Health risk of heavy metals from the consumption of cucumber in Darrehshahr Township, west of Iran

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Abstract

Because of the routine consumption of vegetables and the possibility of heavy metals contamination, it can threaten the health of consumers. In this investigation, the concentration and human health risks of heavy metals (Cd, Pb, Zn, Cu, and Ni) were evaluated in the harvested cucumber samples in nine villages of the Darrehshahr Township, Iran. The average concentrations of elements in all the villages were ranked as follows: Zn < Pb < Cu < Ni < Cd. The concentration of Cd (except village I) and Pb as toxic pollutants in all the samples were higher than maximum levels (ML) of Iran standard. Among all the studied elements, only EDI and EWI values of Pb were found to be higher than recommended value limits of Iran standard. THQ (Target Hazard Quotient) of all the elements except Pb was less than 1and was in the order Pb > Cu > Zn > Ni > Cd. So, the health risk of cucumber consumption, because of Pb, was high. Total Target Hazard Quotient (TTHQ) in all the villages was more than 10. It represented that the health risk for non-carcinogenic diseases due to long term cucumber consumption would be high. Based on the results, there is a health risk from consumption of cucumber grown in Darrehshahr Township because of high Pb concentration.

Introduction

Nowadays, the role of heavy metals in the environmental pollution and their harmful effects on the human health is proven [1] .The contamination of agricultural products by heavy metals, in addition to natural sources, is mainly due to human activities such as agriculture, mining, construction, irrigation by sewage, use of wastewater treatment plant sludge and livestock manure as soil conditioner, pesticide application, and many industrial processes [1, 2]. Due to the lack of decomposition and destruction of heavy metals, they are considered as persistent and durable pollutants in the environment [3]. These elements can affect the quality of agricultural soils and, in addition to being poisonous, enter the human diet through absorption by plants and cause many human health problems [4]. Plants are the most important route of heavy metals transport into the human food chain and subsequently biological cycles [4, 5]. Among heavy metals, some of them, such as Zinc (Zn), Copper (Cu), and Cobalt (Co), are necessary as trace elements for most biological systems, including humans body [6]; While some heavy metals such as cadmium (Cd), lead (Pb), and Arsenic (As) are very toxic for plants, animals, and humans health [7, 8]. Cadmium is known as a carcinogen in the development of most cancers and cardiovascular and blood pressure diseases [9–11]. Lead also affects the blood and kidney system, causing metabolic abnormalities and neuropsychiatric deficits in children. It has also been reported that entering large amounts of heavy metals including Pb into the body of pregnant mothers cause increasing premature infants phenomena and severe mental retardation of newborns [12]. The concentration of heavy elements in vegetables body is one of the most important health factors [13]. Plants can accumulate large amounts of Cd without any damages to themselves and the consumption of these plants as food diet can bio-magnify this element in the human body [7].

Many studies showed that the concentration of heavy metals in edible vegetables was more than standard limits and finally those health impacts were confirmed [14–16], while in other researches, the concentration was less than standard limits and their contribution to human health was ignorable [4, 5]. Cherfi et al. (2015) studied the amount of some heavy metals in cultivated vegetables near of Boumerdes city in Algeria, and their results showed that the mean concentration of Cu, Zn, Pb, and Cr were observed in range of 2.5–3.0, 0.5–0.6, 1.8–12.5, and 0.9–6.2 mg/kg (dry wt.), respectively [17]. Many studies in Iran conducted on heavy metals health risk to human. Asgari Lajayer et al. (2019) showed that Cu, Zn, Fe, Ni, Pb, and Cd in plants that fertilized by sewage sludge were higher than World Health Organization (WHO) and the Food and Drug Administration (FAO) maximum levels (ML).

Also, the results revealed that using non treated sludge in agriculture fields is not permissible [18]. High concentration of Pb and Cd are known as carcinogens especially in the digestive tract [10, 14], and also the toxicity and harmful effects of Cu, Zn, and Ni [9] are proven. Since, cucumber is one of the dominant agricultural products in the Darrehshahr Township (Ilam, Iran), which has been continuously cultivated in the region over the last decades, and most of the production is exported to other provinces and even Iraq. More than 100,000 tons of cucumber is annually produced from this township [19]. Therefore, the purpose of this study was to investigate the concentration of heavy metals (Pb, Cd, Ni, Cu, and Zn) in harvested cucumber from Darehshahr township farms. In continues the Estimated Daily Intake (EDI) and health risk of these elements were also investigated.

