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Study of the Application of Fish Scale as Bioindicator of Heavy Metal Pollution (Pb, Zn) in the *Cyprinus carpio* of the Caspian Sea

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Abstract: The general purpose of this study is investigating the degree of heavy metal accumulation in scales, livers and gonads of the *Cyprinus carpio* and determining fish scale as the most suitable bioindicator for lead and zinc sedimentation in the environment of the sampling stations. Also, amounts of lead and zinc in the livers, scales and gonads tissues of the *Cyprinus carpio* are measured and a comparison is made between the amounts measured in the sediments and those measured in the livers, gonads and scales of the fish. Five sampling stations at different districts in the following cities were chosen: Astara, Hashtpar, Bandar Anzali, Ramsar and Chalous. Samples were prepared and classified according to fish organs as sedimental samples, liver samples, scale samples and gonad samples and then lead and zinc levels were measured in them. Results of this study show that fish scale is a better index of zinc content than liver and gonad in addition; fish scale is a better index of lead content than gonad. As no strong correlation was found between lead pollution level in the environment and that in fish scales, it was concluded that fish scale is a weaker index for lead than for zinc. The results obtained of the bioaccumulation of lead in the related tissues was found to be in the following order: Liver average ‹ Female gonad average ‹ Sediments average ‹ Male gonad average ‹ Scales average. The bioaccumulation of zinc in the studied tissues was found to be in the following order: Male gonad average ‹ Sediments average ‹ Female gonad average ‹ scales average ‹ Liver average.

Key words: Heavy metals, scale, gonad, liver, *Cyprinus carpio*, Caspian Sea

INTRODUCTION

In recent years, because of the importance of heavy metals in human body (both the essential and nonessential ones) many studies were done with rats (Musavi *et al*., 2007).

Metal bioaccumulation can apply to the entire organism, including both metal adsorbed to surfaces or absorbed by the organism, or to specific tissue, it is usually expressed on a weight (dry or wet.) adjusted basis (McGeer *et al*., 2004).

In contrast, several studies have suggested that dermal uptake contributes substantially to total uptake of waterborne chemicals by small fish and juveniles of larger species. Lien and McKim (1993) suggested that dermal uptake should increase in relative importance in small fish because of the way in which gill and skin surface areas scale to fish body weight. Lien and McKim (1993) predicted that skin surface area approaches and may even exceed that of the gills in fish weighing less than 5 g. Reduced skin thickness and increased skin visualization, also contribute to relatively greater dermal uptake in small fish (Di Giulio and Hinton, 2008).

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This study was undertaken to investigate the concentration levels of heavy metals of the selected tissues in the *Cyprinus carpio* and the sediments at five stations differing in locations, also determining fish scale as the most suitable bioindicator for lead and zinc sedimentation in the environment of the sampling stations.

MATERIALS AND METHODS

Five sampling stations were chosen in different regions of Astara, Hashtpar, Bandar Anzali, Ramsar and Chalous (Fig. 1). Samples were collected in the year 2007.

In each station at the fishing area, samples were taken from surface sediments with the aid of the Eckman grab sampling device and by using fishing boats (Obasohan *et al*., 2005). Also, fish samples were taken with the aid of flapping seine net (Andreji *et al*., 2006).

Nets at the Stations

The total length and weight of the sample fish were measured at the site and their scales, livers and gonad were separated. The samples were kept at a temperature less than 4°C until they arrived at the laboratory. After being transferred to the lab, the samples were prepared for digestion (Ayse, 2003; ROPME, 1999).

The sediments and tissues were dried at 105°C for 24 h. The dried sediments were passed through a 60 mesh stainless screen to remove larger particles (Hulya and Erhan, 2000).

Then the samples were dried; their water content was calculated and they were homogenized in three separate longitudinal groups.

An amount equal to 1 g of the dry powdered homogeneous sample (liver and scales) was digested by 10 mL of concentrated Nitric acid and 2 mL of H_2O_2 (Ayse, 2003; ROPME, 1999).

