Original Article

Investigating the Effect of Some Heavy Metal Elements of Agricultural Soil on Esophageal Cancer

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Abstract

Aims: This study designed to investigate the concentration of some heavy metals (HM) in the soil of agricultural land of Gonbad-e Kavus in Golestan province and relationship of these metals with esophageal cancer disease. **Materials and Methods:** For the investigation of pollution, especially HM in the soil, 5 points were randomly selected from each village (3 villages). The samples dried and screened by 200 mesh sieve. Then, the samples were analyzed for HM using ICP/MS. **Results:** The mean of Cadmium (Cd), Zinc, Cobalt, Chromium, Manganese, Nickel, Arsenic, Copper (Cu), Lead (Pb), and Iron (Fe) in soil was 0.5938 ± 1.7, 74.06 ± 18.9, 12.06 ± 1.28, 68.68 ± 5.85, 627.37 ± 53.3, 38.43 ± 4.4, 6.51 ± 1.21, 29.37 ± 4.3, 17.25 ± 3.5, and 27766.06 ± 2200 mg/kg, respectively. **Conclusion:** The concentration of metals except Cd and iron was less than the global standards. The concentration of some metals in the soil is almost high due to the high consumption of urea, phosphate, and nitrogen fertilizers. Therefore, it is recommended to educate farmers and use less chemical fertilizers.

Keywords: Agricultural soil, esophageal cancer, heavy metals

Introduction

Providing food security and quality, with limited natural resources, is one of the most important issues in the world. Heavy metals (HM) are one of the most important pollutants that thousands of these elements enter the soil system on a global scale annually.[1] HM are very important because of toxic properties, aggregation, and high survival in living organisms. These metals are absorbed by the soil and cause pollution of agricultural land and ultimately enter the food chain and may reach toxic levels for plants, animals, or humans. The entry and accumulation of HM in agricultural lands are mainly due to atmospheric deposits from industrial activities, chemical fertilizers, animal fertilizers, wastewater sludge, solid waste leachate, and pesticides.[2-4]

HM are not removed after entering the body, but they also precipitate and accumulate in tissues such as fat, muscles, bones, and joints. These metals may not have a short-term effect and their effects appear only after several years of exposure to these metals. Therefore, regular monitoring of the concentration of HM in agricultural products seems necessary to minimize the harmful effects of these metals.[5]

Access this article online	
Quick Response Code:	Website: www.ijehe.org
	DOI: 10.4103/ijehe.ijehe_7_20

Cancer is one of the diseases that are increasing in the world and environmental factors (soil, water, and air pollution) play an important role in its development and severity. Environmental exposure to HM is a well-known risk factor for cancer.[6] There are several studies for relation between HM from environmental media and cancer from water sources. For example, Türkdoğan *et al*. investigated HM in soil, vegetables, and fruits in the endemic upper gastrointestinal (GI) cancer in the region of Turkey. The results show that volcanic soil, fruit, and vegetable samples contain potentially carcinogenic HM in such a high levels that these elements could be related to the high prevalence of upper GI cancer rates in Van region**.** Six HM (cadmium [Cd], lead, zinc (Zn), manganese [Mn], nickel [Ni], and copper [Cu]) were used in soil samples to

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How to cite this article: Sadeghi M, Noroozi M, Kargar F, Mehrbakhsh Z. Investigating the effect of some heavy metal elements of agricultural soil on esophageal cancer. Int J Env Health Eng 2020;9:11.