Materials And Methods

Study area

The agricultural land in the Darrehshahr township is a narrow strip in the plain of Zagros mountains ranges and southern side of the Seymareh River that is located along the latitude line 32°49´ to 33°14´N and the longitude line 47°13´ to 47°52´E in the southwest of Iran (Fig. 1). The source of irrigation water of these agricultural lands is Seymareh River which is located in the center of Karkheh basin, and it passes from three Hamedan, Kermanshahan, and Ilam provinces to reach Karkheh dam in the Khuzestan province [20]. The length of the Seymareh river is estimated to be about 235 Km. Along its way, it passes from many farmlands, and many industry, agricultural, and urban wastewater and effluent drain into the river [21]. Two main branches of Seymareh River are Gamasiab and Gharasou Rivers that receive many agricultural drainages and industrial wastewaters along their routes [22, 23].

Sampling And Experiments

After selecting 9 sampling site randomly (Fig. 1), the position of selected sampling points was determined using GPS model 76CSX-GARMIN. Then, 1 kg of cucumber was harvested from different parts of the farm. Each sample of the cucumber was collected from healthy bushes that were without disease and pests. After transfer the samples to the laboratory, they were washed with urban water and then distilled water. Then, 500 g of each sample was separated and cut into thin pieces and dried for 24–48 h at 105°C (inside the oven). After drying, the residual mass was ground and dissolved into 15 ml of acid (containing 12 ml of HNO_3 and 3 ml of HCl (4:1 ratio)). To complete the digestion, the solution was poured into special cone tubes and tapered at 40 and 120°C for 1 and 3 h, respectively, in the Heating Block (Labnet, USA). The digested solutions were filtered using Whatman 42 filter paper, and were diluted to 25 ml by distilled water. Flame Atomic Absorption Spectrometry (ContrAA 700, Analytic Jena AG: Germany) was used to determine the concentration of Pb, Zi, Cu, and Ni, and for measuring Cd concentration, Graphite Furnace Atomic Absorption (AA670-G Shimadzoo, Japan) was used. Also, a control sample was used during preparation of samples. The measurement of Cd, Cu, Pb, Ni, and Zn was carried out at wavelengths of 288, 324, 217, 222, and 213 nm, respectively.

Estimated Daily Intake (Edi) Of Metals

For the calculation and evaluation of the heavy metals health risk, some assumptions were considered (Table 1).

Table 1
Assumptions for the calculation of daily intake and risk assessment of cucumber.

Row	Assumption
1	The consumption dose is equal to the intake dose of the pollutants
2	pickling and other processes of cucumber have no effect on the pollutants
3	The average weight of an adult is 70 kg
4	The average lifespan of a person is 70 years

To determine the risk of heavy metals on non-cancerous diseases, the USEPA method was used [24, 25]. First, the amount of contaminant intake per kilogram of body weight per day was calculated using the Equation [1].

$$EDI = \frac{\mathrm{EF} \times \mathrm{ED} \times \mathrm{FIR} \times \mathrm{C}}{\mathrm{BW} \times \mathrm{AT}}$$

1

Where EDI is the Estimated Daily Intake of metals by cucumber consumption (g person^{-1} d^{-1}); EF is the Frequency Exposure (365 days year^{-1}); ED is the exposure duration for non-cancer risk (70 years); FIR is the amount of consumed cucumber by each person (kg day^{-1}); C is the heavy metal concentration in the polluted cucumber (mg kg^{-1}); BW is the average body weight (kg) and usually is 70 kg for adults, and AT is the average time of exposure to the pollutant (ED×365 days year^{-1}).

Provisional Maximum Tolerable Daily Intake (PMTDI) of heavy metals is related to some of the heavy metals that do not have cumulative properties in the human body. This quantity indicates the level of personal exposure to heavy metals through cucumber. In this study, the PMTDI and Provisional Tolerable Weekly Intake (PTWI) for a 70 kg adult person were obtained and compared with Institute of Standards and Industrial Research of Iran (ISIRI) and the USEPA standard.

