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# Concentration of Heavy Metal in Edible Vegetables Widely Consumed in Shahroud, the North East of Iran

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## ABSTRACT

The levels of Five different heavy metal [Pb,As,Cr,Cd and Zn] were determined in eight vegetables leek (Allium_ampeloprasum), Coriander (*Coriandrum sativum*), Parsley (*Petroselinum_rispum*), Cress (*Lepidium_sativum*), Basil (*Ocimum_basilicum*) Radish (*Raphanus sativus*), Radish Leaf (*Raphanus sativus* ) and Beetleaf (*Beta vulgaris*)] widely consumed in Shahroud, the North Easte of Iran. These vegetables raw or cooked to be consumed with food. Two hundred samples (40 samples per month) were collected for five months. Atomic absorption spectrometry was used to determine the concentrations of these metals in the vegetables. The final result of the vegetable samples showed that the heavy metal concentration was in the range of Cr (2.4–5.88), Zn (54.27–170.23), As (1.92–5.49),Cd (1.94–2.43) and Pb (18.48–21.3) ppm , respectively. It is concluded that the vegetables grown in this region are a health hazard for human consumption. The amount of heavy metals in vegetables from the highest to lowest are as follows:

Lead: Crees> Radish> Coriander> Beet leaf > Leek > Parsley> Basil> Radish leaf
Arsenic: Beet leaf> Leek> Radish leaf> Radish> Crees> Coriander> Parsley> Basil
Chromium: Basil>Radish leaf> Beet leaf >Coriander> Parsley>Leek>Radish >Crees
Cadmium: Leek>Radish>Parsley>Coriander>Radishleaf>Beetleaf>Basil>Crees
Zinc:Leek> Parsley> Radish leaf> Crees>Coriander>Beet leaf >Basil>Radish concentrations of heavy metals in soil, respectively, is:Zn>As>Cr>Pb>Cd .The tolerable limit set by the Environmental Protection Organization of Iran. The element with the highest concentration in the study was Zn (263.5) in the Leek while the least was Cd (0.24) in the Beet leaf. The level of concentration of heavy metals in most of the samples exceeds the recommended levels, given by the World Health Organization(WHO)and Food Agricultural organization-(FAO), So public health is at risk of consume these vegetables.

**KEY WORDS**: Concentration. Heavy Metal. Vegetables. Iran. Shahroud.

## INTRODUCTION

Food safety is a major public concern worldwide. During the last decades, the increasing demand for food safety has stimulated research regarding the risk associated with consumption of foodstuffs contaminated by pesticides, heavy metals and/or toxins [1].

Heavy metals are a general collective term which applies to the group of metals and metalloids with an atomic density greater than 4 g/cm³. Although it is a loosely defined term [2], it is widely recognized and usually applies to the widespread contaminants of terrestrial and freshwater ecosystems.

Vegetables constitute an important part of the human diet since they contain carbohydrates, proteins, vitamins, minerals as well as trace elements. The contamination of vegetables with heavy metals due to soil and atmospheric contamination poses a threat to its quality and safety. Dietary intake of heavy metals also poses risk to animals and human health. High concentrations of heavy metals (Cu, Cd and Pb) in fruits and vegetables were related to high prevalence of upper gastrointestinal cancer [3].

Vegetables also act as buffering agents for acidic substances obtained during the digestion process. However, these plants may contain both essential and toxic elements, such as heavy metals, at a wide range of concentrations [4]. Metals, such as lead, chromium, cadmium and copper are cumulative poisons. These metals cause environmental hazards and are reported to be exceptionally toxic [5]. Contamination of vegetables with heavy metal may be due to irrigation with contaminated water, the addition of fertilizers and metal-based pesticides, industrial emissions, transportation, the harvesting process, storage or at the point of sale. It is well known that plants take up metals by absorbing them from contaminated soil as well as from deposits on parts of the plants exposed to the air from polluted environments [6,7]. Publicity regarding the high level of heavy metals in the environment has created apprehension and fear in the public as to the presence of heavy metal residues in their daily food. Keeping in mind the potential toxicity and persistent nature of heavy metals, and the frequent consumption of vegetables and fruits, it is necessary to analyze these food items to ensure the levels of these contaminants meet agreed international requirements [8]. Lead and cadmium are among the most abundant

