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Research Paper:

Human Health Risk of Some Heavy Metals Accumulated in Tomatoe, Cucumber, Potato, and Onion Grown in Dezful and Shushtar

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ABSTRACT

Background & Aims of the Study: This study aimed to evaluate the environmental risk and human health risk of heavy metals in some agricultural products cultivated in Dezful and Shushtar in 2020.

Materials and Methods: In this research, 18 samples of 1 kg of crops grown on farms in the summer of 2020 were collected randomly from 6 stations in two areas of (Safiabad & Shamsabad farms) and two regions of Shushtar (Gelalak & Shoaibiyeh farms). ICP model Varian 710-ES measured heavy metals.

Results: The average amount of zinc in tomatoes, cucumbers, potatoes, and onions grown in farms were 38.396, 23.440, 16.136, and 90.706 mg/kg, and in cultivated lands of Shushtar, 11.690, 6.730, 5.713, and 7.406 mg/kg were obtained. Analysis of variance showed that the heavy metals lead, cadmium, and chromium in crops of Dezful and Shushtar were significantly different ($P<0.05$), but in the case of zinc, copper, and nickel in tomato, cucumber, No significant difference was observed between potato and onion ($P>0.05$). In tomato and cucumber crops grown in Dezful and Shushtar and potatoes in Shushtar, the hazard values of cadmium, chromium, zinc, and copper were higher than 1. In the tomato crop and the potatoes grown in Shushtar, the lead metal risk index values were higher than 1. Nickel metal hazard index values were obtained in cultivated agricultural products of potatoes, cucumbers, and tomatoes in Shushtar and adults and children less than one.

Conclusion: The carcinogenic rates of cadmium, chromium, and lead in the crops of Shushtar and were higher than the allowed limit of 4^{-10}. The carcinogenicity rate of nickel metal in Shushtar and Dezful crops was 4^{-10} lower than the permitted limit.

Keywords:
Environmental pollution, Risk assessment, Health, Metals, Heavy, Dezful, Iran, Shushtar

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1. Introduction

Heavy metals are essential due to their toxic effects and bioaccumulation potential in different animal species and their entry into food chains [1]. In addition to natural processes, soils can be contaminated by elements released from human resources into the environment. These elements can accumulate in plants and animals and are eventually transmitted to humans through the food chain. Swallowing, breathing, and skin contact is the most important routes that human beings are exposed to heavy elements [2, 3]. Multiple metals are naturally part of ecosystems, and even some of them play an essential role in the survival of living organisms. However, suppose the amount of these elements exceeds certain limits for various reasons. In that case, it can endanger the lives of animals and plants because it quickly upsets the ecological balance and causes the destruction and biodegradation of the ecosystem [4, 5].

Production activities, the combustion of fossil fuels, metal extraction, the crop production of pesticides and fertilizers in non-standard use as well as wastewater discharge of daily life, as a result of damage to soil and environment, ecological imbalance of land and soil pollution area increase year by year Finds and leads to land degradation [6, 7]. These generally include soil erosion, desertification, salinization, soil pollution, and reduced soil fertility [8]. However, heavy metal pollution has the characteristics of the long, irreversible residual period, a small amount of transfer, severe toxicity, accumulation, complex chemical properties, and ecological response, so this issue becomes the most severe problem in soil pollution [9].

One of the most critical dangers the environment faces is the entry of chemical pollutants from agricultural activities into the natural environment [10]. Improper and corrupt use of pesticides and chemical fertilizers and reducing economic efficiency and productivity can face many challenges such as reducing the fertility of farmland, destroying microorganisms, and pollution of water resources [11]. Cadmium may impair calcium metabolism, leading to calcium deficiency, resulting in cartilage disease and bone fractures. The agency has named the Cadmium Toxin Management Committee the sixth most toxic substance in human health. Lead enters the human body mainly through the gastrointestinal and respiratory tract and circulates in soluble salts, protein compounds, or ions. 95% of insoluble lead phosphate accumulates in bones.

Lead metal affects numerous organs and systems in the body, such as the kidneys, liver, reproductive system, nervous system, urinary system, immune system, and fundamental physiological processes of cells and gene expression [12, 13]. Copper, zinc, and nickel are essential metals in the human body; however, if the body removes too much copper, zinc, and nickel from the environment, it is harmful to human health. Nickel and copper are tumor enhancers whose carcinogenic effects have been a global concern. Workers in close contact with nickel powder are more likely to suffer from respiratory cancer, and the nickel content in the environment is positively associated with laryngeal cancer [14, 15].

According to agricultural land and using chemical fertilizers and agricultural production diversified in the City of Shushtar and, as well as various industries in the industrial towns and surrounding the cities, the measurement of heavy metals in surface soils city of Shushtar and required appearing. Additionally, the development of urbanization of these two cities, the increase in population, and the importance of the health risk of heavy metals for heavy metals are other reasons justifying the measurement of these pollutants in the surface soils of these two cities.

2. Materials and Methods

Shushtar, with an area of 2436 square kilometers in the north of Khuzestan province of Iran, is located between 48° 35′ to 49° 12′ east longitude of the Greenwich meridian and 31° 36′ to 32° 26′ north of the equator. Shushtar, in addition to the alluvial soil of the Zagros, which is very fertile, has gypsum, lime, building stone, and sand mines. Shushtar has two industrial towns and different industries, such as Azin food industry factories, Khuzestan Golpooneh Company, Sabznam Food Industries Complex, Pars Petro Shushtar Company, and Karun Agro-industry in Shushtar. The city is in Khuzestan Province in southwestern Iran, i.e., located next to the Dez River. The city is geographically located at 48° 24′ east longitude and 32° and 22′ north latitude. This city is the second-largest city in Khuzestan province after Ahvaz. The city has 4 industrial towns; workshops and factories of chemicals, food industries, metal, and rubber industries such as Pars Polymer Elixir Company, Kooshan Food Industries, and Aluminum. In this research, 18 samples of 1 kg of crops grown on farms in the summer of 2020 were collected randomly from 6 stations in two areas of (Safiabad & Shamsabad farms) and two regions of Shushtar (Gelalak & Shoaibiyeh farms). A sampling of tomatoes, cucumbers, onions, and potatoes cultivated by local farmers in the study areas was performed. Approximately 1 kg of these agricultural products was prepared as a sample.

