http://www.pjbs.org

PJBS

ISSN 1028-8880

Pakistan Journal of Biological Sciences

ANSInet
Asian Network for Scientific Information
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

Pakistan Journal of Biological Sciences 16 (9): 412-420, 2013
ISSN 1028-8880 / DOI: 10.3923/pjbs.2013.412.420

Histopathology and Bioaccumulation of Heavy Metals (Cr, Ni and Pb) in Fish (*Channa striatus* and *Heteropneustes fossilis*) Tissue: A Study for Toxicity and Ecological Impacts

Mahino Fatima and Nazura Usmani
Aquatic Toxicological Research Laboratory, Department of Zoology, Faculty of Life Sciences,
Aligarh Muslim University, Aligarh-202002 (U.P), India

Abstract: The water samples were collected from the 22 km segment III of Yamuna River from Okhla barrage. This segment receives water from 17 sewage drains of Delhi, Western Yamuna Canal (WYC), upper Ganga canal via Najafgarh drain and Hindon cut canal. Hence, the water samples collected were used to determine the presence of Chromium, Nickel and Lead through Atomic Absorption Spectrophotometry. The concentration of these heavy metals were much above the maximum permissible limits set by WHO. This was bound to have its influence on the riverine flora and fauna. To evaluate this, two popularly consumed fish species such as *Channa striatus* and *Heteropneustes fossilis* were caught and the bioaccumulation of these heavy metals were estimated in different organs (liver, kidney, gill and muscle). It was found that Cr accumulated the most in these organs (gill being most influenced) in both the species. The accumulation of all these heavy metals were above MPL set by World Health Organisation (WHO) and Food and Drug Administration (FDA). Histopathology was also conducted where heavy damages were observed in both liver and kidney of both the species.

Key words: *Channa striatus*, *Heteropneustes fossilis*, gills, muscles, kidney, liver

INTRODUCTION

Water is most precious natural resource that exists on our planet and is essential for survival but the development of modern technology and rapid industrialization are responsible for aquatic pollution. Discharged waste from industries into the water bodies disturbs the flora and fauna (Gad, 2009; Veena *et al*., 1997; Ashraf, 2005; Farombi, *et al*., 2007; Wong *et al*., 2001). High concentration of heavy metal in water has been reported in different water bodies of India due to heavy metal contamination (Rajaganapathy *et al*., 2011; Ambedkar and Muniyan, 2011; Chattopadhyay, *et al*., 2002), particularly due to anthropogenic activities (domestic, industrial and agriculture) by human (Gumgum *et al*., 1994; Jordao *et al*., 2002; Nimmo *et al*., 1998). This stands true for Yamuna barrage as well. Heavy pollution in river water is attributed to effluent discharges from small and large industries, automobile wastes and surface run-offs from adjoining areas. Tremendous efforts have been put by Indian Government yet the effluents have brought river water quality far below the limits prescribed by EPA. The study was undertaken because rapid industrialisation and colonisation of Okhla region has increased the pollution level of river Yamuna at alarming rate. Now pollution of this river has increased drastically affecting human life, cattle and aquatic species and has reached far below bathing standards (NCT, 2005).

Water quality from various sources have been studied all over world (Ekeanyanwu *et al*., 2010; Mohamed, 2008; Montaser *et al*., 2010; Ozturk *et al*., 2009) but in India it is restricted to Southern region only (Ambedkar and Muniyan, 2011; Mahadev and Gholami, 2010; Sreedhara Nayaka *et al*., 2009; Murugan *et al*., 2008). Studies till now have been focussed on determining the water quality of Okhla barrage but there is no data on its impact on fish biology in general and bioaccumulation and histopathology in particular. The data so presented by us is useful to create awareness so that some preventive measures be implemented by the Government to protect the natural fauna and thus ultimately the health of local population. Fishes form major biota to be studied as it comes in direct contact with polluted water. They possess comparatively higher trophic level thus are used as bio-indicator of heavy metal concentration (Lopes *et al*., 2001; Svobodova *et al*., 2004; Vinodhini and Narayanan, 2009). Also, these fishes owing to their palatability are captured and are sold in local markets of Okhla region which in long term may consequently bio-accumulate in humans as well.

Corresponding Author: Mahino Fatima, Aquatic Toxicological Research Laboratory, Department of Zoology, Faculty of Life Sciences, Aligarh Muslim University, Aligarh-202002 (U.P), India Tel: +91-9411211236

Accumulation of chemical pollutants is known to adversely affect the liver, kidney, muscle and other tissues of fish (Canli *et al.*, 1998; Javed, 2004; Olowu *et al.*, 2010; Puttaiah and Kiran, 2007) which can be visualised through histopathology (Akan *et al.*, 2009; Al-Attar, 2007; Nair *et al.*, 1984). Liver is major target organ for xenobiotics and thus, is frequently cited as the site of parenchymal damage following exposure to various chemical agents (Gingerich, 1982; Montaser *et al.*, 2010). Kidney is severely affected by different toxic chemical which is evident in form of pathological changes such as necrosis of hematopoietic tissue, vacuolation of tubular cells, dilation of glomerular capillaries and degeneration of epithelial cell linings (Abdel-Baki *et al.*, 2011; Kumar and Pant, 1981). Such detrimental effect of heavy metal contamination was also seen in the study with high level of bioaccumulation and marked histopathological evidences. The present study was carried out on naturally affected fish species as it avoided unnecessary killing and induction of healthy fishes with heavy metals and thus avoided ethical issues for the use of animals.

MATERIALS AND METHODS

Study area: The sampling site (Yamuna barrage from where Yamuna River leaves Delhi laden with city's biological and chemical waste) lies in Delhi in North India, at an altitude 216 km above sea level. The 22 km segment III of Yamuna River from Okhla barrage (Fig. 1) (28° 32' 49" N longitude and 77°18' 48" E latitude), receives water from 17 sewage drains of Delhi and also from Western Yamuna Canal (WYC) and upper Ganga canal via. Najafgarh drain and Hindon cut canal. The categories of industries discharging waste water into Yamuna water includes pulp and paper, sugar, distillaries, textiles, leather, chemical, pharmaceuticals, oil refineries, thermal power plants food etc.

