Investigation of pollution level of some heavy metals including cadmium, lead, chromium, and nickel in the flesh of farmed Rainbow Trout in Sepidan City of Fars Province

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Abstract: According to current statistics, per capita consumption of seafood in the world has increased from 14.3 Kilograms (kg) in 1994 to 18.2 kg in 2008. In Iran it has also increased from 1 kg in 1978 (according to the Iranian calendar) to 11 kg in 2010. Parallel to the increasing consumption of seafood, health of fish has been more of concern. Hence, detection and measurement of heavy metals are very vital due to their biological process and accumulation. In order to measure the concentration of cadmium, lead, chromium, and nickel in the flesh of farmed Rainbow Trout, 240 fish were selected from 10 fish farms in Sepidan, Fars Province during the spring and the summer and the amount of these heavy metals was determined after chemical digestion process and using atomic absorption device. Mean concentration of lead, chromium, cadmium, and nickel in tissue of studied fish (at dry weight of fish) were 0.046, 0.06, 0.053, and 0.3 ppm (part per million), respectively. The results also showed that the concentration of lead, cadmium, Chromium, and nickel exceeded the maximum allowable concentration prescribed by WHO (World Health Organization) in 27%, 8%, 3%, and 25% of studied fish, respectively. Distribution of heavy metals in the tissue of studied fish was nearly identical and no significant statistical difference was observed between their concentrations, but the amount of these heavy metals in farmed fish was more than the marine ones. Comparison of obtained figures with standards of WHO showed that the amounts of lead, chromium, cadmium, and nickel were lower than the limits of WHO.

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1. Introduction

Due to increased population and need of humans for food, the use of edible aquatic organisms, especially fish as a reliable source of protein has been growing (ASGHAR A.HENRICHSON RL.1982). As statistics say, per capita consumption of seafood in the world from 14.3 Kilograms (kg) in 1994 reached 18.2 kg in 2008 and in Iran it has also increased from 1 kg in 1978 (according to the Iranian calendar) to more than 11 kg in 2010 . Fish is not only a delicious, quickly digested, and hematopoietic food but also contains proteins, minerals, vitamins, and Omega-3 fatty acids which have many positive effects on physical and mental health. Rapid increase of population and development of residential, commercial, industrial, and agricultural centers have resulted in increased municipal, industrial, and agricultural waste and sewage which have contaminated the environment of humans and aquatic organisms. Contamination of aquatic products by heavy metals is one of the concerned issues. Heavy metals are refractory pollutants that cannot decompose in nature through chemical or biological processes like organic matter (PIEZ KA. 1997). One of the important impacts of heavy metals is their high biological extension in the food chain. As a result of this process, their amount in the food chain can increase to several times more than their amount in water or air. The first outbreak of poisoning caused by consumption of fish contaminated with heavy metals in humans was observed in Minamata Bay in Japan in 1953, during which more than 43 local residents died of consumption of contaminated fish by industrial sewage of a factory and more than 700 suffered permanent disabilities. Hence, the importance of this issue encouraged us to measure and controls these heavy metals in the flesh of farmed Rainbow Trout in Sepidan city in order to ensure the health quality of food products and prevent hazards to humans.

2. Material and Methods

In order to measure the concentration of cadmium, lead, chromium, and nickel in the flesh of farmed Rainbow Trout, 240 fish were selected during the spring and the summer. Fish collected in each stage were thoroughly cleaned and washed with deionized water in the laboratory; 20 to 30 grams of their edible meat weighted, and finally put in oven (105^{0C}) for 44 hours. Then samples were transferred to a desiccator and pulverized in a porcelain mortar until to completely powder after reaching a constant weight (YI –Chun Chen and Meng – Hsin

Chen,2001). Then 0.5 grams of powdered samples of fish was put in a beaker, 5 ml of concentrated nitric acid added to it, and heated on a gravel oven at 140^{0C} until converted to a transparent solution. Obtained suspensions were filtered using filter paper and then transferred to a graded flask and its volume was increased to 50 ml. After stirring and being homogenous, obtained solution was injected to atomic absorption device and absorption and concentration figures were recorded (GUSTAVSON K, 1986).

