

Lead contamination in fishes of the Kor River

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Abstract: Lead concentration in muscle, liver, kidney, brain and gonad tissues of two cyprinid fishes, *Cyprinus carpio* and *Copoeta* spp., from three sections of the upper, middle and lower parts of the Kor River was evaluated in 2006. Totally 225 specimens were caught for this purpose (75 specimens from each zone). Tissue samples were digested in acid and their lead concentrations were assayed by ICP method. Statistical analysis of data showed significantly ($P < 0.05$) higher concentrations of lead in the mid zone than the two other zones. No significant differences ($P > 0.05$) were seen between sexes and species. The same pattern of contamination was also observed in water and sediment samples from three sampling zones. The maximum amount of lead measured in this study (1.85mg/kg), was, however, less than the maximum allowance in fish tissues by European Unions.

Keywords: Lead, Fish, Contamination, Kor River, Fars Province, Iran

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Introduction

Contamination of the aquatic ecosystem by industrial and agricultural pollutants has been of major concern in recent decades (Lee *et al.*, 2006). It is known that heavy metals are amongst the most toxic and environmentally dangerous pollutants (Adami, *et al.*, 2007). Exposure to lead has increased over the century, but has not been of concern until recently. Atmospheric lead concentration worldwide has increased 200-fold during the past 3000 years (Ng *et al.*, 2006). The lead found in estuarine sediment cores comes from regional, large-scale atmospheric sources such as automobile exhaust and industry or from local sources such as gasoline outboard motors or street runoff (Gobel *et al.* 2007).

Lead is a poisonous metal that can damage nervous system, especially in children (Brodkin *et al.*, 2007) and cause blood and brain disorders (Boreland & Lyle, 2006; Rogival *et al.*, 2006). The concern about lead's role in mental retardation in children has brought about widespread reduction in its use (lead exposure has been linked to schizophrenia) (Marjorie Aelion & Davis, 2007; Walker *et al.*, 2007). It has been recognized for a long time that heavy metal toxicity is a cause of or contributor to developmental delays of many aquatic species (Golinska & Bany, 2000; Brown *et al.*, 2005; Mutter *et al.*, 2005).

For an assessment of the toxic effects of different pollutants in the aquatic environment, fish could be very important indicator organisms (Kime *et al.*, 1996). Dead fish as obvious sign of highly polluted water is readily apparent (Rurangwa *et al.*, 1998; Ebrahimi, 2006), while low-level pollution may have no apparent impact on the fish itself, but it may decrease the fecundity of fish populations, leading to a long-term decline and eventual extinction of this important natural resource (Manyin and Rowe, 2006). Such low-level pollution could impact on reproduction, either indirectly via accumulation in the reproductive organs (Cope *et al.*, 1994), or directly on the free gametes (sperm or ovum) which are released into the water (Au *et al.*, 2001).

The Kor River is one of the biggest rivers of northwest Fars province, which originates from Zagros Mountains and joins with Sivand River near city of Marvdasht and finally ends in Bakhtegan Lake. Doroudzan dam was built at the

starting point of the river and many agricultural lands are being irrigated by this river and many big industries are operating at its vicinity. Increase in the number of industries and factories around the river as increased the potential pollution of the river. Shiraz refinery, Shiraz petrochemical complex, Fars leather, Fars dairy factories, Ab-Barik industrial zone, Sina chemical factory, Fars chemical factory, Rishmak factory plus agricultural runoffs and urban and rural sewages are major polluting sources of the Kor River. Since many of those polluting sources drain their wastes directly or indirectly into the Kor River and their sewages may be polluted with Pb, this study was conducted to find out the accumulation of Pb in different tissues of fish caught from the Kor River.

Materials and methods

Samples were collected from three parts of the Kor river, viz upper zone (Doroudzan reservoir as control), mid zone (Band-e-Amir village) and lower zone (Korbal village) (Fig. 1). The upper zone was chosen because there were no agro-industrial activities behind the Doroudzan dam, the mid zone was located at the main industries sewages entry into the river, and the lower zone was the junction of the Kor River to the Bakhtegan Lake.

From each sampling site, 75 fish specimens of two species, *Cyprinus carpio* and *Capoeta* sp. were caught with cast net (225 specimens in total) and transferred alive to lab by keeping them in an ice cooled tanker (4°C). Weight (three different weight groups, 7.5-20g, 20.1-100g and 100.1-600g), length, sex and species of samples were recorded and then their brains, livers, kidneys, ovaries and muscles were dissected and 500 mg from each organ was dissolved in HCl (98%) and nitric acid (65%) solutions (3:7), left for 16 hours in waterbath (100°C) and then deionized water added up to the first volume and kept in freeze till Pb assay.