The samples were washed with distilled water, and mud and soil were separated. Each sample was then labeled in Petri dishes and placed in an oven at 105°C for 48 hours. After drying and reaching a constant weight, the samples were crushed and sieved, and 0.5 g of each sample was weighed with a digital scale with an accuracy of 0.01 g. For chemical digestion, 0.5 g of each sample was poured into a 250 mL balloon, to which 25 mL of concentrated sulfuric acid, 20 mL of 7 M nitric acid, and 1 mL of 2% sodium molybdate solution, and a few boiling stones were added. It was placed so that the boiling operation would be regular and uniform. The sample was then cooled, and 20 ml of a mixture of concentrated nitric acid and concentrated perchloric acid was slowly added to the sample from the top of the refrigerant in a ratio of 1:1. After this step, heat the mixture until the white vapors of the acid have completely disappeared. To the cooled mixture, 10 ml of distilled water was slowly added from the top of the refrigerant while rotating the balloon. An obvious solution was obtained by heating (about 100 minutes), cooled, and transferred to a 100 ml flask after cooling [16]. Heavy metals were measured by atomic spectroscopy with ICP model Varian 710-ES made in England. The detection limits (LOD) of heavy metals cadmium, lead, nickel, copper, zinc, and chromium were 0.004, 0.05, 0.002, 0.007, 0.006, and 0.008 ppb, respectively [17].

Non-Carcinogenic risk (HI) of all swallowing, breathing, and dermal absorption pathways for children and adults was determined from the total daily absorption of heavy metals (ADD) in each path to the reference value of that metal toxicity using Equation 1 [18]:

$$1.\ HQ=\sum\frac{ADD_I}{R_FD_I}HQ_I=\sum\frac{ADD_I}{R_FD_I}$$

In this regard, the HQ of non-carcinogenic risk of metals in each pathway is ADDi daily metal uptake values in each path of metal exposure (mg/kg/day). If HQ is less than 1, it is compatible with human health, and if HQ is higher than 1, it has adverse and worrying effects on human health. The cumulative non-carcinogenic risk index (HI) of all metals for both adults and children was obtained based on Equation 2 [18]:

$$2.\ HQ=\sum HQ_I$$

Assessing the carcinogenic risk of each of the three pathways for these metals was performed using Equation 3 [18]:

$$3.\ RI=\sum ADD_I\times SF_I$$

In Equation 3 (RI) ratio of carcinogenic risk, ADDi daily metal uptake values in each of the metal exposure pathways (mg/kg/day) and SFi cancer risk factor per unit of metal exposure (mg/kg/day).

The obtained data were analyzed in SPSS. Kolmograph-Smirnov test was used for evaluating the data normality. One-Way Analysis of Variance (ANOVA) was used to determine the significant differences between stations, and Tukey's post-hoc test was used to examine the mean squares. Excel was also used to draw tables and calculations of contamination indices. Pearson correlation coefficient was applied to investigate the relationship between heavy metals data, and cluster analysis was employed to detect the origin of heavy metals.

3. Results

The statistical parameters of heavy metals data of agricultural products in some agricultural products of Dezful and Shushtar cities are presented in Table 1. The values of elongation and skewness showed that the data related to heavy metals are normal in the samples of cultivated products because the values obtained were obtained between -2 and 2. The pattern of accumulation of heavy metals in agricultural products was zinc> copper> lead> chromium> cadmium> nickel.

The ANOVA data indicated that the heavy metals lead, cadmium, and chromium in crops of Dezful and Shushtar were significantly different (P<0.05); however, in the case of zinc, copper, and nickel in tomato, cucumber, no significant difference was observed between potato and onion (P>0.05) (Table 2). Pearson correlation analysis of heavy metals in tomatoes, cucumbers, potatoes, and onions suggested no correlation between them, only between chromium-lead metals (R=0.702; P<0.01). There were positive and significant (P<0.01) (Table 3). Based on cluster analysis, heavy metals in tomatoes, cucumbers, potatoes, and onions in Dezful and Shushtar were divided into two main groups. The first group consists of nickel, cadmium, zinc, lead, and chromium, and the second group consists only of copper. Different cluster groups show differences in geochemical behavior and diverse origins of metals (Figure 1). Principal Component Analysis (PCA) indicated a positive correlation in the first principal component, including heavy metals lead, cadmium, chromium, and zinc. In the second central component, a direct and significant relationship was observed between nickel, chromium, and lead in crops (Table 4).

Based on the average concentration of cadmium metal and the reference dose of 0.001 mg/kg/day, and the weight of adults and children at 70 and 25 kg, the highest values of a risk index for consumption of onions grown in

Table 1. Descriptive analysis of heavy metals in some agricultural products of Dezful and Shushtar cities

Heavy Metal	Minimum (ppm)	Maximum (ppm)	Mean±SD	Standard Error	Variance	Skewness	Kurtosis
Cd	0	0.99	0.33±0.03	0.4	0.108	0.539	-1.234
Pb	0.12	2.95	0.81±0.07	0.11	0.622	1.397	1.060
Ni	0	0.10	0.03±0.004	0.03	0.001	0.580	-1.104
Cu	0.39	487	13.69±1.08	69.85	4.880	6.902	0.750
Zn	1.55	267	18.73±5.51	38.19	1.459	6.090	0.968
Cr	0.01	3.78	0.76±0.14	0.001	1.017	1.837	0.753

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Dezful for adults and children 3.276 and 9.172 were obtained, respectively. The lowest cadmium risk index for onions grown in Shushtar was equal to 0.044 for adult consumption. In tomato and cucumber crops grown in Dezful and Shushtar and potatoes in Shushtar city, cadmium metal risk index values were higher than 1. The carcinogenicity rate of cadmium metal in cultivated crops of Shushtar and Dezful was 4^{-10} higher than the allowed limit. The

Table 2. ANOVA data of heavy metals in agricultural products of Dezful and Shushtar

