Assessment of cadmium and lead in the water and trout fish (*Salmo trutta*) of Zayandehroud River, a case study of Zarinshahr rice farms, Isfahan

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Abstract

This study aimed to investigate the concentrations of two heavy metals, lead and cadmium, in the water of Zayandehroud River which is surrounded by Zarinshahr rice farms. Water was sampled from a depth of 30 cm during June, July and August 2015, i.e. during the process of planting, growing and after harvesting, in three stations. Water was collected from three points; 20m before the farms, beside the farms and 100m after the farms. Three water samples and one trout fish (*Salmo trutta*) sample were collected each month and the concentrations of lead and cadmium were measured in the kidney, liver and gills of trout fish. The results showed that the amounts of lead and cadmiumin in the water were less and more than standard levels for these metals, respectively. The average concentrations of cadmium in the water were 15.81, 11.25, 8.92 μg/L during June, July and August, respectively. It is evident that the amount of cadmium in water was significantly higher in June during the planting phase and use of fertilizers and pesticides was more than   the other months ($p \leq 0.01$). There was a correlation in cadmium and lead concentrations between water and fish organs (kidney, liver and gill).

Keywords: Agricultural practices, Heavy metals, Pesticide, Pollution, Fertilizers, Trout fish, Isfahan

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Introduction

Zayandehroud River originates from Deymeh spring of Zardkouh mountain located in Chahar-Mahal-Bakhtiari Province and it ends in the Gavkhoni lagoon. This river is 4200 km is length and water from waterways, springs, returned water and rain water from downstream areas are added to it during its flow and finally it produces the average volume of about $900 \times 10^6 m^3$ of water. This river passes through cities such as Fereidonshahr, Isfahan, Doroche, Felavarjan and Zarinshahr. Its water is used for drinking, agriculture, industry and so on, so the quality of the water is very important (Pourmoghadasi, 2004; Rahmani and Mamanpoush, 2012; Moradi and Nowzari, 2014). Its water pollution has been increased by population growth, development of industries and cities and increased agricultural practices (Witton, 1975; Nriagu, 1978; Karbassi 1989; Chapman, 1992; Bollinger *et al*., 1999; Jonnalagadda and Mhere, 2001; Das and Acharya, 2003; Liou *et al*., 2003; Simeonoy *et al*., 2003; Ramirez and Solano, 2004; TDEC, 2006; Sekonvares, 2012;). Most of its water pollution is caused by agricultural practices and the use of pesticides and fertilizers through which the quantitative effects such as the use of water for irrigation and qualitative effects such as discharge of agricultural drainage influence the water of Zayandehroud (Rahmani and Mamanpoush, 2012).

About 100000 tons of different chemical fertilizers and 450 tons of agricultural pesticides are used in 220000 hactares of lands irrigated by the water from the Zayandehroud River. Agricultural drainage contains dissolved salts, remains of pesticides and herbicides, and remains of chemical fertilizers; therefore, a lot of heavy metals are found in the river water. Excessive amounts of heavy nerals influence aquatic organisms in short or long term and they enter the human body by way of eating fish (Plaskett and potter, 1979; Okonkwo and Mothiba, 2005; Yilitis, 2005; Shrivastava and latoni, 2008; Taghiniu and Rabert, 2010; Imanpour, 2012; Yi *et al*., 2012; Babasaheb, 2014; Darshan, 2014; Shanbezadeh and Karimi, 2014;). This study aims to identify the amount of heavy metals, lead (Pb) and cadmium (Cd), in river water and their bioaccumulation in kidney, liver and gills of trout fish and to survey its reasons.

Previous literature reviews show that Rahmani and Mamanpour (2012) investigated the effects of agricultural practices on the quality of Zayandehroud water by sampling its water. The results show that there are heavy metals in the river water, and that concentrations of copper, manganese, zinc, nickel and cyanide are less than the standard limits for these metals, but levels of Cd vary from 0.01 to 0.02 mg/L which is more than the standard limit for drinking water. Therefore, the quality of used fertilizers and pesticides

must be controlled (Rahmani and Mamanpoush, 2012).

In another investigation, Naderi *et al.* (2013) studied the amount of Pb entering the river water through different ways by sampling of Zayandehroud River water. They concluded that the amount of Pb in the water is less than standard limits so it is not restricted for drinking (Naderi *et al.*, 2013).