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heavy metals and are particularly toxic [9]. Excessive content of these metals in food is associated with a number of diseases, especially of the cardiovascular, renal,nervous and skeletal systmes [10,11]. These heavy metals are also implicated in carcinogenesis, mutagenesis and teratogenesis [8]. Other metals, such as copper and zinc are essential for important biochemical and physiological functions and necessary for maintaining health throughout life [12].

Eight kinds of vegetables that are widely used in the leek (Allium ampeloprasum), Coriander (Ocimum_basilicum), Parsley (Petroselinum_crispum), cress, (Lepidium sativum), Basil (Ocimum_basilicum) Radish (Raphanus_sativus), Radish Leaf (Raphanus_sativus) and Beet leaf (Beta_vulgaris). These vegatables raw or cooked to beconsumed with food.

Areas of Shhnma, Abdolabad, Beheshti, Farhangian and NoroozKhan as the appropriate place for edible vegetables grown are used. The area have been located near Highway, Sugar Industry, electroplating workshops, gas stations, livestock and residential, complexesl. These farms are irrigated by channels that received various pollutants, including municipal and industrial wastewater are increasing uptake of heavy metals is breeding by vegetable.

Several studies have investigated the contamination of heavy metals in soil and vegetables. These studies the amount of heavy metals in vegetables, fruits and crop have demonstrated. These research includes Anthony Kachenko [13] , Emanuoel [14] , Sadra Heidari [15], Anita [16], Latif [17], Harrison and Chirgawi [18], Bahemuka and Mubofu [4], Kursad et al [19], Yoona et al [20], Conesaa et al [21] and Skinnera et al [22].

In Iran, Maleki [23] studied the concentration of heavy metals in selected edible vegetables grown in the main farmlands around Sanandaj city,and in Zanjan Eslami [24] studied the heavy metals in edible green vegetables grown along the sites of the Zanjanrood River in Zanjan, Iran,and Cheraghi [25] studied the effect of waste water on heavy metal accumulation in Hamedan Province vegetables, Bigdeli et al [26] Investigation of metals accumulation in some vegetables irrigated with waste water in Shahre Rey-Iran and toxicological implications.

The aim of this study was to determine the concentrations of heavy metals in selected edible vegetables grown in the main farmlands around Shahroud City, and to estimate their contribution to the daily intake of the metals.

## MATERIALS AND METHODS

### Study Area

The present study was carried out between June and November 2010 in the urban areas of Shhnma , Abdolabad, Beheshti, Farhangian and Norooz Khan in Shahroud, located in the North Eastern Iran ,54°57′ E and 36°25′ N (Fig. 1). The climate of the region is Moderate with two distinct seasons Hot and cold. The Hot season (May to October) is associated with hight temperature during the day ranging from a minimum of 30°C to a maximum of 42°C. The cold season starts in November and continue till end of April. During the cold season, the temperature varies from a minimum of -14°C to a maximum of 16°C. The region will not increase average annual precipitation of 250 mm. Shahroud is one of the most densely populated cities of Semnan Province in the North Eastern Iran. There are several industrial estate located at the periphery of the city. Heavy traffic are near the vegetable farms. The map of the study area is shown in Fig. 1

### Collecttion of Vegetable samples and Processing

Samples of the edible vegetables were randomly collected from the main farmlands around the city. The samples were collected from these growing areas over a period of six months during the cultivation season (June - November) during the year 2010.