Heavy Metal	Region	Sum of Squares	df	Mean Square	F	Sig.
Cd	Between Groups	1.902	3	0.634	8.853	0.000
	Within Groups	3.152	44	0.072		
	Total	5.054	47			
Pb	Between Groups	8.116	3	2.705	5.631	0.002
	Within Groups	21.140	44	0.480		
	Total	29.256	47			
Ni	Between Groups	0.002	3	0.001	0.658	0.582
	Within Groups	0.047	44	0.001		
	Total	0.049	47			
Cu	Between Groups	14484.191	3	4828.064	0.989	0.407
	Within Groups	214857.530	44	4883.126		
	Total	229341.721	47			
Zn	Between Groups	2587.145	3	862.382	0.575	0.634
	Within Groups	65980.863	44	1499.565		
	Total	68568.008	47			
Cr	Between Groups	22.492	3	7.497	13.044	0.000
	Within Groups	25.291	44	0.575		
	Total	47.783	47			

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Table 3. Pearson correlation coefficient of heavy metals of some agricultural products cultivated in Dezful and Shushtar

Heavy Metal	Cd	Pb	Ni	Cu	Zn	Cr	Food
Cd	1	0.395**	-0.313*	-0.086	0.216	0.331*	-0.424**
Pb	0.395**	1	-0.073	-0.040	0.285*	0.702**	-0.294*
Ni	-0.313*	-0.073	1	-0.125	-0.107	0.314*	0.128
Cu	-0.086	-0.040	-0.125	1	0.011	-0.045	-0.094
Zn	0.216	0.285*	-0.107	0.011	1	0.205	0.010
Cr	0.331*	0.702**	0.314*	-0.045	0.205	1	-0.542**
Food	-0.424**	-0.294*	0.128	-0.094	0.010	-0.542**	1

* Correlation is significant at the 0.05 level. **Correlation is significant at the 0.01 level.

Table 4. Principal Component Analysis (PCA) of heavy metals of some agricultural products

Heavy Metal	1	2
Cd	0.744	-0.235
Pb	0.830	0.274
Ni	-0.278	0.877
Cu	-0.027	-0.309
Zn	0.543	-0.108
Cr	0.681	0.630

highest and lowest carcinogenicity rates of cadmium in onions grown in Dezful and Shushtar were 0.1375, respectively (Table 5). Based on the average concentration of lead metal and the reference dose of 0.0035 mg/kg/day, and the weight of adults and children at 70 and 25 kg, the highest values of the risk index for consumption of onions grown in Dezful for adults and children 2.317 and 6.482 were obtained, respectively. The lowest cadmium risk index for cucumber cultivated in Shushtar was 0.203 for adult age group consumption. In tomato crops grown in Dezful, the lead metal risk index values were 1.212 and 3.395, respectively, for adults and children, higher than 1. Additionally, the risk index of consumption of potatoes grown in Shushtar for adults was 2.259. The carcinogenicity rate of lead metal in cultivated crops of Shushtar and Dezful was 4^{-10} higher than the allowed limit. The highest and lowest lead carcinogenicity rates in potatoes and tomatoes grown in Shushtar and Dezful cities in children were 0.0188 and 0.0101, respectively (Table 6). Based on the average concentration of nickel metal and the reference dose of 0.02 mg/kg/day, and the weight of adults and children at 70 and

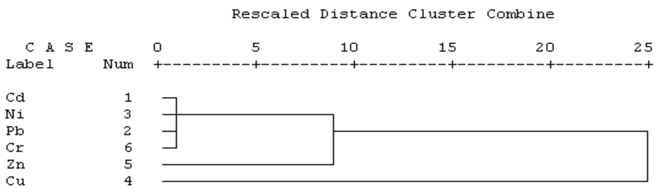

Figure 1. Cluster analysis of heavy metals of some cultivated agricultural products in Dezful and Shushtar

Table 5. Health risk assessment of Cadmium metal in some cultivated agricultural products of Dezful and Shushtar

Age Category	Region	Product	Mean (mg/Kg)	Daily Intake (Kg/Day)	Weight (Kg)	Daily Consumption (Kg/Day)	Reference Dose (mg/Kg/Day)	Risk Index (HQ)	Daily Consumption Limit (Kg/Day)	Cancer Rate (CR)
Adults	Dezful	Tomato	0.744	0.109	70	0.00115	0.001	1.158	0.0940	0.0173
		Cucumber	0.153	0.109	70	0.00023	0.001	0.238	0.4575	0.0035
		Potato	0.078	0.68	70	0.00075	0.001	0.757	0.8974	0.113
		Onion	0.588	0.39	70	0.00327	0.001	3.276	0.1190	0.491
		Tomato	0.305	0.109	70	0.00047	0.001	0.474	0.2295	0.0071
		Cucumber	0.670	0.109	70	0.00104	0.001	1.043	0.1044	0.0156
		Potato	0.014	0.68	70	0.00013	0.001	0.136	5	0.0020
		Onion	0.008	0.39	70	0.00004	0.001	0.044	8.75	0.0006
Children	Shushtar	Tomato	0.744	0.109	25	0.00324	0.001	3.243	0.0336	0.0486
		Cucumber	0.153	0.109	25	0.00066	0.001	0.667	0.1633	0.0100
		Potato	0.078	0.68	25	0.00212	0.001	2.121	0.3205	0.0318
		Onion	0.588	0.39	25	0.00917	0.001	9.172	0.0425	0.1375
		Tomato	0.305	0.109	25	0.00132	0.001	1.329	0.0819	0.0199
		Cucumber	0.670	0.109	25	0.00292	0.001	2.921	0.0373	0.0438
		Potato	0.014	0.68	25	0.00038	0.001	0.380	1.785	0.0057
		Onion	0.008	0.39	25	0.00012	0.001	0.124	3.125	0.0018