In another study Peykanpour *et al.* (2014) investigated the effects of Cd on the liver, kidney, gills and muscle of sturgeon fish. The results show that the amount of Cd has no change in the muscle but a large amount of Cd accumulated in the liver, kidney and gills (Peykanpour *et al.*, 2014).

Velayatzadeh *et al.* (2012) sampled liver of Croaker fish of Bandar Abbas and Bandar Abadan and concluded that the amount of Cd is more than standard limit and Pb is within the standard level (Velayatzade *et al.*, 2012).

Material and methods

Zarinshahr town is located in the center of Lenjan city and is near Zayandehroud River in Isfahan province. Its relative elevation is 1685m from sea level. Its climate is dry and the average annual rainfall and temperature is 511 mm and 14°C, respectively. One of the most important products of this area is rice which is planted on nearly 2000 ha of the farms which are the main factors of Zayandehroud water pollution because of the use of pesticides and chemical fertilizers.

During the planting phase, around mid June, ready rice seedlings enter the farms, and potassium and phosphate fertilizers, micro fertilizers such as zinc sulphate and sulfur, biofertilizers such as nitroxin, fertilized phosphate 2 and Subtilin are used. The pesticides used during this phase are Saturn, Machete and Rustard. The farm is inundated with water at this stage. During the growing phase, rice complex fertilizers, which consist of aluminum sulfate or ammonium nitrate are used. In each of the mentioned phases, when there is a specific problem, other pesticides and fertilizers are used too. The final phase is harvesting, around mid to end of July, because rice ripen in about 30-35 days (Meshkat, 2006).

The method of this study was sampling and measurement. Studied heavy metals were Cd and Pb which enter Zayandehroud river water through the use of pesticides and fertilizers in rice farms of Zarinshahr town and affect water quality and fish in the river. Sampling of river water was performed from 30-cm-depths during June, July and August during planting, growing and after harvesting time. Three stations of sampling were: station 1 (20m before the farms), station 2 (beside the farms) and station 3 (100m after the farms) (Fig. 1). Therefore, 9 water samples and 3 fish samples were sampled.The tool of sampling was a sterile 1.5 L bottle which was filled and emptied by river water several times before sampling.
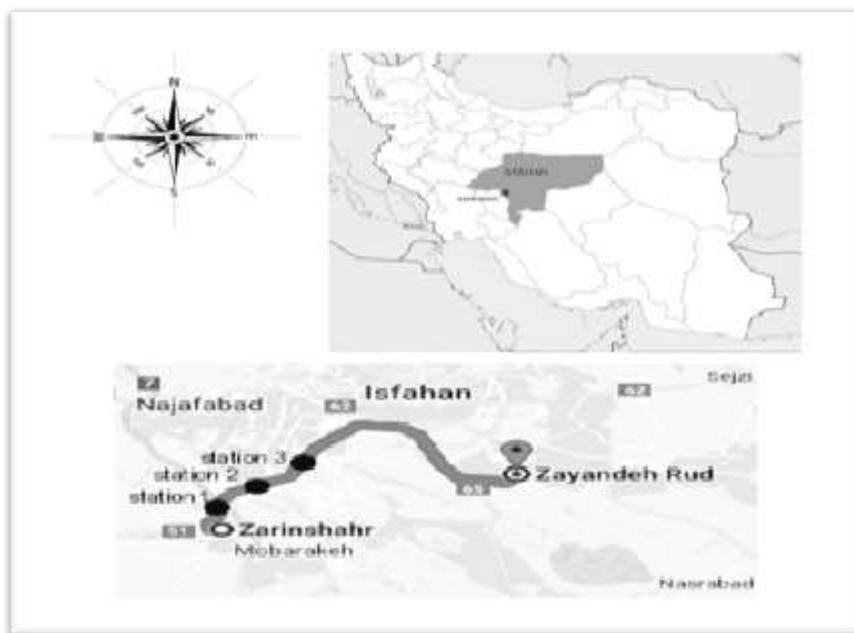
Figure 1: The map of Zayandehroud River and the location of the three stations of sampling.

There was no other condition for this sampling according to light and time when samples arrived at laboratories. The fish samples were collected from the river beside farms and there was not a specific condition. The water samples needed no preparation process while the fish organ samples were treated by acidic digestion. Measurements of the amounts of Pb and Cd in water and fish organ samples were determined by Atomic Absorption Spectrometry.

Normality tests were first used to test data for normality of distribution of frequency. The data were analyzed by One-sample t-test, Paired-sample t-test and Pearson correlation matrix via SPSS software.