Received: 18-01-2020, **Accepted:** 27-04-2020, **Published:** 31-07-2020

study their effect on GI tract. Four metals (Cd, cobalt [Co], lead, and Cu) was higher than standard, but the Zn level was less than 40 times its limit in soil, so using the analysis of the heavy metal zonation map with the help of geological maps. The main factor is the high concentration of HM in the soil.[6]

Chiang *et al*. investigated in Taiwan, the presence of HM such as chromium (Cr), Cu, Ni, and Zn as the first factor and Cd and lead as the second factor in the soil elements of this region have a spatial correlation with the mortality rate of oral cancer in men.[7] Lee *et al*. investigated that Ni is a major risk factor for esophageal cancers in Taiwan due to the positive correlation between Ni and esophageal cancer in Taiwan.[8] According to Keshavarzi *et al*. studies, there is a positive and significant relationship between the incidence of esophageal cancer and the increase in selenium concentration.[9] According to Semnani *et al*. studies, high levels of selenium in the soil have a significant bearing on the incidence of esophageal cancer in Golestan province, so that high levels of selenium in the soil may play an important role in the development of esophageal cancer.[10] Jackson (1988) concluded in their study that there was a direct correlation between the deficiency of selenium in soil with the prevalence of two types of gastric and esophageal cancers, as well as the deficiency of Zn in soils and calcareous soils in the arid regions with abundant gastric cancer.[11] In another study, Wang *et al*. investigated four HM of Cd, lead, Cu, and Zn in soil, water, and plants in this area.[12]

According to a cohort study conducted East of Golestan province, Gonbad-e Kavus has the highest number of esophageal cancers in Iran.[13] According to the latest calculations performed on esophageal cancers registered (according to pathologic diagnosis) in the cancer registry of Golestan University of Medical Sciences, the incidence of disease in the East of Golestan province is 40/100,000 and in the West of province 6/100,000. According to the data comparing the incidence of esophageal cancer worldwide, Northern Iran (Gonbad-e Kavus) is referred to as part of the "esophageal cancer belt" that extends east to China.[13-15]

Therefore, the present study designed to investigate the concentration of some HM in the soil of agricultural land of Gonbad-e Kavus in Golestan province, and also to investigate the relationship of these metals with esophageal cancer disease in the high prevalence areas of Gonbad-e Kavus.

Materials and Methods

The city of Gonbad-e Kavus has been located in 55 ° 18' longitude and 37 ° 17' min latitude in the northern and central parts of Golestan province [Figure 1]. Most of the soils in this region are volcanic plains. The geosciences of the Gonbad-e Kavus city are more marshy and habitable, abandoned and impassable, as well as major faults.[16]

According to the objectives of this study, the investigation of pollution, especially HM in the soil of Gonbad-e Kavus city, and according to previous studies,[13,14] three villages with high risk of esophageal cancer were selected. Samples from Gonbad-e Kavus city and surrounding villages (three villages with the highest incidence of cancer) were completely randomized, and 5 samples were taken from each village and 1 sample were taken from Gonbad-e Kavus city (Total sample = 16). A total of 16 soil samples with approximate weight of 1 kg were taken by auger, an excavator that separates soil from 20 to 30 cm depth and stored in plastic bags. Since the soils of the area were highly adherent due to clay and high humidity, they were first dried in the open air and after a few days they were first prepared with a simple sieve to pass through the laboratory-specific sieve. Soils were screened for heavy metal decomposition. This procedure was performed with 200 mesh metal sieve to obtain the desired size. After sifting, the samples were packed in small plastic bags. Then, samples were sent to the laboratory for the analysis of HM using a ICP/MS (Germany, Spectro Genesis model).[17,18]

Digestion of samples was performed with multiwave PRO microwave apparatus. In this method, 0.5 g of the homogenized sample is weighed into the microwave vessels, added to the microwave after adding nitric acid and hydrochloric acid, and the digestion is performed by adjusting the temperature and pressure. After digestion and cooling, the sample acid was evaporated and diluted with deionized water. Then HM were measured by inductively coupled plasma-mass spectroscopy (Germany, Spectro Genesis) with a silicon drift detector. The power of the device was adjusted to create 1400 W radiofrequency, a plasma gas flow rate of 12 liters/min, auxiliary gas flow rates of 0.8 liters/min, and a nebulizer dispenser gas flow rate of 0.8 liters/min adjusted. In this method, about 45 elements were detected and recorded by the device simultaneously. In this study, HM and elements were selected and compared with the other elements with higher concentrations.