According to the ISIRI, the PMTDI of Pb and Cd for a 70 kg person is 0.004 and 0.001 mg kg^{-1} of body weight, respectively, due to daily vegetable consumption equal to 0.058 kg person^{-1} [26]. The amount of PMTDI for Cu, Zn, and Ni has not been reported in the IRIS. Therefore, to interpret health effects of these three elements, the PMTDI information was obtained from FAO/WHO Technical Report. Accordingly, the PMTDI of Cu, Zn, and Ni were considered to be 0.5, 0.3-1, and 0.3 mg kg^{-1} of body weight, respectively [27]. In continue by using Eq. 2, the Target Hazard Quotient (THQ) of non-carcinogenic diseases related to heavy metals were estimated using the United States Environmental Protection Agency (US EPA) methodology [24, 25].

$$\mathrm{THQ} = \left(\frac{EF \times ED \times IR \times C}{BW \times RfD \times AT} \right) \quad (2)$$

Where THQ is the Target Hazard Quotients; EF, ED, C, BW, and AT are presented in Equation [1]; IR is cucumber ingestion rate (kg day^{-1}); RFD is the reference dose (this value is obtained by experiment on animals and represents the maximum concentration of an element that does not cause any problem for organisms (mg kg^{-1}

day^{-1})). According to USEPA, RFD value for Cd, Pb, Ni, Cu, and Zn is 0.001, 0.004, 0.02, 0.04, and 0. 3 mg kg^{-1} day^{-1}, respectively [28].

By calculating the THQ for each heavy metal element and comparing it to the reference dose, the non-carcinogenic health risk of a specific element was assessed. Given that the risk potential is the ratio of the concentration of an element to the maximum concentration of that element which does not lead to problems in the body. Reaching or above the number 1, represents a high risk of occurrence. Also, in this research, Hazard Index (HI) was obtained from the sum of the risk factors of the total studied elements (Pb, Cd, Zn, Cu, and Ni), based on the proposed method by Chein et al [29].

$$\mathrm{HI} = \sum \mathrm{THQ} = \mathrm{THQCd} + \mathrm{THQPb} + \mathrm{THQCu} + \mathrm{THQNi} + \mathrm{THQZn}$$

3

If the HI for non-carcinogenic diseases is reached to 1, this indicates a higher risk of non-carcinogenic diseases and when the HI is less than 1, this expresses that it is not harmful due to the consumption of cucumber.

After verifying the normalization of the data, T-test statistical analysis was used to compare the mean concentration of heavy metals in the samples with ISIRI and EPA standards. To compare the mean concentration of sampling stations, one-way ANOVA was used. Pearson's test was applied to investigate the correlation between metals concentration in the each sampling site.

Results

The average concentrations of heavy metals of Cd, Pb, Cu, Ni, and Zn in the grown cucumber in the farms of the Darehshahr Township (villages I to IX) are presented in Table 2. The maximum and minimum concentrations of the studied metals were Zn (village II) and Cd (village I), respectively.

Table 2
The heavy metals content (mg kg^{-1}) in cucumber of Darehshahr Township.

Village Code	Metals	Cd	Pb	Cu	Ni	Zn
	ML[a] (mg kg^{-1})	0.05[b]	0.1[b]	0.3[c]	0.5[c]	20[c]
I	Ave	0.247	24.190	21.040	2.813	61.955
	Max	0.251	24.800	21.880	2.850	62.290
	Min	0.024	23.500	20.250	2.720	61.750
	SD	0.000	0.564	0.701	0.062	0.247
II	Ave	0.250	24.930	20.454	3.116	64.142
	Max	0.251	25.080	20.870	3.210	64.700
	Min	0.249	24.800	20.112	3.000	63.600
	SD	0.000	0.116	0.312	0.089	0.450
III	Ave	0.062	24.967	22.888	1.932	62.437
	Max	0.063	25.190	23.125	2.010	62.480
	Min	0.062	24.790	22.540	1.840	62.400
	SD	0.000	0.169	0.251	0.077	0.035
IV	Ave	0.088	24.999	15.831	1.375	55.747
	Max	0.088	25.108	16.063	1.480	56.500
	Min	0.087	24.800	15.360	1.240	55.000
	SD	0.000	0.140	0.322	0.099	0.613
V	Ave	0.087	25.078	19.380	1.367	61.385
	Max	0.087	25.450	19.680	1.400	61.610
	Min	0.087	24.820	18.810	1.330	61.170
	SD	0.000	0.265	0.388	0.029	0.179
VI	Ave	0.012	25.970	22.228	2.385	60.455
	Max	0.012	26.360	22.845	2.440	60.680
	Min	0.012	25.560	21.320	2.290	60.240
	SD	0.000	0.327	0.660	0.065	0.179
VII	Ave	0.087	25.330	18.879	3.530	61.610
	Max	0.087	25.540	19.332	3.600	62.220
	Min	0.086	25.140	17.985	3.480	61.000
	SD	0.000	0.164	0.629	0.053	0.509