Collection of water and fish specimens: The systematic water sampling was adopted to get unbiased profiling of the river. Zonal sampling was done from four sides of barrage with three replica of each zone. Simultaneously, fish (murrel, *Channa striatus* and catfish, *Heteropneustes fossilis*) samples were also collected with the help of local fisherman. Physico-chemical parameters (temperature, pH and dissolved Oxygen) were recorded at the site itself. Water samples were stored for the analysis of Heavy metals as per standard method of sampling techniques (APHA, AWWA and WEF, 1999).

Sample analyses: Fishes (12 specimen) obtained (Length 20-25 cm; Weight 220-280 g) were dissected and organs (liver, kidney, gill and muscle) were removed and collected. Wet digestion of the tissue was conducted to evaluate the bioaccumulation of heavy metals according to the methods proposed by Vanloon (1980) and Du Preez and Steyn (1992). Heavy metals (Cr, Ni and Pb) were analyzed using Atomic Absorption Spectrophotometer and results are expressed in $\mu g\ g^{-1}$ (for tissue samples) and $mg\ L^{-1}$ (for water samples). All the chemicals (Metal stock solutions, Sulphuric acid, Nitric acid and Perchloric acid) used were of analytical grade.

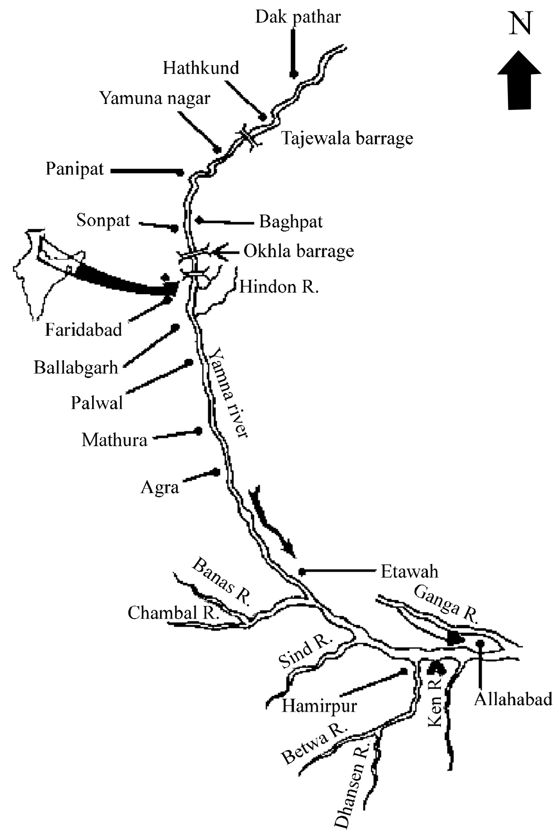

Fig. 1: Map showing sampling location of Okhla barrage of Yamuna River, India

Bioaccumulation factor: Bioaccumulation factor was evaluated for the three heavy metals in four different tissues of the fishes. Bioaccumulation Factor (BAF) is calculated as the ratio of concentration of a pollutant (heavy metal) accumulated in the tissue of organism with respect to the concentration of that pollutant (heavy metal) in water body (Authman and Abbas, 2007). The BAF was calculated using the formula:

$$\text{Bioaccumulation factor (BAF)}: \frac{\text{Concentration of heavy metal in fish tissue } (\mu g\ g^{-1})}{\text{Concentration of heavy metal in water body } (mg\ L^{-1})}$$

Histopathology: Live fishes were considered for histology. Soon after catching, the fishes were dissected and the organs were fixed in Bouins fluid for 24 h. Tissue processing, blocks preparation and staining of the slides were done as per described by Gray (1954). The prepared slides (5 μm sections) were observed under the microscope (Nikon 80i) at 400X and examined for histopathological alterations.

Statistical analysis: Parameters (mean and standard deviation) were calculated for the data obtained for physiochemical properties of water and for the presence of Heavy metals in water and fish samples. One-way analysis of variance (ANOVA) was applied to compare the difference amongst the means. p-values less than 0.05 were considered significant. As post hoc test for multiple comparisons, Duncan's new Multiple Range Test (MRT) was applied (Duncan, 1955).

RESULTS AND DISCUSSION

Physico-chemical properties of river and bioaccumulation in fish: The physico-chemical properties of Yamuna river water, Delhi are given in Table 1. The River water temperature ranged between 22.8-23°C, the pH was found to be slightly alkaline (7.32-7.78). Dissolved oxygen concentration (1.5-3.7 mg L^{-1}) was below normal for fish health. Lead (Pb) (0.4 mg L^{-1}), Nickel (Ni) (0.39 mg L^{-1}) and Chromium (Cr) (0.28 mg L^{-1}) were present in levels beyond the recommended values set by WHO. This had its toll on fish health as the bioaccumulation of heavy metals (Cr, Ni and Pb) (μg g^{-1} wet weight) in different tissues of fish *C. striatus* was detected and is given in (Table 2). Amongst the heavy metals Cr (gills (51.91 μg g^{-1}) followed by kidney (42.01 μg g^{-1}), liver (15.31 μg g^{-1}) and muscle (5.51 μg g^{-1}) accumulated the most in all the organs. It was followed by Pb (kidney (21.49 μg g^{-1})>gill (19.03 μg g^{-1})>liver (13.45 μg g^{-1}) and muscle (3.16 μg g^{-1})]. The least accumulated heavy metal was Ni [gill (9.09 μg g^{-1})>kidney (8.71 μg g^{-1})>liver (4.05 μg g^{-1}), and muscle (1.45 μg g^{-1})]. In *H. fossilis* the pattern observed was comparable to *C. striatus* (Table 3). Cr accumulated the most [gill (157.64 μg g^{-1})> liver (94.82 μg g^{-1})> kidney (21.21 μg g^{-1})> muscle (18.51 μg g^{-1})] in all the organs followed by Ni [gill (42.4 μg g^{-1}), followed by kidney (1.57 μg g^{-1})>muscle (1.2 μg g^{-1})> liver (0.56 μg g^{-1})) and Pb [gill (20 μg g^{-1}) followed by muscle (2.21 μg g^{-1})> kidney (1.63 μg g^{-1}) and liver (0.45 μg g^{-1})]. Gill was the most influenced organ in both the fish species.