Chemicals with high purity degree including concentrated nitric acid (65%) (Merck, Germany), Whatman filter (England), deionized water, etc, Perkin-Elmer 2380 Atomic Absorption Spectrophotometer, Memmr (made in England), and other laboratory supplies were used in this study.

Data obtained from this study were statistically analyzed using SPSS software and two tests including t-test to determine presence or absence of difference in the mean of independent groups and variance analysis test to compare the mean of quantitative variable in 2 or more than 2 independent groups.

3. Results

Standard solution addition and metal recovery percentage were used to ensure the extraction method of heavy metals from fish samples and obtaining the correct amount of them. This method is also applicable for controlling reagents, tools, devices, and methods. In this study, 10 ml of standard solution (cadmium, chromium, nickel, and lead) with a concentration of 1 ppm was added to samples. It is noteworthy to say that two similar samples were prepared in identical condition but standard solution was added only to one of them. Then the concentration of each of them was separately determined and metal recovery percentage was calculated using the following formula (Mark J.Hammer, 2004).

Table 1: The results of standard solution addition and recovery percentage of studied heavy metals in farmed Rainbow Trout

Recovery percentage	Concentration of sample after adding standard solution (ppm)	Concentration of added standard solution (ppm)	concentration of the sample without standard solution (ppm)	Metal
1.97	**078.1**	**1**	**107.0**	cadmium
93	**993.0**	**1**	**063.0**	chromium
96	**48.0**	**1**	**53.0**	Lead
2.95	**363.1**	**1**	**41.0**	nickel

Concentration of cadmium, chromium, lead, and nickel in the flesh of studied fish are listed in Table 2.

Table 2: Concentration of cadmium, chromium, lead, and nickel in the flesh of farmed Rainbow Trout in Sepidan city

Lead (ppm)	Nickel (ppm)	Chromium (ppm)	Cadmium (ppm)	Statistical indices	Studied fish farms
442.0	**322.0**	**333.0**	**065.0**	Mean	Fish farm 1
185.0	**146.0**	**345.0**	**034.0**	Standard deviation	
12.-0 76.0	**09.-0 65.0**	**01.76-0.0**	**02.16-0.0**	Minimum and Maximum	
48.0	**284.0**	**062.0**	**064.0**	Mean	Fish farm 2
226.0	**057.0**	**105.0**	**028.0**	Standard deviation	
06.-0 06.1	**017.-0 41.0**	**03.31-0.0**	**03.-0 015.0**	Minimum and Maximum	
482.0	**303.0**	**079.0**	**058.0**	Mean	Fish farm 3
193.0	**129.0**	**033.0**	**027.0**	Standard deviation	
21.-0 03.1	**11.-0 62.0**	**03.19-0.0**	**1.13-0.0**	Minimum and Maximum	
487.0	**291.0**	**09.0**	**054.0**	Mean	Fish farm 4
181.0	**108.0**	**086.0**	**012.0**	Standard deviation	
26.77-0.0	**19.-0 5.0**	**02.022-0.0**	**03.07-0.0**	Minimum and Maximum	
43.0	**296.0**	**088.0**	**056.0**	Mean	Fish farm 5
148.0	**052.0**	**056.0**	**02.0**	Standard deviation	
26.77-0.0	**26.-0 41.0**	**03.-0.0**	**04.11-0.0**	Minimum and Maximum	
48.0	**31.0**	**085.0**	**068.0**	Mean	Fish farm 6
209.0	**11.0**	**02.0**	**021.0**	Standard deviation	
25.85-0.0	**17.49-0.0**	**06.13-0.0**	**04.11-0.0**	Minimum and Maximum	
44.0	**32.0**	**08.0**	**057.0**	Mean	Fish farm 7
18.0	**15.0**	**03.0**	**03.0**	Standard deviation	
12.-0 76.0	**09.-0 65.0**	**03.19-0.0**	**02.16-0.0**	Minimum and Maximum	
48.0	**28.0**	**06.0**	**06.0**	Mean	Fish farm 8
23.0	**06.0**	**11.0**	**03.0**	Standard deviation	
06.-0 06.1	**17.-0 41.0**	**03.31-0.0**	**03.-0 015.0**	Minimum and Maximum	
4.0	**3.0**	**07.0**	**05.0**	Mean	Fish farm 9
18.0	**15.0**	**03.0**	**03.0**	Standard deviation	
11.-0 75.0	**08.64-0.0**	**02.18-0.0**	**01.15-0.0**	Minimum and Maximum	
46.0	**26.0**	**05.0**	**058.0**	Mean	Fish farm 10
23.0	**06.0**	**11.0**	**03.0**	Standard deviation	
05.-0 05.1	**16.-0 40.0**	**02.30-0.0**	**03.-0 015.0**	Minimum and Maximum	
5.0	**38.0**	**2.0**	**1.0**	Standards of WHO	

