Iranian J. Publ. Health, Vol. 30, Nos. 3-4, PP. 129-132, 2001

Lead and Cadmium Content of Korbal Rice in Northern Iran

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Key Words: Rice, lead, cadmium

ABSTRACT
Every year the entrance of factory wastes such as Shiraz Petrochemical Complex, Marvdasht sugar cube factory, and Charmineh factory, and other industrial units into the Kor and Sivand rivers and also the entrance of the Marvdasht and Zarghan city sewer system wastes into the Kor river and the use of their water in the cultivation of the rice has caused a significant increase in the lead and cadmium content of the grains of rice. To study the effect of the Kor river's pollution on the lead and cadmium content of the Korbal rice samples. The results of the study show that the lead and cadmium content of the grains of rice, 57 samples of 6 different types of rice were prepared in 19 different stations in Korbal region and also 18 samples of 6 different types of rice, cultivated with unpolluted water, were prepared in the National Institute of Rice Research (Gilan). A comparison of the pollution level of the Korbal and Gilan rice samples shows a significant difference and indicates the significant effect of the pollution of the river on the lead and cadmium content of the Korbal rice samples. The results of the study show that the lead and cadmium content of the hybrid, prolific, and late rice sample types were greater than that of unprolific and early types, such that the amount of these two elements were highest in the Hassani type (the lead content was 0.9625 ppm and the cadmium content was 0.0793 ppm), whereas the Gasroddashti type which blooms earlier and is long seeded has the lowest amount of these two elements.

INTRODUCTION
The daily increase in the population has caused an irregular expansion of human activities. Every year factories and industrial units, agricultural lands and city sewers cause the pollution of agricultrural lands by adding large resources of contaminated water containing heavy metals (4, 6).The use of this water for farming can cause potential harm to humans (1).
Lead and cadmium causes accumulation and in the long term cause an insufficiency in different tissues and organs. The use of contaminated water in the rice fields causes an increase in the lead and cadmium content of the grains of rice and the consumption of this rice causes it to enter the body. According to the research done, countries whose main food is rice, the contaminated rice causes an intake of cadmium. In Indonesia, 50 percent of their cadmium intake comes from the rice they consume (17).This amount is 40 to 60 percent in Japan (16). Considering the individual consumption of rice in Iran, which is approximately 42.4 kg (12), and the area under rice cultivation in the Korbal region, which is approximately 15,000 hectares and is equivalent to 25 percent of the area rice cultivation of the Fars Province in 1999, the importance of this issue becomes obvious (3).

MATERIALS AND METHODS
First, the demographic location of the area was done according to the polluting resources, springs, farming in the region, the situation of the different cities in the region, and also about the types of rice grown in the region. The Korbal region was divided into 19 regions (from the Khan bridge to Bande Jahan Abad) and each of the 19 regions were divided further into four areas (two areas to the left of the river and two areas to the right of the river) and one of those areas was chosen as the sampling station (the samples were obtained according to the type of rice that was mostly grown). At each station 3 samples of each type of rice were prepared. Therefore, 57 samples of 6 different types of rice from the Korbal plain were chosen. To compare the level of pollution of the Korbal region rice, 18 samples of 6 types (type as close as possible to the Korbal rice type) were prepared. These rice were grown with unpolluted water. The method used to prepare the samples was the dry ash method (14). Standard solutions for lead and cadmium and also a control solution with the same ingredients were prepared. Determination of lead and cadmium after digestion of samples by nitric acid was estimated by flame atomic absorption spectrophotometer (Zeiss Model AAs. 4 Germany) at 283.3 nm for lead and 228.8 nm for cadmium and expressed as ppm (7,19).
A recovery test took place to measure the accuracy of the experiments, which shows that this amount was 95.92 percent for cadmium and 93.18 percent for lead. T-test was used to show the significant difference by the statistic program Mstat.

RESULTS
The comparison of the difference in the mean amount of cadmium of the different types of rice samples in the Korbal region (compared two by two) shows that the difference in the mean amount of cadmium among the types Comfiroozi-Lenjani, Gasroddashti-Rahmat Abadi, Comfiroozi-Gasroddashti, and Comfiroozi-Rahmat Abadi, was not significant (Table 2) but in other comparisons (Lenjani-Hassani, Hassani -Gasroddashti, Hassani-RahmatAbadi, 7321-Lenjani, 7321-Rahmat Abadi, 7321-Gasroddashti, and Lenjani-Gasroddashti the difference was significant ($p<0.05$). Comparisons between the different types of Gilan rice samples have also shown that the difference between the types Hassani - Comfiroozi, Comfiroozi-Neda and Comfiroozi-7321 were not significant, but others were significant. The highest cadmium content of the Korbal rice samples belongs to the Hassani type (0.0793 ppm). The cadmium content in the Korbal and Gilan rice samples was lower than the acceptable level (90.2 ppm for rice and 0.1 ppm for grains) (9). Comparison of the mean cadmium content of the same types of rice of the Korbal and

