original article

An investigation on the lead and cadmium content in vegetables and irrigating water in some farms in Gorgan, Iran

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ABSTRACT

Aims: The objective of this study is to investigate the levels of lead (Pb) and cadmium (Cd) in the vegetables from the farms of Gorgan, Iran, and compare them with the permissible levels proposed by the Food and Agriculture Organization (FAO) and World Health Organization (WHO) standard.
Materials and Methods: In this descriptive study, 40 samples of irrigating water and vegetables were collected, between the periods of August and December 2008. The Polarography apparatus was used to determine the amount of cadmium and lead after sample preparation. The level of significance was set at 5% for all the tests
Result: The cadmium concentrations in spinach, garden cress, and radish were 0, 0.085, and 1.56 $\mu g.kg^{-1}$, respectively. The lead concentrations in spinach, garden cress, and Radish were 51.21, 40.13, and 87.27 $\mu g.kg^{-1}$, respectively. The cadmium concentration in irrigating water was not detectable with the Polarography apparatus. However, the lead concentration in water was 26.75 $\mu g.kg^{-1.}$ There was no significant variation between the cadmium levels in spinach and garden cress (P<0.05), while there was a significant difference between the amount of cadmium in radish and spinach and garden cress (P<0.05).
Conclusion: All the vegetables and water contained Pb, although Cd was lower than the permissible levels proposed by FAO/WHO and might not cause health hazards to consumers.

Key words: Contamination, farms, heavy metals, vegetables, water

INTRODUCTION

Heavy metal contamination of foodstuffs is one of the main aspects of food quality assurance and is considered the most important problem of our surroundings. Heavy metals are extremely toxic and may have harmful effects on humans, as there is no good mechanism for their removal from the body. In addition, these contaminants are non-biodegradable in nature, have long biological half-lives, and also a potential to accumulate in the human food chain.[1-3]

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Prolonged consumption of unsafe concentrations of heavy metals through foodstuff may lead to the chronic accumulation of metals in the kidneys and liver of humans, which is associated with a number of illness, particularly of the renal, cardiovascular, and nervous systems. Moreover, there is a concern of their causing, mutagenesis, carcinogenesis, and teratogenesis.[4,5] People may be in danger if they consume foodstuff produced in farms that are irrigated with polluted water.[6] Pregnant women or very young children are among the most affected by heavy metal toxicity. Some of the reported effects of heavy metal poisoning are neurological disorders and cancers of various body organs. In some cases where pregnant mothers have ingested toxic amounts of a heavy metal through direct or indirect consumption of foodstuff, low birth weight and severe mental retardation of the newborn children have been reported.[7-10]

People are encouraged to consume vegetables, which are a good source of vitamins, minerals, and fibers. Vegetables take up metals by absorbing them from the contaminated water as well as from the polluted soil and accumulate them in their edible and inedible parts, in quantities high enough to cause clinical problems both to animals and human beings who consume these metal-rich plants. A number of factors influence the concentration of heavy metals on and within plants, including the nature of the soil in which the plant is grown, the degree of maturity of the plant at the time of harvesting, climate, and atmospheric deposition.[11-14]

Maleki and Zarasvand reported that the average concentrations of each heavy metal, regardless of the kind of vegetable cultivated, around Sanandaj City, Iran, for Pb, copper (Cu), chromium (Cr), and Cd were 13.60 ± 2.27, 11.50 ± 2.16, 7.90 ± 1.05, and 0.31 ± 0.17 mg/kg, respectively. Based on the above-mentioned concentrations and the information from the National Nutrition and Food Research Institute of Iran, the dietary intake of Pb, Cu, Cr, and Cd through vegetable consumption was estimated to be 2.96, 2.50, 1.72, and 0.07 mg/day, respectively. It was concluded that the vegetables grown in this region were hazardous to health and were not fit for human consumption.[15] Behbahaninia and Mirbagheri reported that the use of wastewater and sludge application in agricultural lands enriched soils with heavy metals to concentrations that may pose as potential environmental and health risks in the long-term.[16] Bigdeli and Seilsepour reported that the levels of the metals constituted less than the theoretical maximum daily intake (TMDI) (Theoretical maximum daily intake) in some vegetables irrigated with waste water in Shahr-e-Rey, Iran. However, they concluded that with an increase in vegetable consumption by the people, in the future, the situation could be aggravated. Also, they concluded that treatment of industrial wastewater could reduce the health risk.[17] Keeping in view the potential toxicity, persistent nature, cumulative behavior, and the consumption of vegetables, it was necessary to test and analyze them, to ensure that the levels of these contaminants met the agreed international requirements. Regular surveys and programmed monitoring of the heavy metal content in foodstuffs had been carried out for decades in most developed countries. Thus, information on heavy metal concentrations in food products was extremely essential for evaluating the hazard they could cause to human health.[1] Therefore, the objective of this study was to investigate the levels of lead and cadmium in vegetable farms and compare the metal levels in different vegetables with the Food and Agriculture Organization and World Health Organization standards.[18]