All samples were defrosted at room temperature and then Pb was assayed by Induction Coupled Plasma (ICP) method, which makes it possible to assay many heavy metals at the same time with small amounts of samples. Ten microliter of each samples thawed at room temperature injected to ICP. ICP first used in 60s but ignored till 90s because spectrophotometry and atomic absorption were being

practiced at the same time. ICP made of a flame which made from Kurtz tube connected to a high frequency generator with 1-5 kilowatts output with an inert gas (usually argon) flows inside the tube, generates a plasma and finally detects heavy metals concentrations.

SPSS 13 for Windows software (SPSS Inc., 444 N. Michigan Avenue, Chicago, Illinois 60611, USA) was used for the statistical analysis of Pb content in different fish tissues and different sampling sites by using multivariate ANOVA.

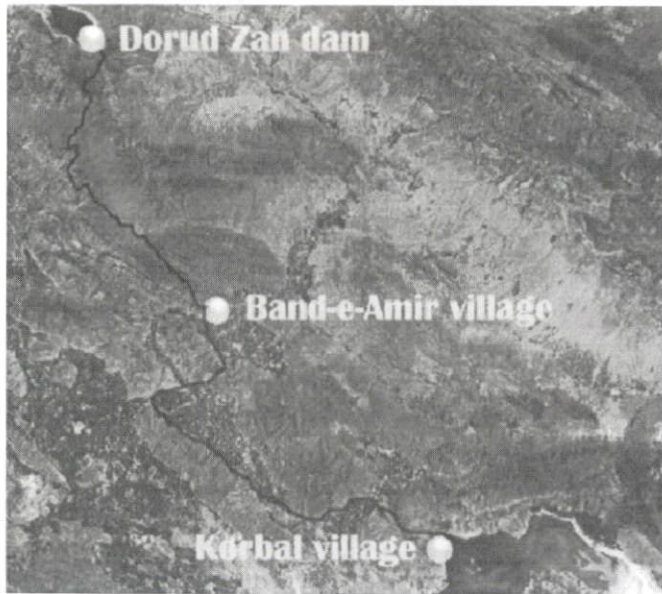


Figure 1: Aerial view of the Kor River and three sampling sites

Results

Maximum and minimum concentrations of Pb in fish tissues were 1.85 and 0.31mg/kg, respectively. The Pb concentrations in fishes tissues (muscle, liver, kidney, brain and gonads) of mid site sampling (Band-e-Amir) were significantly higher ($P < 0.05$) than two other areas (Fig. 2). Applying sex parametere, it revealed the amount of Pb in tissues of male and female fishes of Band-e-Amir were significantly higher ($P < 0.05$) than the same sexes of fishes caught in other areas (Figs. 3 & 4), but no significant differences were observed between male and female fish ($P > 0.05$) (Fig. 5). In both sampled species, Pb concentration was

significantly higher in Band-e-Amir ($P < 0.05$) than the other two sampling sites (Figs. 6 & 7), but no differences seen between the two species ($P > 0.05$) at each site were observed. Finally, no significant differences were seen in three different weight categories ($P > 0.05$) (Fig. 8).

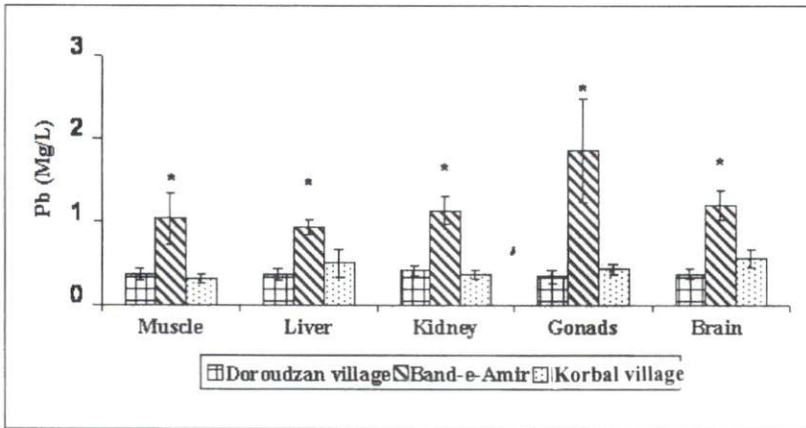


Figure 2: Lead concentrations in different tissues (muscles, liver, kidney, gonads and brain) of fish sampled at three different places. Vertical bars show standard errors of means ($SE \pm Mean$). * indicates significant difference.

