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Accumulation of heavy metals in liver, muscle and gill of *Cyprinus carpio* from the Ganga river at Varanasi, Uttar Pradesh

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Abstract

The Ganga river is located in one of the most human settled part of India and receives may organic and industrial effluents which directly affecting the human population and ichthyfauna. Levels of four heavy metals (Cu, Cr, Pb and Zn) were determined in the tissues (muscle, gills and livers) of *Cyprinus carpio* fish species and water from the Ganga river at Varanasi, India during 2011-2012. The heavy metals (Cu, Cr, Pb and Zn) were assayed using Atomic Absorption Spectrophotometer and the results were given as µg/g dry weight. The analysis of heavy metal Cu in muscle, gills and livers of *C. carpio* was measured 2.07±0.60, 3.52±1.38 and 5.09±1.85 mg/l, respectively. The level of Cr was estimated 0.88±0.34, 1.90±0.68 and 2.46±1.32 mg/l in the muscle, gills and livers, respectively. The analysis of heavy metal Pb in muscle, gills and livers was measured 7.52±2.06, 9.75±3.98 and 22.31±9.18 mg/l, respectively. The level of Zn was observed 19.25±6.95, 24.6±9.50 and 20.65±8.36 mg/l in the muscle, gills and livers, respectively. Overall Zn level was maximum recorded in all organs. The presence of heavy metal in our environment has been of great concern because of their toxicity when their concentrations are more than the permissible level.

Keywords: Level of heavy metals, Muscle, Gill, Liver, *Cyprinus carpio*, Ganga river.

Introduction

Aquatic biota is contaminated with heavy metals as a result of anthropogenic activities and industrialization (Dwivedi *et al.* 2015). It is very commonly accepted that heavy metal uptake occurs mainly from water, food and sediment (bottom feeders and burrowing animals). However, the efficiency of metal uptake from contaminated water and food may differ in relation to ecological needs, metabolism, and the contamination gradients of water, food and sediment, as well as other factors such as salinity, temperature and interacting agents (Canli & Furness 1993). Heavy metals are natural elements that are five times denser than the water. Found abundantly in nature, small quantities of certain metals such as zinc, copper and iron are essential to a healthy body. Overexposure through ingestion, skin contact or respiration can cause metals to accumulate in body tissues and organs such as the liver. Heavy metals can disrupt physiological processes, affecting brain function, heart and circulatory system as well as nervous system. The most commonly encountered heavy metals are arsenic, iron, cadmium, aluminum, lead and mercury. It is known that metals accumulate on sediment surface in benthic living things, planktonic organisms and other living matter and is enhanced through food chain. Fish accumulate xenobiotic chemicals, especially those with poor water soluble occurs because of the very intimate contact with the medium that carries the chemicals in solution or suspension and also because fish have to extract oxygen from the medium by passing the enormous volumes of water over gills. For fish, gills, skin and digestive tract are potential sites of absorption of water borne chemicals. Toxic

substances may knock down immune, reproductive, nervous and endocrine systems in animals and these effects can be at organ, tissue and cell level (Geeraerts & Belpaire 2009).

Material and Methods

Sampling procedures

Present study was conducted in the Ganga river at Varanasi, Uttar Pradesh, India. A consecutive seasonal (summer, monsoon and winter) work was carried out for the collection of fish samples in the year 2011- 2012. Thirty fish samples were collected each season from every site. Hence a total of 90 fish samples were collected. Fish samples were collected from 11.00 to 12.00 am with the help of local fishermen. The size of fish samples ranged from 10 to 30 cm. All the samples were brought to the laboratory in an ice box on same day and were stored at 4 ºC in the refrigerator for further analysis.

Preparation of samples for analysis of heavy metals in fishes

Fish tissues were homogenized and then approximately 10 gm of the homogenate was digested as follows: 1.0 gm of the powdered samples (muscle, gills and livers) was placed in a 100 ml round bottom flask with ground glass joint and mineralized under reflux using the mixture of 6 ml HNO_3, 2 ml HClO and 4 ml H_2O_2. Digestion was done in a water bath. The procedure of digestion lasted for about 6 hour until a clear solution was obtained. The digests were prepared in triplicate and carefully transferred with their respective washing into a 25 ml volumetric flask and were diluted to volume. The digests were then analyzed for Cu, Cr, Pb and Zn, using an atomic absorption spectrophotometer (Model Number SL 173, ELICKO, India) with aqueous calibration standards prepared from the stock standard solutions of the respective elements as reported by Aweke & Taddese (2004).

Result

Copper (Cu)

In case of muscle, average Cu accumulation was recorded 2.07±0.06 mg/l in the year 2011-2012 at Varanasi site from the Ganga river. The minimum Cu was recorded 1.53 mg/l in monsoon season, moderately increased was noted in winter season which was 1.96 mg/l and maximum in summer season 2.72 mg/l (Table 1).

