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ACCUMULATION OF METALS IN FISHES AND ITS IMPACT ON HUMAN HEALTH

Vivek Kumar Gaur[1], Rahul Singh[1], Prachi Srivastava[2] and Jitendra Kumar Pandey[3]

[1]Dabur Research & Development Centre, Sahibabad, Ghaziabad, U.P., India

[2]Standard Analytical Laboratory, Patparganj, New Delhi, India

[3]St. Andrew's College Gorakhpur, U.P., India

ABSTRACT

In order to assess the health risk due to presence of heavy metals (Cr, Cu, Mn, Ni, Pb and Zn) in river Gomti,India, samples of fishes, water and sediments were collected from different selected sites. The concentrations of metals (mg/kg wet weight basis) in muscles of different fish species *(Mastacembelus uncalus, Clupisona garua, Cyrinous carpio, Botia lochachata, Channa punctatus, Heteropneustise fossilis, Puntius sofore and Clarious batrachus)* ranged: Cr (2.20-21.40), Cu (0.29 – 14.30), Mn (2.35-5.53), Ni (0.49-10.91), Pb (1.01-3.93) and Zn (12.28 – 46.88) mg/kg. Overall order of metal accumulation in fish muscle tissue was in the order: Zn > Cr > Ni > Mn > Cu > Pb. Contaminated fishes may cause serious health hazard after consumption. Health risks associated with children are very serious concern rather than adult.

KEYWORDS: Heavy metals, Fish, Gomti, Accumulation.

INTRODUCTION

Fish may accumulate large amount of toxic metals from polluted water, food or sediment as they occupy top position in the aquatic food chain (Mendil and Uluozlu, 2007; Yılmaz et al., 2010) and thus act as good indicator of environmental pollution (Bury et al., 2003). According to Svobodova et al., 1996, metal concentration in water correlates positively with concentrations in fish tissue. Problem of fish contamination by toxic metals has received much attention (Abou-Arab et al., 1996; Barak and Mason, 1990). Numerous studies have been carried out on metal pollution in different species of edible fish (Kucuksezgin et al., 2001; Lewis et al., 2002; Prudente et al., 1997). Fish are a major part of the human diet, thus its contamination with heavy metals content may directly affect the human health.

In India, river Gomti, a major source of water carries a pollution load from industrial towns and agricultural areas of eastern Uttar Pradesh, India (Sinha et al., 2004; Gaur et al., 2005; Singh et al., 2005, 2006, 2007). This is one the major tributaries of the river Ganga and covers a total distance of about 730 km before finally meeting with the river Ganga. It carry maximum pollution load at Lucknow city, approximately 26 drains of Lucknow (state capital of Uttar Pradesh), discharge the urban domestic treated wastewater into it, which badly deteriorate the quality of river water. Surface run-off is also one of the reasons but it is seasonal phenomenon. The water is being used for the irrigation and drinking purposes. National river conservatory directorate (NRCD), Government of India identify river Gomti is one of most polluted river in India. Due to their slow flow velocity and higher sedimentation rate, the river is an ideal depository site to different metals and their bioaccumulation in fish. Metal uptake in fish is predominantly from the food; therefore, their heavy metal loads reflect the pollution in the sediment and its biota, rather than that of the ambient water column (Farkas et al., 2003).

Several studies has been carried out on water quality and metal levels of water and sediments in river Gomti (Gaur et al.,2005, Singh et al., 2004, 2005, 2007) but literature for heavy metal contamination in fish species of river Gomti is scanty. Present study was an attempt to assess metal contamination in different fish species and potential health risk through its consumption.

