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Original Article

Chromium contamination in water, sediment and its bioaccumulation in Indian major carps in River Chenab, Pakistan

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Abstract

Experiment on bioaccumulation of chromium (Cr) in the bodies of *Catla catla, Labeo rohita* and *Cirrhinus mrigala* was conducted from January through May, 2015. Water, sediment and fish samples were collected on monthly basis from upstream and downstream of head Trimmu, river Chenab. Throughout the study period, mmaximum Cr concentrations from upstream and downstream were recorded as 23.54± 3.43 mg/L and 21.12 ± 3.47 mg/L, respectively. Average metal concentration detected from sediment samples was 71.08±8.32 mg/L. Maximum Cr concentration 81.72±2.54 was recorded during February while minimum 61.24±1.23 mg/L during May. Among all the three fish species, maximum metal concentration was accumulated by *Cirrhinus mrigala* followed by *Catla catla* and *Labeo rohita*. Among fish organs, maximum Cr concentration 4.75±0.78 (µg/g) was recorded from liver whereas minimum 1.10±0.21 (µg/g) from muscles of the fish.

Key Words: Chromium, river Chenab, Indian major carps, water quality

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INTRODUCTION

Aquatic pollution due to anthropogenic activities is a global issue and grasped researchers' attention over the last few decades. Water bodies are the ultimate receiver of almost everything including heavy metals, which are non-biodegradable and are amongst most devastating pollutants. They are hazardous for human health, fauna and flora inhabiting these aquatic ecosystems (Rashid *et al.* 2012).In developing countries, water pollution is increasing day by day due to anthropogenic activities. Pakistan is facing problems due to rapid industrialization in province of Punjab which causes riverine pollution by discharging unprocessed industrial effluents, municipal wastes, domestic dung and runoff from agriculture. Only 1% of industrial wastewater is treated before gaining entry into natural water bodies (Rauf *et al.,* 2009).In order to evaluate the extent of heavy metal toxicity, it is important to understand water quality parameters (Ambreen and Javed, 2015).Sediments and aquatic biota are also analyzed to assess heavy metal toxicity (Qadir *et al.,* 2008).Fish meat is rich in omega-3 fatty acids, low in saturated fats and is highly acceptable. It is the major source of protein for humans. It also serves as bio-indicator and often used to assess quality of aquatic ecosystems (Azmat *et al.,* 2016). The accumulation of heavy metals in to the body organs of fish depends on a number of factors including season and physical and chemical properties of water. Heavy metals can bio-accumulate in aquatic biota and bio-magnify in food chains. In aquatic organisms, metals can act as mutagenic compounds and can affect tissues at organ, cellular, subcellular and molecular levels (Strydom *et al.,* 2007). Biochemical and physiological activities of both, the blood and tissues of the fish are affected by the heavy metals. As a result several endemic fish species have become threatened (Azmat *et al.,* 2012).

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Keeping in view the hazardous effects of heavy metals in aquatic ecosystems, the present study was planned to determine chromium contamination in water, sediments and its bioaccumulation in Indian major carps in river Chenab, Pakistan.

MATERIALS AND METHODS

Study area

Present study was conducted at head Trimmu, River Chenab Punjab, Pakistan from January through April, 2015. The river originates from Himachal Pardesh in India, gains entry in Pakistan at district Sialkot and flows through alluvial plains covering distance of 3398 miles in the Punjab province.

River Chenab joins Jhelum river at Trimmu and finally drains into Indus at Mithankot after joining Ravi and Sutlej rivers. Twelve major tributaries of Chenab River include Chandra, Bhaga, Bhut, Maru and Jammu in India and Tawi, ManawarTawi, Doara, Halse, Bhimber, Palkhu and Aik and Bhudi Nallah join in Pakistan.

Sampling

The study area was divided into two sub-sampling sites *i.e.,* upstream and downstream and water and sediment samples were collected on monthly basis. Water samples were collected in quartz bottles from just below the surface and column using Kemmerer bottle. Sediments were collected in polyethylene cans with the help of a PVC pipe(5cm diameter) pressed with pressure through water column to obtain the sediment layer.Ten randomly selected specimens of three fish species *viz., Cirrhinus mrigala, Labeo rohita,* and *Catla catla* were collected on monthly basis from the main fishing sites of head Trimmu.

Samples preparation and laboratory analysis

In Lab, 20 ml of water sample was taken in glass beaker and 10 ml of Conc. HNO_3 was added. Water sample was stirred for 10 min and filtered to store at room temperature for further heavy metal analysis following APHA (2005). Sediment sample was air-dried at room temperature and pulverized for further analysis. Three grams of sediment sample was taken in glass beaker, 28 ml of 30% HCl and 70% HNO_3 were taken in 3:1 ratio and mixed. Then the suspension was digested at 130 °C for the period of 2 hours. After that, suspension was scrutinized and sieved via Whatman filter paper. The prepared samples of sediment were then preserved at 4 °C for heavy metal estimation (Alpers *et al*., 1994).Fish was dissected and organs were dried in oven at 65 °C for 24 hours. The dried organs were burnt in furnace at 700-1000°C for ash and then solution was prepared in 5 ml nitric acid and filtered using filter paper for heavy metals analysis (Rauf, 2009).

Statistical analysis

The obtained data was subjected to statistical software SAS 9.1 and Analysis of Variance (ANOVA) was applied to find out the relationship between the parameters recorded during present study.