Bioaccumulation factor: The heavy metal accumulation in water and values accumulated in tissues were used to calculate Bioaccumulation Factor (BAF) (Table 4 for *C. striatus*) and (Table 5 for *H. fossilis*). The values observed during the present study have been compared with the recommended values for the three heavy metals (Cr, Ni, and Pb) and they were found to be above the Maximum permissible limit (MPL) of WHO (1985) and FEPA (1999) (Table 6).

Histopathological effects: Histological changes in the two species due to the exposure to the heavy metals are

Table 1: Physico-chemical properties of Yamuna river, Delhi

Parameter	Minimum	Maximum	Mean±SD (n = 12)
Temperature (°C)	22.8	23	23.10±0.36
pH	7.32	7.78	7.49±0.25
DO (mg L^{-1})	1.5	3.70	2.60±1.10
Chromium (mg L^{-1})	0.28	0.295	0.28±0.01
Nickel (mg L^{-1})	0.31	0.44	0.39±0.07
Lead (mg L^{-1})	0.38	0.44	0.40±0.04

Table 2: Bioaccumulation of heavy metals (Cr, Ni and Pb) in (μg g^{-1}) wet weight in different tissues of fish *C. striatus*

Samples	Cr, μg g^{-1}	Ni, μg g^{-1}	Pb, μg g^{-1}
Gills	$51.91\pm0.729^{a,a}$	${}_{a}9.09^{c}\pm0.733$	${}_{b}19.03^{b}\pm0.469$
Liver	$15.31\pm0.689^{c,a}$	${}_{b}4.05^{c}\pm0.151$	${}_{c}13.45^{b}\pm0.403$
Kidney	$42.01\pm0.182^{b,a}$	${}_{a}8.71^{c}\pm0.171$	${}_{a}21.49^{b}\pm0.491$
Muscle	$5.51\pm0.439^{d,a}$	${}_{c}1.45^{c}\pm0.183$	${}_{d}3.16^{b}\pm0.240$
*Average	28.69	5.83	14.28

*Average heavy metal load (mean of all the four organs studied) in order to compare with workers who have taken the average values/fish as a whole, Data is shown as ${}_{y}V^{x}\pm SD$, whereas V = Mean value of twelve replicates, x = Superscript of different letters which are statistically significant for the accumulation of different heavy metals within a tissue and y = Subscript of different letters which are statistically significant for a heavy metal accumulation within tissues, at the p = 0.05 level

Table 3: Bioaccumulation of heavy metals (Cr, Ni and Pb) in μg g^{-1} wet weight in different tissues of fish *H. fossilis*

Samples	Cr (μg g^{-1})	Ni (μg g^{-1})	Pb (μg g^{-1})
Gills	${}_{a}157.64^{a}\pm0.720$	${}_{a}42.4^{b}\pm0.22$	${}_{a}20^{c}\pm0.24$
Liver	${}_{b}94.82^{a}\pm0.56$	${}_{b}0.56^{b}\pm0.063$	${}_{d}0.45^{b}\pm0.07$
Kidney	${}_{c}21.21^{a}\pm0.39$	${}_{c}1.57^{b}\pm0.25$	${}_{c}1.63^{b}\pm0.085$
Muscle	${}_{d}18.51^{a}\pm0.06$	${}_{b}1.2^{c}\pm0.25$	${}_{b}2.21^{b}\pm0.25$
*Average	73.045	11.43	6.07

*Average heavy metal load (mean of all the four organs studied) in order to compare with workers who have taken the average values/fish as a whole, Data is shown as ${}_{y}V^{x}\pm SD$, whereas V = Mean value of twelve replicates, x = Superscript of different letters which are statistically significant for the accumulation of different heavy metals within a tissue and y = Subscript of different letters which are statistically significant for a heavy metal accumulation within tissues, at the p = 0.05 level

Table 4: Bioaccumulation Factor (BAF) in *C. striatus* tissue samples

Tissues	Chromium	Nickel	Lead
Gill	182.14	23.31	47.58
Liver	53.72	10.38	33.63
Kidney	147.4	22.33	53.73
Muscle	19.33	4.00	7.78

Table 5: Bioaccumulation Factor (BAF) in *H. fossilis* tissue samples

Tissues	Chromium	Nickel	Lead
Gill	553.12	108.72	50
Liver	332.7	1.43	1.125
Kidney	74.42	4.03	4.08
Muscle	64.95	4.17	5.53

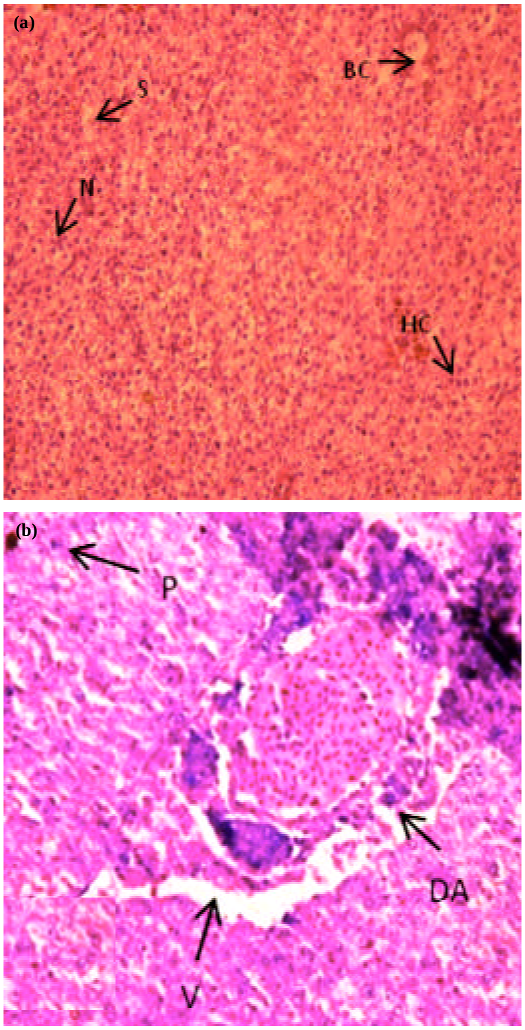

Fig. 2(a-b): Transverse section of liver from two fishes, *C. striatus* (a) Liver of control fish characterized by Nucleus (N), Hepatic Cell (HC), Bile Canaliculi (BC) and sinusoid (S), (b) Liver of infected fish features Tissue vacuolization (V), Pyknotic Nuclei (P) and Distorted Artery wall (DA) (400x)