A total of 200 samples of eight vegetables [leek (*Allium ampeloprasum*), Coriander (*Coriandrum,sativum*), Parsley(*Petroselinum_rispum*),Cress*(Lepidium_ativum)*,Basil(*Ocimum_asilicum)*,Radish(*Raphanus sativus*), RadishLeaf(*Raphanus sativus* ) and Beet leaf*(Beta vulgaris*)] were collected (four composite samples of each kind of vegetable during each month). All samples were collected and stored in polythene bags according to their type and brought to the laboratory for preparation and treatment. For chromium, Arsenic, Lead, Cadmium and Zinc analyses, vegetable samples were washed with distilled water to eliminate suspended particles. The leafy stalks were removed from all samples and these were sliced and dried on a sheet of paper to eliminate excess moisture. Once dried, each sample was weighed and oven-dried at 60ºC to a constant weight. Each oven-dried sample was ground in a mortar until it could pass through a 60 mesh sieve. The samples were stored in clean, dry,high density polyethylene bottles of 100 ml capacity with screw caps. Bottles were prewashed with nitric acid, rinsed with de-ionized water, dried and tested for contamination by leaching with 5% nitric acid. The bottles contained no metal liners that could contaminate the samples. Samples were precisely weighed (2 grams each) and ground in a mortar followed by wet digestion with $HNO_3$:$HClO_4$ (2:1) in a conical flask for 2-3 hours on a sand bath[8]. Some 10 ml of HCl was added. Digested samples were filtered with 0.45 µm pore size cellulose nitrate membrane filter paper (Millipore) and the volume was increased to 100 ml with distilled water and bottles were stored until inductively coupled plasma emission spectrophotometry (Varian710 - ICP-OES), was performed at the Water Research Institue (WRI) at Abbaspour University.

### Soil Samples

Composite surface soil (0-20cm) samples (from a bulk soil made up of 20 different soil samples per farm) of the farms were collected separately and properly labeled. The soil samples were then air-dried, and crushed to

pass a 2-mm mesh sieve. Zero point five gram of finely ground soil samples were digested using 2-ml technical grade $HNO_3$ in beakers at 95°C for 1 h after which 2-ml $H_2O_2$ was added[8]. After cooling, the samples were decanted and diluted with MilliQ water to the 10 ml mark for analyses.

**Quality Control**

Accuracy and precision of the ICP-QES facility was compared to results of the standard reference material, The National Institute of Standards and Technology (NIST) Standard Reference Material ( SRM) 1515 for the vegetable samples, and NIST SRM 2709 was used for the accuracy in heavy metal levels in the soil samples. The Standard Reference Material( SRM) results obtained are shown in Tables 1 and 2. With the exception of Cr and Zn, where recoveries obtained were below 70% in NIST SRM 2709, all the others were in good accord with the certified values. Percentage recoveries from NIST SRM 1515 for the vegetable samples, were all above 70%. (29)

## RESULTS AND DISCUSSION

**Heavy Metals in Vegetables**

The amount of heavy metals in the vegetable breeding Suburbs Shahroud as the average concentration in part per million of vegetables and 95% for concentrations of heavy metals by vegetable type is presented in Table 3. According to Table 3 Mean concentration of lead in the vegetables not against each other difference is a significant difference (P<0.001), and which is seen Crees highest concentration of lead (59.30) and radish leaves are the lowest concentration (4.72). The highest arsenic concentration to Beet leaf (6.90) and lowest in Basil (4.12). But the test shows a significant difference between the average arsenic concentration of these vegetables does not exist (P = 0.173).

The average concentration of chromium (P<0.001), cadmium (P<0.001) and zinc (P> 0.001) among the 8 different species of edible vegetable that is a significant difference is seen as the highest concentration of chromium to Basil (8.82) and the lowest concentration of Crees (3.05). The highest concentration Codemium to Leek (6.30) and the lowest Cress (0.36). The highest concentration of zinc in vegetables, Leek (263.5) and the lowest zinc concentration measured in the radish root (106.42) have been measured. As is seen in Table 3 Leek contains is the highest amount of heavy metal and Basil containing heavy metal is the lowest.