Sedimental samples from 5 stations were first mixed and heated with Nitric acid and then 10 mL of HCl was added to them before they were heated again (ROPME, 1999).

The volume of the clear solutions obtained from digestion was increased to 50 mL and then by using the atomic absorption device, the amounts of zinc and lead were measured (Ayse, 2003; ROPME, 1999).

Fig. 1: Stations of sampling

RESULTS

The highest lead content was measured as 48.27 mg g^{-1} in the scales of the small fish belonging to the group < 48 cm, at Bander Anzali sampling station (Table 1) and the least amount in the liver of the big fish (> 54 cm) as 4 mg g^{-1} at Astara sampling station (Table 2). Also, the highest amount of zinc was measured in the liver of the medium fish as 174.28 mg g^{-1} at Chalous sampling station

Table 1: Variation of lead and zinc concentration in fish scales at sampling stations

Sampling stations	Fish scales	Lead concentration	Zn concentration
Astara	Small (< 48 cm)	22.22	43.93
	Medium (48< >53.99 cm)	15.90	37.34
	Big (>54 cm)	7.52	26.25
Hashtpar	Small (<48 cm)	19.04	18.84
	Medium (48< >53.99 cm)	11.66	35.55
	Big (>54 cm)	22.50	52.37
Bandar Anzali	Small (<48 cm)	48.27	20.41
	Medium (48< >53.99 cm)	6.06	16.68
	Big (>54 cm)	8.71	12.94
Ramsar	Small (<48 cm)	22.22	41.70
	Medium (48< >53.99 cm)	16.98	23.27
	Big (>54 cm)	-	-
Chalus	Small (<48 cm)	13.20	26.97
	Medium (48< >53.99 cm)	14.50	17.42
	Big (>54 cm)	12.09	21.23
Max.		48.27	52.37
Min.		6.06	12.94
Mean		17.34±2.79	28.20±3.19
DS		10.45	11.96

Table 2: Variation of lead and zinc concentration in fish livers at sampling stations

Sampling stations	Liver scales	Lead concentration	Zn concentration
Astara	Small (<48 cm)	14.06	55.75
	Medium (48< >53.99 cm)	6.00	45.66
	Big (>54 cm)	4.00	52.17
Hashtpar	Small (<48 cm)	4.63	33.60
	Medium (48< >53.99 cm)	4.63	31.70
	Big (>54 cm)	6.45	46.42
Bandar Anzali	Small (<48 cm)	25.00	161.85
	Medium (48< >53.99 cm)	12.50	16.99
	Big (>54 cm)	5.50	10.12
Ramsar	Small (<48 cm)	9.61	65.59
	Medium (48< >53.99 cm)	6.00	57.29
	Big (>54 cm)	-	-
Chalus	Small (<48 cm)	6.50	165.85
	Medium (48< >53.99 cm)	25.00	174.28
	Big (>54 cm)	6.00	32.79
Max.		14.06	174.28
Min.		4.00	10.12
Mean		9.70±1.90	67.86±14.98
DS		7.11	56.06

Table 3: Variation of zinc concentration in the male gonad of fish at sampling stations

Sampling stations	Fish male gonad	Zn concentration
Astara	Small (<48 cm)	12.03
	Medium (48< >53.99 cm)	16.57
	Big (>54 cm)	9.05
Hashtpar	Small (<48 cm)	11.36
	Medium (48< >53.99 cm)	-
	Big (>54 cm)	8.06
Bandar Anzali	Small (<48 cm)	7.96
	Medium (48< >53.99 cm)	7.29
	Big (>54 cm)	6.79
Ramsar	Small (<48 cm)	14.28
	Medium (48< >53.99 cm)	17.12
	Big (>54 cm)	-
Chalus	Small (<48 cm)	12.68
	Medium (48< >53.99 cm)	12.72
	Big (>54 cm)	-
Max.		17.12
Min.		6.79
Mean		11.32±1.02
SD		3.54

Table 4: Variation of average lead and zinc concentration in fish scales at sampling stations

