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Bioaccumulation of Mercury in Fishes of Kor River

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Abstract: Mercury concentration in muscles, liver, kidneys, brain and gonad tissues of two Cyprinid families, *Cyprinous carpio* and *Copoeta spp.*, of the Kor river was evaluated in 2006. The river was divided into three parts (75 speciments from each part): Upper zone (Doroodzan dam zone as control), mid zone (Band-e-Amir village) and lower zone (Korbal village). Tissue samples were digested in acid and their Hg concentrations were assayed by Induction Coupled Plasma method. Statistical analysis of data showed significantly ($P<0.05$) higher concentrations of Hg in the mid zone than the two other zones. No significant differences ($P>0.05$) were seen between different sexes and species. The same pattern of contamination was also observed in water and sediment samples from three sampling zones. The maximum amount of Hg measured in this study was 0.99mg/kg BW which was lower than the maximum allowance in fish tissues by European Unions.

Key words: Mercury, Fish, Bioaccumulation; Kor River, Fars, Iran

INTRODUCTION

A number of wide-ranging monitoring studies have been performed in order to estimate the degree of mercury (Hg) contamination in freshwater ecosystems (Gamberg *et al*., 2005, Ikingura *et al*., 2006, Jewett and Duffy, 2007). Knowledge regarding contamination of different levels of the food chain is necessary for estimation of total pollutant input fluxes and subsequent partitioning among different phases in the aquatic system (Tsui and Wang, 2004, Ikingura *et al*., 2006, Evers *et al*., 2007). The growing international concern about this environmental data is closely related to the strongly developing ecological risk assessment activities (Lewis and Chancy, 2007). In addition, freshwater monitoring outputs hold a key position in the estimation of the Hg dose consumed by the human population as it is highly dependent on fish consumption. So monitoring of Hg in the tissue of edible fish is extremely important because consumption of contaminated fish has caused serious neurological damage to newborn babies and adults (Ramirez-Perez *et al*., 2004, Sankar *et al*., 2006, Burger *et al*., 2007). Mercury tends to accumulate in fish tissue, particularly, in the form of methylmercury, which is about 10 times more toxic than inorganic mercury (Andreji *et al*., 2006). 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 bioaccumulation 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 has 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 Hg, this study was conducted to find out the bioaccumulation of Hg in different tissues of fish caught from the Kor River.

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

MATERIALS AND METHODS

Sampling:

Samples were collected from three parts of the Kor river, 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 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 speciemens of two species, *Cyprinus carpio* and *Capoeta* sp. were caught with cast net (225 speciemens in total) and transferred alive to lab by keeping them in an ice cooled tanker (4°C). Weight (three different weight groups, 7.5-20 g, 20.1-100 g and 100.1-600 g), 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 was added up to the first volume and kept in freeze till Hg assay.

Hg assay:

All samples were defrosted at room temperature and then Hg was assayed by Induction Coupled Plasma (ICP-OES) 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 into ICP. SPSS 13 for Windows software was used for the statistical analysis of Hg content in different fish tissues and different sampling sites by using multivariate ANOVA (95% significancy level).

RESULTS

Maximum and minimum concentrations of Hg in fish tissues were 0.99 and 0.08mg/kg BW, respectively. The Hg concentrations in fishes tissues (muscle, liver, kidney, brain and gonads) of mid site sampling (Band-e-Amir) were significantly higher ($P<0.05$) than the two other areas (Table 2). The amount of Hg in tissues of male and female fishes of Band-e-Amir were significantly ($P<0.05$) higher than the same sexes of fishes caught in other areas (Figs. 3 & 4). No significant differences were observed between Hg concentrations of male and female fish (Table 5). In both sampled species, Hg concentration was significantly ($P<0.05$) higher in Band-e-Amir than the other two sampling sites. No differences were seen between the two species ($P>0.05$) among different sites (Table 6). Finally, no significant differences were found in three different weight categories ($P>0.05$) (Table 7).

Table 2: Hg concentrations in different tissues (muscles, liver, kidney, gonads and brain) of fish sampled at three different places (SE ± Mean).