VIII	Ave	0.135	24.952	22.320	1.690	53.040
	Max	0.137	25.100	22.890	1.880	54.040
	Min	0.131	24.800	21.450	1.580	52.040
	SD	0.003	0.123	0.617	0.137	0.822
IX	Ave	0.163	24.445	18.277	2.465	58.067
	Max	0.166	24.960	19.990	2.580	58.150
	Min	0.016	23.960	16.450	2.380	58.000
	SD	0.003	0.409	1.450	0.092	0.066

[a]Maximum Level, [b]Based on ISIRI, [c]Based on FAO/WHO.

As Table 3 shows, according to one-way ANOVA results, homogeneity of the data was rejected ($P > 0.05$). Therefore, the Dunnett's test was used to compare the average concentration of cucumber heavy metals at different sampling sites ($P < 0.05$).

Table 3
Comparison of the average concentrations of heavy metals in cucumbers in villages by one-way ANOVA.

Metals	Parameter	Levene's test		Dunnett's test for equality for means		
		P	t-test	df	F	P
Cd	Homogeneity of variances Assumption	0.001	5.206	-	-	-
	Equal mean assumption	-	-	8	4979.571	0.000
Pb	Assuming homogeneity of variances	0.082	2.019	-	-	-
	Assumption of averages	-	-	8	11.872	0.000
Co	Assuming homogeneity of variances	0.274	1.325	-	-	-
	Assumption of averages	-	-	8	44.494	0.000
Ni	Assuming homogeneity of variances	0.393	1.100	-	-	-
	Assumption of averages	-	-	8	335.022	0.000
Zn	Assuming homogeneity of variances	0.116	1.824	-	-	-
	Assumption of averages	-	-	8	278.325	0.000

Also Table 3 shows that there was a significant difference between the average concentration of heavy metals in cucumber tissue at all the sampling sites ($P < 0.05$).

Table 4
Estimation of PTDI, EDI, PTWI, and EWI (μg/kg bw/day) of each element via consumption of cucumber from nine sample sites.

Metals	Village Code	I	II	III	IV	V	VI	VII	VIII	IX
Cd	PTDI	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
	EDI	0.0002	0.0000	0.0000	0.0001	0.0001	0.0001	0.0001	0.0002	0.0002
	PTWI	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007
	EWI	0.0014	0.0002	0.0006	0.0009	0.0009	0.0012	0.0009	0.0014	0.0017
Pb	PTDI	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004
	EDI	0.0361	0.0372	0.0372	0.0373	0.0374	0.0387	0.0378	0.0372	0.0365
	PTWI	0.0252	0.0252	0.0252	0.0252	0.0252	0.0252	0.0252	0.0252	0.0252
	EWI	0.2528	0.2605	0.2609	0.2612	0.2621	0.2714	0.2647	0.2607	0.2555
Cu	PTDI	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
	EDI	0.0314	0.0305	0.034	0.0236	0.0289	0.033	0.0281	0.0333	0.0272
	PTWI	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5
	EWI	0.219	0.213	0.239	0.165	0.202	0.232	0.197	0.233	0.191
Ni	PTDI	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
	EDI	0.0042	0.0046	0.0029	0.0020	0.0020	0.0036	0.0052	0.0025	0.0037
	PTWI	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1
	EWI	0.0294	0.0325	0.0201	0.0143	0.0142	0.0249	0.0368	0.0176	0.0257
Zn	PTDI	0.3-1	0.3-1	0.3-1	0.3-1	0.3-1	0.3-1	0.3-1	0.3-1	0.3-1
	EDI	0.092	0.059	0.093	0.083	0.0916	0.0902	0.0919	0.079	0.0867
	PTWI	2.1-7	2.1-7	2.1-7	2.1-7	2.1-7	2.1-7	2.1-7	2.1-7	2.1-7
	EWI	0.647	0.67	0.652	0.582	0.641	0.631	0.643	0.554	0.606

Table 5 shows the THQ of different studied elements at the various sampling sites.

Table 5
Estimation the THQ of non-carcinogenic diseases related to studied heavy metals.