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25 kg, the nickel-metal risk index values in cultivated agricultural products of potatoes, cucumbers, and tomatoes in Shushtar and Dezful. For adults and children, less than one was obtained. The highest nickel-metal risk index values for consumption of potatoes cultivated in Dezful for adults and children were 0.039 and 0.111, respectively. The lowest risk index of nickel for tomatoes grown in Shushtar was 0.0004 for adult age consumption. The carcinogenicity rate of nickel metal in Shushtar and Dezful crops was 4^{-10} lower than the allowed limit. The highest and lowest nickel-metal carcinogenic rates in potatoes and tomatoes cultivated in Dezful and Shushtar were 0.002 and 0.0000008, respectively, in the age group of children and adults (Table 7). Based on the average concentration of copper metal and the reference dose of 0.0377 mg/kg/day and the weight of adults and children at 70 and 25 kg, the highest values of a copper metal risk index for consumption of potatoes grown in Dezful for adults and children were 1.517 and 4.249, respectively. The lowest risk index of copper for tomatoes cultivated in Dezful was 0.098 for adult age group consumption. Furthermore, the copper metal risk index values in cultivated agricultural products of potatoes, cucumbers, and tomatoes in Shushtar agricultural farms for the consumption of children and adults were 1.021, 1.945, and 1.557, respectively (Table 8). Based on the average concentration of zinc metal and the reference dose of 0.03 mg/kg/day and the weight of adults and children at 70 and 25 kg, the highest values of zinc metal risk index for onions grown in Dezful for adults and children was 1.684 and 4.716, respectively. The lowest zinc risk index for cucumber grown in Shushtar was 0.034 for adult age group consumption. Also, the zinc metal risk index values in the cultivated agricultural product of potatoes in Dezful agricultural farms for the consumption of children age group were 1.462 (Table 9). Based on the average concentration of chromium metal and the reference dose of 0.003 mg/kg per day, and the weight of adults and children at 70 and 25 kg, the chromium metal risk index values in cultivated agricultural

Table 6. Health risk assessment of Lead in some cultivated agricultural products of Dezful and Shushtar

Age Category	Region	Product	Mean (mg/Kg)	Daily Intake (Kg/Day)	Weight (Kg)	Daily Consumption (Kg/Day)	Reference Dose (mg/Kg/Day)	Risk Index (HQ)	Daily Consumption Limit (Kg/Day)	Cancer Rate (CR)
Adults	Dezful	Tomato	2.726	0.109	70	0.00424	0.0035	1.212	0.0898	0.0036
		Cucumber	0.674	0.109	70	0.00104	0.0035	0.299	0.3635	0.0008
		Potato	0.148	0.68	70	0.00143	0.0035	0.410	1.6554	0.0012
		Onion	1.456	0.39	70	0.00811	0.0035	2.317	0.1682	0.0068
		Tomato	0.470	0.109	70	0.00073	0.0035	0.209	0.5212	0.0006
		Cucumber	0.458	0.109	70	0.00071	0.0035	0.203	0.5349	0.0006
		Potato	0.814	0.68	70	0.00790	0.0035	2.259	0.3009	0.0067
		Onion	0.259	0.39	70	0.00144	0.0035	0.412	0.9459	0.0012
Children	Shushtar	Tomato	2.726	0.109	25	0.01188	0.0035	3.395	0.0320	0.0101
		Cucumber	0.674	0.109	25	0.00293	0.0035	0.839	0.1298	0.0024
		Potato	0.148	0.68	25	0.00402	0.0035	1.150	0.5912	0.0034
		Onion	1.456	0.39	25	0.02271	0.0035	6.489	0.0600	0.0193
		Tomato	0.470	0.109	25	0.00204	0.0035	0.585	0.1861	0.0017
		Cucumber	0.458	0.109	25	0.00199	0.0035	0.570	0.1910	0.0016
		Potato	0.814	0.68	25	0.02214	0.0035	6.325	0.1074	0.0188
		Onion	0.259	0.39	25	0.00404	0.0035	1.154	0.3378	0.0034

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products of potatoes, cucumbers, onions, and tomatoes in Shushtar. And Dezful was obtained for consumption of adults and children above 1. The highest chromium metal risk index values for consumption of potatoes and tomatoes are grown in Dezful for children were 13.264 and 5.323, respectively. The lowest risk index of chromium for cucumber cultivated in Shushtar was 0.024 for adult age group consumption. Moreover, the risk index values for potatoes and tomatoes grown in Dezful for adult consumption were 4.737 and 1.901, respectively, and for cucumbers and onions grown in Dezful farms for children, 1.135 and 1.428, respectively. Concerning tomato and potato crops are grown in Shushtar, the risk index values for children were 1.395 and 1.069, respectively. The carcinogenicity rate of chromium metal in Shushtar and Dezful crops was 4^{-10} higher than the allowed limit. The highest and lowest carcinogenic rates of chromium metal in potatoes and onions cultivated in Dezful and Shushtar cities for children and adults were 0.098 and 0.00005, respectively (Table 10).

The average extent of cadmium in tomatoes, cucumbers, potatoes, and onions cultivated in agricultural fields of Dezful 0.744, 0.153, 0.078, and 0.588 mg/Kg and cultivated lands of Shushtar 0.305, 0.670, 0.014, and 0.008 mg/Kg were obtained, respectively. The concentration of cadmium in tomatoes, potatoes, and onions are grown in Dezful was higher than Shushtar ($P<0.05$), but the amount of cadmium in cucumber in Shushtar was higher than Dezful ($P<0.05$). The average amount of lead metal in tomatoes, cucumbers, potatoes, and onions cultivated in agricultural fields of Dezful city is 2.726, 0.674, 0.148, and 1.456 mg/Kg. In cultivated lands of Shushtar city, 0.470, 0.458, 0.814, and 0.259 mg/Kg were obtained. Lead concentration in tomatoes and cucumbers grown in Dezful was higher than Shushtar ($P<0.05$); however, the amount of lead in potatoes and onions of Shushtar farms was more elevated than Dezful ($P<0.05$). The average amount of nickel metal in tomatoes, cucumbers, potatoes, and onions cultivated in agricultural fields of Dezful city is 0.077, 0.037, 0.082, and

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Table 7. Health risk assessment of Nickel in some cultivated agricultural products of Dezful and Shushtar