Results

The standard levels of heavy metals, Pb and Cd, obtained by the Iranian National Standards Organization (INSO) were as follows: standard levels of Cd and Pb in the water are 3 µg/L and 10 µg/L, respectively; standard levels of Cd and Pb in the fish are 50 µg/kg and 300 µg/kg, respectively (APHA, 1992; WHO, 2008; Rahmani and Mamanpoush, 2012;).

Fig. 2 One-sample t-test showed that there was a significant difference between Cd concentrations with standard levels during the three months ($p \leq 0.01$ for each of 3 months). According to Fig. 2, it was concluded that Cd levels in Zayandehroud River are more than the standard level; on the other hand, in Fig. 2, one-sample t-test shows that there was a significant difference between Cd concentrations with standard levels during three months and there was no significant difference between Pb concentrations with standard levels during the three months.
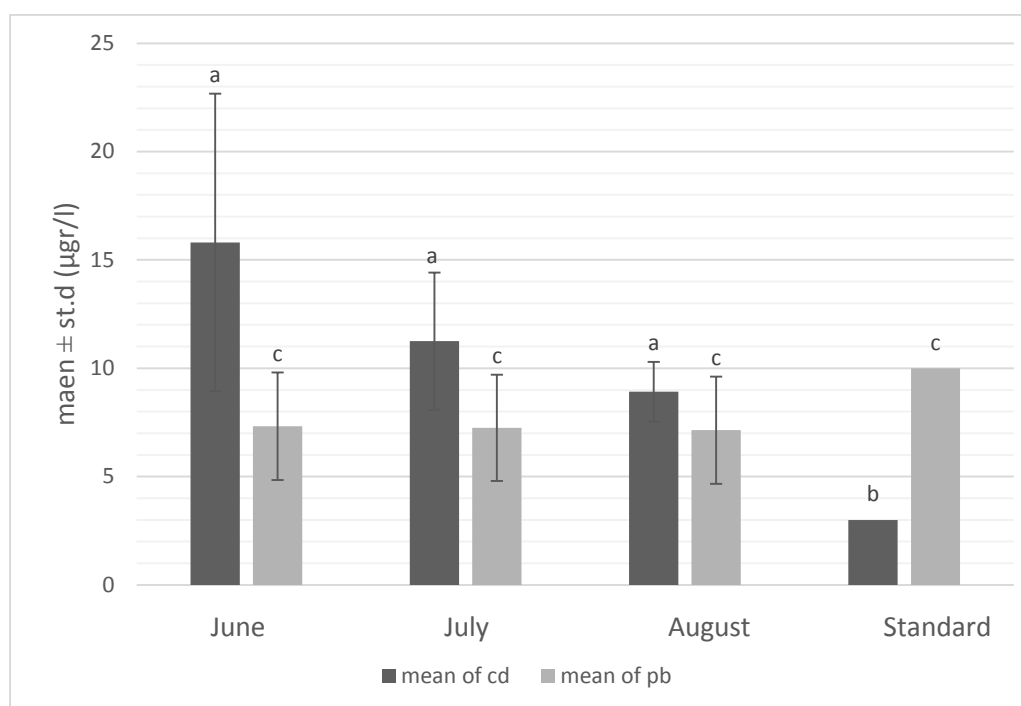
Figure 2: Mean ± standard deviation of Cd and Pb levels in Zayandehroud River water during three months and their standard levels based on INSO.

Therefore, it was concluded that Pb levels are not more than the standard level for this metal in the Zayandehroud River ($p=0.203$, $p=0.191$, $p=0.840$).

In Fig. 3, one-sample t-test shows that there is a significant difference between concentrations of Cd in liver, kidney and gills of fish with standard level ($p\leq0.01$ for eachorgans). Therefore, it was concluded that Cd level in trout fish of Zayandehroud River is more than the acceptable levels for this metal.