Metals	Village Code								
	I	II	III	IV	V	VI	VII	VIII	IX
Cd	0.02	0.03	0.09	0.13	0.13	0.17	0.13	0.2	0.24
Pb	9.029	9.306	9.320	9.331	9.361	9.694	9.455	9.31	9.125
Cu	0.78	0.76	0.85	0.59	0.72	0.82	0.7	0.83	0.68
Ni	0.21	0.23	0.14	0.10	0.10	0.17	0.26	0.12	0.18
An	0.308	0.319	0.31	0.277	0.305	0.3	0.306	0.263	0.289
TTHQ (HI)	10.527	10.645	10.71	10.428	10.616	11.154	10.851	10.723	10.514

Discussion

Concentration of heavy metals in samples

In the Table 2, the statistical analysis of the metal elements concentration is summarized. The highest metal concentration in the cucumber samples was related to Zn, Cu, Ni, Pb, and Cd, respectively. The results of Yang et al. (2018) showed that heavy metal pollution and associated risks with Cd, Pb, and As were more serious [30]. Pajević et at al. (2018) showed that, the concentration of Cd, Pb, Ni, and Cr in many vegetable samples of Vojvodina Province in Serbia was dangerously high [31], and in more than half of the samples Cd was higher than the maximum permissible concentrations. Similarly, the concentration of Cd in the samples of present study except samples of villages I and II was higher than the recommended ML by ISIRI. The average of Cd concentration in this study was 2.08 mg kg^{-1} dry weight. Cd content from the West to the East of the study area was increased and the average Cd concentration in samples of villages I, II, III, IV, V, VI, VII, VIII, and IX was 4.49, 5, 1.24, 1.76, 1.74, 0.24, 1.74, 2.7, and 3.26 times more than ML by ISIRI, respectively. The results of Sharma et al. (2008) investigation showed that the concentration of Cd in most of the vegetables was higher than the safe limits of both Indian and FAO/WHO standards [32]. According to Yang et al. (2018) findings, the location of the vegetable cultivation was influenced on the mean concentration heavy metals in the 402 industrial sites and 1041 agricultural sites in China, where the concentration of heavy metals were different in the various places [30]. The of Balkhair et al. (2016) study on the irrigation of crops by treated wastewater in the western region of Saudi Arabia led to increase of Cd, Cr, Cu, Pb, and Zn concentration above the safe limit [15]. Water source of farms in the present research was from Seymareh River and its potential for receiving many contamination resources, because of its route, is high. So, the bioaccumulation of heavy metals in the vegetables tissue is possible. The study of Mirzaei-Takhtgahi et al. (2018) on heavy metals (Cu, Fe, Zn, Cd, and Mn) accumulation in vegetables (spinach, fenugreek, and dill) irrigated with Gharasou River, as one of the main branches of Seymareh River, showed that the concentration of some metals were more than standard limits, and the concentration of Cd in the most samples was more than standards limits [33]. Song et al. (2018) proved that water and fertilizer are highly contribute in increasing As, Cd, Cu, Pb, and Zn contents in the vegetables among cultivated crops along with the Changjiang River delta in China [34].

