Universal Journal of Environmental Research and Technology
 eISSN 2249 0256
Available Online at: **www.environmentaljournal.org**
2013 Volume 3, Issue 6: 690-694

•

Open Access **Short Communication**

Accumulation of Heavy Metals in Fish after Chronic Exposure to the Industrial Effluent

Waghmode, S. S. and D.V. Muley*

Department of Zoology, D. B. J. College, Chiplun, Ratnagiri, 415 605.
*Department of Zoology, Shivaji University, Kolhapur, 416 004.

Corrosponding author: suhas_dbj@yahoo.com

Abstract:

The present study aims to assess the accumulation of heavy metals in various organs of *Mystus gulio* (Ham.) after chronic exposure for 30 days at 1/10 th of LC_{50} to industrial effluent, collected from Lote M.I.D.C., Tal. Khed, Dist. Ratanagiri, Maharashtra. The concentrations of Cu, Fe, Zn, Cd, Ni, Co and Mn were measured. The result showed that the concentration of heavy metals from different organs were ranged from Cu 0.011 to 0.22 ppm, Fe 0.055 to 1.12 ppm, Zn 0.006 to 1.47 ppm, Co 0.001 to 0.002 ppm, and that of Cd, Ni, and Mn were below detectable level. The order of concentration of metals in the organs as: Zinc - Gills > Liver > Kidney; Copper – Kidney > Liver > Gills; Cadmium - Liver > Gills > Kidney. The concentrations of heavy metals in various organs were within the acceptable limits of international standards.

Keyword: Heavy metals, accumulation, *Mystus gulio* (Ham.)

1.0 Introduction:

India is one of the ten most industrialized nations in the world. But industrialization has resulted in unplanned urbanization, pollution and increased level of risk to human health and safety. India's over 70 % of surface water is seriously polluted (India's Environment Action Programme, 1995).For many purposes water is used by industries, such as processing, cooling and in this process water may become polluted. Such polluted water released by industries may directly or indirectly, reach water bodies. All major rivers in the country are being polluted by unchecked industrial effluents being discharged into them. A variety of industries such as coal washeries, coke - oven plants, the countries major iron and steel plants, thermal power plants, glass and cement plant, fertilizers and chemical factories seriously pollute the rivers (Kumar and Thakore, 2004).

The heavy metals accumulation in an aquatic environment has direct consequences to the ecosystem and man. Metals such as Cu and Zn are generally regarded as essential trace metals as they have valuable role for metabolic activities in organisms. Other metals like Cd, Pb, Ni and Hg exhibit extreme toxicity even at trace levels (Merian, 1991). Heavy metal contamination in aquatic environments is of critical concern due to the toxicity of metals and their accumulation in aquatic habitats. The heavy metal pollution in freshwater fish first became an issue in the sixties when serious mercury contamination was detected in Sweden and later in Canada. Ibok, *et. al.,* (1989) reported elevated levels of Hg, Zn, Cu, Co, Sb, Cd, and Pb in fishes from some streams in IkotEkpene area of Nigeria. Heavy metals are non-biodegradable can bio-accumulate in fish, directly from the water or by ingestion of food (Kumar and Mathur, 1991). The heavy metals have a great ecological significance due to their toxicity and accumulation nature. World have a great concern to aquatic environment due to release of heavy metals. Water pollution resulted from various sources like accidental spillage of chemical wastes, discharge of industrial or sewage effluents, domestic waste water and agriculture drainage led to affect fish with toxic metals (Jent, *et. al.,* 1998).

For the evaluation of health in aquatic organisms fishes are widely used, these pollutants build up in the food chains which are responsible for adverse effects and death in the aquatic systems (Farkas, *et.*

al., 2002). The heavy metals show toxic effects and bioaccumulation in tuna fish (Waqar, 2006).