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Gilan regions shows that the difference between the mean cadmium content of the two regions (Korbal and Gilan) was significant ($p<0.001$). Comparison of the mean lead content of the grains of rice in the samples of the Korbal plain shows that the difference between the mean cadmium content of the Lenjani - Rahmat Abadi types was insignificant and the difference was significant among the rest of the types. On the other hand, comparison of the mean lead content of the Gilan rice sample shows that mean difference of the Comfiroozi - Nedatypes was insignificant and the mean difference of the lead content was significant among the rest of the types of rice. Further study showed that the highest lead content of the Korbal rice samples belonged to the Hassani type and was equal to 0.9625 ppm but the lowest lead content belonged to the Gasroddashti type (0.5566 ppm). The lead content of the Korbal rice samples was higher than the acceptable amount but in the Gilan rice samples this element was lower than the acceptable amount (the acceptable amount for grains is 0.1 ppm). In the cluster analysis that was done on all of the samles, from the viewpoint of the level of lead and cadmium pollution, the Korbal rice samples belong in one group and Gilan samples belong in another group, shows the difference in the level of contamination of the rice samples of these two regions.

DISCUSSION

The results of this research shows that the entrance of drainage water from different factories like the Petrochemical Complex (with 21 different factories), Charmineh factory, Marvdasht Kor and Sivand rivers and also the entrance of the Marvdasht and Zarghan city sewer system wastes into the Kor river (4,12) and the use of their water in the cultivation of the rice has sugar cane factory, and other factories located in the path of the caused a significant increase in the lead and cadmium content of the rice samples of the Korbal region, such that the cluster analysis to compare the level of pollution of the Korbal rice samples and the Gilan rice samples (which were cultivated with unpolluted water) showed that because of the difference in the level of lead and cadmium pollution, the rice samples of these regions belong to two different groups. This situation may caused by the Kor river's heavy metal pollution which increases the lead and cadmium content of the grains of rice of the Korbal region.

The result of other researchers indicates that many factors and variables may have an effect on the absorption and storage of cadmium and lead in the grains of rice. The phenomenon of self-cleansing has an effecton the concentration of lead and cadmium in the river (10) because a few of these elements are absorbed by the sediments andthe organic and mineral compounds of the water, therefore, this lowers their level of pollution and concentration in the water (1). pH is an important factor that effects the concentration of the cadmium and lead of the solution because an increase of pH causes a decrease in the solubility of the lead and cadmium compounds. Of course, other factors including the ionic exchange capacity and the competitive effect of the other metallic cations on each other have an effect on the rate of obsorption of lead and cadmium in the rice (2, 15).

Table 1. **Mean cadmium (Cd) and lead (pb) content of the different types of rice samples of the Korbal region (2000) Data are mean of 3 triplicate samples**

Station	Type of Rice	Mean Cd ppm	Standard Deviation	Mean Pb ppm	Standard Deviation
Bande Amir – 1	Hassani	0.0857	0.0004	0.9744	0.0335
Bande Amir – 2	7321	0.0691	0.0005	0.881	0.0455
Zain Abad	Comfiroozi	0.0556	0.0008	0.7964	0.0534
Sultan Abad	Lenjani	0.0527	0.0014	0.6688	0.0629
Bonjeer	Comfiroozi	0.0546	0.0005	0.7977	0.0101
Basheer Abad	7321	0.0634	0.0009	0.869	0.0544
Sofla (Akbar Abad)	Lenjani	0.0519	0.0008	0.6504	0.0431
Koshak	Comfiroozi	0.0679	0.0014	0.7224	0.0152
Hassan Abad	Gasroddashti	0.0569	0.0007	0.854	0.0268
Haji Abad	7321	0.0719	0.0011	0.8307	0.0329
Hossein Abad	7321	0.0672	0.0012	0.8856	0.0145
Amood Abad	Gasroddashti	0.0542	0.0006	0.6014	0.0277
Koorki	Comfiroozi	0.0543	0.0007	0.7402	0.0407
Footooh Abad	Rahmat Abadi	0.0568	0.001	0.6753	0.0379
Rahmat Abad	Hassani	0.0779	0.0017	0.9524	0.0324
Safe Abad	Gasroddashti	0.0561	0.0008	0.5205	0.0126
Movan	Hassani	0.0774	0.0013	0.9606	0.0436
Koodgear	7321	0.0633	0.0007	0.9046	0.0058
Bande Hassan Abad	Comfiroozi	0.0606	0.0003	0.7078	0.0221

A comparison done on the mean lead and cadmium content of the different types of rice showed that genetic makeup of the rice plant is an important factor in the absorption of lead and cadmium. Even though 88 percent of the cadmium and 70 percent of lead absorbed by the rice plant is accumulated in the roots and a small portion of them are stored in the grains (20), since their rate of absorption and storage in the period before clustering is insignificant, in the season of clustering their absorption rate suddenly increases and this has to do with the metabolism of the plant (11).