In addition to Cadmium, lead is also toxic and its high concentration may lead to major problems for human health such as disorder in hemoglobin synthesis, perturbation in the reproductive and cardiovascular systems, and chronic damage to the nervous system [31]. The results of this study showed that the concentration of Pb in the cucumber samples was significantly higher than the ML of ISIRI (0.1 mg kg^{-1} weight of plant). As shown in the Table 2, the average of Pb in the cucumber tissue of the samples in the villages of I, II, III, IV, V, VI, VII, VIII, and IX were 241.90, 249.30, 249.67, 249.99, 250.78, 259.70, 253.30, 249.52, and 244.45 times greater than the ML of ISIRI. Because the irrigation water source of these farmlands is Seymareh river and it received many wastewater and effluent along its way [21, 23], it can be the possible source of heavy metals including Pb in the soil and finally cultivated cucumber. Gharasou River as one of the main branches of Seymareh River is located in the upstream of Darrehshahr Township, and many pollutants enter the river through surface flows. Mansouri et al. (2016) detected considerable concentration of Cd, Pb, Cr, Cu, and Zn in the tissues of Cyprinus carpio and Capoeta trutta fishes in Gharasou River [35]. In the study of Zhang et al. (2018), the concentrations of heavy metals including Pb in vegetables from Sihui and Shunde (Pearl River Delta, South China) meet the food hygiene standards [36]. Also, the study of Mahmood and Malik (2014) on the assessment of human health risks to heavy metals through the use of contaminated vegetables collected from various sources of irrigation in Lahore-Pakistan showed that Pb in all the irrigated vegetables with sewage was higher than the permissible limit [24]. Pb content exceeding standard limits in many grown products (lettuce, cabbage, cauliflower, spinach, rockets, parsley, carrots, onions, and potatoes) in Brazil was registered by Guerra et al. (2012) [37]. Ye et al. (2015) claimed that there was a significant correlation between metal concentrations including Pb in the soil texture and Lead content in the vegetables tissue [38]. Vicinity of road traffic [39], transferring of dust particles contain lead, and irrigation of farms using raw wastewater and effluents [40] could be attributed to the high concentration of Pb in the vegetables tissue [41]. The average concentration of Ni, Cu, and Zn in all samples was more than the recommended range by FAO/WHO. Overuse of pesticides and fertilizers and use of Seymareh River as irrigation water source are the possible causes of high concentration of these metals in the cucumber samples. Other studies showed that the concentration of heavy metals in Gharasou River [35] and Gamasiab River [42] as the two main branches of Seymareh River were considerable. The highest and the lowest concentrations of Ni in the samples were related to the villages VII (3.53 mg kg^{-1}) and V (1.37 mg kg^{-1}). So that, the difference of the highest concentration with the lowest mean concentration was 2.16 mg Kg^{-1} was obtained. Table 2 shows that the amount of Ni in the cucumber of the village of VII was 7.06 times more than the limit and its value in the village V was 2.74 times greater than the ML of FAO/WHO (0.5 mg kg^{-1}) ($P < 0.05$) [20]. The concentration of Cu in the studied samples was 15.83 mg kg^{-1} to 22.89 mg kg^{-1} of cucumber weight. The average concentration of Cu in the samples was 21.04, 20.45, 22.89, 15.83, 19.38, 22.23, 18.88, 22.32, and 18.28 mg kg^{-1} related to the villages I, II, III, IV, V, VI, VII, VIII, and IX, respectively. The lowest and the highest concentration of Cu was 52.76 (village IV) and 76.29 times (village of III) more than the ML of FAO/WHO (0.3 mg kg^{-1}). According to Table 2, Zn concentration in all the samples was greater than the ML. Ni concentration of villages I, II, III, IV, V, VI, VII, VIII, and IX were 2.813, 3.116, 1.932, 1.375, 1.367, 2.385, 3.530, 1.690, and 2.465, respectively, that were 3.09, 3.2, 3.12, 3.06, 3.02, 3.08, 2.65, and 2.9 times over the ML of FAO/WHO, respectively (0.5 mg kg^{-1}). Song et al. (2009) showed that Cd, Pb, Cr, Ni, As, and Cu (except Zn) in the cultivated vegetables in the open space were higher than those grown in greenhouses [30]. In a study conducted by Pajević et al. (2018) in Serbia, they found that the concentrations of As, Cr, Pb, Cd, and Zn in all samples were higher than FAO/WHO ML [31].

The Rate Of Heavy Metals Intake In Daily Diet

In order to study the intake of heavy metals by cucumber consumption in the daily diet, the EDI and EWI values should be considered. Based on the results of Table 3, only EDI and EWI values of Pb were found to be higher than PTDI and PTWI recommended by ISIR. The highest and the lowest levels EWI of Pb were obtained for the cucumber samples of villages I and VI, respectively. The study of Wachirawongsakorn (2015) in Thailand considered that the most leading EDI was related to Pb [14]. The EDI and EWI levels for Cd, Ni, Cu, and Zn were much lower than the PTDI and PTWI limits. Therefore, the risk of these elements does not affect the cucumber consumers in all the studied villages. This study was similar to Shaheen et al (2016) that they proved EDI of As, Cd, Pb, Cr, Mn, Ni, Cu, and Zn revealed no health risks associated with the intake of these metals [43]. The study of Bempah et al. (2011) in assessing the potential of heavy metals consumption in some selected fruits and vegetables from the Ghana markets showed that EDI level of all investigated metals (Pb, Cd, Cu, Zn, and Cr) in all vegetables and fruits was lower than the FAO/WHO recommendations [44].