In the aquatic fauna, fish is the most susceptible to heavy metal toxicants so, are more vulnerable to metal contamination than any other aquatic fauna. After reaching sufficiently high concentrations in body cells the metals can alter the physiological functioning of the fish (Heath, 1987). Estuarine cat fish *Mystus gulio* (Ham.) has great commercial importance because it is widely consumed by local peoples. Therefore it can be good model to study environmental contamination. We reported for the first time the levels of Cu, Fe, Zn, Cd, Ni, Co and Mn in the Gills, Liver and Kidney of *Mystus gulio* (Ham.).

2.0 Materials and Methods:

Quantitative estimation of heavy metal was carried out in locally available and economically important estuarine catfish *Mystus gulio* (Ham.) was done after chronic exposure to the industrial effluents for 30 days at 1/10th of LC_{50} value (18 ppm) which was collected from the Lote M.I.D.C.

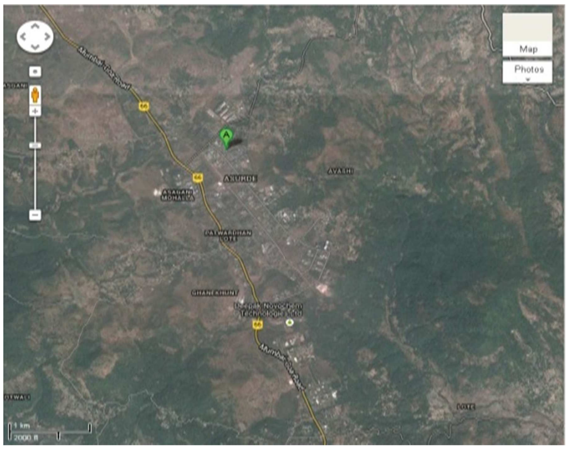

Fig.1. Satellite image of the Lote M.I.D.C.

The heavy metals such as Cu, Fe, Zn, Cd, Ni, Co and Mn were detected from the test organs of catfish.
The fish species *Mystus gulio*(Ham) exposed to industrial effluent were carefully dissected to segregate gills, muscles, liver and kidney to determine the concentration of heavy metals in them. Each tissue was dried in oven at 60^{0}C for 72 hours; dried tissues were pulverized in mortar, kept in polythene bags and stored in the refrigerator. The powdered 100 mg sample was digested with 10ml nitric acid and perchloric acid mixture (1:1) till 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 HCL (5ml), are again diluted with glass distilled water (35ml). Test solutions were then analyzed for different trace metals using Atomic Absorption Spectrophotometer (Perkin Elmer Model No. 3030 USA) and finally the concentration quantified is expressed in ppm (Lithnor, 1975).

3.0 Result and Discussion:

The results showed that Copper (Cu) content of different organs of *Mystus gulio* (Ham.) was from 0.011 to 0.22 ppm. The maximum concentration of Cu was detected in the kidney (0.22 ppm) which was followed by the liver (0.053 ppm), gill (0.027 ppm), and minimum was detected in the muscle (0.011 ppm). Iron (Fe) content was in the range from 0.055 to 1.12 ppm. The maximum concentration of Fe was detected in the kidney (1.12 ppm) followed by the liver (0.35 ppm), gill (0.091 ppm) and muscle (0.055 ppm). Zinc (Zn) content was in the range of 0.060 to 1.47 ppm. The maximum concentration of Zn was detected in kidney (1.47 ppm) followed by liver (0.25 ppm), gill (0.14 ppm) and muscle (0.060 ppm). Cadmium (Cd) content was below detectable level in all the organs except liver (0.002 ppm). Nickel (Ni) content of all the organs was below detectable level. Cobalt (Co) content of different body organs was from 0.001 to 0.002 ppm. It was high in the muscle (0.002 ppm) and low (0.001 ppm) in gill, liver and kidney. Manganese (Mn) content of all the organs as gill, muscle, liver and kidney of fish was below detectable level. The order of concentration of metals in the organs as: Zinc - Gills > Liver > Kidney; Copper – Kidney > Liver > Gills; Cadmium - Liver > Gills > Kidney.