Table 6: Recommended values (Maximum permissible limit) of Heavy metals in fish (µg g^{-1}) and water (mg L^{-1}) compared to present study

	Metals			
Concentration	Chromium	Nickel	Lead	References
Food fish	0.15	0.5- 0.6	0.3	WHO (1985), FEPA (1999)
C. striatus	5.51	1.56	3.11	
H. fossilis	18.51	1.63	2.21	Present study*
Water	0.05	0.07	0.01	WHO (1985)
Yamuna water	0.285	0.39	0.40	Present study*

*Presence in the edible part i.e., the muscle

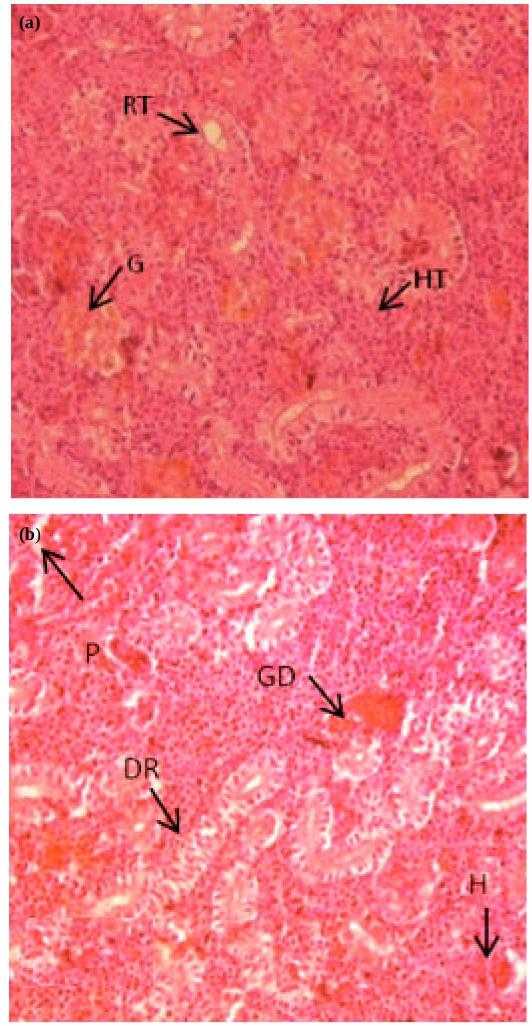

Fig. 3(a-b): Transverse section of the kidneys from two fishes, *C. striatus* (a) Kidney of control fish showing Glomerulus (G), Renal Tubule (RT), Hematopoietic Tissue (HT), (b) Kidney of infected fish with marked Degenerated Renal tubules (DR), pyknotic nuclei (P), Haemorrhage (H) and Glomerular Degeneration (GD) (400x)

evident from the Fig. 2-5. Marked changes were observed in liver and kidney. Industrial effluents induced significant structural changes in *C. striatus* liver tissue (Fig. 2b) such as pyknosis and vacuolization of tissue. Ruptured liver tissue can also be seen in adjoining areas of distorted artery wall. Kidney morphology also changed markedly due to the presence of heavy metals in the water (Fig. 3b). Alterations are visible in the form of kidney tubules necrosis, pyknosis, hemorrhage and glomerular

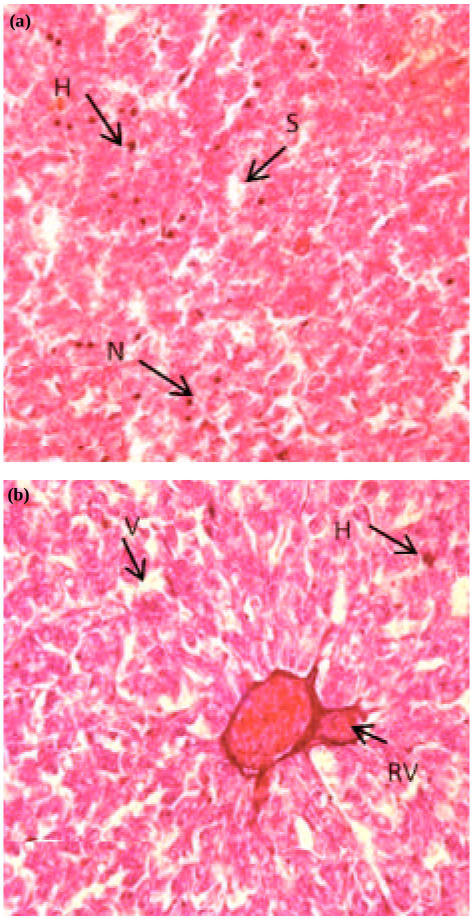

Fig. 4(a-b): Transverse section of the liver from two fishes, *H. fossilis* A. liver of control fish characterized by Hepatic cells (H), Sinusoids (S) and Nucleus (N), (b) Liver of infected fish with marked Tissue Vacuolization (V), Ruptured Vein (RV) and Haemorrhage (H) (400x)