In case of gill, average Cu level was recorded 3.52±1.38 mg/l at Varanasi site from the Ganga river. The lowest Cu was recorded 2.08 mg/l in monsoon season, modest increased was noted in winter season which was 3.65 mg/l and highest in summer season 2.56 mg/l (Table 1).

In case of liver, average Cu distribution was recorded 5.09±1.85 mg/l at Varanasi site from the Ganga river. The minimum Cu was recorded 3.08 mg/l in monsoon season, moderately increased was noted in summer season which was 5.48 mg/l and maximum in winter season 6.72 mg/l (Table 1).

Table 1 Cu level (mg/l) in muscle, gills and livers of *C. carpio* from the Ganga river at Varanasi

Organs	Summer	Monsoon	Winter	Mean ±Sd
Muscle	2.72	1.53	1.96	2.07± 0.60
Gills	4.85	2.08	3.65	3.52 ±1.38
Livers	6.72	3.08	5.48	5.09 ±1.85

Chromium (Cr)

In case of muscle, average Cr accumulation was recorded 0.88±0.34 mg/l in the year 2011-2012 at Varanasi site from the Ganga river. The minimum Cr was recorded 0.52 mg/l in monsoon season, moderately increased was noted in winter season 0.93 mg/l and maximum in summer season 1.20 mg/l (Table 2).

In case of gill, average Cr level was recorded 1.90±0.68 mg/l at Varanasi site from the Ganga river. The lowest Cr was recorded 1.20

mg/l in monsoon season, modest increased was noted in winter season which 1.95 mg/l and highest was noted in summer season 2.56 mg/l (Table 2).

In case of liver, average Cr distribution was recorded 2.46±1.32 mg/l at Varanasi site from the Ganga river. The minimum Cr was recorded as 1.03 mg/l in monsoon season, moderately increased was noted in winter season which was 2.72 mg/l and maximum was noted in summer season 3.65 mg/l (Table 2).

Table 2 Cr level (mg/l) in muscle, gills and livers of *C. carpio* from the Ganga river at Varanasi

Organs	Summer	Monsoon	Winter	Mean ±Sd
Muscle	1.20	0.52	0.93	0.88 ±0.34
Gills	2.56	1.20	1.95	1.90 ±0.68
Livers	1.03	1.03	2.72	2.46 ±1.32

Lead (Pb)

In case of muscle, average Pb accumulation was recorded 0.60±0.20 mg/l in the year 2011-2012 at Varanasi site from the Ganga river. The minimum Pb was recorded 5.63 mg/l in monsoon season, moderately increased was noted 7.23 mg/l in winter season and maximum was noted in summer season 9.72 mg/l (Table 3).

In case of gill, average Pb level was recorded 9.75±3.98 mg/l at Varanasi site from the Ganga river. The lowest Pb was recorded 5.70 mg/l in monsoon season, modest increased was noted in winter season which 9.89 mg/l and highest was noted in summer season 13.67 mg/l (Table 3).

In case of liver, average Pb distribution was recorded 22.31±9.18 mg/l at Varanasi site from the Ganga river. The minimum Pb was recorded 12.36 mg/l in monsoon season, moderately increased was noted in winter season which 24.13 mg/l and maximum was noted in summer season 30.45 mg/l (Table 3).

Table 3 Pb level (mg/l) in muscle, gills and livers of *C. carpio* from the Ganga river at Varanasi

Organs	Summer	Monsoon	Winter	Mean ±Sd
Muscle	9.72	5.63	7.23	7.52± 2.06
Gills	13.67	5.70	9.89	9.75± 3.98
Livers	12.36	12.36	24.13	22.31 ±9.18

Zinc (Zn)

In case of muscle, average Zn accumulation was recorded 19.25±6.95 mg/l in the year 2011-2012 Varanasi site from the Ganga river. The minimum Zn was recorded 12.72 mg/l in monsoon season, moderately increased was noted in winter season which 18.46 mg/l and maximum was noted in summer season 26.57 mg/l (Table 4).

In case of gill, average Zn level was recorded 24.6±9.50 mg/l at Varanasi site from the Ganga river. The lowest Zn was recorded 14.03 mg/l in monsoon season, modest increased was noted in winter season which 27.31 mg/l and highest was noted 32.46 mg/l in summer season (Table 4).

In case of liver, average Zn distribution was recorded 20.65±8.36 mg/l at Varanasi site from the Ganga river. The minimum Zn was recorded 12.01 mg/l in monsoon season, moderately increased was noted 21.23 mg/l in winter season. The maximum Zn 28.72 mg/l accumulation was noted in summer season (Table 4).