MATERIALS AND METHODS

Selection of sites and sampling

Six sampling sites in the urban area of Lucknow were selected based on the predicted degree of contamination at different locations **(Map-1).** One sampling site was at Gaughat (S-I), that was moderately polluted upstream. Other sampling sites included: Mohan Meikin (S-II), Martyr's Memorial (S-III), Hanuman Setu (S-IV), Nishatganj Bridge (S-V) representing the mid-stream of the river at Lucknow and Piparaghat (S-VI) at the downstream of the river that was heavily influenced by anthropogenic activities. Water and sediment samples were collected from all the sampling sites. Samplings of fishes were done randomly based on their availability at the sites with the help of fisherman. Eight fish species which are common in all selected sites namely *Mastacembelus uncalus, Clupisona garua, Cyrinous carpio, Botia lochachata, Channa punctatus, Heteropneustise fossilis, Puntius sofore* and *Clarious batrachus* were collected. These fishes are of common occurrence in India, Pakistan and Bangladesh especially in rivers/ponds/fresh water streams. Collected fishes were properly washed with river water to remove any sand or clay particles at the site and transported to the laboratory in cleaned labeled polyethylene bags. At the laboratory they were thoroughly cleaned and any epiphyte and sediments were carefully removed with nylon brushes under tap water for a few seconds.

Water samples were collected in acidified PVC bottles (Duncan and Harrison, 1981). For collection of water sample, sampling bottles were soaked overnight in 10% HNO_3, washed twice with double distilled water rinsed three times with stream water, leaving the last rinse for five minute to equilibrate (Johnson and Hornton, 1987). At the sampling sites, separate water samples were acidified with conc. HNO_3 to lower the pH of the sample below pH 2 for heavy metals analysis. The sediment samples were collected with the help of Grab sampler and placed in acid washed polypropylene plastic containers. All the samples immediately brought to the laboratory for further analysis.

Metals analysis in water, sediment and fish

Acid digestion was carried out for water and sediment samples. 100 ml of water sample was digested with conc. nitric acid (10 ml), cooled and filtered through whatman no. 42 filter paper. The volume was made upto 20 ml with 0.1N nitric acid. In case of sediment, samples were air dried, sieved with 230 mesh sieve to separate only big materials and pebbles from the sediment and digested with 4:1 mixture of nitric acid and perchloric acid (Moon et al., 1994). The volume was again made up to 20 ml with 0.1N HNO3. Wet digestion of fish samples was accomplished using 10g fish sample in a mixture of 10mL nitric acid and 10mL hydrogen peroxide. The mixture was refluxed until brown fumes ceased to evolve. The digest was then filtered and was made up to 20 ml using Milli-Q water for analysis. The metal content of digested samples was determined with ICP-AES (Labtam Plasmalab 8440). All analysis was carried out in triplicate.

Reagents and standards

The Analytical Grade chemicals were used for analysis. Certified reference material of metals (E-Merck, Germany) was used to plot standard curve for ICP-AES. All the standards, reagents solution and samples were stored in polyethylene containers previously cleaned with 4 M HNO_3 and rinsed with Milli-Q water.