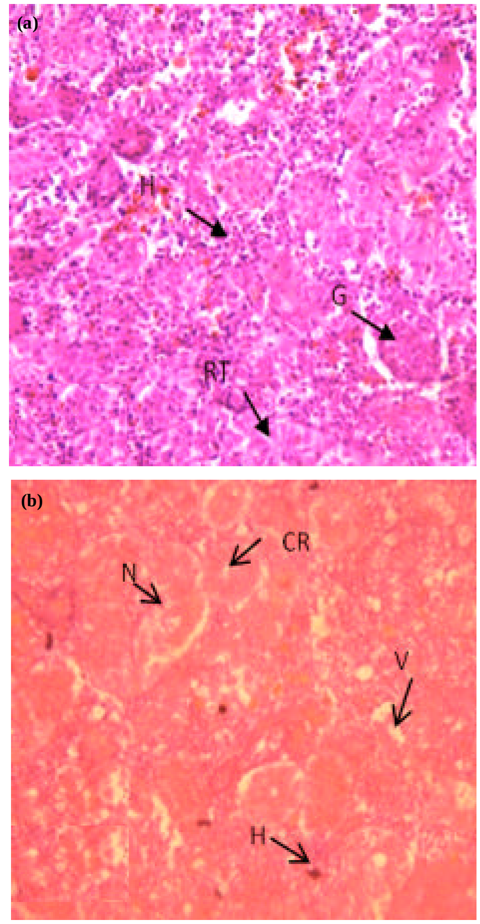

Fig. 5(a-b): Transverse section of the kidney from two fishes, *H. fossilis* (a) Kidney of control fish showing Renal tubule (RT), Glomerulus (G) and Hematopoietic Tissue (HT), (b) Kidney of infected fish with marked Necrosis (N), Tissue Vacuolization (V), Congested Renal Tubules (CR) and Hemorrhages (H) (400x)

degeneration. Liver of infected *H. fossilis* (Fig. 4b) shows vacuolization of the tissue, ruptured vein and hemorrhages. Similarly, the infected kidney due to the influence of heavy metal shows several changes (Fig. 5b). The variations observed were necrotic urinary tubules, vacuolization, hemorrhages and congested renal tubules.

Aquatic environment is loaded with wide range of pollutants. Puttaiah and Kiran (2007), studied the levels of heavy metals in Jannapura lake, Karnataka and they were in the order Pb>Cu>Zn>Cd>Ni>Co and their value exceeded Maximal Permissible Level (MPL) as per WHO standards. Seyhan River, Turkey (Canli *et al*., 1998); Lithuania fresh waters (Staniskiene *et al*., 2006) and Okumeshi River, Turkey (Ekeanyanwu *et al*., 2010) are few other heavy metal polluted rivers. Heavy metals have become a serious issue now-a-days because of its persistent nature and for causing serious health complications. Presence of heavy metals in aquatic environment is dependent upon wide range of chemical, biological and environmental factors (Ajmal and Razi-ud-Din, 1988). This has been realized and work has been done on estimation of various heavy metals in different water bodies. But this work was conducted to study the presence of Cr, Pb and Ni in Yamuna Barrage, a zone used as source to supply fish to various markets. Heavy metals then accumulate in different tissues of the fish from three possible ways i.e., through body surface, gills and digestive tract (Pourang, 1995). Food may also be an important source of heavy metal accumulation in fish (Javed and Hayat, 1996) which may be attributed to the fact that the food sources of these fishes are polluted which leads to biomagnifications of these heavy metals in food chain (Javed, 2004). Heavy metals (Pb 0.4 mg L^{-1}), Ni (0.39 mg L^{-1}) and Cr (0.29 mg L^{-1})) estimated from the site selected were above the maximum permissible limit set by WHO (1985). This can exert toxic effects on human beings if is used for drinking and irrigation. The accumulation of these heavy metals was also observed. Cr ranged from 5.51-51.91 µg g^{-1} in the tissue of *C. striatus* (gill>kidney>liver>muscle), while between 18.51-157.64 µg g^{-1} in *H. fossilis* (gill>liver>kidney> muscle) and these values are higher than WHO and FEPA recommended limits of 0.15 µg g^{-1} in food fish. Other workers have reported lesser (0.8-1.07 µg g^{-1}) Cr in various fish species such as *Chrysichthys nigrodigatatus* (taken as a whole) from Yamuna River in Delhi region (Sen *et al.*, 2011). Comparable accumulation of Cr (3.7-26.9 µg g^{-1}) was reported in tissue of *H. fossilis* obtained from the Yamuna River water (Ajmal and Razi-ud-Din, 1988). Whereas, fishes *Wallago attu* and *Labeo dyocheilus* obtained from water sources such as Kabul River, Pakistan showed higher accumulation of Cr (Yousafzai *et al.*, 2010). The amount of Cr accumulation reported in different tissues was 600 µg g^{-1} (gills)>533.3 µg g^{-1} (muscle)>510 µg g^{-1} (liver) and 730.3 µg g^{-1} (gills) 647.3 µg g^{-1} (muscle)> 643.7 µg g^{-1} (Liver), respectively.

Ni ranged from 1.45-9.09 µg g^{-1} (gill> kidney> liver> muscle) in *C. striatus* and 0.56-42.40 µg g^{-1} (gill>kidney> muscle>liver) in *H. Fossilis* tissues and values are higher than WHO and FEPA recommended limits of 0.5-0.6 µg g^{-1}, respectively in food fish. Studies conducted on fishes such as *Mugil cephalus* and *Trachurus mediterraneus* from Iskenderun Bay, Turkey (Yilmaz, 2003) exhibited lower accumulation of Ni ranging between 7.35 and 0.99 µg g^{-1} in various organs. Similarly, study conducted by OztUrk *et al.* (2009) in Avsar Dam Lake in Turkey also revealed the accumulation of Ni in muscle (1.27 µg g^{-1}), gills (3.52 µg g^{-1}) and liver (7 µg g^{-1}) of *Cyprinus carpio*, which shows from Iskenderun Bay and Avsar Dam Lake are less polluted than present study. Whereas higher accumulation observed in *L. dyocheilus* [152 µg g^{-1} (gills)>117.7 µg g^{-1} (muscles)>111.7 µg g^{-1} (liver)] and *W. Attu* (122.7 µg g^{-1} (gills)>108 µg g^{-1} (liver)>106.7 µg g^{-1} (muscle)] obtained from river Kabul as reported by Yousafzai *et al.* (2010). But in all these studies, gill was most influenced organ as also been reported in the present study.

