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BIOMONITORING OF HEAVY METAL ACCUMULATION IN SELECTED INLAND FISHES OF KERALA

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Abstract: Inland fishing is a time old practices in the extensive network of interconnected water bodies of Kerala and most of the production is consumed locally and marketed domestically. However, with the increasing urbanization and industrialization, the discharge of untreated or partially treated sewage and industrial wastes along with wash out of agricultural pesticides, the water resources are getting polluted extensively and our fish resources are dwindling rapidly. Fish production plays an important role in the socio- economic life of Kerala. Therefore, toxic effects of the different pollutants in fishes may have significant socio-economic and environmental impression in our society. In this context, present study was aimed to determine the accumulation of heavy metals in most common and commercially important inland fish species of Kerala. Based upon commercial importance and consumption rate especially for common people, four fish species *viz*. *Etroplus suratensis*, *Catla catla*, *Labeo rohita* and *Hypselobarbus curmuca* were selected for the study. Acid digested tissues like gills, liver and muscles were analysed for heavy metals viz. Hg, As, Cd, Pb, Cu and Zn using ICP – AES method. The results confirmed that our inland fishes are highly accumulated heavy metals especially the toxic Pb, which is comparatively higher than the permissible limit recommended by WHO. In general, all the fishes accumulated metals in the order Zn > Cu > Pb > As, Hg, Cd. In muscles, the total metal accumulation were in the order Pb (33.6 %) > Zn (10.4%) > Cu (4.1%) > As, Hg, Cd (bdl). Present study confirms the necessity of regular monitoring of our fish resources for the wellbeing of the human beings and also emphasize that the liver and gills of fishes can be considered as a reliable bio-monitor of heavy metal pollution in our aquatic ecosystem.

Key words: Water pollution, ICP-AES, Bio-monitoring

INTRODUCTION

Blessed with two monsoons, Kerala situated in the south west part of peninsular India is known for its fish wealth dominated by marine fish production. Despite small land area, the inland fishing is also a time old practice in the extensive network of 32 interconnected backwaters/estuaries (*kayals*), which have an area of 93730.5 ha and also in the freshwater resources consisting of 44 rivers, lakes, reservoirs, ponds, irrigation canals, paddy fields, rock pools, etc. All these water bodies provide rich sources of inland fisheries. Freshwater fishes that are cultivable food fishes native to Kerala include Thooli (*Labeo dussumieri*), Kooral (*Hypselobarbus curmuca*), Manjakoori (*Horabagrus brachysoma*), Musi (*Clarius batrachus*), Wyanad Musi (*Silurius wynadensis*), etc. Besides, exotic fishes like Rohu (*Labeo rohita*), Catla (*Catla catla*), African catfish (*Clarias gariepinus*), etc. are also widely reared in inland water bodies. During 2004-2011 periods, the inland fish production was increased by 82.44%. The inland fishing sector of the State contribute around 1.39 lakh metric tonnes of fish annually and most of the production is consumed locally and marketed domestically. They provide significant contribution to animal protein supplies in rural areas of the State.

Fish is culturally important and indispensable part of the diet of both rich and poor in Kerala. It is estimated that 96 per cent of the 30 million populations may eat fish and accounts for over three-quarter of the animal protein intake of the average Keralite. The per capita consumption of fish ranges between 15-20 kg $capita^{-1}$ $year^{-1}$ (Harikumar and Rajendran, 2007). However, with the increasing urbanization and industrialization, the discharge of untreated or partially treated sewage and industrial wastes along with wash out of agricultural pesticides, the water resources are getting polluted extensively and our fish resources are dwindling rapidly. The fish mortalities in the Chaliyar River and Periyar estuary due to industrial effluents are by now well known. As a consequence, Kerala, as a whole, is facing an acute shortage in fishery resources and the State has been forced to turn to neighbouring States for its fish supplies even for Kerala's most relished fish, pearlspot (*Karimeen*). Hundreds of tonnes of Kerala's most relished fish, pearlspot (*karimeen*), and Tilapia, arrive in Kochi in refrigerated lorries from aqua farms of Andhra Pradesh; anchovy and sardines arrive here from Tamil Nadu, Karnataka and even from fish landing centers further North.

One of the consequences of aquatic pollution is the increase in the contaminants especially heavy metals from industrial waste, pesticides, automobile waste and human waste. Heavy metal contaminations have devastating effects on the ecological balance of the recipient environment and a diversity of aquatic organisms (Ashraj, 2005; Vosyliene and Jankaite, 2006). Being conservative in nature, the heavy metals have devastating effects on the ecological balance of the recipient environment and the diversity of aquatic organisms. Fishes are capable of accumulating heavy metals in their living cells to concentrations much higher than those present in water, sediment and micro flora in their environment (Forstner and Wittmann, 1981). Heavy metals accumulated in various organs of fish, which enter into the human metabolism through consumption may cause serious health hazards in two ways: (i) they accumulate and thereby disrupt function in vital organs and glands such as the heart, kidneys, bone, liver, etc.; (ii) they displace the vital nutritional minerals from their original place, thereby, hindering their biological function. Toxic heavy metals may knock down immune, reproductive, nervous and endocrine systems in animals and these effects can be at organ, tissue and cell level (Geeraerts and Belpaire, 2009). Even essential metals like Cu, Co, Zn, Fe and Mn are also become toxic at high concentration (Bryan, 1976; Alloway and Ayres, 1993).