* According to the agreement with Department of Fisheries, the name of fish farms were decided not to be mentioned.

3. Discussions

The results of variance analysis showed that there is no significant difference between the mean concentration of lead (0.691), nickel (0.418), and cadmium (0.662) and they uniformly existed in the tissue of studied fish. The amount of these heavy metals in fish farm 3 was slightly more than other fish farms. This may be attributed to contamination of fish food and water of fish farm.

Mean concentration of lead, chromium, cadmium, and nickel in tissue of studied fish (at dry weight of fish) was 0.046, 0.06, 0.053, and 0.3 ppm (part per million), respectively which are lower than the maximum allowable concentration prescribed by World Health Organization. The results of t-test showed that there is no significant difference between mean concentration of lead, nickel, and cadmium in tissue of farmed fish.

Comparison of the results of the present study with previous research in the Caspian Sea shows that mean concentration of lead in fishes of the Caspian Sea (1.04 ppm at dry wet of fish) is 2 times more than farmed fish. This may be because of several reasons including more pollution of the Caspian Sea; massive entry of municipal, industrial, and especially agricultural wastewater into the sea; blockade of the Caspian Sea and lack of connection with the open sea; different methods of chemical digestion of samples, fish species, type of tested tissue, etc (APHA, AWWA1992., American Society for Testing and Materials, 1994). Also, a comparison between concentration of cadmium, lead, and chromium in farmed Rainbow Trout of Sepidan City with those of Guilan Province (0.009, 0.027, 0.337-0.892, and 0.16-0.522 ppm, respectively) showed that concentration of lead and chromium in farmed fish of Guilan Province are 2 times more than those of Sepidan City, but concentration of cadmium in fish farms of Sepidan City is 2 times more than those of Guilan Province. These differences may be due to different quality of water supplies and different methods of chemical digestion of samples.

Comparison of the results of the present study with results of research in other countries shows that the accumulation of studied heavy metals in farmed trout of Sepidan City is approximately equal to fish of Greek waters and Lake Ataturk (15, 16), but is less than fish of border waters of Norway with Russia (17). Compared with marine fishes of Hong Kong, concentration of cadmium and nickel in farmed trout of Sepidan City are less, concentration of chromium is more, and concentration of lead is equal (18). Fishes off the coast of Saudi Arabia and studied farmed trout of Sepidan City share the same accumulation of chromium but concentration of lead and nickel is more in farmed trout of the present study (19). The results also showed that concentration of cadmium in farmed trout of Sepidan City is less than fishes off the coast of Mauritania but more than fishes of Pekooda and An Ping rivers in Thailand (Michele Romeo et al.1999, S.M.Allen – Gill, V. g. Martynov.1995).

Generally, it can be concluded that difference in concentration of heavy metals between farmed fish of the present study and fishes of other countries is due to geographical and environmental conditions, quality of water supplies, adjacent industries, fish species, tested tissue, different experimental conditions, etc.

1.3. Results summary:

Although mean concentration of lead, chromium, nickel, and cadmium in farmed trout of Sepidan City were less than the maximum allowable concentration prescribed by WHO, their amount exceeded this limit in 27%, 8%, 3%, and 25% of studied samples, respectively.

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