Accumulation of Pb found to be 3.16-21.49 µg g^{-1} (kidney>gill>liver>muscle) in *C. striatus* while 0.45-20 µg g^{-1} (gill>muscle>kidney>liver) in *H. fossilis*. These values are higher than WHO and FEPA recommended limits of 0.3 µg g^{-1} in food fish. Our values are comparable to those reported by (Ajmal and Razi-ud-Din, 1988), in fish *H. fossilis* obtained from five different sampling stations of Yamuna River from Delhi to Allahabad with concentration of Pb between 1.4-12.8 µg g^{-1}. While, Sen *et al.* (2011) shown range from 0.47-24 µg g^{-1} in a catfish, *Chrysichthys nigrodigatatus* (fish as a whole) caught from river Yamuna (Delhi), which is comparable to the present study for catfish, *H. fossilis*. This shows that Yamuna river been contaminated with respect to the increasing load of Ni over the last decade. Kabul River of Pakistan showed the values for Pb accumulation as 528.7 µg g^{-1} (muscle)> 377 µg g^{-1} (liver)> 301.3 µg g^{-1} (gills) for *L. dyocheilus* and 623.3 µg g^{-1} (liver)> 599.3 µg g^{-1} (muscle)> 453.3 µg g^{-1} (gills) in *W. attu*, as reported by (Yousafzai *et al.*, 2010) and thus reveals the fact that heavy metal loads are much higher than Yamuna Barrage. Their report also reveals higher accumulation of Pb in muscle and liver while in the present study Pb accumulated the most in gills. Studies conducted by Olowu *et al.* (2010) on *Tilapia zilli* and *Chrysichthys nigrodigatatus* to determine the influence of heavy metals (Fe, Zn and Ni) in fish tissue (head, trunk, tail, gills and intestine) and water sample from Epe [Fe(7.30)>Ni(0.69)>Zn(0.42)} and Badagry (Fe(6.65)> Zn(0.54)>Ni(0.10)) lagoons shows that Fe and Ni were present in highest concentration in the head and gills as water passes through these two organs. Preset study also depicted gill to be most influenced organ with highest bioaccumulation factor due to the fact gills have large surface area and branchial respiration leads to direct contact of heavy metal laden water to enter the gills.

In order to study the impact of these heavy metals on histopathology two organs i.e., liver and kidney are used as they are commonly studied organs by other workers as well. Teleost liver is major target organ for xenobiotics metabolism and thus, frequently cited as the site of parenchymal damage following exposure to various chemical agents (Gingerich, 1982). Microscopically, the parenchyma can be seen as a three-dimensional network of sinusoids composed of cuboidal hepatocytes with narrow spaces lined with, endothelial cells. While, kidney is involved in removal of wastes from blood (Fange, 1986) and is severely affected by different toxic chemical which is evident in form of pathological changes such as necrosis of hematopoietic tissue, vacuolation of tubular cells, dilation of glomerular capillaries and degeneration of epithelial cell linings (Kumar and Pant, 1981). The influenced liver of *C. striatus* exhibited tissue vacuolization, pyknosis and distorted artery wall which has been in comparison with control (Fig. 2a) shows normal arrangement of hepatocytes with nucleus, bile canaliculi and sinusoid. Liver of control *H. fossilis* (Fig. 4a) showing Normal histology of liver tissue with hepatic cells, nucleus and sinusoids while liver of infected fish is marked by vacuolization of the tissue, ruptured vein and hemorrhages. Kidney of *C. striatus* showed degenerated renal tubules, pyknosis, hemorrhages and glomerular degeneration as compared to its control (Fig. 3a) with normal histology showing glomerulus, renal tubules and hematopoietic tissue. The control kidney of *H. fossilis* (Fig. 5a) showed normal renal tubules, glomerulus and hematopoietic tissue while necrosis, tissue vacuolization, congested renal tubules and hemorrhages were evident in the kidney of infected *H. fossilis*. Such changes have been reported by other workers but from fishes inhabiting water bodies lying in Southern India. Similar to the present study, in other report hepatocytes showed marked cytoplasmic vacuolization and sinusoids, in most areas were distended and central veins appeared severely damaged due to marked swelling and degeneration of the endothelial lining cells (Radhakrishnan and Hemalatha, 2010). Acute toxicity impacts of hexavalent chromium on kidney of *Channa punctatus* showed hypertrophy of epithelial cells of renal tubules with reduced lumens, atrophy of the renal tubules, glomerular contraction in the Bowman's capsules and necrosis of hematopoietic tissues. The inter-renal cells of the head kidney exhibited distinct hypertrophy and vacuolization (Mishra and Mohanty, 2008). Thus, these changes influences fish health and therefore the population of the fish in this zone. This will ultimately influence the major protein source available to the population as well as can endanger the species surviving there.

CONCLUSION

To conclude, the present study generates data regarding the increasing pollution in the Yamuna Barrage and it confirms that it is having strong impact on fish health as these heavy metals are accumulating in different tissues of the selected fish species i.e., *C. striatus* and *H. fossilis* This is further supported by the deformities that occur in two major organs such as kidney and liver. The edible fish species thus is unfit for human consumption. Further studies can be conducted in order to study the impact of these heavy metals on the reproductive system as it will reveal the decline in the population of species inhabiting the site selected. Effective measures such as legislative provision and other waste management tools for environmental protection should be implemented for the well being of dwelling flora and fauna and ultimately the health of local populations.

ACKNOWLEDGMENTS

The author gratefully acknowledges the Chairman, Department of Zoology, AMU, Aligarh for providing facilities for undertaking the studies. The author is grateful to the Maulana Azad National Fellowship (GRANTNo.F.40-3(M/S)/2009(SA-III/MANF), University Grant Commission, New Delhi, for financial assistance (awarded Junior Research Fellowship). Author is also thankful to the Instrumentation Unit, Department of Chemistry, AMU, Aligarh for technical support.

