ORIGINAL ARTICLE

Heavy Metals in the Imported and Iranian Rice Consumed in Hormozgan Province

Mohsen Dehghani[1], Fatemeh Mosaferi[2], Vali Alipour[3]

[1]Assistant Professor of Department of Environment, Islamic Azad University Bandar Abbas Branch, Bandar Abbas, Iran
[2]Master of Science Student, Islamic Azad University Bandar Abbas Branch, Bandar Abbas, Iran
[3]Assistant Professor of Department of Environmental Health Engineering, Hormozgan University of Medical Sciences, Bandar Abbas, Iran

Correspondence:
Vali Alipour,
Department of Environmental Health Engineering, Hormozgan University of Medical Sciences,
Bandar Abbas, Iran
Email: v_alip@yahoo.com
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Abstract

Background: Given that the share of imported rice from India and Pakistan, the current study was conducted to determine the concentration of lead, arsenic and cadmium in the rice imported from the two mentioned countries in comparison to Iranian rice.
Methods: This cross-sectional study was conducted in 2014 in Bandar Abbas, using a completely randomized block design. Five samples of each brand (India,Pakistan and Iran) and a total of 75 samples were selected. To measure the amount of arsenic in them, atomic spectrum poll and to determine the amount of lead and cadmium, the graphite furnace atomic absorption spectrometer optical-compliant were used. To analyze the data, we applied descriptive statistics and analysis of variance using SPSS software.
Results: The mean of Cd, As and Pb were 0.045, 0.057, and 0.022 mg/kg, respectively. There was a significant difference for Cd in the local and imported rice (P=0.002). Difference for As in the local and imported rice was not significant (P=0.218). A statistically significant difference was found between the imported and Iranian rice (P=0.354). There were no significant differences among all the measured heavy metals in the tested samples of India and Pakistan rice, both legally and illegally (P=0.144).
Conclusion: It was found that the rice was contaminated with heavy elements; it is recommended that measures should be taken to promote healthy rice production, including periodic monitoring of heavy metals in the water and rice seeds, establishing an appropriate operating system to reduce heavy metal emissions, using international experiences on the effects and complications of heavy metals in water resources and farming, and performing quality control measures on the imported rice.

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Introduction

Rice is one of the main components of world population food basket in about 4.2 billion people, According to FAO, almost 30% of world energy resources and 20% of the protein source are provided through rice consumption.[1] Per capita consumption of rice in the world is about 58.8 kg and this rate in Iran is about 42.5Kg; thus, it is estimated that rice is the second most widely consumed product in the country.[2]

Pollution caused by toxic metals' accumulation is one of the main threats for soil and water; given the central role of soil and water in the plants' growth and crop production, plants and their products are also part of the pollution in their own context.[3]

Soil may be contaminated due to the accumulation of heavy metals through human activities (anthropogenic) such as farming, mining, construction, fertilizers, irrigation with wastewater, sewage sludge on agricultural lands, livestock manure, use of pesticides, and industrial processes.[4,5] As heavy metals are non-bio-degradable, they remain for a long time in environmental ecosystems. The metals enter rice paddies with chemical fertilizers and irrigation water, through which they enter the human nutritional cycle.[6] Among the main agricultural products, rice is a special product because of high uptake and accumulation rate of heavy metals.[7] The entrance of these metals into the food chain and reaching a critical concentration may cause metabolic and physiological adverse effects on living organisms.[8] Cadmium (Cd) can cause kidney damage, high blood pressure, reproductive effects, mutagenicity, and carcinogenicity. Arsenic (As) has been proven to have carcinogenic properties, and lead (Pb) has had serious consequences for the children's health. In the case of high level exposures, Pb attacks the brain and central nervous system to cause coma, convulsions and even death.[9,10]

Given that the share of the imported rice from India and Pakistan in year of 2013 (73.97 and 7.46 percent respectively; about 1956000 tons), the concentration of heavy metals in the imported rice from the two mentioned countries in comparison to Iranian rice must be further taken into consideration. Hormozgan province with multiple ports is one of the points of entry of imported rice. As a part of the rice imports is legal and the rest are illegally imported (legal: products that have been imported with permission and illegal: products that have been smuggled into the country), measurement of heavy metals' concentrations in imported rice in Hormozgan province can represent the heavy metal concentration in the rice consumed in Iran. Hence, the current study was conducted to determine the concentration of Pb, As and Cd in consumed rice in this province.

Material and Methods

This cross-sectional study was conducted in Bandar Abbas city, center of Hormozgan province, during the year of 2014 in a completely randomized block design. Five samples of each brand and a total of 75 samples (legal and illegal rice imported from India and Pakistan and Iran rice) were selected. Standard samples of different levels of the rice bags were taken by bamboo straw; then, the samples were encoded and transported to the laboratory.