Risk Potential Of Heavy Metals

The THQ of non-carcinogenic diseases related to heavy metals by consumption of cucumber for consumers are shown in Table 4. The highest and the lowest levels of THQ were related to Pb (9.7) and Cd (0.03), respectively. The risk level of Pb as a result of cucumber consumption was higher than other elements and the THQ content of all the elements except Pb metal was less than 1. So because of Pb, the risk of non-cancerous diseases was high due to consumption of cucumber. Ghasemidehkordi et al. (2018) investigated the hazard assessment of heavy elements on the human health through consumption of green leafy vegetables and herbs in Markazi province, Iran. They found that the amount of THQ for Hg and Pb for 15–24 and 35–44 years old age groups in both rural and urban consumers was estimated upper than 1 [45]. Fakhri et al. (2018) investigation proved that THQ and TTHQ of Pb and Cd due to onion bulb consumption in HashtBandi and Ravang region of Iran for all age groups of males and females were less than 1 value. However the concentration of Cd in the soil texture of these regions was more than soil threshold values [46]. Wachirawongsakorn (2015) assessed the risk of Cd and Pb as a possible risk in the assessment of fresh vegetables in Thailand [14]. THQ indicated that the consumption of root/tuber and stem contaminated by Pb and leaf vegetable contaminated by Cd influence the health of the population in the study area [14]. Table 4 shows that the risk of non-carcinogenic diseases for each element solely (except Pb) is not exist for cucumbers consumers. The risk potential of elements due to cucumber consumption was reduced by Pb > Cu > Zn > Ni > Cd. The TTHQ or HI for the target species in all the villages was above 10, which indicated that in the long term cucumber consumption, the risk for non-carcinogenic diseases would be high for the consumers. In the study of Orisakwe et al. (2018), the concentration of heavy metals in vegetables harvested near artisanal mining sites of Dilimi River, Bukuru and Barkin Ladi North Central Nigeria was in the order Cd < Se < Cr < Cu < Ni < Zn. The THQ values in at least 62.5% of vegetable samples were less than 1 and all the HI values for the adults were less than 1 [47]. Fathabad et al. (2018) study showed that the THQ of heavy metals was in the order Al > Sn > As > Pb > Cd > Hg for fruits juices and canned samples in Tehran markets, Iran. Beside Al and Sn, the THQ of other heavy metals was less than 1 [48]. Ding et al. (2018), in evaluation the health risk of heavy metals in fruit vegetables planted in the Tongling Mining area of China, the amount of Cd was the highest. The THQ of Zn for children was more than 1 in some vegetables and TTHQ of Cu and Zn were more than 1 through consumption of all the vegetables [49]. Harmanescu et al. (2011) reported the measure of health risk of Fe, Mn, Zn, Cu, Ni, Cd, and Pb via consumption of vegetables and fruits grown in old mining area Banat County, Romania. They reported that Cd and Pb, as the most toxic metals to human, had an great share in the combined THQ for cabbage and cucumber [50]. Li et al. (2013) in evaluating the concentration of As, Ni, Cu, Pb, Cd, and Zn in eight kinds of vegetables in the fragmentary vegetable plots of Tongling city; the THQs of As, Ni, Cu, Pb, Cd, and Zn were 17.92, 1.01, 10.14, 0.73, 0.21, and 1.93, respectively. The major risk for inhabitants was via As and Cu; so that TTHQ value due to the average vegetable consumption was 56.10% and 31.75%, respectively [51]. A study by Harmanescu et al. (2011) in Romania on the health risk assessment of heavy metals for the consumers of vegetables grown in the old mine area (city of Banat) showed that THQ levels due to the consumption of vegetables (parsley, carrot, cabbage, cucumber and bean green) was not risk free. Also, the combined THQ for all the studied vegetables was higher than 1 [50]. A study by Cherfi et al. (2015) on the health risk assessment of heavy metals through the use of irrigated vegetables treated with urban treated wastewater in Algeria showed that the THQ value for all metals was higher than 0.85. But, there was no risk of using these vegetables in the consumers [17]. In the study of Hang et al. (2016), the accumulation of heavy metals in vegetable species planted in contaminated soils and health risk assessment, the THQ level of adults and children by vegetables was 12.4 and 5.41, respectively. They reported in the study that children were more vulnerable population than others for consuming these vegetables [52].