To compare the amount of metals in vegetables with food standards authorized by plants (provided by the FAO-&WHO) mean concentrations of metals and about the general standard provided in Table 6 that the results of this table shows the Except on the remaining heavy metal concentration measured with the proposed higher standards for metals uptake by plants.

**Heavy Metals in Soil**

Mean concentrations of heavy metals in soil and also the standard it can be seen in Table 5. 95% confidence intervals for the mean concentration of heavy metals in soil and its comparison with the standard view is The concentration of heavy metals (lead, arsenic, chromium, cadmium and zinc) in soils with no significant statistical difference between the proposed standard.

**Heavy metal in Soil and Bioconcenteration factor**

Mean heavy metals in vegetables grown in soil beds is presented in Figure 2. Mean concentrations of heavy metals, respectively, is:Zn>As>Cr>Pb>Cd .The tolerable limit set by the Environmental Protection Organization of Iran.The calculated values for Bioconcentration factor (BF) for heavy metals from soil to vegetable tissue (Table 4) is used. BF fear factor to get direct contact between the Trace elements in the environment indicated by the texture of vegetables. The transfer from soil to vegetables by Harrison and Chirgawi and Chamberlain has been described.

**Table 1 Mean ICP-QES Results for SRM Apple Leaves NIST Number 1515**

| Heavy metal | ICP-QES (ppm), n=3 | Certified value (ppm) | Percentage recovery |
|---|---|---|---|
| Cr | 0.29 | 0.30 | 96 |
| As | 0.27 | 0.38 | 71 |
| Pb | 0.37 | 0.47 | 78 |
| Cd | 0.012 | 0.014 | 86 |
| Zn | 11.70 | 12.50 | 94 |

The National Institute of Standards and Technology (NIST)
Standard Reference Material(SRM**)**

**Table 2 Mean ICP-QES Results for SRM San Joaquin Soil NIST Number 2709**

| Heavy metal | ICP-MS (ppm), n=3 | Certified value (ppm) | Percentage recovery |
|---|---|---|---|
| Cr | 40.29 | 79 | 51 |
| As | 18.42 | 20 | 92 |
| Pb | 12.52 | 13 | 96 |
| Cd | 0.72 | 1 | 72 |
| Zn | 63.1 | 100 | 63 |

The National Institute of Standards and Technology (NIST)
Standard Reference Material(SRM)

**Table 3** Mean Heavy Metal in Vegetables (ppm)

| Heavy metal | *Vegetabels* | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **Leek** | **Coriander** | **Parsely** | **Cress** | **Basil** | **Radish** | **Beet leaf** | **Radish leaf** |
| Cr | 5.20 | 6.37 | 6.15 | 3.05 | 8.82 | 4.76 | 6.99 | 8.62 |
| | (1.55) | (1.39) | (2.36) | (0.41) | (0.97) | (1.48) | (0.44) | (2.4) |
| As | 5.85 | 4.83 | 4.17 | 4.88 | 4.12 | 5.33 | 6.90 | 5.54 |
| | (1.98) | (0.39) | (1.49) | (1.12) | (0.53) | (1.83) | (0.66) | (2.73) |
| Pb | 9.07 | 9.41 | 7.32 | 59.3 | 6.69 | 52.42 | 9.18 | 4.72 |
| | (1.23) | (1.82) | (2.08) | (11.4) | (0.36) | (13.04) | (0.69) | (1.54) |
| Cd | 6.3 | 2.73 | 3 | 0.36 | 0.54 | 3.15 | 1.50 | 2.33 |
| | (1.79) | (0.85) | (1.47) | (0.17) | (0.08) | (1.12) | (0.24) | (0.89) |
| Zn | 263.5 | 168.29 | 198.93 | 191.93 | 145.19 | 106.42 | 157.8 | 192.86 |
| | (15.87) | (9.24) | (9.86) | (5.41) | (3.46) | (13.87) | (10.47) | (90.4) |