High concentration of Cu was detected in the liver (0.35 ppm), which was followed by the kidney (0.22 ppm), gill (0.027ppm), and minimum concentration was detected in the muscles (0.011ppm).The observed concentration was below the prescribed permissible limit (30 ppm) by WHO/ FAO (1983). The high copper concentration in kidney may be due to the fact that fish kidney contains a cystine rich copper binding protein which is thought to have either a detoxifying or storage function (Luckey and Venugopal, 1977).

The high concentration of copper in liver compared to gill, kidney, and muscle can be due to the binding of Cu to the metallothionein in the liver, which serves as a detoxification mechanism (Olafia, *et. al.,* 2004). Kalay and Canli (1999) reported higher concentration of copper in the liver of *Mugil cephalus* fish from the North Mediterranean Sea. Observed Iron (Fe) concentration was maximum in the kidney (1.12 ppm) followed by the gill (0.091 ppm), muscle (0.055 ppm), and liver (0.053 ppm).

Table 1: Accumulation of heavy metals (ppm) in various organs of fish *Mystusgulio*(Ham.) after chronic exposure to industrial effluent. (Chronic concentration 18 ppm)

Organ	Heavy metal concentration in ppm(dry weight)						
	Cu	**Fe**	**Zn**	**Cd**	**Ni**	**Co**	**Mn**
Gill	0.027 ± 0.002	0.091 ± 0.001	0.14 ±0.001	BDL	BDL	0.001 ± 0.001	BDL
Muscle	0.011 ± 0.001	0.055 ± 0.002	0.060 ± 0.003	BDL	BDL	0.002 ± 0.001	BDL
Liver	0.053 ± 0.005	0.35 ± 0.002	0.25 ± 0.001	0.002 ± 0.002	BDL	0.001 ± 0.001	BDL
Kidney	0.22 ± 0.001	1.12 ± 0.004	1.47 ± 0.002	BDL	BDL	0.001 ± 0.001	BDL

The results are expressed as mean of 10 fishes ± S.D.; BDL: Below Detectable Level

The maximum concentration of Zn was detected in kidney (1.47 ppm) followed by liver (0.25 ppm), gill (0.14 ppm), and muscle (0.060 ppm). The Zn was accumulated in gills may be due to the fact that, gills serve as respiratory organs through which metal ions are absorbed (Bebianno, *et. al.,* 2004). The high level of Zn in liver may possibly reflect storage and also due to fact that liver being the center and target for metabolism may concentrate heavy metals. The high accumulation of Zn in the kidney could be based on specific metabolism process and co-enzyme catalyzed reactions involving Zn taking place in the kidney. Cadmium (Cd) concentration was below detectable level in all the organs except liver (0.002 ppm).The cadmium concentration reported in study within permissible limit in liver where as cadmium is below detectable level in kidney, muscle and gill. Ashraf (2005) reported concentration of 0.41 ppm in the kidney of *Epinephelus microdon* from Arabian Gulf. Nickel (Ni) concentration was below detectable level in all the organs. Observed concentration of Cobalt (Co) in different body organs was from 0.001 to 0.002 ppm, it was high in the muscle (0.002 ppm) and low (0.001 ppm) in gill, liver and in kidney.

Concentration of Manganese (Mn) in all the organs as gill, muscle, liver and kidney of fish was below detectable level. The high metal concentration in fish was mostly found in liver and it was followed by Kidney, gonad, gill and muscle. Liver, known to have high metabolic activities has been widely recognized as valuable indicator of pollution (Hansen *et al.,* 1982).