RESULTS AND DISCUSSION

Metal content in river water and sediments

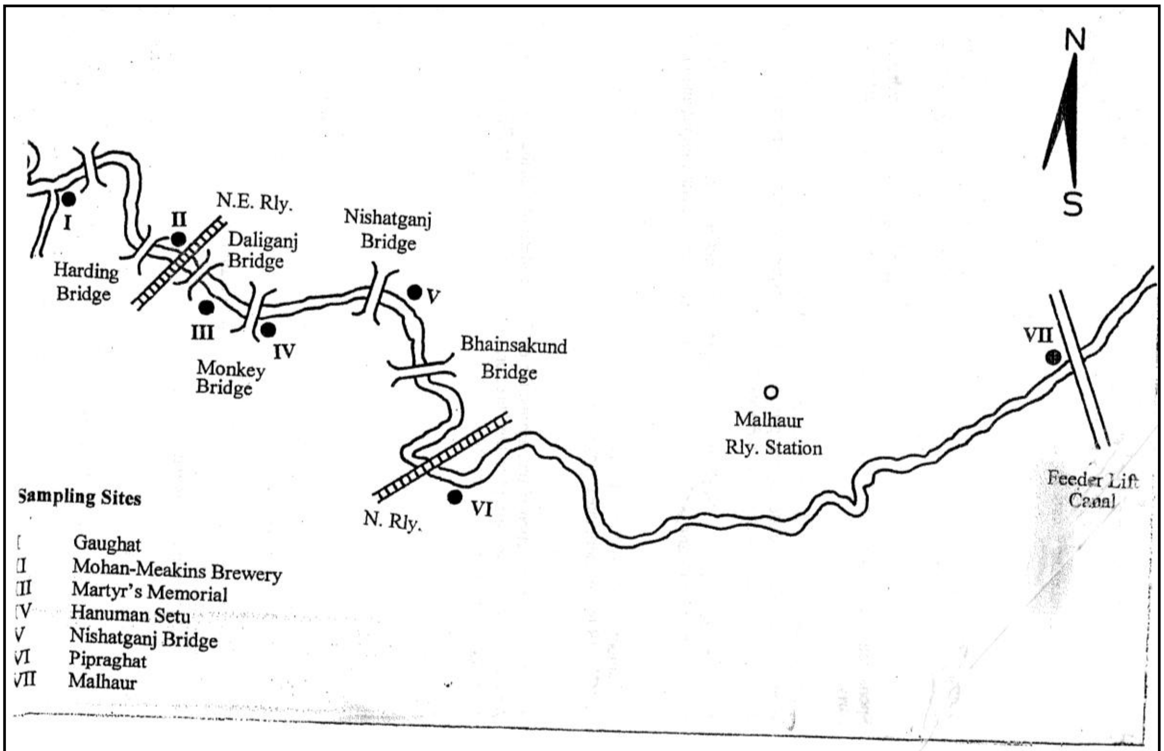
The descriptive analysis of heavy metals contents in water and sediment is presented in **Table 1.** The ranges of metals in water (mg/l) were: Cr (0.045-0.332), Cu (0.014-0.042), Mn (0.007-0.063), Ni (0.030-0.069), Pb (0.007-0.026) and Zn (0.056-0.075). Concentration of metals in Gomti river sediments ranged (mg/kg) from: Cr (11.71 - 50.34), Cu (4.36 - 79.54), Mn (43.20 - 193.47), Ni (5.32 - 27.54), Pb (5.80 - 51.11) and Zn (41.93 - 182.14).

Metal content in muscle tissue of selected fishes

Metal concentration in different fish species are shown in **Table 2**. It can be clearly observed that different fish species showed significant variation of metal accumulations in the muscle tissues. It was observed that metal accumulation was not consistent among all species. Maximum Cr accumulation was observed in *P. sofore* (21.40 mg/kg) and minimum was in *C. garua* (2.20 mg/kg). Levels of 10.0 mg/kg of chromium in the diets of birds are considered to cause adverse effects in some wildlife species (Eisler, 1986). Present study showed that level of Cr exceeded this level in all studied fish species except in *C. garua* thus suggesting probable risk from chromium to predators or scavengers upon consuming them in the wild. Cu showed maximum accumulation (14.30 mg/kg) in *C. garua* and minimum (0.29 mg/kg) in *C. punctatus***.** Ni and Pb accumulation was highest accumulation (10.91 and 3.93 mg/kg) in *P. sofore* and lowest in *C. garua* (0.49 mg/kg) and *H. fossilis* (1.01 mg/kg) respectively. Concentration of dietary Pb as low as 0.1–0.5 ppm are associated with learning deficits in some vertebrates (Eisler, 1988). In this study, levels of lead in all species exceeded this range, suggesting that the risk associated with their consumption. Zinc, an essential micronutrient for animals and humans are known to have a protective effect against the toxicities of both cadmium and lead (Calabrese et al., 1985).

In present study, Zn ranged from 12.28 mg/kg (*H. fossilis*) to 46.88 mg/kg (*B. lochachata*) and was similar to the values reported by Yılmaz et al., 2010. Overall order of metal accumulation in fish muscle tissue was in the order: Zn>Cr>Ni>Mn>Cu>Pb. Significant difference in the metal accumulation pattern in different fish species may be due to multiple factors. Apart from metal concentrations in water as well as exposure period; other factors which may influence metal accumulation in muscle tissue include salinity, pH, hardness and temperature, play significant roles in metal accumulation, ecological needs, sex, size, seasonal change

(Yılmaz et al., 2010; Yılmaz and Yılmaz, 2007).