**Table 4** Bio concentration factor for Heavy Metal from soil to Vegetable

| Heavy metal | *Vegetabels* | | | | | | |
|---|---|---|---|---|---|---|---|
| | **Leek** | **Coriander** | **Parsely** | **Cress** | **Basil** | **Radish** | **Beet leaf** |
| Cr | 0.38 | 0.47 | 0.45 | 0.22 | 0.65 | 0.35 | 0.52 |
| As | 0.36 | 0.3 | 0.26 | 0.3 | 0.25 | 0.33 | 0.43 |
| Pb | 0.73 | 0.76 | 0.59 | 4.81 | 0.54 | 4.40 | 0.74 |
| Cd | 0.47 | 0.2 | 0.22 | 0.02 | 0.04 | 0.23 | 0.11 |
| Zn | 4.14 | 2.64 | 3.12 | 3.01 | 2.28 | 1.67 | 2.48 |

**Table 5:** Mean Heavy Metal in Soil (ppm)

| | | | **%95 Confidence interval** | |
|---|---|---|---|---|
| Heavy metal | Mean | Std. Deviation | Lower Bound | Upper Bound |
| Pb | 12.31 | 1.2 | 9.32 | 15.3 |
| As | 15.88 | 2.32 | 10.11 | 21.65 |
| Cr | 13.4 | 1.18 | 10.45 | 16.34 |
| Cd | 1.29 | 0.21 | 0.76 | 1.81 |
| Zn | 63.6 | 3.46 | 54.99 | 72.22 |

**Table 6**: Guideline and standard for Heavy Metal in Vegatable and Soil

| Heavy metal | WHO standards (µgr/gr)a | Weigert (mg/kg)b | US grower (ppm)c | EU 2002 (mg/kg)d | Alloway (mg/kg)e |
|---|---|---|---|---|---|
| Pb | 0.05 | 0.3 | 1 | 100 | 2-200 |
| As | nl | 0.43 | nl | 20 | 0.1-40 |
| Cr | 0.05 | 2.3 | nl | 100 | 5-300 |
| Cd | nl | 0.2 | 0.05 | 3 | 0.1-7 |
| Zn | 5-15 | 99.4 | nl | 300 | 50-600 |

**a**Source:WHO,2002;www.spirulina.com.nl not listed,
**b**Source :European Union 2002; http://ec.europa.eu/environment
**c**Source :Spirulina Food safety Us grower
**d**Source :Weigert P 1991[27]
**e**Source: Alloway BJ [28]