Just as we've shown in the results, in the hybrid and prolific types, the rate of absorption and storage of lead and cadmium was higher. For example, the highest amount of these two metals belongs to the Hassani type, which is a prolific type. On the other hand, the lowest amount of lead and cadmium absorption and storage belongs to the unprolific and desirable types such as Rahmat Abadi and Gasroddashti.

The main reason for higher lead and cadmium content of these types is the great need of mineral element of the plant during the clustering period. On the other hand, the longer the drying time of the cereals before harvesting, the higher the rate of absorption and accumulation of the heavy metals in the grains of rice, such that the highest cadmium content of the Korbal rice samples belonged to the Hassani type (0.0793 ppm) and the highest lead content belonged to the Hassani type (0.9625 ppm) and the lowest lead content belonged to the Gasroddashti type (0.5566 ppm).

The comparison of the mean lead and cadmium content of the different types shows that when two types that are being compared have greater genetic differences, there is a greater difference in the rate of storage of these two elements in the grains of rice. According to our research, the Korbal rice pollution is so critical. Moreover, the rice of this region has a lower quality compared to the rice of other parts of Fars which use unpolluted water for rice cultivation. Eventhough there have been plans to reduce the entrance of pollution to the Kor River by the Fars Environmental Protection Agency (18), but this doesn't seem to be enough. Also, the education and control of correct chemical fertilizers and pesticides use in farms and surrounding plains can play an important role in the reduction of heavy metals contamination. The filtration and prevention of the entrance of polluting resources like Marvdasht city sewer wastes also plays an important role in the reduction of pollution (5). Rinsing and soaking the rice before cooking also has an effect on the quality of the rice and the elimination of the metalic contaminants (especially soaking in a water and salt solution). Therefore, repetitive washing of the rice and the drainage of the excess water after cooking can greatly reduce the level of metalic elements (8).

Table 2. **The comparison of mean cadmium content of the different types of rice samples of the Gilan (National Rice Research Institute) Data are mean of 3 triplicate samples**

Type of Rice	Mean Cd Ppm	Standard Deviation	P Value
Gasroddashti **Hassani**	0.0011 0.0111	0.0007 0.0008	P<0.01
Gasroddashti **7321**	0.0011 0.0103	0.0007 0.0003	P<0.01
Gasroddashti **Comfiroozi**	0.0011 0.0095	0.0007 0.0007	P<0.05
Hassani **Comfiroozi**	0.0111 0.0095	0.0008 0.0007	P>0.05
Gasroddashti **Neda**	0.0011 0.0122	0.0007 0.0004	P<0.01
Gasroddashti **Nemat**	0.0011 0.0151	0.0007 0.0006	P<0.05
Neda **Nemat**	0.0122 0.0151	0.0004 0.0006	P<0.05
7321 **Neda**	0.0103 0.0122	0.0003 0.0004	P<0.05
7321 **Nemat**	0.0103 0.0151	0.0003 0.0006	P<0.01
Comfiroozi **Neda**	0.0095 0.0122	0.0007 0.0004	P>0.05
Comfiroozi **Nemat**	0.0095 0.0151	0.0007 0.0006	P<0.05
Comfiroozi **7321**	0.0095 0.0103	0.0007 0.0003	P>0.05
Hassani **7321**	0.0011 0.0103	0.0007 0.0007	P=0.00
Hassani **Nemat**	0.0111 0.0151	0.0008 0.0006	P=0.00

Hassani	0.0111	0.0008	P<0.05
Neda	0.0122	0.0004	

Table 3. **The comparison of mean lead content of the different types of rice samples of the Gilan (National Rice Research Institute). Data are mean of 3 triplicate samples**

Type of Rice	Mean Pb ppm	Standard Deviation	P Value
Gasroddashti	0.0521	0.0001	P=0.000
Hassani	0.1073	0.0007	
Gasroddashti	0.0521	0.0001	P=0.000
7321	0.0895	0.0025	
Gasroddashti	0.0521	0.0001	P=0.000
Comfiroozi	0.0782	0.0072	
Hassani	0.1073	0.0007	P<0.0001
Comfiroozi	0.0782	0.0072	
Gasroddashti	0.0521	0.0001	P=0.00
Neda	0.0774	0.0072	
Gasroddashti	0.0521	0.0072	P=0.00
Nemat	0.0603	0.0001	
Neda	0.0774	0.0077	P<0.01
Nemat	0.0603	0.0035	
7321	0.0895	0.0035	P<0.01
Neda	0.0774	0.0077	
7321	0.0895	0.0025	P<0.01
Nemat	0.0603	0.0035	
Comfiroozi	0.00782	0.0072	P<0.05
Neda	0.0774	0.0077	
Comfiroozi	0.0782	0.0072	P<0.01
Nemat	0.0603	0.0035	
Comfiroozi	0.0782	0.0072	P<0.01
7321	0.0895	0.0025	
Hassani	0.1073	0.0007	P<0.01
7321	0.0895	0.0025	
Hassani	0.1073	0.0007	P<0.001
Nemat	0.0603	0.0035	
Hassani	0.1074	0.0007	P<0.01
Neda	0.0774	0.0077	

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