MATERIALS AND METHODS

In this descriptive study, irrigating water and three species of vegetables — spinach, garden cress, and radish — were selected at five farms around Gorgan (36°50′19″N 54°26′05″E), north Iran. A total of 40 samples were collected in the tenth and twentieth months, between the periods of August and December, 2008, from the planting to the harvesting of vegetables. The samples were then brought in plastic bags to the laboratory and repeatedly cleaned with deionized water. Inedible sections of the vegetables were eliminated and the edible section was cut down into small parts. The samples were then oven dried at 90°C for 24 hours and then crushed using a stainless steel blender and passed through a 2 mm sieve. Then, 0.5 g of dried samples was digested with Nitric acid (HNO_3) and Perchloric acid ($HClO_4$) in a 5:1 ratio, until a transparent solution was obtained. The vegetable digests were filtered and diluted to 25 ml, with distilled water.[19,20]

Samples of water were taken from where the rivers were diverted to the vegetable farms. The water samples were collected in plastic containers previously cleaned by washing in non-ionic detergent, rinsed with tap water, and later soaked in 10% HNO_3 for 24 hours, and finally rinsed with deionized water prior to use. During sampling, the sample bottles were rinsed with sampled water thrice and then filled to the brim at a 20-cm depth. The samples were labeled and transported to the laboratory, stored in the refrigerator at about 4°C, prior to analysis. Lead and Cd concentrations in the vegetables and water were determined using the Polarography apparatus 797 VA. Standard solutions of heavy metals, namely lead and cadmium were provided by Merck. The standards were prepared from the individual 1000 mg/l standards (Merck), in 0.1 N HNO_3. Working standards were prepared from the previous stock solutions. The calibration curves for these standard metal ions were drawn with the working standards 1, 2.5, 5, and 10 ppm.[19] The data were analyzed with the statistical software SPSS16. One-way analysis of variance (ANOVA) was used to look for significant differences between the metal levels. A probability of 0.05 was considered significant.

RESULTS

The mean concentrations of heavy metals (Cd and Pb) found in the water and vegetables sampled from the cultivated sites along the Gorgan farms are presented in Tables 1 and 2, respectively. The heavy metal concentrations were expressed based on the vegetables' dry weight. Table 3 compares the levels of Cd and Pb by one-way ANOVA, for all vegetables that were studied. Our results revealed that the highest levels of lead and cadmium (87.27 and 1.56 μg kg^{-1} respectively) were discovered in radish. The amounts of heavy metals present in the vegetables studied were generally higher than those present in the water. However, the concentration of the all metals was within the permissible levels proposed by the FAO/WHO.

Table 1: Concentration of cadmium detected in the irrigating water and vegetables in 2008

Cd concentration	Farm 1 Mean ± SE	Farm 2 Mean ± SE	Farm 3 Mean ± SE	Farm 4 Mean ± SE	Farm 5 Mean ± SE	Total Mean ± SE
Water (μg/l)	N.D	N.D	N.D	N.D	N.D	N.D
Spinach (μg/kg)	N.D	N.D	N.D	N.D	N.D	N.D
Garden cress (μg/kg)	N.D	N.D	0.43	N.D	N.D	0.08 ± 0.51
Radish (μg/kg)	2.906 ± 4.08	1.159 ± 2.79	0.562 ± 1.91	1.074 ± 2.57	2.098 ± 3.89	1.56 ± 3.10

N.D: Not detectable

Table 2: Concentration of lead detected in the irrigating water and vegetables in 2008

Pb concentration	Farm1. Mean ± SE	Farm2. Mean ± SE	Farm3. Mean ± SE	Farm4. Mean ± SE	Farm5. Mean ± SE	Total Mean ± SE
Water (μg/L)	27.05 ± 6.75	25.731 ± 7.29	28.02 ± 6.86	26.88 ± 7.58	26.75 ± 8.01	26.75 ± 7.49
Spinach (μg/kg)	41.41 ± 14.86	47.76 ± 19.32	52.14 ± 19.82	64.41 ± 14.54	51.21 ± 15.08	51.21 ± 16.43
Garden cress (μg/kg)	44.61 ± 14.78	41.81 ± 14.06	39.84 ± 12.48	37.53 ± 12.95	40.13 ± 15.06	40.13 ± 13.43
Radish (μg/kg)	84.31 ± 28.68	81.85 ± 26.27	75.18 ± 20.83	97.47 ± 22.47	87.27 ± 26.06	87.27 ± 24.07