On the other hand, in Fig. 3, one-sample t-test shows that there were no significant differences between concentrations of Pb in liver, kidney and gills of fish with standard level ($p=0.162$, $p=0.167$, $p=0.164$, respectively). So, it was concluded that
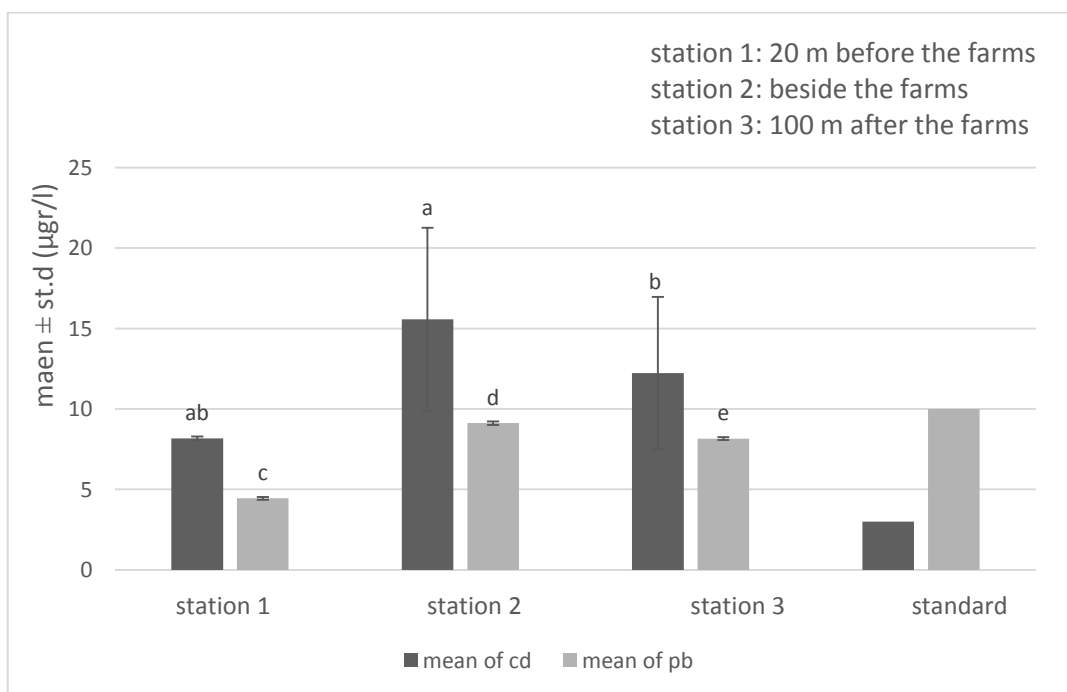
Pb levels in trout fish of Zayanderoud River were not more than standard acceptable level for ths metal. Also, the amount of Cd in liver, kidney and gills was more than the standard level and there were no significant differences.

In Fig. 4, Paired-sample t-test shows that there were significant differences between Cd concentrations in station 2 and 3 ($p\leq0.01$) but there were no significant differences between stations 1 and 2 and 1 and 3($p=0.149$, , $p=0.268$).

On the other hand, in Fig. 4, paired-sample t-test shows that there were significant differences between Pb concentrations in sampling stations ($p\leq0.01$, $p\leq0.01$, $p\leq0.01$, respectively).
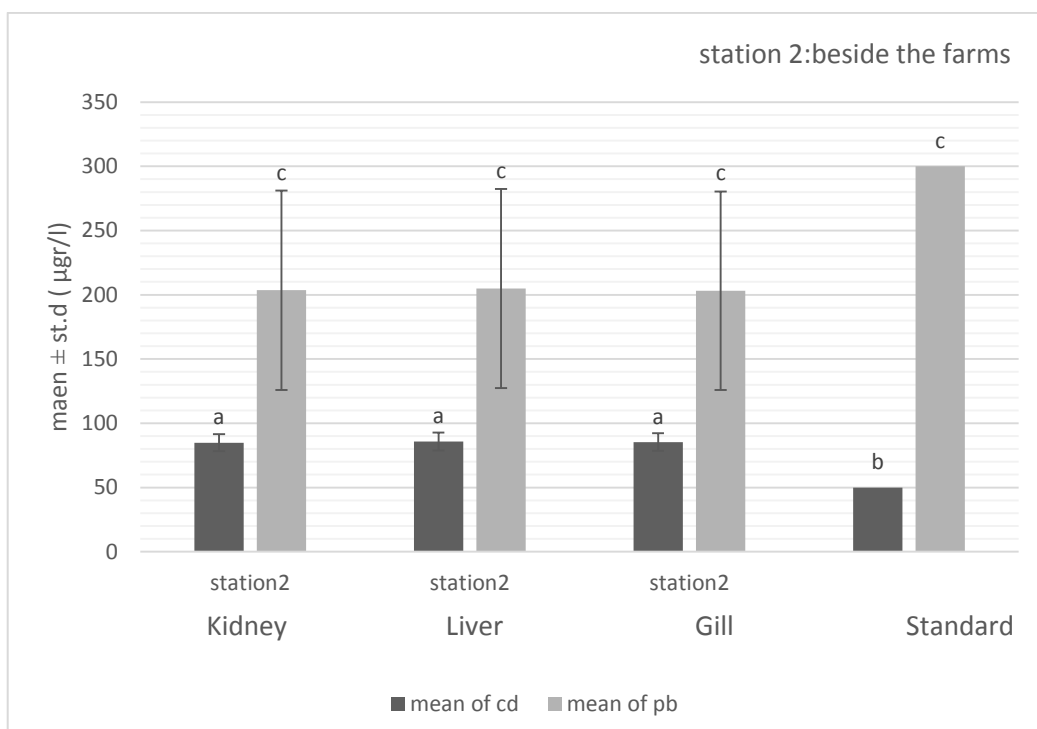
Figure 3: Mean ± standard deviation of Cd and Pb levels in organs of trout fish from Zayandehroud River and the standard levels for these metrals based on INSO.