Age Category	Region	Product	Mean (mg/Kg)	Daily Intake (Kg/Day)	Weight (Kg)	Daily Consumption (Kg/Day)	Reference Dose (mg/Kg/Day)	Risk Index (HQ)	Daily Consumption limit (Kg/Day)	Cancer Rate (CR)
Adults	Dezful	Tomato	0.007	0.109	70	0.00011	0.02	0.005	18.181	0.0001
		Cucumber	0.037	0.109	70	0.00005	0.02	0.002	37.837	0.00005
		Potato	0.082	0.68	70	0.00079	0.02	0.039	17.073	0.0007
		Onion	0.002	0.39	70	0.00001	0.02	0.0005	700	0.00001
		Tomato	0.006	0.109	70	0.000009	0.02	0.0004	233.333	0.000008
		Cucumber	0.022	0.109	70	0.00003	0.02	0.001	63.636	0.00003
		Potato	0.013	0.68	70	0.00012	0.02	0.006	107.692	0.00011
		Onion	0.084	0.39	70	0.00046	0.02	0.023	16.666	0.00042
Children	Shushtar	Tomato	0.007	0.109	25	0.00033	0.02	0.016	6.493	0.0003
		Cucumber	0.037	0.109	25	0.00016	0.02	0.008	13.513	0.0001
		Potato	0.082	0.68	25	0.00223	0.02	0.111	6.097	0.002
		Onion	0.002	0.39	25	0.00003	0.02	0.001	250	0.00002
		Tomato	0.006	0.109	25	0.00002	0.02	0.001	83.333	0.00002
		Cucumber	0.022	0.109	25	0.00009	0.02	0.004	22.727	0.00008
		Potato	0.013	0.68	25	0.00035	0.02	0.017	38.461	0.0003
		Onion	0.084	0.39	25	0.00131	0.02	0.065	5.952	0.0011

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0.002 mg/Kg, respectively, and in the cultivated lands of Shushtar city 0.006, 0.022, 0.013 and 0.084 mg/Kg were obtained. Nickel concentration in tomatoes, cucumbers, and potatoes grown in Dezful was higher than Shushtar ($P<0.05$); however, the amount of nickel in onions grown in agricultural fields in Shushtar was higher than Dezful ($P<0.05$). The average amount of copper metal in tomatoes, cucumbers, potatoes, and onions are grown in agricultural fields of Dezful City were calculated to be 2.340, 16.513, 5.780, and 1.626 mg/Kg, respectively, and in cultivated lands of Shushtar city is 13.220, 3.223, 1.390 and 1.563 mg/Kg were obtained. Copper concentration in potatoes, cucumbers, and onions are grown in Dezful was higher than Shushtar ($P<0.05$); however, the extent of copper in Shushtar tomatoes was greater than Dezful ($P<0.05$).

The copper content of onions and potatoes was not significantly different ($P>0.05$). The average amount of zinc in tomatoes, cucumbers, potatoes, and onions grown in Dezful farms was 38.396, 23.440, 16.136, and 90.706 mg/Kg and in cultivated lands, Shushtar 11.690, 6.730, 5.713, and 7.406 mg/Kg were obtained. Zinc concentration in tomatoes, cucumbers, potatoes, and onions are grown in Dezful was higher than Shushtar ($P<0.05$). The amount of zinc in cucumber, potato, and onion in Shushtar was not significantly different ($P>0.05$). The average amount of chromium metal in tomatoes, cucumbers, potatoes, and onions cultivated in Dezful farms were 3.663, 0.781, 1.463, and 0.467 mg/Kg. In cultivated lands of Shushtar City, 0.960, 0.048, 0.118, and 0.018 mg/Kg were obtained. The concentration of chromium in tomatoes, cucumbers, potatoes, and onions are grown in Dezful was higher than Shushtar ($P<0.05$); however, the amount of chromium in cucumbers, potatoes, and onions in Shushtar was not significantly different ($P>0.05$) (Table 11).

Table 8. Health risk assessment of Copper metal in some cultivated agricultural products of Dezful and Shushtar

Age Category	Region	Product	Mean (mg/Kg)	Daily Intake (Kg/Day)	Weight (Kg)	Daily Consumption (Kg/Day)	Reference Dose (mg/Kg/Day)	Risk Index (HQ)	Daily Consumption Limit (Kg/Day)
Adults	Dezful	Tomato	2.3400	0.109	70	0.00364	0.037	0.098	1.1068
		Cucumber	16.513	0.109	70	0.02571	0.037	0.694	0.1568
		Potato	5.780	0.68	70	0.05614	0.037	1.517	0.4480
		Onion	1.626	0.39	70	0.00905	0.037	0.244	1.5928
		Tomato	13.220	0.109	70	0.02058	0.037	0.556	0.1959
		Cucumber	3.223	0.109	70	0.00501	0.037	0.135	0.8035
		Potato	1.390	0.68	70	0.01350	0.037	0.364	1.8633
		Onion	1.563	0.39	70	0.00870	0.037	0.235	1.6570
Children	Shushtar	Tomato	2.3400	0.109	25	0.01020	0.037	0.275	0.3952
		Cucumber	16.513	0.109	25	0.07199	0.037	1.945	0.0560
		Potato	5.780	0.68	25	0.15721	0.037	4.249	0.1600
		Onion	1.626	0.39	25	0.02536	0.037	0.685	0.5688
		Tomato	13.220	0.109	25	0.05763	0.037	1.557	0.0699
		Cucumber	3.223	0.109	25	0.01405	0.037	0.379	0.2869
		Potato	1.390	0.68	25	0.03780	0.037	1.021	0.6654
		Onion	1.563	0.39	25	0.02438	0.037	0.658	0.5918

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4. Discussion

Usually, in research and studies of heavy metals in food and feed, the amounts of heavy metals are compared with the allowable limits of national and international standards because heavy metals, in addition to harming food and agricultural products, enter the food chain. Finally, accumulation in the organs of the human body in the short and long term leads to the effects of poisoning, pathogenicity, carcinogenesis, and genetic mutations [19, 20]. In this study, the cadmium in tomatoes, cucumbers, potatoes, and onions grown in Dezful and tomatoes and cucumbers sampled in Shushtar were higher than the WHO/FAO standard, the national standard of Iran and China. Still, copper, zinc, and nickel were lower than the acceptable standards. The concentration of chromium metal in the studied agricultural products was higher than the WHO/FAO standard and the Chinese national standard. The extent of zinc in onions grown in Dezful (90.706 mg kg) was also higher than the WHO/FAO standard and the national standard of India and China (Table 11). One of the high levels of heavy metals cadmium and lead in cultivated agricultural products can be attributed to the increased consumption of pesticides, herbicides, and fungicides and the increased use of phosphate fertilizers that contain high amounts of cadmium [21, 22]. In other research on cucumber and tomato crop studies, the use of high doses of chemical fertilizers and herbicides and pest control of agriculture was stated as the reason for the accumulation of high concentrations of cadmium and copper [23, 24].