For analyzing geochemical data including descriptive statistical parameters of elements, the SPSS software was used.

Results

The concentration of HM (mg/kg) in the study regions is shown in Table 1. Some of the statistical characteristics of the total concentration of HM are shown in Table 2. According to the results of the study, the concentration of metals except Cd and iron was less than the global standard than their concentration in their background concentrations.

According to the epidemiologic map of esophageal cancer [Figure 1], in the village of Gonbad-e Kavus, Soltanali, with 87 cases, the highest rate of the disease was reported in 87 patients per 100, 000 people and the villages of Aq Abad and Fajr were 57 and 39 per 100, 000, respectively, the next ranks are the most prevalent areas in the Gonbad-e Kavus.

Discussion

The prevalence of cancer and disease statistics in areas with lower altitude (Soltanali) is more prevalent, and high-altitude

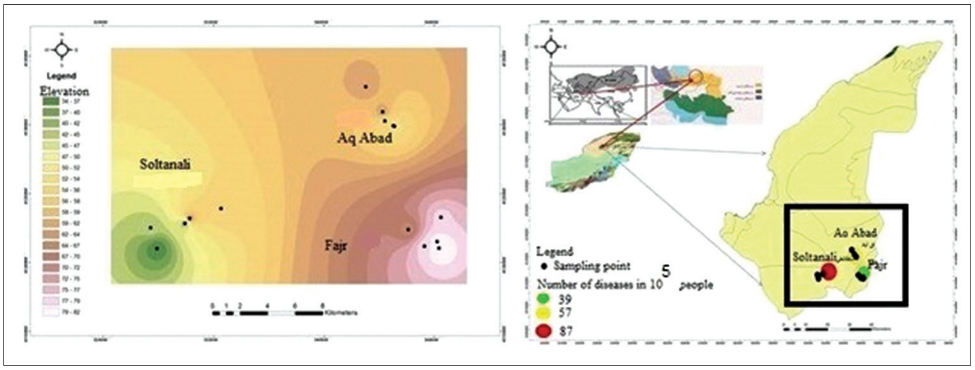

Figure 1: Soil map and Epidemiology of Esophageal Cancer and Altitude Points in Study Areas

Table 1: The concentration of heavy metals (mg/kg) in the study region

Sample site	As	Cd	Co	Cr	Cu	Fe	Ni	Mn	Pb	Zn
Soltanali1	8.1	7.1	13.5	71	36	30,288	45	679	26	135
Soltanali2	7.4	0.1	13.1	76	33	28,640	41	658	18	69
Soltanali3	6.6	0.1	12.6	73	35	29,530	42	660	16	90
Soltanali4	8.1	0.3	12.7	66	29	28,782	40	632	17	71
Soltanali5	7.1	0.1	11.8	75	37	27,690	38	617	18	66
Fajr1	5.6	0.5	13.0	72	29	29,589	42	584	22	72
Fajr2	4.8	0.1	12.6	67	32	28,480	40	564	19	81
Fajr3	6.4	0.1	14.2	76	30	30,950	43	680	20	75
Fajr4	7.4	0.2	13.3	76	30	29,319	42	739	19	77
Fajr5	5.3	0.1	10.1	62	25	23,747	28	552	16	57
Aq Abad1	7.4	0.1	11.4	67	28	26,923	37	637	16	63
Aq Abad2	5.3	0.1	10.1	60	26	24,100	33	581	12	58
Aq Abad3	8.1	0.1	11.7	65	25	28,075	38	655	15	64
Aq Abad4	5.5	0.1	12.1	71	28	27,806	38	646	15	63
Aq Abad5	6.6	0.2	10.7	63	23	25,891	35	613	14	59
Gonbad	4.5	0.2	10.2	59	24	24,447	33	541	13	85

Table 2: The statistical characteristic of the concentration of heavy metals (mg/kg) in the study area