Conclusion

The Cd levels in all the cucumber samples except villages I and II and the Pb concentration in all the samples were more than Iran National Standards for vegetables. The average concentration of other heavy metals (Ni, Cu, and Zn) was greater than the recommended range by FAO/WHO. Among all the studied heavy metals only EDI and EWI values of Pb were more than PTDI and PTWI recommended by ISIR. The risk potential of heavy metals due to cucumber consumption were in the order Pb > Cu > Zn > Ni > Cd, respectively. Except Pb, the measure of THQ for all the metals was less than 1. The TTHQ for all the samples of villages was above 10 that represented the risk for non-carcinogenic diseases would be high for consumers due to the long term cucumber consumption.

Declarations

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Conflict of Interest

The authors declare that there is no conflict of interests.

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Figures

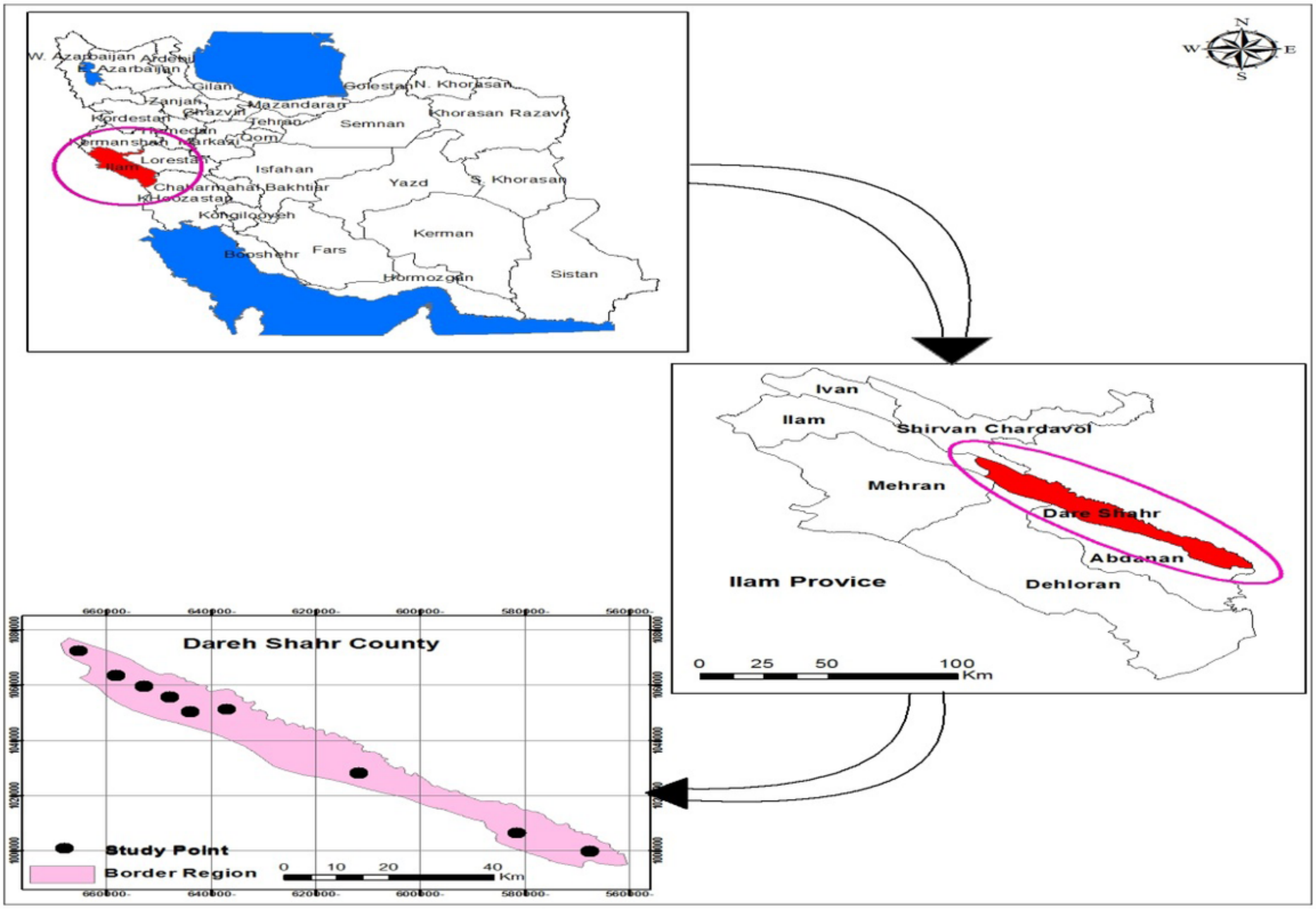

Figure 1

Study area and location of the sampling points for cucumber collection.