INDUSTRIAL POLLUTION CAUSED BIOACCUMULATION OF HEAVY METAL CADMIUM IN FRESH WATER FISHES OF PAUNA RIVER, MAHARASHTRA

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ABSTRACT: Effects of heavy metals on fish are multidirectional and manifested by numerous changes in the physiological and chemical processes of their body systems. 11 Nalas (drains) carrying the industrial and domestic waste in Pauna River from Pimpri-Chinchwad Municipal Corporation area. Metal Plating industries are the main source of cadmium pollution in river. Cadmium metal content were analyzed by Atomic Absorption Spectroscopy (Perkin Elmer model No. 3030 USA) and values are expressed in ppm from water sample and various organs of two fresh water fish species *Ompok bimaculatus* and *Puntius sarana sarana* collected from four sampling sites on Pauna river. The maximum Cd content found in kidney (1.5ppm) was considerably higher than gill (0.65ppm), muscle and liver (0.60ppm) and ovary (0.5ppm). The Cd contents in the organs was in the order of kidney > gill > liver > muscle > ovary. The present investigation is useful to find out the indicators of cadmium pollution in river water habitat.

KEY WORDS : Cadmium, Bioaccumulation, Fish organs

1. INTRODUCTION

As a result of industrial pollution, many important habitats of fishes are lost. River Saraswati in West Bengal, Khan river at Indore, Ganga river at Kanpur, River Satluj in Punjab, Yamuna river in Delhi, Bhadra river in Karnataka, Panchganga at Ichalkaranji, Tapi river in Gujrat, river Krishna and Koyana in Maharashtra, Kuttiadi in Kerala are few examples (Trivedy, 2000). Jayaram (1997) reported that, some taxonomicaly important fish species could not be collected from its type locality which are *Rasbora labiosa* from Darna river, a tributary of Godavari river, *Silonai childreni* from Mula - Mutha river near Pune, similarly, the Mahseer, *Tor mussullah and Osteobrama* spp. from Ghod river at Shirur, Pune.

Effects of heavy metals on fish are multidirectional and manifested by numerous changes in the physiological and chemical processes of their body systems (Dimitrova et. al., 1994). The outbreak of Cd poisoning occurred in Japan in the form of itai itai or “Ouch ouch” disease. Many people suffered from this disease in which their bones became fragile. At high levels, Cd causes kidney problems, anemia and bone marrow disorders. Industrial waste waters are more likely to be treatment limited due to higher toxicity levels and the risks associated with exposure to wild life. (USEPA, 1993). 11 Nalas (drains) carrying the industrial and domestic waste in Pauna River from Pimpri-Chinchwad Municipal Corporation area. Metal Plating industries are the main sourceof cadmium pollution in river. Therefore present work was undertaken to study

the bioaccumulation of cadmium in fish organs and to find out bioindicators of industrial pollution in Pauna river

2. Material and methods

2.1. Heavy - Metal Analysis:

I. Heavy metal Cadmium analysis from water samples:

Water samples were collected from four sampling stations (A, B, C and D) of Pauna river during three seasons. In the laboratory they were treated with 1:1 perchloric and nitric acid and refrigerated to 4^0c temperature to prevent change in volume due to evaporation. Then Cadmium metal content was analyzed by Atomic Absorption Spectroscopy (Perkin Elmer model No. 3030 USA) and values are expressed in ppm.

II. Heavy metal Cadmium analysis from fish organs:

Two fish species *Ompok bimaculatus* and *Puntius sarana sarana* collected from four sampling sites were carefully dissected to segregate gills, muscles, liver, kidney and ovary to determine the concentration of Cd in them. Each tissue was dried in an oven at 60^0 C for 72 hr. dried tissues were pulverized in mortar, kept in polythene bags and stored in the refrigerator. The powdered sample100 mg was digested with 10 ml nitric acid and perchloric acid mixture (1:1) till a clean solution was obtained. The digested samples were cooled at room temperature and filtered through Wattman filter paper. The filtrate was then diluted with concentrated hydrochloric acid (5 ml) and again diluted with glass distilled water (35 ml). Test solutions were then analysed for different trace metals using Atomic Absorption Spectroscopy (Perkin Elmer model No. 3030 USA) and finally the concentration quantified is expressed in ppm.(Lithnor,1975).