Average lead concentration in fish scale at sampling station	Concentration (μg g^{-1}) Lead	Zinc
Scale average at Astara	15.21	35.84
Scale average at Hashtpar	17.73	35.58
Scale average at Bandar Anzali	21.01	16.67
Scale average at Ramsar	19.60	32.84
Scale average at Chalus	13.26	21.87

Table 5: Variation of average lead and zinc concentration in the studied tissues

The bioaccumulation of lead in the studied tissues	Concentration (μg g^{-1}) Lead	Zinc
Scale average	17.34	28.20
Liver average	9.70	67.86
Female gonad average	14.23	22.16
Male gonad average	16.84	11.32
Sediment average	14.37	14.05

(Table 2) and the least amount of zinc in the male gonad of the big (long) fish as 6. 79 mg g^{-1} at Bandar Anzali sampling station (Table 3). Variations of average lead concentration in fish scales at the sampling stations under study:

Bandar Anzali › Ramsar › Hashtpar › Astara › Chalous (Table 4).

Variations of average zinc concentration in fish scales at the sampling stations under study:

Astara › Hashtpar › Ramsar › Chalous › Bandar Anzali (Table 4).

The bioaccumulation of lead in the related tissues was found to be in the following order:

Liver average ‹ Female gonad average ‹ Sediments average ‹ Male gonad average ‹ Scales average (Table 5).

The bioaccumulation of zinc in the studied tissues was found to be in the following order:

Male gonad average ‹ Sediments average ‹ Female gonad average ‹ scales average ‹ Liver average (Table 5).

Results of correlation tests show that fish scale is a better index of zinc content than liver and gonad in addition; fish scale is a better index of lead content than gonad.

As no strong correlation was found between lead pollution level in the environment and that in fish scales, it was concluded that fish scale is a weaker index for lead than for zinc.

DISCUSSION

In the study conducted in the Nairobi River about metal analysis of fish and water in 2005, the highest bioaccumulation of zinc in fish scales was measured as 360 mg g^{-1} and the lowest as 55 mg g^{-1} in the Female Gonad of the ovaries (Budambula and Wachiro, 2005).

The Zn content of the scales from juvenile fish was linearly correlated with environmental Zn concentrations. At elevated environmental Zn concentrations, the fraction of the total Zn body burden contained by the scales increased. The results suggest that fish scales may play an important role in the metabolism and detoxification of heavy metal pollutants. The relationship between metal uptake and calcification is discussed (Sauer and Watabe, 1984).

Lead also accumulation in or adsorbs on scales of fish at considerably high levels and the absorption ratio of lead may be more than some other heavy metal like cadmium (Kalay and Canli, 1999).The results obtained from Nasser Lake study in 2000 showed that of all the fish parts, fish liver accumulated the highest levels of Cu and Zn. Scales exhibited the highest levels of Co, Cr, Ni and Sr (Rashed, 2001).

The surface layer of sediments in the east of the Anzali Lagoon was surveyed for heavy metal contamination during the year 2004 at the National Inland Water Aquaculture Institute. Concentration of Pb, Fe, Cu and Cd were 7.92, 0.2775%, 25.8 and 1.645 µg g^{-1} dry weight, respectively. The Fe and Cu have the highest concentration (Babaei *et al*., 2007).

The liver, kidney, gill, ovary and muscle tissues of the caught *Liza aurata* have been sampled in spring 2002 in the southern Caspian Sea. The highest concentration of lead in the liver tissue followed by gill, kidney and. The lowest concentration of lead was seen in muscle tissue of *Liza aurata*. The highest accumulation of Ni and Zn was detected in ovary followed by liver, gill and kidney of the fish. The lowest concentration of Nickel and Zinc in the muscle tissue and also determined the highest contamination of the fish with these chemicals to be occurring in the southwest followed by south center and southeast Caspian Sea (Fazeli *et al*., 2005).