Fishes are widely used to evaluate the health of aquatic ecosystems because pollutants build up in the food chain and are responsible for adverse effect and death in aquatic systems (De Gieter *et al.*, 2002; Senarathne and Pathiratne, 2007; Javed and Usmani, 2011; Selami *et al.*, 2011). Fish production and associated activities plays an important role in the socio- economic life of Kerala. Therefore, the toxic effects of different pollutants in fishes may have significant socio-economic and environmental impression in our society. In this context, present study was aimed to determine the accumulation of heavy metals in most common and commercially important inland fish species of Kerala.

MATERIALS AND METHODS

Four inland fish species were selected (Table 1) and collected for the study during the period January – March months of 2013. All the fishes, except *Hypselobarbus curmuca* were collected from different markets in the coastal and urban centres of Thiruvananthapuram and Kollam Districts. *Hypselobarbus curmuca* were collected from the upstream of Kallada River. Effort has been taken to collect minimum seven samples for each species on every month. After cleaning with distilled water, the fish samples were immediately placed in plastic bags and stored in icebox until it transferred to the laboratory for further analysis. After thawing, the samples were dissected and tissues such as gills, liver and muscles were separated for heavy metal analyses. These tissues were chosen on the basis: (i) they are all known to accumulate metals (Seymore *et al.*, 1994); (ii) the gills constantly exposed to the metals in the water and subsequent effects that metals have on the gill; (iii) liver is known as a storage and detoxification organ (Klaassen, 1976) the amount of metal accumulated therein might reflect the severity of the pollution, and (iv) muscle is the tissue generally consumed by humans and the metal accumulation content is important for the presumed effect on human health (Du Preez *et* *al.*, 1997). The samples were kept in a drying oven at 105°C until a constant weight was observed and were grounded to powder for a grain size of less than 125ìm. 1 gram of homogenized samples was then digested with nitric acid and perchloric acid in the ratio 2:4 to remove the organic content. The digested samples were filtered using Whatman filter paper and then diluted to 100 ml and were analyzed for six heavy metals *viz*. As, Hg, Cd, Cu, Pb and Zn using ICP-AES.

RESULTS AND DISCUSSION

Due to increased terrestrial and industrial effluents inputs and better adsorption capacity of sediments, the aquatic ecosystems are the reservoir of various toxic pollutants including a wide range of metals. Many studies on metal accumulation in fishes living in polluted waters showed that considerable amounts of various metals may be deposited in fish tissues without causing mortality. Present study is also a revelation of such an extensive water pollution that our aquatic ecosystems confronting nowadays. The results obtained for the four commercially important inland fishes analyzed for six heavy metals (As, Hg, Cd, Cu, Pb and Zn) were summarized in Table 2. The results confirmed high accumulation of heavy metals in inland fishes, which is comparatively more than permissible limit recommended by FAO (1983). Fortunately, As and Hg was below detection limit and Cd was reported only in the liver of *Catla catla*. However, potentially toxic Pb was reported in the tissues of all fishes, which signifies the extent of pollution of our freshwater resources due to automobile exhaust, solid waste dumping, destructive use of insecticides and pesticides.

Among the tissues, gill accumulates about 49.83% of total metal burden, which followed by liver (40.38%). The analysed metals showed different affinity towards each tissue. Compared to other metals analysed, about 57.2% of Zn got accumulated in the gills. Several studies confirmed high concentrations of Zn and Cu in the gills and liver (Coetzee *et al.*, 2002; Arunkumar and Hema, 2007; Yousafzai and Shakoori, 2008). Similarly, Cu (92.2%) and Pb (63.0%) got heavily accumulated in the liver. In *Catla catla*, Cd was totally accumulated in the liver. Comparative to gills, the Pb concentration was found to be high in liver and muscles. Studies conducted across the world corroborate high concentration of heavy metals in the liver tissue (Yousuf *et al.*, 2000; Usero *et al.*, 2003; Dural *et al.*, 2007; Safahieh *et al.*, 2011). In muscles, the total metal accumulation were in the order Pb (33.6 %) > Zn (10.4%) > Cu (4.1%) > As, Hg, Cd (bdl). Comparatively high accumulation of Pb in the muscles observed in the present study was contradicted the studies of Sorensen (1991) and Allen (1995).