3. RESULTS:

3.1.Cadmium metal detection from water sample:

Water samples of Pauna river from four sampling stations were analyzed for quantitative estimation of Cadmium metal concentration during three seasons, winter, summer and monsoon. The results are expressed in ppm and presented in table 1.

Table 1 .Cadmium content (ppm) in water samples at four stations from Pauna

Season	Station	Cd
Monsoon	A	0.0
	B	0.0
	C	0.0
	D	0.051
Winter	A	0.0
	B	0.0
	C	0.0
	D	0.05
Summer	A	0.0
	B	0.0
	C	0.0
	D	0.03

Table 2 :Bioaccumulation of Cadmium (ppm) in various organs of two fresh water fishes at four stations from Pauna river in three seasons.

Organ	Station	Cadmium concentration in ppm (dry weight)					
		Ompok bimaculatus			*Puntius sarana sarana*		
		Monsoon	winter	summer	monsoon	winter	summer
Gill	**A**-control	0.0	0.0	0.025	0.025	0.0	0.0
	B	0.250	0.0	0.0	0.325	0.0	0.0
	C	0.0	0.0	0.550	0.0	0.0	0.0
	D	0.0	0.0	0.60	1.0	0.650	0.700
Muscle	**A**-control	0.0	0.0	0.0	0.0	0.0	0.0
	B	0.250	0.0	0.250	0.025	0.30	0.350
	C	0.0	0.650	0.0	0.0	0.0	0.0
	D	0.650	0.0	2.00	0.0	0.700	0.500
Liver	**A**-control	0.025	0.0	0.025	0.0	0.0	0.0
	B	0.250	0.0	0.0	0.0	0.250	0.250
	C	0.500	0.0	0.0	0.0	0.750	0.0
	D	0.0	0.5	0.600	0.650	0.500	0.0
Kidney	**A**-control	0.0	0.0	0.0	0.0	0.0	0.0
	B	0.0	0.325	0.0	0.0	0.0	0.0
	C	0.0	0	0.0	0.0	0.0	0.0
	D	1.500	0.800	0.500	0.650	0.650	0.600
Ovary	**A**-control	0.0	0.0	0.0	0.0	0.0	0.0
	B	0.250	0.0	0.300	0.025	0.30	0.0
	C	0.500	0.0	0.0	0.0	0.600	0.500
	D	0.0	0.500	0.0	0.0	0.0	0.700

A – Pauna dam B – Parandwadi

C – Chinchwad- Kalewadi bridge D – Pimple- Gurav.

Concentration of heavy metal Cd from water samples at four different stations showed that, Cd was absent at Pauna dam (St. A) in all three seasons. Cd and Pb concentrations were also not observed at Parandwadi (St. B) during three seasons.

Concentration of cadmium in Pauna river water was higher at Pimple- Gurav (St. D) in monsoon (0.051 ppm) than winter (0.050 ppm) and summer (0.030 ppm). Level of Cd was not recorded at St. C.
The higher values of metal concentration were detected in monsoon than winter and summer.

The concentrations of Cd were below the detectable level in Pauna dam water in all seasons. In general, order of Cd concentration at various stations of Pauna river was st.D (Pimple- Gurav) > St.C (Chinchwad-Kalewadi bridge) > st.B (Parandwadi) > st A (Pauna dam).

3.2.Cadmium metal detection from fish organs :

Table 2 shows bioaccumulation of Cd in various organs of *O. bimaculatus* and *Puntius sarana sarana***.**

***Ompok bimaculatus* :**

The range of Cd concentration in different body organs of *O. bimaculatus* was from 0.025 to 1.5ppm. At Pauna dam the Cd content was mostly absent in various organs except in gill and river (0.025ppm). For Parandwadi it was ranged from 0.25 to 0.325ppm, for Chinchwad – Kalewadi bridge 0.5 to 0.65ppm and for Pimple Gaurav it was 0.5 to 1.5ppm. The order of bioaccumulation of Cd at various sampling stations was D>C>B>A.

The maximum Cd content found in kidney (1.5ppm) was considerably higher than gill (0.65ppm), muscle & liver (0.60ppm) and ovary (0.5ppm). The Cd contents in the organs was in the order of kidney > gill > liver > muscle > ovary.

The analysis of Cd load in fish during different seasons showed that, the higher values of metal content were detected in monsoon than winter & summer seasons.