Elements	Minimum	Maximum	Mean	SD	Variance	Average shell element	Background concentration in global shell
Cd	0.1	7.10	0.5938	1.73838	3.022	0.098	0.3
Zn	57.00	135.0	74.06	18.92	358.06	71	95
Co	10.10	14.2	12.06	1.28	1.65	-	-
Cr	59.00	76.00	68.68	5.85	34.22	35	90
Mn	541.00	739.00	627.37	53.30	2841.71	600	850
Ni	28.00	45.00	38.43	4.44	19.72	20	68
As	4.50	8.10	6.51	1.21	1.47	20	20
Cu	23.00	37.00	29.37	4.30	18.51	25	45
Pb	12.00	26.00	17.25	3.51	12.33	20	20
Fe	23,747.00	30,950.00	27,766.06	2199.81	4,839,194.06	-	46,700

areas (Fajr) are relatively less prevalent. Soltanali and Aqabad provinces relative to Fajr village due to near and in the proximity of the Turkmen Desert region are relatively dry, but the Fajr village has a wetter climate and more green than two other villages. These results similar to Wu *et al*. (2008) study relationships between esophageal cancer and spatial environment factors by using the Geographic Information System. The results show that known high-risk areas in China were faced with drought and were geographically low-lying areas.[19]

However, considering that the study area is an agricultural area, the probability of increasing the concentration of HM in the soil due to agricultural practices is due to the high consumption of chemical fertilizers in farming lands and because of these elements in the structure of chemical fertilizers also exists.

In Gonbad-e Kavus, the level of heavy metal contamination in the soil is analyzed and determined by geoaccumulation index (I_{geo}), which was established by Muller. I_{geo} is obtained by comparing the contamination levels before contamination and present contamination. Equation 1 indicates the computation of Igeo:

$$I_{geo} = Log_2 (C_n/1.5B_n) \quad (1)$$

Where C_n is the measured mass fraction of the metal (mg/kg). B_n is the background mass fraction of the metal (mg/kg). Muller's evaluation method can be used to evaluate the level of heavy metal contamination in soils, as shown in Table 3.[20,21] The Geoaccumulation index (I_{geo}) in the study region was shown in Table 4.

According to Table 4, the Geoaccumulation index (I_{geo}) in all samples except for (Soltanali 1) were lower than 1, indicating light contaminated to moderate contamination for most samples and extremely serious contamination for Soltanali 1 sample. As a result, the concentration of HM in the soil was related to their natural origin. This results according to Bhuiyan *et al*. study. They investigated heavy metal contamination in agricultural soils using I_{geo}. The results showed a significant enrichment of the soils with titanium, Mn, Zn, lead, arsenic (As), iron, strontium, and antimony obtained from mineral activity input.[22]

Table 3: Classification of geoaccumulation index

I_{geo}	Classification	Level of contamination
$5<I_{geo}\leq10$	6	Extremely serious
$4<I_{geo}\leq5$	5	Strong to extremely serious
$3<I_{geo}\leq4$	4	Strong
$2<I_{geo}\leq3$	3	Moderate to strong
$1<I_{geo}\leq2$	2	Moderate
$0<I_{geo}\leq1$	1	Light to moderate
$I_{geo}\leq0$	0	Noncontamination

I_{geo}: Geoaccumulation index

The result of this study is according to Vahid Dastjerdi *et al*.'s study. They were to measure the concentration of Pb, Cd, and Ni in the effluent of Isfahan north wastewater treatment plant as well as in the soils and agricultural products. The results show that the cation exchange capacity (CEC) of soil changes over time. This leads to further accumulation of HM in the soil.[23]