In the laboratory, all glass and plastic containers were washed by detergent solution and tap water; then, they were placed in a solution of diluted nitric acid (50 mL concentrated nitric acid and 4500 mL demonized water) for at least 24 hours. After that, to make ash, about 10 grams of the milled rice samples (in a cruise) was placed in the flame. At first, the cruise was placed in the furnace at 200 to 250°C for 8 hours. Ash was mixed with about 3 ml of twice distilled water, and was placed on the heater to evaporate the content water. To prepare samples for measuring Pb and Cd, we added 50 ml of 6 M HCl and 10 to 30 ml of 1.0 M nitric acid; then, the contents of the cruise was filtered by Whatman filter number 41, and brought to volume in a 50 mL volumetric flask.[11,12]

To prepare the arsenic solution, we added 2 ml of concentrated nitric acid to the cruise; then, it was placed on the heater until the excess acid evaporated. After complete evaporation of the acid, 10 to 15 ml of 2 M HCl was added to solve the remaining contents, and after 2 hours, similar to the above step, the contents of cruise was stirred until all of the contents were solved. Then, the solution was passed through a paper filter and 50 ml of 0.1N HNO3 was added to the contents of the flask. Finally, according to the standards of AOAC.999: 11: 1999, to measure the level of arsenic, we used atomic spectrum poll and to measure Pb and Cd, the graphite furnace atomic absorption spectrometer optical –compliant.[11,12]

To perform statistical analysis, we compared the data to the allowable limits set by FAO/WHO and the national standards of Iran[13] and (mean±SD) analysis of variance (ANOVA), using SPSS. Also, student t-test was used for the comparison of two independent communities with the normal controls. To determine the normality of data, analysis of Kolmogorov-Smirnov was used, and in cases of non-normal data, to check the hypotheses, Mann-Whitney tests, Kruskal-Wallis and correlation analysis were used.

Results

The average concentrations for As, Pb and Cd in all samples were 0.045, 0.057 and 0.022 mg/kg, respectively and that of As in legal and illegal imported rice from India were 0.038 and 0.055 mg/kg. However, in legal and illegal Pakistani rice, the average concentrations were 0.052 and 0.043 mg/kg, respectively. The average concentrations of Cd in legal and illegal Indian rice were 0.017 and 0.024 respectively and in legal and illegal Pakistan rice they were 0.024 and 0.032 mg/kg, respectively. The results showed that the Pb concentration in the legal and illegal Indian rice were 0.063 and 0.046 mg/kg, while in Pakistan rice they were 0.052 and 0.080 mg/kg, respectively.

The mean and standard deviation of As, Cd and Pb concentrations in India rice, the mean and standard deviation of As, Cd and Pb concentration were 0.004±0.035, 0.013±0.009 and 0.030±0.040 mg/kg, respectively. The highest measured level for As in Pakistani rice was 0.760 mg/kg. The highest and lowest measured values of Cd were 0.060 and 0.002 mg/kg, while this range for Pb concentrations was between 0.010 to 0.300 mg/kg (Table 1).

In Table 2, comparison of the average concentration of heavy metals in the samples with current standards

Table 1: Descriptive statistics of values for As, Cd and Pb in the rice samples (mg/kg)

Heavy metal	Rice type	Minimum		Maximum		SD		Average	
		Illegal	Legal	Illegal	Legal	Illegal	Legal	Illegal	Legal
As	India	0.028	0.023	0.13	0.053	0.033	0.020	0.055	0.038
	Pakistan	0.028	0.017	0.060	0.76	0.009	0.093	0.043	0.052
	Iran	0.031		0.031		0.044		0.044	
Cd	India	0.002	0.009	0.060	0.040	0.018	0.056	0.024	0.017
	Pakistan	0.020	0.010	0.050	0.040	0.018	0.032	0.032	0.024
	Iran	0.002		0.002		0.050		0.050	
Pb	India	0.006	0.100	0.100	0.020	0.022	0.026	0.046	0.063
	Pakistan	0.010	0.020	0.300	0.200	0.090	0.070	0.080	0.052
	Iran	0.010		0.100		0.030		0.040	

Table 2: Comparison of the average concentration of heavy metals in the samples with current standards.[14]

Heavy metal	Rice type			Standard references		
	India	Pakistan	Iran	WHO	FAO	IRISI
As	0.047	0.048	0.035	0.20	0.20	*
Cd	0.021	0.028	0.009	0.10	0.10	0.06
Pb	0.055	0.066	0.040	0.15	0.15	0.20

is displayed.[14]

As shown in Table 2, in all cases, the concentration of heavy metals was higher than all current standards; however, the total concentration of heavy metals in the domestic product was lower than both imported products.

Discussion

The results showed that the measured concentrations of Pb was higher than As and As was higher than Cd in all tested rice samples; the maximum content of heavy metals was related to Indian rice and the minimum values were found in Iranian rice. The minimum concentration of Cd was related to Iranian race and the imported rice from Pakistan showed the maximum amount of this heavy metal. In addition, the maximum rate of Pb was related to Pakistani rice (0.080 mg/Kg). In general, the most concentration of all the heavy metals tested was detected in Pakistani rice.