Puntius Sarana Sarana

The range of Cd concentration in various body organs of *Puntius sarana sarana* was from 0.025 to 1.00ppm. At Pauna dam, Cd content was absent in all organs except in gill (0.025ppm in monsoon). At Parandwadi it was ranged between 0.025 to 0.325 ppm, at Chinchwad – Kalewadi bridge 0.5 to 0.75ppm and at Pimple - Gurav it was 0.5 to 1.00ppm. Order of bioaccumulation of Cd at various sampling stations was D > C > B > A.

The maximum concentration of Cd was recorded in Gill (1.0ppm), which was followed by liver (0.75ppm), muscle, ovary (0.7ppm) and kidney (0.65ppm). The order of Cd. content of the organs was gill> liver> muscle & ovary> kidney.

The higher values of metal content were detected in monsoon than winter and summer seasons. The higher concentration of Cd was observed in fish O. bimaculatus than *Puntius sarana sarana*.

DISSCUSSION:

Heavy metals such as mercury and cadmium uptake by fishes and prawns, at least when present in low concentration in the water, may be restricted by strong complexing agents in mucous layer (Part and Lock 1983). In present study, observed range of heavy metal Cd, content in Pauna river water was quite low (0.002 ppm to 0.148 ppm). Olaifa et. al. (2004) reported higher concentrations of metals in tissues of *Clarius gariepinus* than the water in which they lives.

Concentration of Cd as indicated in the present study is increased at the downstream of river by various drains carrying industrial effluents from various industries. Concentration of Cd in Pauna river was recorded only at St. D. It might be attributed to the number of drains carrying waste from varieties of industries located along the river stretch.

In present study, level of Cd in river water was found to be maximum during the monsoon period.. It was related with industrial discharge in different seasons. Mitra et. al. (1999) reported that, concentration of

heavy metals in the brackish water wetland ecosystem of West Bengal found to be maximum during the monsoon period.

Aquatic animals are in direct contact with the heavy metals both, natural and anthropogenic origin. According to Tinsil (1982), there are two ways for penetrating metal into the organism – via direct water adsorption or fish feed. Carnivorous animals at the top of the food chain obtain most of their heavy metal burden by way of their food, especially where fish are present, and so there exists the considerable biomagnifications (Cumbie1975; Mance,1987 and Langston, 1990). Similar studies were conducted by Komarovski et. al. (1988); Velcheva(1998); Storelli and Marcotrigiano (2001); Fent (2003), and considered fish species as heavy- metal bioindicators.

In present study, Cd metal detection was carried out in two economically important fish species *Ompok bimaculatus* and *Puntius sarana sarana* which were considered as heavy metal bioindicators of industrial pollution of Pauna river. Cd content depends on the fish organ as well as fish species. This observation was coincided with work of Velcheva (2006). Bhilave et. al.(2004) have observed that, freshwater fish *Cirrhinus mrigala* and *Cyprinus carpio* when exposed to acute concentration of cadmium and lead, there was more accumulation of heavy metals in liver followed by gill and muscle.

Cyril Arun Kumar et. al. (1994) reported the uptake and persistence of cadmium in tissues of the fresh water fish *Cyprinus carpio* and reported that, persistence of cadmium in tissues was suggested to depend on availability and persistence of the contaminant in the medium. In present study, Cd concentration was maximum in fish *Ompok bimaculatus* kidney (1.5 ppm), while it was maximum in gill (1.0 ppm) in *Puntius sarana sarana*. Allen (1995) reported that highest level of cadmium was consistently accumulated by the kidney of *Oreochromis qureus*. Grady and Abdulah (1985) recorded maximum level of Cu, Cd and Hg in gill, may be attributed to constant passage of ambient water through the gills. In present study, maximum Cd level was recorded in monsoon at St. D. It was due to runoff of large amount of effluents from electroplating, chemical, pigment work, and metal industries from Pimpri and Bhosari MIDC area during monsoon. Observed concentration of Cd was more than WHO/FAO permissible limit (1.0 ppm). The high metal concentration in fish was mostly found in kidney and it was followed by gill ,liver, muscle and ovary.

Conclusion:

The present investigation is useful to find out the indicators of cadmium pollution in river water habitat. The fish organs are indicators of bioaccumulation of cadmium in fresh water ecosystem.