The concentration of cadmium in tomatoes, potatoes, and onions are grown in Dezful was higher than Shushtar ($P<0.05$); however, the amount of cadmium in cucumber in Shushtar was higher than Dezful ($P<0.05$). Cadmium in the plant is usually absorbed by the roots and slowly enters the stems and leaves, and its transfer from the leaves to the fruit is minimal [25, 26]. Cadmium is a mobile metal that is easily absorbed from the

Table 9. Health risk assessment of Zinc in some cultivated agricultural products of Dezful and Shushtar

Age Category	Region	Product	Mean (mg/Kg)	Daily Intake (Kg/Day)	Weight (Kg)	Daily Consumption (Kg/Day)	Reference Dose (mg/Kg/Day)	Risk Index (HQ)	Daily Consumption Limit (Kg/Day)
Adults	Dezful	Tomato	38.396	0.109	70	0.05978	0.3	0.199	0.5469
		Cucumber	23.440	0.109	70	0.03649	0.3	0.121	0.8959
		Potato	16.136	0.68	70	0.15674	0.3	0.522	1.3014
		Onion	90.706	0.39	70	0.50536	0.3	1.684	0.2315
		Tomato	11.690	0.109	70	0.01820	0.3	0.060	1.7964
		Cucumber	6.730	0.109	70	0.01047	0.3	0.034	3.1203
		Potato	5.713	0.68	70	0.05549	0.3	0.184	3.6758
		Onion	7.406	0.39	70	0.04126	0.3	0.137	2.8355
Children	Shushtar	Tomato	38.396	0.109	25	0.16740	0.3	0.558	0.1953
		Cucumber	23.440	0.109	25	0.10219	0.3	0.340	0.3199
		Potato	16.136	0.68	25	0.43889	0.3	1.462	0.4647
		Onion	90.706	0.39	25	1.41501	0.3	4.716	0.0826
		Tomato	11.690	0.109	25	0.05096	0.3	0.169	0.6415
		Cucumber	6.730	0.109	25	0.02943	0.3	0.097	1.1144
		Potato	5.713	0.68	25	0.15539	0.3	0.517	1.312
		Onion	7.406	0.39	25	0.11553	0.3	0.385	1.0126

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root surface of plants and moves to their woody tissue, and accumulates in the upper parts of the plant [13, 27]. The amount of cadmium accumulated in vegetables depends on several factors, including cultivar, subspecies, soil type, initial cadmium concentration in the soil, and smelters' existence. In the vicinity of these factories, suspended particles containing cadmium in the air have settled on the arable ground. Sometimes, cadmium concentration in agricultural products, especially fruits and vegetables, is dangerous [15, 28]. Although cadmium is not an essential element for plants, its easy absorption and accumulation have a high potential for contamination. It is the first metal among heavy metals that have received much environmental attention [29]. In agricultural soils, cadmium is less than one milligram per kilogram, and higher amounts are observed in farming soils with long-term use of phosphorus fertilizers and sewage sludge. Phosphorus fertilizers are critical sources of cadmium contamination of agricultural soils [30]. The most important sources of cadmium are phosphorus fertilizers, sewage sludge, mining, and smelting of cadmium-containing sulfide ores [27].

Lead concentration in tomatoes and cucumbers grown in Dezful was higher than Shushtar ($P<0.05$), but the amount of lead in the potatoes and onions of Shushtar farms was more elevated than Dezful ($P<0.05$). The primary source of lead metal in vegetables and summer vegetables, their growing environment is soil, water, air, and nutrients that are absorbed by roots or leaves. The uptake and bioaccumulation of lead in plants are influenced by characteristics, such as climate, atmospheric sediments, concentrations of heavy metals in the soil, the nature of the soil, and their growth rate [31, 32]. Lead is a metal that plants usually can absorb and accumulate this element without changing its appearance. In numerous plants, the accumulation of lead will be hundreds of times higher than acceptable and acceptable [33]. The impact of urban activities and industrial uses in Dezful City is among the reasons for the high amount of lead

Table 10. Health risk assessment of Chromium in some cultivated agricultural products of Dezful and Shushtar

Age Category	Region	Product	Mean (mg/Kg)	Daily Intake (Kg/Day)	Weight (Kg)	Daily Consumption (Kg/Day)	Reference Dose (mg/Kg/Day)	Risk Index (HQ)	Daily Consumption Limit (Kg/Day)	Cancer Rate (CR)
Adults	Dezful	Tomato	3.663	0.109	70	0.00570	0.003	1.901	0.0573	0.0028
		Cucumber	0.781	0.109	70	0.00121	0.003	0.405	0.2688	0.0006
		Potato	1.463	0.68	70	0.01421	0.003	4.737	0.1435	0.0071
		Onion	0.467	0.39	70	0.00260	0.003	0.867	0.4496	0.0013
		Tomato	0.960	0.109	70	0.00149	0.003	0.498	0.2187	0.0007
		Cucumber	0.048	0.109	70	0.00007	0.003	0.024	4.3750	0.00003
		Potato	0.118	0.68	70	0.00114	0.003	0.382	1.7796	0.0005
		Onion	0.018	0.39	70	0.00010	0.003	0.033	11.6666	0.00005
Children	Shushtar	Tomato	3.663	0.109	25	0.01597	0.003	5.323	0.0204	0.0079
		Cucumber	0.781	0.109	25	0.00340	0.003	1.135	0.0960	0.0017
		Potato	1.463	0.68	25	0.03979	0.003	13.264	0.0512	0.0198
		Onion	0.467	0.39	25	0.00728	0.003	2.428	0.1605	0.0036
		Tomato	0.960	0.109	25	0.0418	0.003	1.395	0.0781	0.0020
		Cucumber	0.048	0.109	25	0.00020	0.003	0.069	1.5625	0.0001
		Potato	0.118	0.68	25	0.00320	0.003	1.069		6355/0
		Onion	0.018	0.39	25	0.00028	0.003	0.093		1666/4