According to Hedayatifar and colleagues' research, concentrations of Pb and Cd in the rice of Lorestan province were, respectively, 0.08±0.077 and 0.06±0.037 mg/kg, which were higher than the measured concentrations in the current survey.[15] Mosayebi and Mirzaee in 2013 measured the concentration of Pb, As and Cd in samples of rice from India and Pakistan; the means were 0.067, 0.007 and 0.024 mg Pb kg, respectively. The reported value for Pb was higher than the current investigation and lower levels for As and Cd were reported.[16] Rezaeian Attar and Hesari results also showed that the average concentration of Cd in rice samples was in the rage of 0.034 to 0.58, for Pb it was 0.011 to 0.59 and concentration of As was 0.01 to 0.096 mg/Kg.[17] Zazouli and colleagues showed that the average concentration of Cd in the rice of Qaemshahr City, in Mazandaran was in the range of 0.12 to 0.83 mg/g of dry weight.[18] In the study of Batista and colleagues, the total concentration of As has been reported 0.22 mg/kg which is less than the measured amount in the current study.[19] According to Cao and colleagues, the average concentrations of Cd and Pb were 0.014 and 0.054 mg/kg respectively, being less than the current results.[20]

However, the concentrations of As and Pb in 20 percent of the studied samples (Hindi and Pakistani rice) do not meet the related standards. In addition, the results showed that the lowest concentration of Cd, As and Pb was measured in Iranian rice; this isconsistent to Malakoutian and Zazouli's studies.[2,18]

Based on the result of ANOVA test, there was a significant difference for the average Cd in three types of rice. Post Hoc test results showed no significant difference between the average Cd in Indian, Pakistani and Iranian rice (P=0.016 &0.081). ANOVA showed a significant difference in the average of Cd in two types of rice; the difference among legal and illegal Indian and Pakistani rice and Iranian rice was significant (P=0.003). According to Tukey HSD test results for comparison of Cd between legal and illegal Hindi and Pakistani rice, there was no significant difference (P=0.985), while the difference of the amount of Cd in Iranian rice and legal and illegal imported rice from India and Pakistan was significant (P=0.002 and 0.001). ANOVA test for As did not show a statistically difference between the two type of imported rice from India and Pakistan; legal and illegal rice and Iranian rice (P=0.218). ANOVA test for Pb did not show a statistically significant difference between the two type of imported rice; legal and illegal rice and

Iranian rice (P=0.354). Based on Mann-Whitney test result, there was no significant difference among all measured heavy metals in the tested samples of legal and illegal of Indian and Pakistani rice (P=0.144).

The results of Pearson correlation test samples showed that there was no relationship between concentration of Cd and As in India rice, while it was found a significant and direct relationship was found between Cd and Pb in this rice type (correlation coefficient; 0.365). In addition, the correlation between the arsenic and Pb concentrations in Indian rice was meaningful but indirect (-0.520). The concentrations of Cd and Pb in Indian rice did not meet the related standard and the correlation between them was significant and direct. The concentrations of As and Pb in the Indian rice did not meet the related standard too, and the correlation between the two metals was significant but indirect (-0.612) and in the Pakistani type, concentrations of As and Pb were not allowable and the correlation between them was significant and direct (0.224). The correlation between Cd and As in Iran rice was significant and direct (0.484).The difference in the amount of heavy metals in crops, especially rice, depends on several factors such as weather, geographical area, type of seed, planting, harvesting, and correct way to store rice, rice varieties, seasons, and soil conditions[21,22] In addition, many researchers have reported that multiple sources of environmental pollution including industrial and agricultural effluents, fertilizers and agricultural pesticides in rice are the sources of increased pollution by heavy metals.[23,24] Therefore, it is recommended that interventions for health promotion of agricultural products such as rice should be done. These measures could include monitoring of heavy metals in the water and rice seeds periodically in different areas, planning comprehensively to establish an appropriate operating system to reduce heavy metals' emissions, encouraging organic farming, carrying out similar studies in other regions and agricultural land, especially paddy fields, educational and cultural programs and creation of databases and database related to the topic in the region and the country, using international experience in the environmental and economic effects and complications of heavy metals in water resources and the farming. Due to the nature of the accumulation of heavy metals in various organs and their adverse effects; according to the recent studies, approximately 65.9% of the daily intake of Cd comes from rice,[14] so selection of products with high confidence level has a vital importance. In addition, proper implementation of the guidelines for evaluating the quality of rice varieties can greatly help community health and food security.

Conclusion

The results of this study revealed that the mean concentrations for Pb and Cd in domestic and imported rice samples were considerably higher than the allowable limits set by related standards; of course, the values were higher in the imported rice than domestic product. considering the fact that rice is the staple food in the diet of Iranian population and the health risk potential of the rice contaminated with heavy metals, we should take the following measures into account: periodic monitoring of heavy metals in the water and rice seeds in different areas, planning comprehensively to establish an appropriate operating system to reduce heavy metal emissions, and using international experiences.

Conflict of Interest: None declared.

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