Correlation between the elements in wheat in the study areas

Spearman correlation coefficient was used to study the geochemical relationship of potentially HM in the soil environment. The correlation results show that: Ni element with iron and Co had a strong positive correlation ($r > 0.96$) with a significant level of $P < 0.01$, indicating a geochemical and pollutant origin for these metals. Iron element with most metals (except Cd and As) has positive and significant correlations. Positive correlations ($r > 0.81$) of Co with Pb and Cr as well as Ni and Pb have a significant level of $P < 0.01$ which these elements have the same chemical origin. Between Ni and Cr, Mn, Zn and Cu at the significant level of $P < 0.01$ had a strong positive correlation ($r > 0.7$). It is natural that the elements have the same origin and geochemical behavior. Zn with iron and Ni also showed such a positive and strong correlation with this significant level. Finally, the Cu element with Zn and Mn has a positive correlation with $r > 0.5$ at a significant level of $P > 0.05$. Zn also has a similar correlation with lead.

The results are according to Wang *et al*.'s study. They investigated four HM of Cd, lead, Cu, and Zn in soil, water, and plants in this area. They concluded that the presence of Cd and lead in the environment increased the risk of several types of cancer, especially abdominal, esophageal and lung cancers, there was a significant positive correlation between male and female sexes, and mentioned metals showed no correlation with the prevalence of this disease.[12]

Table 4: The geoaccumulation index in the study region

Sample site	As	Cd	Co	Cr	Cu	Fe	Mn	Ni	Pb	Zn
Soltanali1	0.036	7.1	0.26	0.24	0.3	0.024	0.251	0.27	0.4	0.31
Soltanali2	0.032	0.1	0.29	0.25	0.27	0.023	0.24	0.25	0.27	0.15
Soltanali3	0.029	0.1	0.24	0.24	0.29	0.24	0.24	0.25	0.24	0.21
Soltanali4	0.036	0.3	0.24	0.22	0.24	0.23	0.23	0.24	0.27	0.16
Soltanali5	0.031	0.1	0.23	0.25	0.3	0.022	0.22	0.23	0.27	0.15
Fajr1	0.024	0.5	0.29	0.24	0.24	0.8	0.21	0.25	0.33	0.15
Fajr2	0.021	0.1	0.24	0.22	0.26	0.023	0.2	0.25	0.29	0.19
Fajr3	0.028	0.1	0.27	0.25	0.25	0./025	0.25	0.25	0.30	0.17
Fajr4	0.032	0.2	0.26	0.25	0.25	0.023	0.27	0.25	0.29	0.18
Fajr5	0.023	0.1	0.19	0.21	0.2	0.019	0.2	0.16	0.24	0.13
Aq Abad1	0.032	0.1	0.22	0.22	0.23	0.022	0.23	0.22	0.24	0.14
Aq Abad2	0.023	0.1	0.19	0.2	0.21	0.019	0.21	0.2	0.18	0.13
Aq Abad3	0.036	0.1	0.22	0.22	0.2	0.022	0.24	0.23	0.23	0.15
Aq Abad4	0.24	0.1	0.23	0.24	0.23	0.25	0.23	0.23	0.23	0.14
Aq Abad5	0.029	0.2	0.2	0.21	0.19	0.021	0.22	0.21	0.21	0.13
Gonbad	0.019	0.2	0.19	0.2	0.19	0.019	0.2	0.2	0.18	0.12

Conclusion

The concentration of metals except Cd and iron was less than the global standards. However, the concentration of some metals such as selenium, lead, and Cd in the Sultan Ali region was more than the other two villages. Furthermore, Zn deficiency was not consistent with the results of the above studies, since in both Soltanli and Fajr regions, according to the same plot, have been same. The concentration of some metals in the soil is almost high due to the high consumption of urea, phosphate, and nitrogen fertilizers. Therefore, it is recommended to educate farmers and use less chemical fertilizers.

Acknowledgments

This article has been derived from a research project supported by the Golestan University of Medical Sciences, under grant #17 110412.

Ethics code

Research Ethic Approval ID: IR.GOUMS.REC.1398.034.

Financial support and sponsorship

Golestan University of Medical Sciences, Gorgan, Iran.

Conflicts of interest

There are no conflicts of interest.

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