pollution in the community. It is worth noting that the heavy metal contamination in the vegetables examined in this study is only a small part of a person's food chains that will be at high risk in the overall feeds and is indeed a threat to vegetarian's people who think they are eating healthy food.

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CONFLICT OF INTEREST
The authors declare that there is not any conflict of interests regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/ or falsification, double publication and/or submission, and redundancy has been completely observed by the authors.

LIFE SCIENCE REPORTING
No life science threat was practiced in this research.

REFERENCES
Abad-Garcia, B., Berrueta, L. A., Garmon-Lobato, S., Urkaregi, A. and Vicente, B. (2012). Chemo metric characterization of fruit juice from Spanish cultivars according to their phenolic compound contents: I Citrus Fruits. J. Agri. Food Chem., 60; 3635–3644.

Aghili, F., Khoshgoftarmanesh, A. H., Afyuni, M. and Schulin R. (2009). Health risks of heavy metals through consumption of greenhouse vegetables grown in central Iran. Human Ecol. Risk Asses., 15; 999-1015.

Ali, H., Khan, E. and Ilahi, I. (2019). Environmental Chemistry and Ecotoxicology of Hazardous Heavy Metals: Environmental Persistence, Toxicity, and Bioaccumulation. J. Chem., 67; 14-18.

Amiri, Z., Asgharipour, M. R., Campbell, D. E., and Armin, M. (2019). A sustainability analysis of two rapeseed farming ecosystems in Khorramabad, Iran, based on emergy and economic analyses. J. Clean. Prod., 226; 1051-1066.

Asgharipour, M. R., Shahgholi, H., Campbell, D. E., Khamari, I., and Ghadiri, A. (2019). Comparison of the sustainability of bean production systems based on emergy and economic analyses. Environ. Monit. Assess. 191(1), 2. /doi.org/10.1007/s10661-018-7123-3

Baghaie, A. H. and Fereydoni, M. (2019). The potential risk of heavy metals on human health due to the daily consumption of vegetables. Environ. Health Engin. Manage. J., 6(1); 11–16.

Bo, S., Mei1, L., Tongbin, C., Yuanming, Z., Yunfeng, X., Xiaoyan, L. and Ding, G. (2009). Assessing the health risk of heavy metals in vegetables to the general population in Beijing, China. J. Environ. Sci., 21; 1702-1709.

Bordean, D. M., Gergen, I., Gogoaşă, I., Oprea, G., Pirvulescu, L., Alda, L. M., Alda, S, Breica, B. A. and Harmanescu, M. (2011). Mathematical model evaluation of heavy metal contamination in vegetables and fruits. J. Food, Agri. Environ., 9(1); 680–683.

Cherfi, A., Cherfi, M., Maache-Rezzoug, Z. and Rezzoug, S. A. (2016). Risk assessment of heavy metals via consumption of vegetables collected from different supermarkets in La Rochelle, France. Environ. Monit. Assess., 1; 136-188.

Cui, Y. J., Zhu, Y. G., Zhai, R., Huang, Y., Qiu, Y. and Liang, J. (2005). Exposure to metal mixtures and human health impacts in a contaminated area in Nanning, China. Environ. Int., 31; 784–790.

Esmaeilzadeh S, Asgharipour MR, Bazrgar AB, Soufizadeh S, Karandish F. Assessing the carbon footprint of irrigated and dryland wheat with a life cycle approach in bojnourd. Environ Prog Sustain. 2019.

FAO/WHO. (2011). Food additives and Contaminants. Joint Codex Alimentarius Commission, FAO/WHO Food Standards Programme. FAO/WHO, Rome, Italy.

Food & Feed-Maximum limit of heavy metals. (2010). National Standard of Iran N. 12968, Institute of Standards and Industrial Research of Iran. 1st. Edition 1389 [in Persian].

Gergen, I. and Harmanescu, M. (2012). Application of principal component analysis in the pollution assessment with heavy metals of vegetable food chain in the old mining areas. Chem. Cent. J., 6, 1-13.

Ghahremanzadeh, H., Noori, R., Baghvand, A., and Nasrabadi, T. (2018). Evaluating the main sources of groundwater pollution in the southern Tehran aquifer using principal component factor analysis. Environmental geochemistry and health, 40(4), 1317-1328.

Gupta, S., Jena, V., Jena, S., Davic, N., Matic, N., Radojevic, D. and Solanki, J. S. (2013). Assessment of heavy metal contents of green leafy vegetables. Croatian J. Food Sci. Technol., 5(2); 53-60.