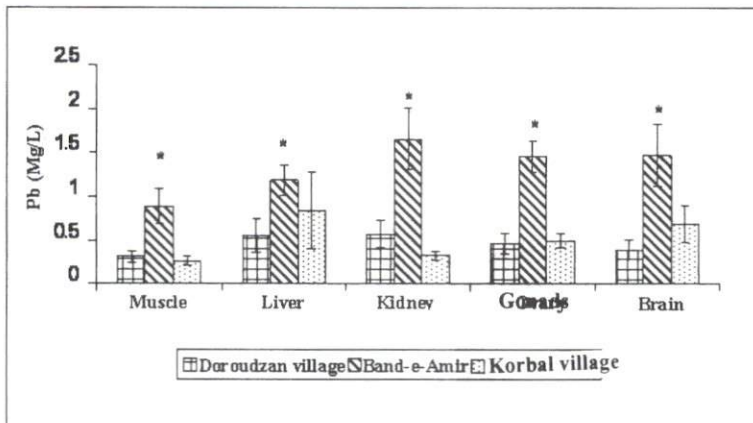


Figure 3: Lead concentrations assayed in different tissues (muscles, liver, kidney, gonads and brain) of male fish sampled at three different places. Vertical bars show standard errors of means ($SE \pm Mean$). * indicates significant difference.

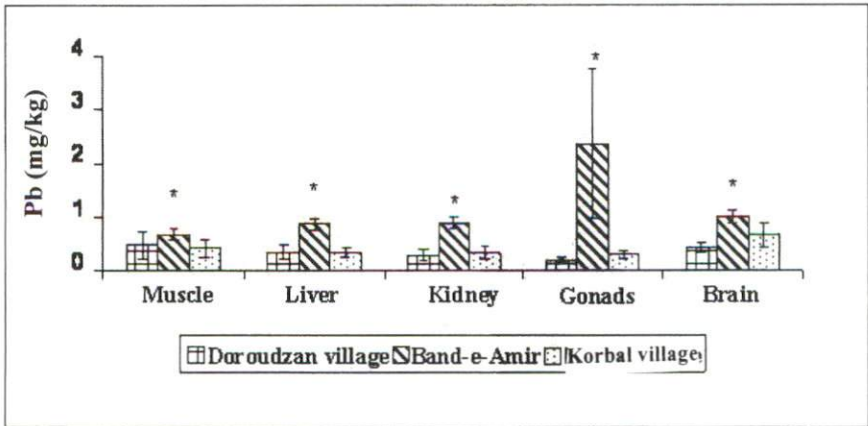


Figure 4: Lead concentrations assayed in different tissues (muscles, liver, kidney, gonads and brain) of female fish sampled at three different places. Vertical bars show standard errors of means ($SE \pm Mean$). * indicates significant difference.

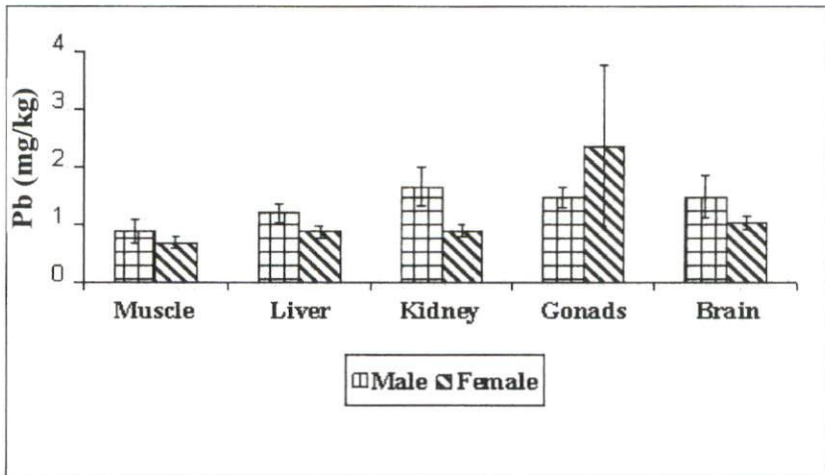


Figure 5: Lead concentrations assayed in different tissues (muscles, liver, kidney, gonads and brain) of male and female fish sampled at three different places. Vertical bars show standard errors of means ($SE \pm Mean$).