REFERENCES

APHA, AWWA and WEF, 1999. Standard Methods for the Examination of Water and Wastewater. 20th Edn., American Public Health Association, American Water Works Association and Water Environment Federation, Washington DC, USA.

Abdel-Baki, A.S., M.A. Dkhil and S. Al-Quraishy, 2011. Bioaccumulation of some heavy metals in tilapia fish relevant to their concentration in water and sediment of Wadi Hanifah, Saudi Arabia. Afr. J. Biotechnol., 10: 2541-2547.

Ajmal, M. and Razi-ud-Din, 1988. Studies on the Pollution of Hindon River and Kali Nadi. In: Ecology and Pollution of Indian Rivers, Trivedy, R.K. (Ed.). Ashish Publishing House, New Delhi, pp: 87-112.

Akan, J.C., F.I. Abdulrahman, V.O. Ogugbuaja and J.T. Ayodele, 2009. Heavy metals and anion levels in some samples of vegetable grown within the vicinity of challawa industrial area, kano state, Nigeria. Am. J. Applied Sci., 6: 534-542.

Al-Attar, A.M., 2007. The influences of nickel exposure on selected physiological parameters and gill structure in the teleost fish, *Oreochromis niloticus*. J. Biol. Sci., 7: 77-85.

Ambedkar, G. and M. Muniyan, 2011. Accumulation of metals in the five commercially important freshwater fishes available in Vellar River Tamil Nadu, India. Arch. Applied Sci. Res., 3: 261-264.

Ashraf, W., 2005. Accumulation of heavy metals in kidney and heart tissues of *Epinephelus microdon* fish from the Arabian Gulf. Environ. Monit. Assess., 101: 311-316.

Authman, M.M. and H.H. Abbas, 2007. Accumulation and distribution of copper and zinc in both water and some vital tissues of two fish species (*Tilapia zillii* and *Mugil cephalus*) of lake Qarun, Fayoum Province, Egypt. Pak. J. Biol. Sci., 10: 2106-2122.

Canli, M., O. Ay and M. Kalay, 1998. Levels of heavy metals (Cd, Pb, Cu, Cr and Ni) in tissue of *Cyprinus carpio*, *Barbus capito* and *Chondrostoma regium* from the Seyhan River, Turkey. Turkish J. Zool., 22: 149-157.

Chattopadhyay, B., A. Chatterjee and S.K. Mukhopadhyay, 2002. Bioaccumulation of metals in the East Calcutta wetland ecosystem. Aquati. Ecosyst. Health Manage., 5: 191-203.

Du Preez, H.H. and G.J. Steyn, 1992. A preliminary investigation of the concentration selected metals in the tissues and organs of the tiger fish (*Hydrocynus vittatus*) from the Oilfants river, Kruger national park, South Africa. Water SA, 18: 131-136.

Duncan, D.B., 1955. Multiple range and multiple F tests. Biometrics, 11: 1-42.

Ekeanyanwu, C.R. C.A. Ogbuinyi and O.F. Etienajirhevwe, 2010. Trace metals distribution in fish tissues, bottom sediments and water from Okumeshi river in Delta State, Nigeria. Ethiopian J. Environ. Stud. Manage., 3: 12-17.

FEPA, 1999. Guidelines to standard for environment pollution control in Nigeria, Lagos. Nigeria.

Fange, R., 1986. Physiology of Haemopoiesis. In: Fish Physiology: Recent Advances, Nilsson, S. and S. Holmgren (Eds.). Routledge, London, pp: 1-23.

Farombi, E.O., O.A. Adelowo and Y.R. Ajimoko, 2007. Biomarkers of oxidative stress and heavy metal levels as indicators of environmental pollution in African cat fish (*Clarias gariepinus*) from Nigeria Ogun River. Int. J. Environ. Res. Public Health, 4: 158-165.

Gad, N.S., 2009. Determination of glutathione related enzymes and cholinesterase activities in *Oreochromis niloticus* and *Clarias gariepinus* as bioindicator for pollution in Lake Manzala. Global Vet., 3: 37-44.

Gingerich, W.H., 1982. Hepatic Toxicology of Fishes. In: Aquatic Toxicology, Weber, L.J. (Ed.). Raven Press, New York, pp: 55-105.

Gray, P., 1954. The Microtomist's Formulary and Guide. Blakiston, New York, pp: 403-409.

Gumgum, B., E. Unlu, Z. Tez and Z. Gulsun, 1994. Heavy metal pollution in water sediment and fish from the Tigris River in Turkey. Chemosphere, 29: 111-116.

Javed, M. and S. Hayat, 1996. Planktonic productivity of river water as a bio-indicator of freshwater contamination by metals. Proc. Pak. Cong. Zool., 16: 283-298.

Javed, M., 2004. Comparison of selected heavy metals toxicity in the planktonic biota of the river Ravi. Ind. J. Biol. Sci., 1: 59-62.

Jordao, C.P., M.G. Pereira, C.R. Bellato, J.L. Pereira and A.T. Matos, 2002. Assessment of water systems for contaminants from domestic and industrial sewages. Environ. Monit. Assess., 79: 75-100.

Kumar, S. and S.C. Pant, 1981. Histopathology effects of acutely toxic levels of copper and zinc on gills, liver and kidney of *Punctius conchonius* (Ham.). Ind. J. Expt. Biol., 19: 191-194.

Lopes, P.A., T. Pinheiro, M.C. Santos, M. da Luz Mathias, M.J. Collares-Pereira and A.M. Viegas-Crespo, 2001. Response of antioxidant enzymes in freshwater fish populations (*Leuciscus alburnoides* complex) to inorganic pollutants exposure. Sci. Total Environ., 280: 153-163.

Mahadev, J. and S. Gholami, 2010. Heavy metal analysis of cauvery river water around KRS dam, Karnataka, India. J. Adv. Lab. Res. Biol., 1: 13-19.