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in the soil of this region. Fossil fuels, coal fuels, vehicle traffic, and red tape coatings also increase lead in the soil [34]. In a study, researchers stated that the increase in lead in agricultural soils of Dezful City and its functions is the excessive use of chemical fertilizers and fungicides containing this element by farmers [35]. The proximity of farming lands in Dezful and Shushtar to roads and the movement of vehicles, the subsidence of lead metal from the air on vegetables is one of the main reasons for the accumulation of lead metal in vegetables. Another reason is that the soil of Dezful is alkaline, and the mobility of lead metal for adsorption in vegetables in alkaline soils is less than acidic soils [36]. Using chemical fertilizers can also be another reason for lead in agricultural products since per kilogram of chemical fertilizer is added to the soil as an impurity of 0.0008 to 0.93 mg of lead. Animal waste and municipal wastewater are also sources of lead contaminants [32, 35].

Nickel concentration in tomatoes, cucumbers, and potatoes grown in Dezful was higher than Shushtar ($P<0.05$); however, the amount of nickel in onions grown in agricultural fields in Shushtar was higher than Dezful ($P<0.05$). Copper concentration in potatoes, cucumbers, and onions are developed in Dezful was higher than Shushtar ($P<0.05$), but the amount of copper in Shushtar tomatoes was higher than Dezful ($P<0.05$). Concentrations of Zinc and chromium in tomatoes, cucumbers, potatoes, and onions are grown in Dezful were higher than Shushtar ($P<0.05$). Dezful city is one of the agricultural hubs in Khuzestan Province, where various strategic and industrial products are produced. Shushtar also has several agricultural lands of wheat and rapeseed that have a large annual harvest. One of the most essential dangers the environment faces is the entry of chemical pollutants from agricultural activities into the natural environment. Improper and corrupt use of pesticides and chemical fertilizers and reducing economic efficiency

Table 11. Comparing heavy metal concentrations in crops grown in Dezful and Shushtar cities with national and international standards

Region	Product	Cd	Pb	Ni	Cu	Zn	Cr
Dezful	Tomato	0.744	2.726	0.077	2.340	38.396	3.663
	Cucumber	0.153	0.674	0.037	16.513	23.440	0.781
	Potato	0.078	0.148	0.082	5.780	16.136	1.463
	Onion	0.588	1.456	0.002	1.626	90.706	0.467
Shushtar	Tomato	0.305	0.470	0.006	13.220	11.690	0.960
	Cucumber	0.670	0.458	0.022	3.223	6.730	0.048
	Potato	0.014	0.814	0.013	1.390	5.713	0.118
	Onion	0.008	0.259	0.084	1.563	7.406	0.018
WHO/FAO		0.05	0.1	66.7	40	60	0.1
China National Standard		0.05	0.2	-	-	20	0.5
Indian National Standard		1.5	2.5	1.5	-	50	-
National Standard of Iran		0.05	0.1	-	-	-	-

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and production efficiency can face many challenges such as reducing the fertility of farmland, destroying microorganisms, and pollution of water resources [37]. A study has reported that pesticides and chemical fertilizers by farmers in Shushtar have high levels.

Furthermore, the results of phosphate fertilizer application and cadmium accumulation in wheat fields in Khuzestan province have shown a direct relationship between fertilizer application and cadmium accumulation in soil. In this study, it has been reported that phosphate fertilizers were the most important reason for the increase in cadmium concentration in the region's soils. Nickel content in infected plants has been notified between 100 and 1000 micrograms per kilogram. Still, none of the products studied fall into this range and present much lower concentrations. Phosphate fertilizers also contain high levels of nickel, which causes the accumulation of this metal in vegetables [38]. The distribution of metals such as nickel in vegetables is also determined by the bioavailability of nutrients, which depends on the properties of soil and minerals and their toxicological properties [39].

Pearson correlation analysis of heavy metals in tomatoes, cucumbers, potatoes, and onions showed no correlation, only a positive and significant correlation between chromium-lead metals ($P<0.01$). The negative correlation between heavy metals indicates that metals have independent and multiple sources. Still, the correlation between heavy metals lead and chromium demonstrates that they are somewhat common in origin and originate from sources of human activity. Based on cluster analysis, heavy metals in tomatoes, cucumbers, potatoes, and onions in Dezful and Shushtar were divided into two main groups. The first group consists of nickel, cadmium, zinc, lead, and chromium, and the second group consists only of copper. Different cluster groups indicate differences in metals' geochemical behavior and diverse origins. Therefore, the metals in a group have the same natural source. Cluster analysis is a multivariate statistical method used in this study to identify the origin of elements. Principal component analysis (PCA) showed a positive correlation in the first principal component, including heavy metals lead, cadmium, chromium, and zinc.

In the second principal component, a direct and significant relationship was observed between nickel, chromium, and lead in crops. According to the correlation and multivariate analyzes of heavy metals, the results show that Pearson correlation, cluster analysis, and principal component analysis confirm each other's effects. In a study based on the correlation test results in wheat plants and irrigation water in the Zarandieh region of Markazi province, a positive and robust correlation was reported between the levels of each element of lead and cadmium in wheat and irrigation water samples.