The results obtained from Nairobi River study were analyzed by using variance method. No significant difference was found for the following concentrations at six sampling stations: Manganese, Aluminum, Zinc, Copper, Cadmium, Lead, Calcium and Magnesium. But for Fe/Na/ and k/a significant difference (level 0.05) was observed at the sampling stations (Budambula and Wachiro, 2005). A significant difference at the level of 0.05 was observed in test results related length comparison of 42 short, medium and long (large) fish for ANOVA-One Way test and Tukey test. Otherwise, no significant differences were obtained when comparing lead and zinc concentrations of the sediment samples between stations. The same lack of significant difference was observed for lead and zinc amounts compared in the scales, livers, male gonad and female gonad related to the three length groups (short, medium and long).

Musavi *et al*. (2007) found that there was significant difference of Sexes (male and female) for Zn in their Kidney and bone may be related to the generating and lactation functions of the female that cause heavy metals get out of the body. Moreover, the high levels of Pb and Cd in rat's bone are due to the existence of such elements in their environment.

In the study conducted of the southern coast of the Caspian Sea, the results were statistically analyzed and mean, one-way ANOVA test, LSD test, mean of variance were compared. Coefficient Correlation and linear regression were calculated by Pearson method and figure or curve of Hierarchical Cluster Analysis, using average linkage, Euclidian distance were drawn. There was also positive correlation between kidney-liver and Kidney-sediment for Cu concentration and between liver-sediment, kidney-sediment for Pb concentration (Amini *et al*., 2003).

The correlation coefficient was calculated for establishing possible relations between lead and zinc concentrations found at average sediments in different stations. Variations in concentrations of these elements in the scales, liver and gonad of the fish samples (in three groups : short, medium and long) and also between related tissues.

Relative coefficient factor between lead concentration in sediments and its concentration in fish scales (in small sized group) showed an average relevancy for two parameters ($r = 0.542$) and scale can be an average environmental indicator for small sized group. However, relative coefficient factor between zinc concentration in sediments and its concentration in fish scales (in large sized group) showed a high relevancy for two parameters ($r = 0.703$) and shows a positive linear relation between parameters so that increasing in zinc concentration in sediments, increase its concentration in scale too. Regarding to zinc concentration changes procedure in sediments and fish scales (large sized group); scale could be an environmental indicator.

Consideration of relative coefficient factor between sediment lead concentration in noted stations and its concentration in fish liver (small sized group) showed a proportional high relevancy for two parameters ($r = 0.717$) it means there is a positive linear relation between parameters. Consideration of relative coefficient factor between sediment lead concentration in noted stations and its concentration in fish gonads (small sized group) showed a high relevancy for two parameters ($r = 0.961$).

Relative coefficient factor between sediment lead concentration in noted stations and its concentration in female gonads showed an average relevancy for two parameters ($r = 0.564$).

Consideration of relative coefficient factor between liver lead concentration in and its concentration in fish scales (small sized group) showed a high relevancy in $p<0.05$ for two parameters ($r = 0.939$). It means there is a positive linear relation between parameters and increasing in liver lead concentration.

Considering the studied cases, the following conclusion can be drawn:

Scales can be a more suitable index for showing zinc content than the liver and female gonad and male gonad and a more suitable index for showing lead content than male gonad.

CONCLUSION

Comparison of the present study amounts with the corresponding standards values Obasohan *et al.* (2005) shows that they exceed the maximum allowable Pb level for human beings in food materials.

Therefore, food consumption of *Cyprinus carpio* gonad should be avoided in the study areas of Gilan and Mazandaran (Obasohan *et al*., 2005).

In sediment, mean metal levels were generally higher than pre-dredging levels in sediment, when compared to available predredging recorded by Obasohan and Oronsaye (2000) and Obasohan *et al*. (2005).

The reason could be due to human activity and entering in the area of organic and mineral pollutants as unnatural pollutions.

REFERENCES

Amini, R.G.H., M. Bahmani, C.P. Farsh and F. Shariat, 2003. Coefficient correlation of heavy metals (Cu, Cd, Zn, Pb) in Persian sturgeons liver and kidney (*Acipenser persicus*) and in the sediments of the southern coast of the CASPIAN SEA. J. Environ. Sci. Technol., 17: 61-84.