Hammer, Ø., Harper, D. A. T. and Ryan, P. D. (2001). Past: Paleontological Statistics Software Package for Education and Data Analysis. Palaeontol Electron., 4(1); 4-9.

Harmanescu, M., Alda, L. M., Bordean, D. M., Gogoasa I. and Gergen I. (2011). Heavy metals health risk assessment for population via consumption of vegetables grown in old mining area; a case study: Banat County Romania. Chem. Cent. J., 5(1); 1-10.

Jafari, M., Asgharipour, M. R., Ramroudi, M., Galavi, M., and Hadarbadi, G. (2018). Sustainability assessment of date and pistachio agricultural systems using energy, emergy and economic approaches. J. Clean. Prod., 193; 642-651.

Li, M. S., Luo, Y. P. and Su, Z. Y. (2006). Heavy metal concentrations in soils and plant accumulation in a restored manganese mineland in Guangxi, South China. Environ. Pollut., 147; 75-168.

Liu, X., Song, Q., Tang, Y., Li, W., Xu, J., Wu, J., Wang, F. and Brookes, P. C. (2013). Human health risk assessment of heavy metals in soil–vegetable system: A multi-medium analysis. Sci. Total Environ., 463; 530–540.

Lv, P., Wei, Z., Yu, Z., Zhang, J. and Wang, L. (2019). Heavy metal contamination in soils of greenhouse vegetable production systems in a cold region of China. Int. J. Agric. Biol. Eng., 12(2); 98-103.

Matyssek, R., Schulin, R. and Günthardt-Goerg, M. S. (2006). Metal fluxes and stresses in terrestrial ecosystems: synopsis towards holistic understanding. Forest Snow Land. Res., 80(2); 139–148.

McBride, M. B., Shayler, H. A. and Spliethoff, H. M. (2014). Concentrations of lead, cadmium and barium in urban garden-grown vegetables: the impact of soil variables. Environ. Pollut., 194; 254-271.

Moradi, A., Honarjoo, N., Najafi, P. and Fallahzade, J. (2016). Human health risk assessment of soil and crops contaminated by heavy metals in industrial regions, central Iran. Human Ecol. Risk Asses., 22; 153-167.

Nasrabadi, T., Maedeh, P. A., Sirdari, Z. Z., Bidabadi, N. S., Solgi, S. and Tajik, M. (2015). Analyzing the quantitative risk and hazard of different waterborne arsenic exposures: case study of Haraz River, Iran. Environ Earth Sci., 74; 521-532.

Orisakwe, O. E., Nduka, J. K., Amadi, C. N., Dike, D. O. and Bede, O. (2012). Heavy metals health risk assessment for population via consumption of food crops and fruits in Owerri, South Eastern, Nigeria. Chem. Cent. J., 6; 77-81.

Pop, H. F., Einax, J. W. and Sârbu, C. (2009). Classical and fuzzy principal component analysis of some environmental samples concerning the pollution with heavy metals. Chem. Int. Lab. Syst., 97; 25–32.

Salehipour, M., Ghorbani, H., Kheirabadi, H. and Afyuni, M. (2015). Health Risks from Heavy Metals via Consumption of Cereals and Vegetables in Isfahan Province, Iran. Human and Ecol. Risk Asses., 10; 1–16.

Sandeep, G., Vijayalatha, K. R. and Anitha, T. (2019). Heavy metals and its impact in vegetable crops. Int. J. Chem. Stud., 7(1); 1612-1621.

Singh, A., Sharma, R. K., Agrawal, M. and Marshall, F. M. (2010). Risk assessment of heavy metal toxicity through contaminated vegetables from waste water irrigated area of Varanasi, India. Trop. Ecol., 51(2), 375–387.

Srinivas, N., Ramakrishna, R. S. and Kumar, S. K. (2009). Trace metal accumulation in vegetables grown in industrial and semi-urban areas – a case study. App. Ecol. Environ. Res., 7; 131–139.

USEPA (United States Environmental Protection Agency). (2010). Integrated Risk Information System (IRIS); United States Environmental Protection Agency: Washington, DC, USA, Available online: www.epa.gov/ncea/iris/index.html

USEPA (US Environmental Protection Agency). (2005). Human health risk assessment: Risk-based concentration table.

Wu, H., Yang, F., Li, H., Li, Q., Zhang, F., Ba, Y., Cui, L., Sun, L., Ly, T., Wang, N. and Zhu, J. (2019). Heavy metal pollution and health risk assessment of agricultural soil near a smelter in an industrial city in China. Int. J. Environ. Health Res. 27; 1-13.

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