Table 3: Results of one way ANOVA of the three vegetable

Compare	Cadmium		Lead	
	(Mean ± SE)	*P* value	(Mean ± SE)	*P* value
Garden cress				
Spinach	N.D	0.978	51.26 ± 16.243	0.0230
Radish	0.0805 ± 3.098	0.001	87.27 ± 24.072	<0.0001
Spinach				
Garden cress	0.0805 ± 0.509	0.978	40.13 ± 13.423	0.023
Radish	1.560 ± 3.098	0.001	87.27 ± 24.072	<0.0001
Radish				
Garden cress	0.0805 ± 0.509	0.001	40.13 ± 13.423	<0.0001
Spinach	N.D	0.001	51.26 ± 16.243	<0.0001

Results of the one-way ANOVA revealed that a statistical difference was found between radish and spinach ($P<0.001$) and radish and garden cress ($P<0.001$), but they did not reveal any significant difference between the levels of cadmium in the garden cress and spinach ($P=0.978$). Moreover, there was a statistical difference in the levels of lead between garden cress and spinach ($P=0.023$), radish and spinach ($P<0.001$), and radish and garden cress ($P<0.001$).

DISCUSSION

The amount of heavy metals in the vegetables studied was compared with the permissible levels by FAO/WHO. This study has shown that the concentrations of both lead and cadmium in the vegetables from the five sites of Gorgan farm were not similar. Within the selected vegetables, the highest concentrations of Pb were noticed in radish followed by spinach and garden cress. In another study, the Pb concentration was in the descending order of cauliflow er>coriander>chillies>biennial>peppermint>spinach. Also, the mean concentration of cadmium in spinach, garden cress, and water were not detectable in all farms of sampling, except for farm 3. The highest mean Cd concentration (2.906 $\mu g\ kg^{-1}$) was found in radish, whereas, the Cd levels in water, spinach, and garden cress were significantly lower compared to radish. The trends in the different vegetables for mean Cd concentration was in the descending order of radish>garden cress>spinach. Although, in another study, the Cd concentrations were in the descending order of cor iander>peppermint>cauliflower>chillies>brinjal>point ed gourd>sorghum>spinach.[7] The standard concentration of Cd in leafy and root vegetables was 100 and 200 $\mu g\ kg^{-1}$, respectively, and the standard concentration of Pb was 100 μg kg-1.[18]

We can state that the levels of lead and cadmium obtained in this study were lower than in other regions of Iran.[15-17] Furthermore, the Cd and Pb levels reported in this study were lower than those reported for vegetables in Nigeria, India, Zimbabwe, Tanzania, and Egypt.[7-9,12,14] In a similar study, the amount of heavy metals, chromium, zinc, and lead in vegetables that were irrigated by urban and industrial effluents, were, 0.28, 18.89, and 1.6 ($mg\ kg^{-1}$), respectively.[9] In another study, the Pb and Cd concentrations in vegetables had been reported to be 19 – 280 and 2 – 29 (mg kg-1), respectively, and the trend in descending order was Fe>Zn>Ni>Cu>Pb>Co>Cd.[7] However, the bioaccumulation factor for heavy metal transfer from soils to vegetables showed a descending order of Cd>Zn>Cu>Pb,[1] and this trend for another study was Fe>Mn>Zn>Cu for spinach, turnip, brinjal, cauliflower, lotus stem, mint, and coriander, respectively.[6]

The amounts of lead and cadmium reported were lower than the permissible levels by FAO/WHO (Cd 0.03 mg/kg, and Pb 0.5 mg/kg) in all the vegetables that were studied, and hence may not cause any health risk to the people. The authors recommended that the people working on these farms should not irrigate them with wastewater and should not use a lot of fertilizer, which could cause potential health risks for consumers. Hence, it was required that the farmhands be taught this and persuaded to follow it, to decrease heavy metal levels in vegetables. The authors also recommended that regular monitoring of heavy metals must be conducted on foodstuff, in order to estimate the health risk from heavy metals in the human food chain.

ACKNOWLEDGMENT

This study was financially supported by the Golestan University of Medical Sciences, Gorgan, Iran. The authors would like to convey their sincere thanks to Hussein Naseri, Kolsom Golfirozi, Saiyede Zahra Husseini, and Yeganeh Shahryari, for their help in this study.

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How to cite this article: ???

Source of Support: Golestan University of Medical Sciences, Gorgan, Iran., **Conflict of Interest:** None declared.