In tomato and cucumber crops grown in Dezful and Shushtar and potatoes in Shushtar, the hazard values of cadmium, chromium, zinc, and copper were higher than 1. In the tomato crop grown in Dezful and the potatoes are grown in Shushtar, the lead metal risk index values were higher than 1. Less than one nickel-metal hazard index value for adults and children was obtained in cultivated agricultural products of potatoes, cucumbers, and tomatoes in Shushtar and Dezful. A higher risk ratio than 1 indicates a higher risk of non-cancerous diseases, and a score below one indicates that the consumption of the studied foods does not have an acute and harmful effect on human health [18]. Cadmium metal health assessment index for children, adults, and adults for consumption of tomatoes grown in Hamadan province are higher than one. This index for the mentioned age groups for copper metal is lower than reported [40].

A study assessing the risk of heavy metals through crop consumption near the Dabaoshan mine in southern China showed that the concentrations of cadmium, lead and zinc in vegetables grown exceeded the maximum concentrations allowed in China [41]. The results of the health index evaluation indicate the risk of consuming this product for consumers. Cadmium in all three age groups of children, adults, and adults poses risks to consumers' health. Unauthorized amounts of cadmium cause damage to the kidneys, bones, and lungs [42]. In another study, the results of calculating the health assessment index show that the concentration of zinc and lead in cucumber samples collected in Hamadan province does not threaten consumers' health [43]. The potential risk of consuming vegetables around Tehran was less than one for chromium, nickel, and zinc, a little more than one for copper, and much higher than one for lead. The risk index value for children, adults, and the elderly was 31.33, 24.58, and 21.14, respectively, with the largest share related to lead [44].

The carcinogenic risk of heavy metals in food is a factor used to assess potential health risks to humans [45, 46]. The carcinogenic rates of cadmium, chromium, and lead in the crops of Shushtar and Dezful were higher than the allowed limit of 4^{-10}. The carcinogenicity rate of nickel metal in Shushtar and Dezful crops was 4^{-10} lower than the permitted limit. The carcinogenic rates of cadmium, lead, and chromium in tomatoes, cucumbers, onions, and potatoes indicate that their consumption has a high potential for pathogenicity in humans. The results of calculating the carcinogenicity index in a study showed that the use of (Lactuca sativa longifolia) and cabbage (Brassica oleraceacapitata) in Dezful and Hamidiyeh regions of Khuzestan province is safe for consumers and has no adverse health effects for the consumer [47]. Indicators of health risks to assess the health risks of human beings obtained from the diet of food products contaminated with a variety of heavy metals. In a study on health risks, especially cancer caused by the heavy metals lead, cadmium, and chromium, the total risk index was higher than 1 in food products, and it was found that lead causes stomach and liver cancer [48]. Health risk studies on food consumption in developing Bangladesh were conducted to assess 30 agricultural and environmental areas in terms of health indicators, which showed that the consumption of vegetables contaminated with heavy metals, especially manganese and copper, is more harmful to human health than Consumption of infected fruits [49].

In the other research, in 70 samples of basil, radish, and purslane vegetables grown in Ahvaz, results showed that lead, cadmium, and chromium contents in vegetables were in the range of 9.7-11.13, 1.97-3.20, and 0.12-0.17 mg/kg, respectively. Comparing the results with the WHO/FAO limit showed that the concentration of lead and cadmium in vegetables was higher than the recommended amount [50]. It is stated that the type of water used, and water sources for irrigation of agricultural products are also effective in the accumulation of heavy metal concentrations in vegetables. Therefore, frequent irrigation with contaminated water can increase the extent of metals in the soil and eventually transfer them to plants [51]. Also, health risk assessment of heavy metals of copper, zinc, cadmium, lead, and nickel in Sohan city of Qom showed that the consumption of Sohan samples had no potential risk for children and adults. When rising pollutants and hefty metals enter the natural environment, it is crucial to evaluate food before introducing it. According to the study results, increasing exposure to heavy metals can potentially cause various health problems [52].

5. Conclusion

In this study, the cadmium in tomatoes, cucumbers, potatoes, and onions grown in Dezful and tomatoes and cucumbers sampled in Shushtar were higher than the WHO/FAO standard the national standard of Iran and China. Still, copper, zinc, and nickel were lower than the acceptable standards. The concentration of chromium metal in the studied agricultural products was higher than the WHO/FAO standard and the Chinese national standard. The amount of zinc in onions grown in Dezful was higher than the WHO/FAO standard and the national standard of India and China. The cadmium concentration in tomatoes, potatoes, and onions are grown in Dezful was higher than Shushtar, but the amount of cadmium in cucumber in Shushtar was higher than Dezful. The lead concentration in tomatoes and cucumbers grown in Dezful was higher than in Shushtar. Still, the amount of lead in potatoes and onions of agricultural farms in Shushtar was higher than Dezful. The nickel concentration in tomatoes, cucumbers, and potatoes are grown in Dezful was higher than in Shushtar. Still, the amount of nickel in onions grown in agricultural fields of Shushtar was higher than Dezful. The concentration of copper in potatoes, cucumbers, and onions are produced in Dezful was higher than in Shushtar. Still, the amount of copper in tomatoes in Shushtar was higher than in Dezful. Concentrations of Zinc and chromium in tomatoes, cucumbers, potatoes, and onions are grown in Dezful were higher than in Shushtar. The carcinogenic rates of cadmium, chromium, and lead in the crops of Shushtar and Dezful were higher than the allowed limit of 4^{-10}. The carcinogenicity of nickel metal in cultivated crops of Shushtar and Dezful was 4^{-10} lower than the permitted limit. In tomato and cucumber crops grown in Dezful and Shushtar and potatoes in Shushtar, the hazard values of cadmium, chromium, zinc, and copper were higher than 1. In the tomato crop grown in Dezful and the potatoes are grown in Shushtar, the lead metal risk index values were higher than 1. For adults and children, less than one nickel metal hazard index value in cultivated agricultural products of potatoes, cucumbers, and tomatoes in Shushtar and Dezful were obtained.

Ethical Considerations

Compliance with ethical guidelines

This study was approved by the Ethics Committee of Islamic Azad University of Ahvaz Branch (Code: 34188).

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Authors' contributions

All authors equally contributed to preparing this article.

Conflict of interest

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