Mishra, A.K. and B. Mohanty, 2008. Acute toxicity impacts of hexavalent chromium on behavior and histopathology of gill, kidney and liver of the freshwater fish, *Channa punctatus* (Bloch). Environ. Toxicol. Pharmacol., 26: 136-141.

Mohamed, F.A.S., 2008. Bioaccumulation of selected metals and histopathological alterations in tissues of *Oreochromis niloticus* and *Lates niloticus* from Lake Nasser, Egypt. Global Vet., 2: 205-218.

Montaser, M., M.E. Mahfouz, S.A.M. El-Shazly, G.H. Abdel-Rahman and S. Bakry, 2010. Toxicity of heavy metals on fish at Jeddah coast KSA: Metallothionein expression as a biomarker and histopathological study on liver and gills. World J. Fishes Mar. Sci., 2: 174-185.

Murugan, S.S., R. Karuppasamy, K. Poongodi and S. Puvaneswari, 2008. Bioaccumulation pattern of zinc in freshwater fish *Channa punctatus* (Bloch.) after chronic exposure. Turk. J. Fish. Aquat. Sci., 8: 55-59.

NCT, 2005. Measures to control water pollution in river Yamuna in Delhi. Report on Government of NCT of Delhi of 2005.http://saiindia.gov.in/english/home/Our_Products/Audit_report/Government_Wise/state_audit/recent_reports/Delhi/rep_2004/civilvolII_yamu_rev.pdf

Nair, K.R., F. Manji and J.N. Gitonga, 1984. The occurrence and distribution of fluoride in groundwaters of Kenya. Proceedings of the Symposium on Challenges in African Hydrology and Water Resources, July 23-27, 1984, Harare, Zimbabwe, pp: 75-86.

Nimmo, D.R., M.J. Willox, T.D. Lafrancois, P.L. Chapman, S.F. Brinkman and J.C. Greene, 1998. Effects of metal mining and milling on boundary waters of yellowstone national park, USA. Environ. Manage., 22: 913-926.

Olowu, R.A., O.O. Ayejuyo, G.O. Adewuyi, I.A. Adejoro, A.A.B. Denloye, A.O. Babatunde and A.L. Ogundajo, 2010. Determination of heavy metals in fish tissues, water and sediment from Epe and Badagry lagoons, Lagos, Nigeria. E-J. Chem., 7: 215-221.

Ozturk, M., G. Ozozen, O. Minareci and E. Minareci, 2009. Determination of heavy metals in fish, water and sediments of Avsar dam Lake in Trukey. Iran J. Environ. Health Sci. Eng., 6: 73-80.

Pourang, N., 1995. Heavy metal bioaccumulation in different tissues of two fish species with regards to their feeding habits and trophic levels. Environ. Monitor. Assess., 35: 207-219.

Puttaiah, E.T. and B.R. Kiran, 2007. Heavy metal transport in a sewage fed lake of Karnataka, India. Proceedings of the Taal 2007: 12th World Lake Conference, October 29-November 2, 2007, Jaipur, India, pp: 347-354.

Radhakrishnan, M.V. and S. Hemalatha, 2010. Sublethal toxic effects of cadmium chloride to liver of freshwater fish *Channa striatus* (Bloch.). Am.-Eurasian J. Toxicol. Sci., 2: 54-56.

Rajaganapathy, V., F. Xavier, D. Sreekumar and P.K. Mandal, 2011. Heavy metal contamination in soil, water and fodder and their presence in livestock and products: A review. J. Environ. Sci. Technol., 4: 234-249.

Sen, I., A. Shandil and V.S. Shrivastava, 2011. Study for determination of heavy metals in fish species of the river Yamuna (Delhi) by inductively coupled plasma-optical emission spectroscopy (ICP-OES). Adv. Applied Sci. Res., 2: 161-166.

Sreedhara Nayaka, B.M., S. Ramakrishna and M.R. Delvi, 2009. Impact of heavy metals on water, fish (*Cyprinus carpio*) and sediments from a water tank at Tumkur, India. Oceanol. Hydrobiol. Stud., 38: 17-28.

Staniskiene, B., P. Matusevicius, R. Budreckiene and K.A. Skibniewska, 2006. Distribution of heavy metals in tissues of freshwater fish in Lithuania. Polish J. Environ. Stud., 15: 585-592.

Svobodova, Z., O. Celechovska, J. Kolarova, T. Randak and V. Zlabek, 2004. Assessment of metal contamination in the upper reaches of the Ticha Orlice River. Czech J. Anim. Sci., 49: 458-464.

Vanloon, J.C., 1980. Analytical Atomic Absorption Spectroscopy Selected Methods. Academic Press Inc., Orlando, London.

Veena, B., C.K. Radhakrishnan and J. Chacko, 1997. Heavy metal induced biochemical effects in an estuarine teleost India. J. Mar. Sci., 26: 74-78.

Vinodhini, R. and M. Narayanan, 2009. The impact of toxic heavy metals on the hematological parameters in common carp (*Cyprinus carpio* L.). Iran. J. Environ. Health Sci. Eng., 6: 23-28.

WHO., 1985. Guidelines for Drinking Water Quality. Vol. 5, World Health Organization, Geneva, Switzerland.

Wong, C.K., P.P.K. Wong and L.M. Chu, 2001. Heavy metal concentrations in marine fish collected from culture sites in Hong Kong. Arch. Environ. Contami. Toxicol., 40: 60-69.

Yilmaz, A.B., 2003. Levels of heavy metals (Fe, Cu, Ni, Cr, Pb and Zn) in tissue of *Mugil cephalus* and *Trachurus mediterraneus* form Iskenderun Bay, Turkey. Environ. Res., 92: 277-281.

Yousafzai, A.M., D.P. Chivers, A.R. Khan, I. Ahmad and M. Siraj, 2010. Comparison of heavy metals burden in two freshwater fishes *Wallago attu* and *Labeo dyocheilus* with regard to their feeding habits in natural ecosystem. Pak. J. Zool., 42: 537-544.