Among the fishes, *Hypselobarbus curmuca* reported comparatively low heavy metal accumulation and *Catla catla* accumulated the maximum. The liver of *Etroplus suratensis* showed substantially very high concentration of metals like Pb (5.66 ìg g-1), Cu (204.1 ìg g-1) and Zn (278.30 ìg g-1). Pb was below detection limit in gills and in muscles, the metal concentration was in the order Pb (1.28) < Cu (2.84) < Zn (50.49). In *Catla* catlla, metals are largely got accumulated in the liver and muscles. Cd was reported in the liver sample of the fishes. In muscles, the metal concentration was in the

Table 1. Inland fish species selected for the Study (Local Name in parenthesis)

Sl. No.	Common Name	Scientific Name	Family
1.	Pearl Spot (*Karimeen*)	*Etroplus suratensis*	Cichlidae
2.	Catla	*Catla catla*	Cyprinidae
3.	Rohu	*Labeo rohita*	Cyprinidae
4.	Red-tailed Barb (*Kooral*)	*Hypselobarbus curmuca*	Cyprinidae

Table 2. Mean concentration (μg g-1) of heavy metals in inland fishes

Fish	Tissue	As	Hg	Cd	Cu	Pb	Zn
E. suratensis	Gill	BDL	BDL	BDL	3.47 ± 0.17	BDL	275.70 ± 5.18
	Liver	BDL	BDL	BDL	204.10 ± 2.16	5.66 ± 0.06	278.30 ± 2.52
	Muscle	BDL	BDL	BDL	2.84 ± 0.14	1.28 ± 0.28	50.49 ± 2.48
C. catla	Gill	BDL	BDL	BDL	2.68 ± 0.13	1.05 ± 0.05	793.90 ± 3.02
	Liver	BDL	BDL	0.94 ± 0.05	37.71 ± 0.22	7.55 ± 0.19	370.10 ± 4.49
	Muscle	BDL	BDL	BDL	4.32 ± 1.89	3.89 ± 0.38	89.86 ± 5.92
L. rohita	Gill	BDL	BDL	BDL	5.01 ± 0.25	BDL	430.40 ± 1.76
	Liver	BDL	BDL	BDL	82.89 ± 0.24	4.04 ± 0.20	162.70 ± 2.46
	Muscle	BDL	BDL	BDL	4.86 ± 1.44	3.97 ± 0.18	69.12 ± 1.48
H. curmuca	Gill	BDL	BDL	BDL	3.90 ± 0.20	BDL	89.65 ± 4.48
	Liver	BDL	BDL	BDL	55.79 ± 0.25	2.45 ± 0.07	89.12 ± 3.91
	Muscle	BDL	BDL	BDL	4.97 ± 1.79	1.38 ± 0.12	78.29 ± 4.46
Permissible level of heavy metals as per in μg g^{-1}							
FAO (1983)		0.1 – 5.0	0.5	0.5	30	0.5	50

(BDL - Below Detection Limit)

order Pb (3.89) < Cu (4.32) < Zn (89.86). In the muscles of Rohu, the metal concentration was in the order Pb (3.97) < Cu (4.86) < Zn (69.12). Among the tissues, liver accumulates maximum concentration of metals in water, which is followed by gills and muscles. Comparatively low heavy metal accumulation could be observed in *H. curmuca*, in which liver accumulated the maximum concentration followed by muscles and gills. In general, all the fishes, accumulated the metals in the order Zn > Cu > Pb > Cd, As, Hg. According to Jezierska and Witeska (2006), metal levels in live fish usually follow the ranking: Fe > Zn > Pb > Cu > Cd > Hg and the maximum concentrations of lead and copper in muscles are lower and usually do not exceed 10 ìg g^{-1} d.w. Present study was also in accordance with above findings and findings of similar studies like Voigt (2004), Vinodhini and Narayanan (2008) and Abdel-Baki *et al*. (2011). However, metal accumulation in fish depends on pollution, and may differ for various fish species living in the same water body.

CONCLUSIONS

Fish species mostly absorbed heavy metals from its feeding diets, sediments and surrounding waters resulting to their accumulation in reasonable amounts. The accumulation of heavy metals in fish species are found to be influenced by several factors like temperature, pH of water, conductivity, rainfall, hardness, salinity and also by biotic community interactions (Arvind, 2002). Heavy metals may exhibit extreme toxicity even at low level under certain conditions, thus necessitating regular monitoring of our fish resources for the wellbeing of the human beings. While the muscles usually showed low metal concentrations, they must often examine for metal content due to human consumption. Present study also confirms that the liver and gills of fishes can be considered as a reliable bio-monitor of heavy metal pollution. While considering the results, the study is significant to evaluate the health and the extent of heavy metal pollution in our aquatic systems and the degree of heavy metal contamination in our daily diet.

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