Farombi, *et. al.,* (2007) reported the accumulation levels of Zn, Cu, Cd, AS and Pb in the kidney, liver, gills and heart of African cat fish *(Clarias gariepinus).* The accumulation trend of the metals in organs as: Gills- Zn > Cu > Pb > Cd > As; Kidney- Zn > Cu > Pb > As > Cd; Liver- Zn > Cu > Pb > As > Cd. The levels of heavy metal ranged between 0.69 – 19.05 ppm in kidneys, 2.10 – 19.75 ppm in liver and 1.95 – 20.35 ppm in gills. The gills are in direct contact with contaminated water and have thinnest epithelium of all the organs and metals can penetrate through the thin epithelial cells (Bebianno, *et. al.,* 2004).

Reddy, *et. al.,* (2007) reported the higher concentration Fe followed by Zn and Mn in some commercial fishes. The accumulation order of heavy metals in fish was as Fe > Zn > Mn > Cu > As > Pb > Hg > Cr > Co > Cd. Metal concentrations were always lowest in the muscle and highest in the gill and liver. This is due to their physiological roles in fish metabolism. It has been shown that target tissues of heavy metals are metabolically active ones, like liver, kidney and gill. Therefore, metal accumulation in these tissues occur higher level compared to some other tissues like muscle, where metabolic activities is comparatively low (Roesijadi and Robinson, 1994; Canli, *et. al.,* 1998).

4.0 Conclusion:

During investigation, maximum concentration of Cu was detected in the liver (0.35 ppm), followed by the kidney (0.22 ppm), gill (0.027ppm), and minimum was detected in the muscle (0.011ppm).The bioaccumulation of Cu was below the prescribed permissible limit. Observed Iron (Fe) content of kidney was maximum (1.12 ppm) followed by gill (0.091 ppm), muscle (0.055 ppm) and liver (0.053 ppm). The maximum concentration of Zn was detected in kidney (1.47 ppm) followed by liver (0.25 ppm), gill (0.14 ppm) and muscle (0.06 ppm). The high level of Zn in the liver may possibly reflect storage and also due to fact that liver being the center and target for metabolism may concentrate heavy metals. In the present study, accumulation of Zn in the gill may be due to the fact that they serves as respiratory organs through which metal ions are absorbed. The Cadmium (Cd) content was below detection level in all the organs except liver (0.002 ppm), while Nickel (Ni) content was below detectable level in all the organs. The concentration of Cobalt (Co) was high in the muscle (0.002 ppm) and low (0.001 ppm) in gill, liver and kidney. The Manganese (Mn) concentration was below detectable level in all the organs of fish. The concentrations of all the heavy metals were more in liver followed by kidney, gill and muscle. Liver, known to have high metabolic activities, has boon widely recognized as valuable indicator of pollution. The study indicated that, the concentration of Cu, Fe, Zn, Cd, Ni, Co and Mn were within acceptable limits by international standards (FAO, 1992 and FAO / WHO, 1983).

References:

1) Ashraf, W., (2005): Accumulation of heavy metals in kidney and heart tissues of *Epinephelusmicrodon*from Arabian Gulf. *Environ. Monit. Assess.* 101, 311.
2) Bebianno, M. J., Geret, F., Hoarau, P., Serafim, M.A., Coelho, M. R., Gnassia-Barelli, M., and Romeo, M., (2004): Biomarkers in Ruditapes decussates: a potential bio-indicator species, Biomarkers. 9: 3
3) Canli, M., Ay, O., Kalay, M., (1998): Levels of heavy metals (Cd, Pb, Cu, Cr and Ni) in tissues of *Cyprinuscarpio, Barbuscapito* and *Chondrostomareguim* from the Seyhan River, Turkey. *Turkish. J. Zoology* 22:149 – 157.
4) Farkas, A., Salanki, J., Specziar, A., (2002): Relation between growth and the heavy metal concentration in organs of bream *Abramisbrama L*. populating Lake Balaton. Arch. *Environ. Contam. Toxicol.*, 43 (2), 236 - 243.
5) FAO (1992): Committee for Inland Fisheries of Africa. Report of the third session of the Working Party on Pollution and Fisheries. Accra, Ghana, 25-29 November 1991. FAO Fisheries Report, 471, Rome, FAO.
6) Farombi, E. O., Adelowo, O. A., and Ajimoko, Y. R., (2007): Biomarkers of oxidative stress and heavy metal levels as indicators of environmental pollution in African cat fish *(Clariasgariepinus)* from Nigeria Ogun River. Int. *J. Evviron. Res. Public. Health*: 4(2), 158 – 165.
7) Hansen, M.M., Jensen, A., and Lasen, H., (1982): Trend monitoring problems in the interpretation of concentration using fish as indicator organisms, ICES, S.M.E., 25.
8) Heath, A. G., (1987): Water pollution and fish physiology, CRC Press Inc. Boca Rotan, Florida, pp. 245.
9) Ibok, U. J., Udosen, E. D., Udoidiong, O. M., (1989): Heavy metals in fishes from some streams in IkotEkpene Area of Nigeria. *Nig. J. Tech Res.*, 1, 61-68.
10) India's Environment Action Programme (1995): Approaches and Initiatives towards Sustainability Developed by centre for Environment Education, Ahmedabad, supported by ministry of Environment and Forests, Government of India.

11) Jent, S., Heing, J. S., and Tate, C. M., (1998): 'Concentration distribution and composition of selected trace elements in bed sediment and fish tissue in the South Platte River Basin, USA, 1992–1993', National Water-Quality Assessment (NAWQA) program report, 1998.
12) Kalay, K., Ay, O., and Canli, M., (1999): Heavy metal concentration in fish tissues from the North Mediterranean Sea. Bull. *Environ. Contam. Toxicol.* 63: 673 – 681.
13) Kumar, A., and Mathur, R. P., (1991): Bioaccumulation kinetics and organ distribution of lead in a fresh water teleost, *Colisafasciatus. Environ. Technol.* 12 731 - 735.
14) Kumar, A., and Thakore, S., (2004): Water in understanding Environment. Ed. Kiran B. Chhokar, Mamata Pandya, Meena Raghunathan, CEE. Sage Publ. New Delhi.
15) Lithor, G., (1975): Methods for detection measurement and monitoring of water pollution, FAO. Rome, pp. 41.
16) Luckey, and Venugopal, (1977): A new classification system for toxic compounds. *J. Toxicol. Environ. Health.* 2: 633 - 638.
17) Merian, E., (1991): Metals and their compounds in the Environment. Occurrence, Analysis and Biological Relevance. UCH. Weinhein-New York-Basel-Cambridge.
18) Olafia, F. G., Olafia, A. K., Onwude, T. E., (2004): Lethal and sub lethal effects of copper to African cat fish *Clariasgariepinu*. *African. J. Biomed. Research.* 65 - 70.
19) Reddy, M. S., Mehta, B., Dave, S., Joshi, M., Karthikeyan, L., Sarma, V. K. S., Basha, S., Ramachanraiah, G., and Bhatt, P., (2007): Bioaccumulation of heavy metals in some commercial fishes and crabs of the Gulf of Cambay, India. *Current Science*, Vol. 92. No.11.1489 - 1491.
20) Roesijadi, G., and Robinson, W. E. (1994): Metal regulation in aquatic animals: Mechanism of uptake, accumulation and release. In: Malins D. C., Ostrander, G.K., editors. Aquatic Toxicology (Molecular, biochemical and Cellular Perspectives), Lewis Publishers, London, 539 pp.
21) Waqar, A., (2006): Levels of selected heavy metals in Tuna fish. *Arab. J. Sci. Eng.*, 31 (1A), 89 – 92.
22) WHO / FAO (1983): Compilation of legal limits for hazardous substances in fish and fishery products, FAO fishery circular No. 464:5 - 100.