RESULTS AND DISCUSSION

Changes in physico-chemical parameters viz., pH, sodium, calcium and dissolved organic matter can cause heavy metal toxicity to the aquatic biota (Azmat *et al.,* 2016).

Table I: Physico-chemical parameters of Trimmu Barrage during study period

Sampling Months	Physico-chemical parameters						
	Temperature	pH	Hardness	DO	Alkalinity	E.C	Turbidity
January, 2015	17.31± 0.26 c	6.42± 0.04 d	142.51± 10.02 d	3.14± 0.41b	387.31± 10.21 a	260.25± 10.11 d	41.79± 2.25 d
February, 2015	19.03± 0.45 b	6.88± 0.03 c	160.21± 20.00 c	3.86± 0.73b	360.26± 20.25 b	281.63± 12.41 c	51.74± 3.58 c
March, 2015	21.84± 0.23 b	7.08± 0.81 b	193.57± 20.56 b	4.21± 0.49a	310.58± 30.48 c	320.51± 12.65 b	70.85± 5.65 a
April,2015	23.26± 0.71 a	7.81± 0.02 a	230.14± 30.03 a	4.82± 0.65a	240.54± 20.18 d	360.42± 15.21 a	65.96± 4.96 b
Mean	20.33± 2.30	7.02± 0.50	181.5± 33.46	3.99± 0.61	324.625± 55.83	305.65± 38.28	57.54± 11.48

Means with different letters in a column are statistically significant at $p<0.05$.

Water temperature may influence the metal deposition in various organs of fish. Higher temperature promotes metal accumulation especially in kidneys and liver. Water hardness also affects the uptake of metals across the gill epithelium (Anazawa *et al.,* 2004). Significant ($p<0.05$) variations in water temperature, pH, hardness, dissolved oxygen, alkalinity, electrical conductivity and turbidity were recorded between different months during present investigation (Table 1).

Table II: Chromium concentrations (mg/L) in water of Trimmu Barrage during study period

Sampling Months	Upstream	Downstream
January, 2015	21.57±1.12 a	19.87±0.98 b
February, 2015	25.30±0.98 a	21.29±1.24 b
March, 2015	19.17±1.11 a	16.87±2.13 b
April, 2015	28.12±0.68 a	26.48±1.56 b

Means with different letters in a row are statistically significant at $p<0.05$.

Heavy metals are amongst most devastating aquatic pollutants as their uptake negatively affects aquatic biota and ultimately they reach humans through food chain (Trivedi *et al.,* 2010). During present study, significantly ($p<0.05$) higher Cr concentrations were recorded from upstream as compared to downstream water samples while non-significant variations in metal concentrations were observed during different months from any sub-sampling station.

Table III:. Chromium concentration (µg/g) of bed sediment in Trimmu Barrage during study period

Sampling Months	Sediment (µg/g)
January, 2015	76.39±2.13 b
February, 2015	81.72±2.54 a
March, 2015	64.97±3.25 c
April, 2015	61.24±1.23 d
Mean	**71.08±8.32**

Means with the same letters in the column are statistically similar at $p<0.05$

These findings are in line with the results of Trivedi (2010) who documented seasonal variations in physico-chemical parameters from Kanpur, India. Similar, findings have been documented by Makwee*t al.* (2013) at Karu Abattoir. Maximum metal concentrations from upstream 28.12±0.68 mg/L and downstream 26.48±1.56 mg/L water samples were recorded during April while the same was minimum during March, 2015 (Table II).

These findings are in line with the results of Diagomanolin (2004) who observed higher metal concentrations from water samples collected from up-stream as compared to downstream from Karoon waterway river, Iran. This is because when water moves towards downstream,dilutiontakes place.Month-wise significant ($p<0.05$) differences were recorded in Cr ion concentrations in sediment samples. Metal ion concentration decreased in the order February>January>March>April (Table III).

Table IV: Relationship between chromiumtoxicity of water and bed sediments in Trimmu Barrage.

Mean concentration in water (MgL^{-1})(x)	Mean concentration in Sediments (μgg^{-1}) (Y)	Regression equation Y= a + bx	R^2
20.72±0.85	76.39±2.13	**Y= 81.058 + (-0.4468)x**	**0.0339**

A linear relationship of Cr uptake in water with accumulation in river bed sediments was observed. Regression equation between water and sediments for the uptake and accumulation of Cr is presented in Table IV.Similar results have been documented bySingh *et al.* (2005) for Cr from Gomti river sediments.Significant ($p<0.05$) variations in mean Cr concentrations were recorded between liver>gills>skin>muscle during present study (Table V). Nwamaka (2013) reported bioaccumulation of heavy metals into the bodies of the fish through gills, liver, stomach and intestine.Qadir and Malik (2008) determined concentration of lead, cadmium, chromium, and copper in gills, liver, gills, kidneys and muscles of eight fish species. Metal concentration was higher in liver followed by gills, kidneys and muscles. Similar findings have been documented by Moselhy *et al.* (2014).Among all the three fish species, maximum metal concentration was accumulated by *Cirrhinus mrigala* followed by *Catla catla* and *Labeo rohita*. These findings are in line with the results of Shakir *et al.* (2014), who observed accumulation of heavy metals in major carps in the order *Cirrhinus mrigala*>*Labeo rohita*>*Catla catla*.

CONCLUSION

It can be concluded from the present study that upstream at Trimmu barrage contained higher Cr concentrations than the downstream. Among Indian major carps, *Cirrhinus mrigala* accumulated higher concentrations of Cr while highest Cr concentrations were recorded from liver as compared to the gills, skin and muscle samples of the fish.

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