	Muscle	Liver	Kidney	Gonads	Brain
Upper Zone	0.16±0.04	0.24±0.12	0.13±0.07	0.08±0.02	0.27±0.12
Mid Zone	0.77±0.19	0.99±0.16	0.92±0.22	0.84±0.12	0.81±0.13
Lower Zone	0.24±0.10	0.31±0.11	0.47±0.03	0.32±0.10	0.28±0.09

Table 3: Hg concentrations assayed in different tissues (muscles, liver, kidney, testis and brain) of male fish sampled at three different places (SE ± Mean).

	Muscle	Liver	Kidney	Gonads	Brain
Upper Zone	0.29±0.04	0.09±0.05	0.25±0.11	0.23±0.10	0.32±0.11
Mid Zone	0.80±0.19	0.70±0.16	0.88±0.18	1.10±0.30	0.81±0.12
Lower Zone	0.37±0.10	0.10±0.02	0.33±0.18	0.21±0.06	0.47±0.12

Table 4: Hg concentrations assayed in different tissues (muscles, liver, kidney, ovary and brain) of female fish sampled at three different places (SE ± Mean).

	Muscle	Liver	Kidney	Gonads	Brain
Upper Zone	0.13±0.02	0.12±0.02	0.31±0.09	0.21±0.09	0.28±0.08
Mid Zone	0.72±0.15	0.94±0.16	0.82±0.18	1.12±0.24	0.69±0.11
Lower Zone	0.49±0.12	0.18±0.05	0.72±0.42	0.35±0.12	0.27±0.07

Table 5: Hg concentrations assayed in different tissues (muscles, liver, kidney, gonads and brain) of male and female fish sampled at three different places (SE ± Mean).

	Muscle	Liver	Kidney	Gonads	Brain
Female	0.16±0.04	0.24±0.12	0.47±0.17	0.08±0.02	0.27±0.12
Male	0.29±0.13	0.09±0.05	0.25±0.11	0.23±0.10	0.32±0.11

Table 6: Hg concentrations assayed in different tissues (muscles, liver, kidney, gonads and brain) of Common Carp and *Capoeta spp* fish sampled at three different places (SE ± Mean).

	Muscle	Liver	Kidney	Gonads	Brain
Capoeta Spp.	0.134±0.021	0.118±0.022	0.314±0.086	0.210±0.091	0.277±0.084
Common Carp	0.253±0.071	0.195±0.089	0.374±0.131	0.087±0.029	0.257±0.088

Table 7: Hg 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 (SE ± Mean).

	Muscle	Liver	Kidney	Gonads	Brain
7.5-20g	0.311±0.079	0.233±0.070	0.302±0.082	0.208±0.097	0.320±0.091
20.1-100g	0.385±0.076	0.156±0.024	0.619±0.239	0.150±0.041	0.326±0.077
100.1-600g	0.202±0.059	0.205±0.061	0.231±0.060	0.298±0.071	0.305±0.105

DISCUSSION

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 has 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 Hg, this study was conducted to find out the bioaccumulation of Hg in different tissues of fish caught from the Kor River.

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).

The amount of Hg in Band-e-Amir sampling heavily polluted site was significantly higher than the two other sites. Although the Korbal receives all the polluted water before letting them down to the Bakhtegan Lake, no differences in Hg contamination between Doroudzan reservoir and Korbal sampling sites was evident,. 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 Hg contamination in this area.

The amounts of Hg measured in gonads were higher than other organs. It has been shown that heavy metal 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 Hg 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 among fish of different sizes which could be due to the low level of pollution and the long time of exposure to contaminants.

Maximum Hg contamination of fish tissues measured in this study was 0.99mg/kg BW from samples caught at Band-e-Amir site, which was still less than 1mg/kg BW of maximum allowance contamination of Hg in fish tissues by European Unions (Regulation 466/2001 of 8 March 2001, setting maximum levels for certain contaminants in foodstuffs, OJ L 77, 16.03.2001, as amended by Commission Regulation 221/2002 of 6 February 2002, OJ L 37, 7.02.2002) (Biggeri *et al*., 2006). The average Hg contamination of water samples taken from Doroudzan reservoir, Band-e-Amir and Korbal were 0.006, 0.036 and 0.011mg/liter, respectively, which were still less than lethal concentrations for cyprinids (4mg/liter), even though low levels of Hg pollution could insert some adverse effects on fish health and reproduction (Delistraty and Stone, 2007).

There are no industrial activities before Doroudzan dam and Hg residue in fish tissues captured from this point could be due to deposition of Hg 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 Hg 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 Hg in fish tissues but this is still worrisome.

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