Table 4 Zn level (mg/l) in muscle, gills and livers of *C. carpio* from the Ganga river at Varanasi

Organs	Summer	Monsoon	Winter	Mean ±Sd
Muscle	26.57	12.72	18.46	19.25± 6.95
Gills	32.46	14.03	27.31	24.6 ±9.50
Livers	12.01	12.01	21.23	20.65± 8.36

Discussion

Copper (Cu)

The level of Cu varied from 1.53 to 6.72 mg/l in muscle, gills and livers from the Ganga river at Varanasi. Dwivedi *et al.* (2015) observed

that the maximum Cu accumulated in livers in *Oreochromis niloticus* from the Gomti river at Lucknow site. Mendil *et al.* (2010) reported that concentration of Cu was 1.2±0.1mg/l in autumn season and 1.1 ± 0.1 in winter season in muscle of *C. carpio* from Yesihrmak river in Turkey which was lower than present finding. Tiwari *et al.* (2014a) reported higher concentration in *C. carpio* from Gomti river at Jaunpur. Uysal (2011) reported that value of Cu was 0.25±0.02 in muscle, 0.37±0.01in gill, and 17.15 ±0.62 in liver of *C. carpio* from Porsuk Dam Lake in Turkey which is lower than the present study. Celechovska *et al.* (2007) reported that 0.237±0.217 mg/kg in muscle of *C. carpio* which is lower than *C. carpio* of the river Ganga. According to the median international standard and FAO/WHO for food present finding of Cu value is below the tolerable levels 20 mg/kg and 30 mg/kg, respectively. Maximum permissible limit set by FAO/WHO (2006) for Cu 30 µg/g.

Chromium (Cr)

The level of Cr varied from 0.52 to 2.72 mg/l in muscle, gills and livers from the Ganga river at Varanasi. Nayaka *et al.* (2009) reported that Cr 2.0 ± 1.2 in muscle of same fish which was similar to *C. carpio* of the Ganga river. Yousayzai *et al.* (2012) reported higher level of Cr as compared to present finding in all study organs, 489 ±497 for muscle, 570.3± 52.1 for gill and 493.7±56.5 µg/g for liver from the Kabul river (Pakistan) in case of *C. carpio.* Celechovska *et al.* (2007) reported that lower concentration of Cr in muscle, gill, and liver.

Lead (Pb)

The level of Pb varied from 5.63 to 24.13 mg/l in muscle, gills and livers from the Ganga river at Varanasi. Mendil *et al* (2010) reported mean 0.11±0.01in summer season from Turkey which was lower than present study. Celechovska *et al* (2007) reported that lower concentration of Pb in muscle, gill, and liver of *C. carpio* from Ganga river. Tiwari *et al.* (2014b) reported lower accumulation in *C. carpio* from Gomti river at Sultanpur. Lead a non essential and toxic metal is released into the aquatic environment by industries sources such as chemical and fertilizer industries, refining of ores (Handy 1994).

Zinc (Zn)

The level of Zn varied from 12.72 to 32.46 mg/l in muscle, gills and livers from the Ganga river at Varanasi. Dwivedi *et al*. (2015) reported that the Zn was more accumulated in gills compared to livers and muscle of *O. niloticus* from the Gomti river at Lucknow and Jaunpur sites. Uysal (2011) reported lower mean value of Zn11.75 ±1.02 in muscle but much higher 539.83± 38.96 in gill and 205 ± 47.08 in liver of *C. carpio* from Porsuk Dam lake. Tiwari & Dwivedi (2014) reported lower concentration in *C. carpio* from Gomti river at Lucknow. Maximum permissible limit set by FAO/WHO for Zn 100 µg/g. Celechovska *et al* (2007) reported that higher concentration of cr in muscle, gill, and liver of C. carpio of the Ganga river.

Conclusion

The results of our present study show that there is no threat of any hazard at present except Pb, because it crosses WHO permissible limit. However, their increasing accumulating tendency in water, muscles, gill and liver of the fish species indicates that a constant monitoring of this river is needed before the level cross its threshold and become toxic to the aquatic animals and their predators including humans. High concentration of Pb and Cr in the fish tissue such as liver, muscles and gills of *C. carpio* has been reported specially in area close to industries (Thompson *et al.* 2000, Vinodhini & Narayana 2008). The increase in concentration of metals in fish could be mainly due to metals contaminated

diet that comes from discharge of effluents into rivers from different industries and other sources in the form of particulate and solution (Mount & Stephon 1969). The heavy metals accumulated predominantly in gill, liver, intestine and kidney (Brown *et al.* 1986, Thomas *et al.* 1985). Most laboratory research on the bioaccumulation of heavy metals suggests that no single mechanism is responsible for metal uptake in aquatic systems. The accumulation of a particular metal depends to a large degree on the presence of the metal in the water column.

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