MAP- I: Map of river Gomti in Lucknow region showing sampling sites

Health Risks

Potential health risk may occur due to consumption of fishes, contaminated with toxic metals like Ni, Pb & Cr. Wang et al., 2005 reported that serious health risk due to Cr through fish consumption in Tianjin, China. High risks due to Ni and Pb particularly in children need to be addressed properly as they are usually sensitive targets of pollutants. Lead is a neurotoxin that can cause decreases in survival, growth rates, learning, and metabolism (Eisler, 1988; Burger and Gochfeld, 2000). Children may be affected by encephalopathy with lethargy, mental dullness, vomiting, irritability, and anorexia; in severe cases, the prolonged exposition of lead can decrease the cognitive function and increase behavior disorders, specially aggression, psychosis, confusion and mental deficit (Bellinger et al., 1992; Gwalteney-Brant, 2002; Jarup, 2003; ATSDR, 2005). Serious harmful health effects from exposure to nickel include chronic bronchitis, reduced lung function, and cancer of the lung and nasal sinus (ATSDR, 2005).

CONCLUSIONS

Heavy metals (Cr, Cu, Mn, Ni, Pb and Zn) were determined in river water, sediment and different fish species. Metal accumulation in different fish species did not show any specific pattern and was showing significant difference among different species. Attempt was made to determine the potential health risk through consumption of fish species. Contaminated fishes and their consumption may enhance the concentration of toxic metals in the fatty tissues of epidermis. The accumulation of toxic metals may cause hepatotoxic, neurotoxic and cytotoxic effects in the children as well as adult human being. It is suggested and concluded by this study that anthropogenic and industrial waste water/ effluents may directly influence the toxic metal concentration in fishes so the effluent treated first before discharge.

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Table1. Descriptive statistics of heavy metal content in water and sediments of Gomti river.

River water (mg/l)	Cr	Cu	Mn	Ni	Pb	Zn
Mean	0.102	0.021	0.026	0.043	0.016	0.068
Range	0.045 - 0.332	0.014 - 0.042	0.007 - 0.063	0.030 - 0.069	0.007 - 0.026	0.056 - 0.075
SD	0.103	0.010	0.019	0.016	0.006	0.007
Sediments (mg/kg)						
Mean	35.17	32.76	123.30	18.97	28.47	90.03
Range	11.71 - 50.34	4.36 - 79.54	43.20 - 193.47	5.32 - 27.54	5.80 - 51.11	41.93 - 182.14
SD	12.99	25.09	56.02	7.76	14.67	47.39

Table 2. Statistical summary of metal content in muscle tissue of different fish species.

Species		Cr (mg/kg)	Cu (mg/kg)	Mn (mg/kg)	Ni (mg/kg)	Pb (mg/kg)	Zn (mg/kg)
M. puncalush	Range	18.36-19.58	2.87-3.15	4.26-4.92	8.94-9.61	1.27-1.84	21.62-22.10
	Mean	19.11	2.99	4.58	9.33	1.58	21.86
C. garua	Range	2.20-2.67	13.83-14.30	2.14-2.69	0.49-0.61	1.38-1.97	20.35-21.80
	Mean	2.42	14.09	2.35	0.56	1.62	20.96
C. carpio	Range	7.92-8.61	1.33-1.95	4.18-4.67	5.39-5.62	1.40-1.90	36.20-38.80
	Mean	8.31	1.60	4.42	5.49	1.71	37.59
B. lochachata	Range	11.88-12.50	2.12-2.53	5.19-5.77	7.99-8.77	1.27-1.97	45.50-46.88
	Mean	12.25	2.29	5.53	8.41	1.68	46.29
C. punctatus	Range	12.11-12.90	0.29-0.88	3.00-3.52	6.85-7.78	2.08-2.81	26.44-27.80
	Mean	12.51	0.61	3.23	7.38	2.42	27.21
H. fossilis	Range	12.20-12.96	0.47-0.84	3.24-3.85	6.10-6.71	1.01-1.99	12.28-12.70

	Mean	12.50	0.67	3.50	6.36	1.44	12.53
P. sofore	Range	20.37-21.40	3.28-3.66	6.17-6.94	10.32-10.91	3.20-3.93	31.47-32.60
	Mean	20.86	3.45	6.49	10.64	3.60	32.01
H.batrachus	Range	13.83-14.60	1.21-1.70	6.37-7.55	9.06-9.35	1.25-1.81	24.00-24.88
	Mean	14.14	1.52	7.01	9.19	1.45	24.43
International Standards[a] (range) (mg/kg)		1.0	-	-	-	0.5-10.0	40.0-100.0