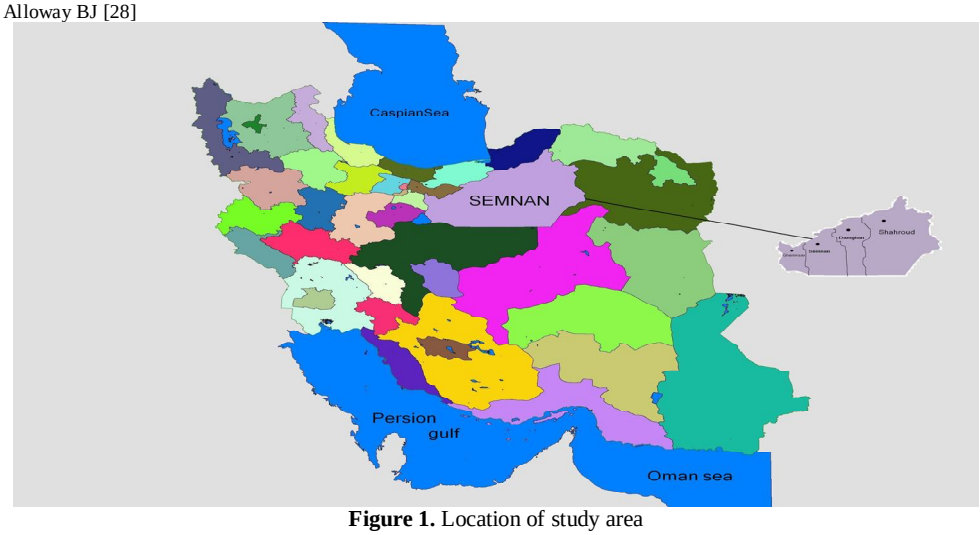


**Figure 1.** Location of study area

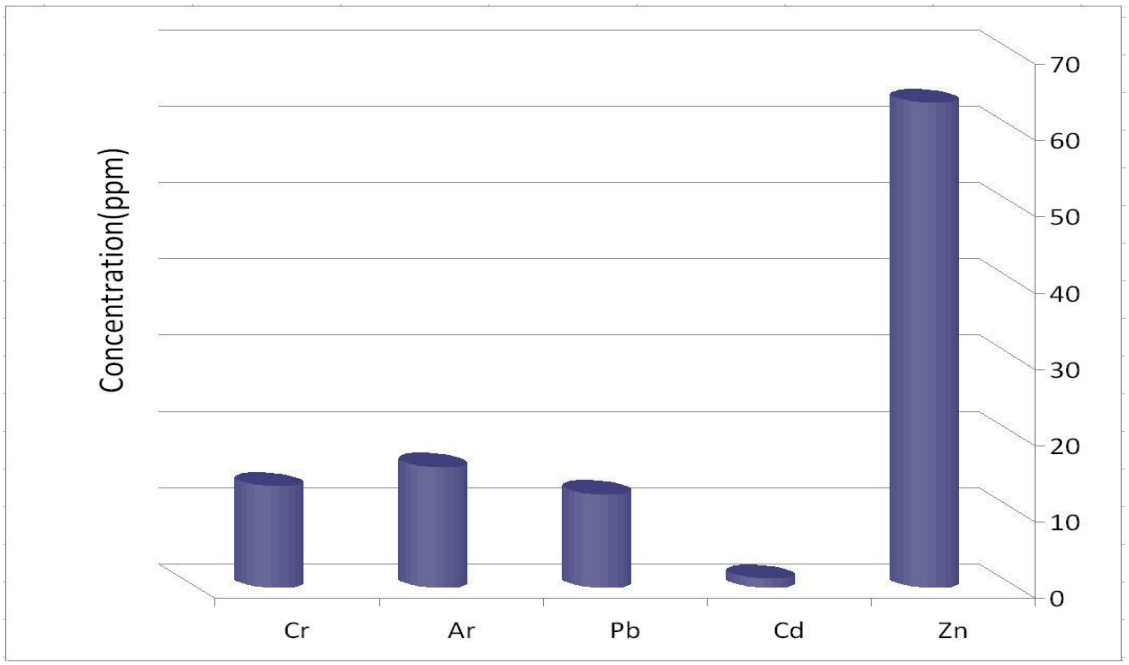


**Figure 2.** Heavy metal level in soil of vegetable bed

## Conclusion

The present study provides data on heavy metal pollution in shahroud. The levels of heavy metals in the studied vegetables, and the permissible levels required for safe food were compared. High Pb content was found in Crees. A high level of Cd was found in Leek. High Cr content was found in Basil .A high level of As was found in Beet leaf. . This study has shown that there is greater risk of human exposure to lead (Pb) in Crees consumption than other vegatables .These amounts can be hazardous if the vegetables are taken in large quantities. However, the results of this study indicate that the daily intake of Zn through edible vegetables from farmland areas may not constitute a health hazard for consumers because the values were below the recommended daily intake of this metal. these metals have toxic potential, but the detrimental impact becomes apparent only after decades of exposure. It is therefore suggested that regular monitoring of heavy metals in plant tissues is essential in order to prevent excessive build-up of these metals in the human food chain. According to the results of this study recommended:

1 - identify industries and small workshops and organizing them.
2 - accelerating the construction of sewage collection network .
3 - Improvement of canal and prevent sewage entering the residential area.
4 - educating growers on how the proper use of chemical fertilizers.
5 - teaching people about the adverse effects heavy metals in vegetables and ways to control and reduce it.
6 - replace vegetables with lower uptake of heavy metals in the area.

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