Andreji, J., I. Stranai, M. Kacániová, P. Massányi and M. Valent, 2006. Heavy metals content and microbiological quality of carp (*Cyprinus carpio* L.) muscle from two Southwestern Slovak fish farms. Environ. Sci. Health A Tox. Hazard Subset Environ. Eng., 41: 1071-1088.

Ayse, B.Y., 2003. Comparison of heavy metal levels of grey mullet (*Mugil cephalus* L.) and sea bream (*Sparus aurata* L.) caught in is kenderun bay (Turkey). Turky J. Vet. Anim. Sci., 29: 257-262.

Babaei, H., S.H.K. Parast and A. Abdini, 2007. Contamination of sediments with heavy metals Cd, Cn, Fe, Ph in the east of Anzali lagoon. Iran. Sci. Fish. J., 16: 9-16.

Budambula, N.L.M. and E.C.M. Wachiro, 2005. Metal status of Nairobi river waters and their bioaccumulation in *Labeo cylindricus.* Water Air Soil Pollout., 169: 275-291.

Di Giulio, R.T. and D.E. Hinton, 2008. The Toxicology of Fishes. 1st Edn., CRC Press, Boca Raton, ISBN: 9780415248686.

Fazeli, M.S., B. Abtshi and A.S. Kashani, 2005. Assessing Pb, Ni and Zn accumulation in the tissues of *Liza aurata* in the South Caspian Sea. Iran. Sci. Fish. J., 14: 65-78.

Hulya, K. and U. Erhan, 2000. Concentrations of some heavy metals in water, sediment and fish species from the Atatürk Dam Lake (Euphrates), Turkey. Chemosphere, 41: 1371-1376.

Kalay, M. and M. Canli., 1999. Elimination of essential (Cu, Zn) and non essential (Cd, Pb) metals from tissues of a freshwater fish *Tilapia zilli*. Environ. Pollout., 121: 129-136.

Lien, G.J. and J.M. McKim, 1993. Predicting branchial and cutaneous uptake of 2,2',5,5'-tetrachlorobiphenyl in fathead minnows (*Pimephales promelas*) and Japanese medaka (*Oryzias latipes*): Rate limiting factors. Aquatic Toxicol., 27: 15-32.

McGeer, J., H. Gerry, L. Roman, F. Nicholas and K. Sappington *et al.*, 2004. Issue paper on the bioavailability and bioaccumulation of metals Submitted to: US. Environ. Protect. Agency, 69: 59226-59227.

MOOPAM., 1999. Manual of oceanographic and observations pollutant analysis methods. ROMPE, Kuwait. http://books.google.com/books?id=UWcLHAAACAAJ&dq=MOOPAM+(1999).

Musavi, M., E.A. Sari and A.R. Riahi Bakhtiari, 2007. Determination of Cu, Zn, Pb and Cd levels in tissues of *Rattus norvegicus* and evaluation of Pb and Cd pollution in Noor(A province of Iran). Daneshvar Medicine, 14: 49-55.

Obasohan, E.E. and J.A.O. Oronsaye, 2000. Heavy metals in water, sediment and some important commercial fish species from Ikpoba River, Benin City, Nigeria. J. Applied Sci. Environ., 4: 263-268.

Obasohan, E.E., J.A.O. Oronsaye and O.l. Eguavoen, 2005. Determination of post-dredging concentrations of selected trace metals in water, sediment and the freshwater mudfish (*Clarias gariepinus*) from Ikpoba River in Benin City, Edo State, Nigeria. Afr. J. Biotechnol., 6: 470-474.

Rashed, M.N., 2001. Egypt monitoring of environmental heavy metals in fish From Nasser Lake. Environ. Int., 27: 27-33.

Sauer G.R. and N. Watabe, 1984. Zinc uptake and its effect on calcification in the scales of the mummichog, *Fundulus heteroclitus.* Aquatic Toxicol., 5: 51-66.