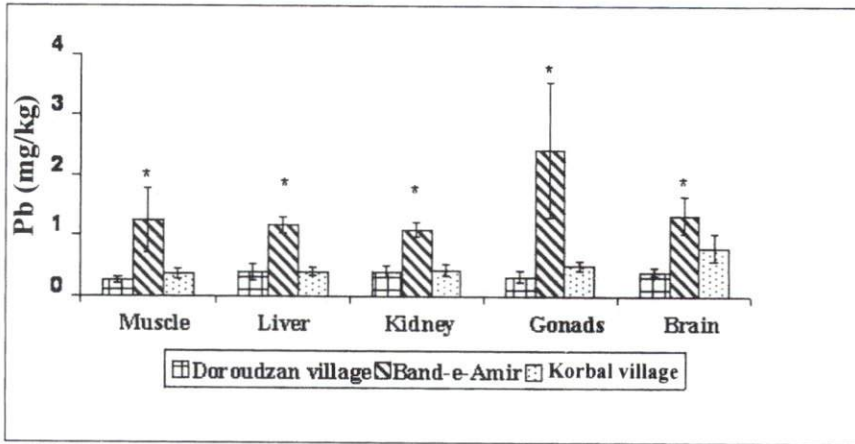


Figure 6: Lead concentrations assayed in different tissues (muscles, liver, kidney, gonads and brain) of common carp sampled at three different places.

Vertical bars show standard errors of means ($SE \pm Mean$).
* indicates significant difference.

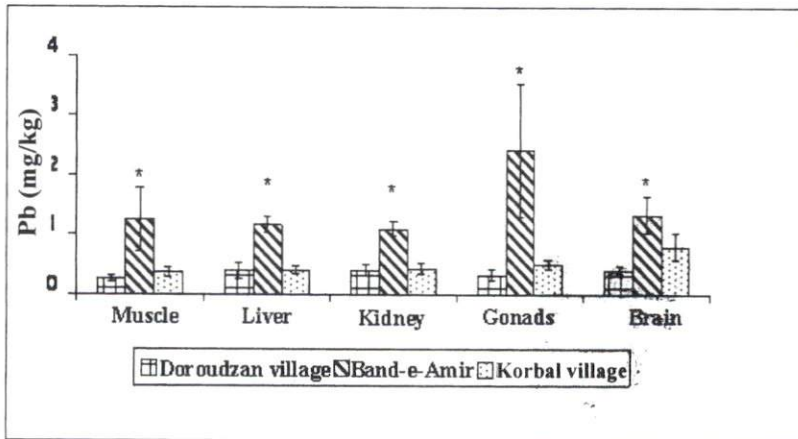


Figure 7: Lead concentrations assayed in different tissues (muscles, liver, kidney, gonads and brain) of *Capoeta spp* sampled at three different places.

Vertical bars show standard errors of means ($SE \pm Mean$).
* indicates significant difference.

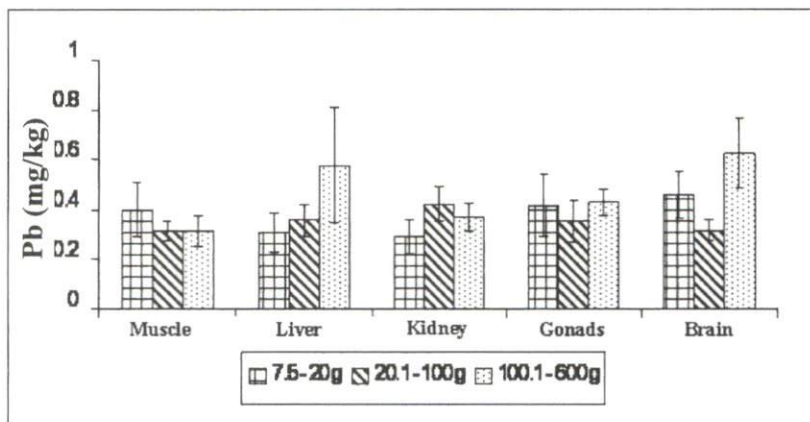


Figure 8: Lead concentrations assayed in different tissues (muscles, liver, kidney, gonads and brain) of three weight categories (7.5-20g, 20.1-100g and 100.1-600g) fish sampled at three different places. Vertical bars show standard error of means (SE \pm Mean).