Figure 4: Mean ± standard deviation of Cd and Pb levels in the water of Zayandehroud River in the sampling stations.

In Fig. 4, amount of cadmium in the water of Zayanderoud River from 3 stations show that the highest amount of cadmium was in June when it was the month of planting and the most chemical fertilizers and pesticides were used. The amount of cadmium is reduced in the other two months. According to Fig. 4, the amount of lead in the warer from Zayanderoud River is the highest in June when it is the month of planting and the most chemical fertilizers and pesticides are used. The amount of lead is alsp reduced in the other two months.

In Fig. 5, paired-sample t-test shows that there were significant differences between concentrations of Cd in different fish organs ($p \leq 0.01$, $p \leq 0.01$, $p \leq 0.01$ for each 3 months).

Also, Fig. 5 shows that there were significant differences between concentrations of Pb in different fish organs ($p \leq 0.01$, $p \leq 0.01$, $p \leq 0.01$ for each 3 months).

In Fig. 5, the amount of cadmium in the liver of trout fish of Zayanderoud River was the highest. Similarly the amount of lead in the liver was the highest.

Significant relationship between the Cd and Pb contents of water and of body organs of the fish by Pearson correlation matrix are given in Tables 1 and 2. The results show that Pb and Cd content of water showed significant and nearly significant association with Pb and Cd content of kidney, liver and gill of the fish during the 3-month-period.
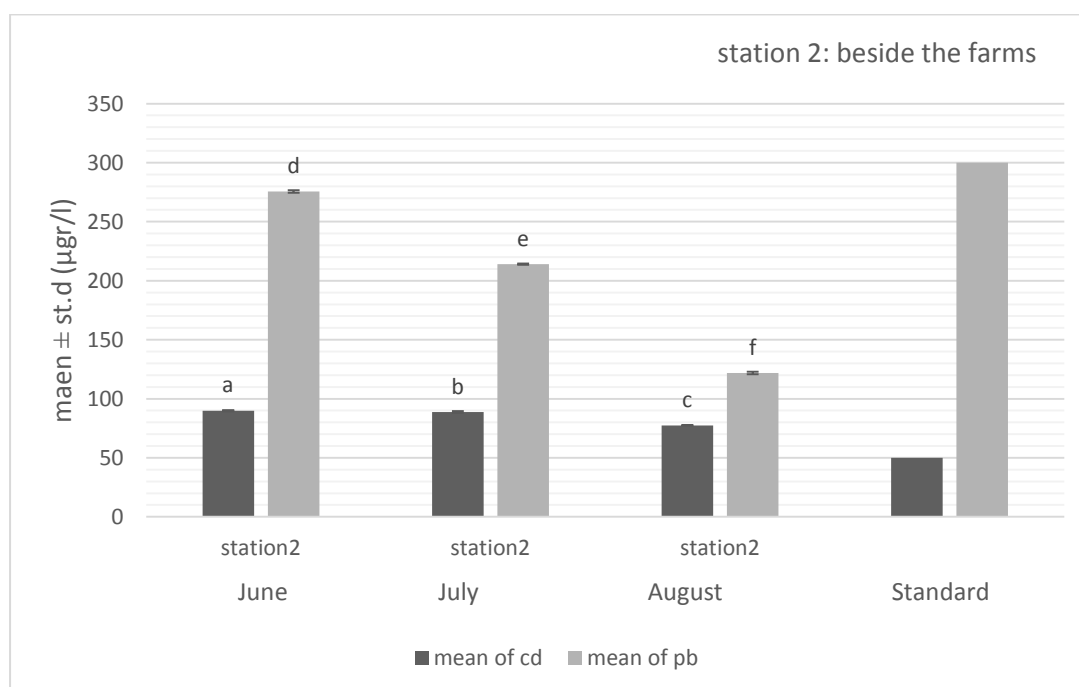
Figure 5: Mean ± standard deviation of Cd and Pb levels in trout fish of Zayandehroud River during 3 months.