REFERENCES:

1.Allen, P. (1995) : Chronic accumulation of cadmium in the edible tissues of *Oreochromis aureus* (Steindachner) : Modification by mercury and lead. Arch. Environ Contam. Toxicol., Jul. 29 (1): 8-14.

2. Bhilave, M. P., Muley, D. V. and V. Y. Deshpande (2004): Bioaccumulation of Heavy Metals in Various Organs of the fish, *Cirrhinus mrigala* and *Cyprinus carpio* after acute exposure. J. Aqua. Biol., Vol. (19) 2: 115 – 118.

3. Cumbie, P.M. (1975): Mercury levels in Geondia Otter, mink and freshwater fish. Bull. Environ. Contam. Toxicol., 14 N2: 193 – 196.

4. Cyril, Arun Kumar, L. Vincent, S. and T. Ambrose (1994): Uptake and persistence of the heavy metal Cadmium in tissues of the freshwater fish, *Cyprinus carpio*. Poll. Res., 13 (4): 361 – 364.

5. Dimitrova, M. S., Tishinova, T. and V. Velcheva (1994): Combined effects of zinc and lead on the hepatic superoxide dismutase - catalase system in carp. comp. J. Biochem. Physiol., 108 : 43-46.

6. Fent, K. (2003): Ecotoxicological problems associated with contaminated sites. In: Proceedings of Eurotox 2002. The XI. European congress of Toxicology Science. Direct, (11 April 2003). pp. 353 – 365.

7. Grady, O and M.I. Abdulah (1985): Mobility and residence on Zn in brown trout *Salmo trutta*, environmentally induced changes through transfer. Environ. Pollut. (A ECOL. BIOL.) 38 (2): 109 – 127.

8. Jayaram, K. C. (1997): Nomenclature and Systematic Status of *Barbus mussullah* Sykes 1839. J. Bombay Nat. Hist. Soc., 94(1): 40-55.

9. Komarovskii, F., Kulik, V and F. Karasina (1988): Biomonitors of toxic pollution of aquatic ecosystems. Proceedings of the fifth. All. Union Conference on Aquatic Toxicology, Odessa, 1998, Moscow, UNIRO, 40.

10 Langston, W.J. (1990): Toxic effects of metals and incidence of marine ecosystems. In: Furness, R.W. and Rainbow, P.S. (ed.) Heavy metals in the marine environment, 256 pp. CRC Press, New York.

11. Lithnor, G. (1975): Methods for detection measurement and monitoring of water pollution, FAO. Rome, pp. 41.

12. Mance, G. (1987): Pollution threat of heavy metals in aquatic environment. Elsevier. pp 363, London.

13. Mitra, A. T. Mandal and D.P. Bhattacharya (1999): Concentrations of heavy metals in Penaeus spp. of brackinshwater wetland ecosystem of West Bengal, India. Indian J. Environ. and Ecoplan, 2 (2): 97 – 106.

14. Olaifa, F.E., Olaifa, A.K., Adelaja, A.A. and A.G. Owolabi (2004): Heavy metal contamination of *Clarias gariepinus* from a lake and fish farm in Ibadan, Nigeria. African J. Biomed. Res., 7: 145-148.

15. Part, P. and R.A.C. Lock (1983): Diffusion of calcium and mercury in a mucous solution from rainbow trout. Comp. Biochem. Physiol., 76 C (2): 259 – 263.

16. Tinsil, I. (1982): Environmental behaviour of chemical pollutants. Moscow, Mir.

17. Storelli, M. and G. Marcotrigiano (2001): Heavy metals monitoring in fish, bivalve molluscs, water and sediments from Varna Lagoons, Italy Bull. of Environ. Contam. Toxicol., 66 (3): 365 – 370.

18. USEPA (1993): Created and National Wetlands for Controlling Nonpoint Sources of Pollution. CRS Press, Inc., Florida.

19. Velcheva Iliana G. (2006): Zinc content in the organs and tissues of freshwater fish from the Kardjali and Studen Kladenets dam lakes in Bulgaria. Turk. J. Zool., 30 : 1-7.

20.Velcheva, I.G. (1998): Ecological study of cadmium lead and zinc load of bleak (*Alburnus alburnus* L.) Common carp (*Cyprinus carpio* L.) and perch (*Perca fluviatilis* L.) populating the "Kardjala and the student Kladenetz" dam lakes. Authors summary of a Ph.D. dissertation Plovdiv University.