Discussion

In this study, Pb concentrations in different tissues of two cyprinid species from the upper, middle and lower parts of the Kor River were determined by ICP method. Bioaccumulation occurs when organisms incorporate and retain chemicals from the surrounding environment (Jeffrey *et al.*, 2006). In aquatic ecosystems, these chemicals are associated with water, sediments, suspended solids and prey organisms. If the incorporation of the chemical outpaces the metabolism or excretion of the chemical, then bioaccumulation occurs. The result is that the concentration of the chemical inside the organism is greater than it is in the environment (Dural *et al.*, 2006). Therefore, tissue analysis can reveal the presence of contaminants that may not be detected otherwise, that is, they have such low concentrations in the environment that they cannot be observed through chemical analysis of the water column or sediments (Dural *et al.*, 2006). When used in combination with other diagnostic indicators (e.g. physical habitat and water chemistry) and response indicators (e.g. fish, benthic macroinvertebrate and algal

assemblages), fish tissue analysis can be an effective tool for determining the overall condition of an aquatic ecosystem (Dalmacija *et al.*, 2006).

Fish tissue studies have traditionally focused on the bioaccumulation of contaminants in large game fish because these fish are more likely to pose health risks to humans (Bayen *et al.*, 2005). Fish tissue studies have also focused on the bioaccumulation of toxic chemicals in the fillets and livers of fish as well as in the whole fish (Burger *et al.*, 2005). This study analyzed whole fish of both large and small species and both game and non-game species. While an analysis of the bioaccumulation of toxic chemicals in the fillets of large game fish may give a better indication of the risks to human potential predators, both human and non-human forms consume these organisms. Whole fish analysis that also includes small non-game fish will, therefore, give a better indication of the risks to all potential predators, both human and non-human (Burger *et al.*, 2005).

Therefore, to evaluate the amount of the Kor River contamination with Pb due to industrial sewage pollution, we used fish tissues bioaccumulation from three sites, namely Doroudzan reservoir, Band-e-Amir village (midpoint as a heavily polluted site) and Korbali village (the endpoint of the river before entering to the Lake). The amount of Pb in Band-e-Amir sampling site was significantly higher than the two other sites. It was interesting that no differences in Pb contamination between Doroudzan reservoir and Korbali sampling sites was evident, although the Korbali receives all the polluted water before letting them down to the Bakhtegan Lake. This could be due to recycling of heavy metals in the river and deposition of them into sediments. All big industries are located before the Band-e-Amir and this could be the cause of more Pb contamination in this area.

The amounts of Pb measured in gonads were higher than other organs. It has been shown that heavy metals contamination in reproductive organs may decrease the fecundity of fish populations either indirectly via accumulation in the reproductive organs (Popek *et al.*, 2006), or acting directly on sperm and ovum (Rurangwa *et al.*, 1998).

No differences in Pb accumulation were either seen between the two sexes or between the two fish species in different sampling sites, which could be attributed

to similar degree of accumulation in both sexes and species. It was interesting that no differences were seen between fish of different sizes, which could be due to the low level of pollution and the long time of exposure to contaminants.

Maximum Pb contamination of fish tissues measured in this study was 1.85mg/kg from samples caught at Band-e-Amir site, which was still less than 2mg/kg of maximum allowance contamination of Pb in fish tissues by European Unions (Biggeri *et al.*, 2006). The average Pb contamination of water samples taken from Doroudzan reservoir, Band-e-Amir and Korbali were 2.83, 7.49 and 4.68mg/liter, respectively, which were still less than lethal concentrations for cyprinids (100mg/liter), even though low levels of Pb pollution could insert some adverse effects on fish health and reproduction (Delistraty & Stone, 2007).

There are no industrial or agricultural activities before Doroudzan dam and Pb residue in fish tissues captured from this point could be due to deposition of Pb from atmosphere and polluted air (Ettler *et al.*, 2005). This area could be exposed to polluted air from the nearby large cities (Shiraz, Marvdasht and many industrial towns).

In conclusion, this study shows that industrial activities around the Kor River have already polluted the River and Pb residues in fish tissues and its water is higher than the upstream and terminal parts. The contamination, nevertheless, is still lower than the maximum allowed for Pb in fish tissues but this is still worrisome.

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