Table 1: Pearson correlation matrix between samples of water and organs of the fish in Cd; ln-transformed amounts of Cd in water is related to ln-transformed amounts of Cd in fish organs.

Three-month period	Correlation
Cd in water* Cd in kidney	+ 0.877
Cd in water* Cd in liver	+ 0.857
Cd in water* Cd in gill	+ 0.876

Table 2: Pearson correlation matrix between samples of water and organs of fish in Pb; amounts of Pb in water is related to amounts of Pb in fish organs.

Three-month period	Correlation
Pb in water* Pb in kidney	+ 0.999*
Pb in water* Pb in liver	+ 0.998*
Pb in water* Pb in gill	+ 0.998*

* Correlation that were significant ($p<0.05$).
** Correlation that were significant ($p<0.01$).

Discussion

It is concluded that amount of Cd in water was the most in June because this is the month of planting and fertilizers and pesticides are used. In July, the amount of Cd was reduced because fertilizers and pesticides were used only when it was necessary. In August when it is the month after harvesting, amount of Cd was reduced again.

Also, the results show that the highest amount of Cd in water was beside the rice farms of Zarinshahr due to the use pesticides and fertilizers in the farms. As we go farther from the farms, the amount of Cd in the water was reduced due to the self-purification of the river. The results show that the amount of Cd in fish organs was more than the standard level for this metal and Cd accumulated equally in liver, kidney and gill and affects these organs and

their functions. As a result, it indicated that fish was polluted by Cd. The amount of Cd was more in June than in the other two months.

Although, the amount of Pb was not more than the standard level during these 3 months, its amount was more in the station beside these rice farms and it showed that the use of fertilizers and pesticides is involved in increasing Pb in the water and it is necessary to control quality of fertilizers and pesticides used.

According to the studies about heavy metals of the river water, Rahmani and Mamanpoush (2012) showed that levels of Cd were more than standard levels, while Naderi *et al.*(2013) indicated that amounts of Pb were less than standard levels (Rahmani and Mamanpoush, 2012; Naderi *et al.*, 2013;). Our study revealed that the river water was not polluted by Pb but there was a pollution of Cd and proved what had been found by previous authors.

According to the results of Peykanpour *et al.* (2014), accumulation of Cd was more in fish liver, kidney and gills than in other organs (Peykanpour *et al.*, 2014). Also, Monsefrad *et al.* (2012) indicated that Pb and Cd levels were more than standard levels in the Kutum fish muscles and liver, respectively (Monsefrad *et al.*, 2012). On the other hand, Velayatzade *et al.* (2012) concluded that Pb level was equal to standard level but Cd level was more than standard level in the Croaker fish liver (Velayatzade *et al.*, 2012). Those

results were in accordance with what we found about bioaccumulation of Cd and Pb in trout fish liver, kidney and gills.

In contrast, Ates *et al*. (2008) and Talas *et al*. (2008) showed that Pb and Cd lead to dramatic changes in biochemical and hematological parameters of liver, spleen, heart, and brain tissues of rainbow trout (Ates *et al*., 2008; Talas *et al*., 2008). Also, Oran *et al*. (2008) and Oran and Talas (2008) discussed the oxidative stress induced by Cd in rainbow trout spleen, heart and blood (Oran *et al*., 2008; Oran and Talas, 2008). While Reyahi-khoram *et al*. (2016) concluded that concentration of Cd and Pb were high in Rainbow trout during dry season (Reyahi-khoram *et al*., 2016), our results showed that the increase of Cd and Pb concentration in the water during three months of planting, growing and after harvesting of rice caused to increase concentrations of these heavy elements in liver, kidney and gill of the fish, so it is recommended that people don't do fishery around the rice farms during these three months.

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