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METALS CONCENTRATIONS IN THE RIVERINE WATER, SEDIMENTS AND FISHES FROM RIVER RAVI AT BALLOKI HEADWORKS

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ABSTRACT

The river Ravi has been one of the major recipients of industrial effluents and domestic sewage in Punjab. In this study concentrations of heavy metals, such as Fe, Zn, Cu, Cr and Ni were determined in riverine water, sediment and muscle of three fish species, *Labeo rohita, Cirrhina mrigala, Catla catla* procured from river Ravi at Balloki. The data obtained after water analysis reflected the order of occurrence of heavy metals to be Fe> Zn >Cu > Cr >Ni. The analysis of heavy metals in sediment indicated that among the five heavy metals tested; Fe was maximally accumulated followed by Zn, Cr, Cu and Ni. The trend of heavy metals accumulation in fish muscles was found to be similar to that observed in sediment and water such as Fe> Zn >Cu > Cr >Ni. Data indicated that Fe accumulated maximally in the sediment as well as muscles of the three fish species in comparison to other metals. In water Fe and Cr but in sediment Fe, Cu, Cr, Ni concentrations were significantly higher than some international limits for these metals. Zn, Cu, Cr, Ni values in fish exceeded almost all the international limits. Highest concentrations of all the metals were found in *Cirrhina mrigala* whereas *Catla catla* showed lowest accumulation in muscles.

Key words: Metals, Fish species, Water Sediment, Balloki Headworks.

INTRODUCTION

Rivers systems are being excessively contaminated with heavy metals released from domestic wastes, industrial effluents, and agricultural runoff Adnano (1986). According to Mendil *et al*. (2005), unlike other toxicants of organic nature, metallic elements are environmentally ubiquitous, readily dissolved in, transported by water, readily taken up by aquatic organisms and are considered to be persistent component in the aquatic environment. Fishes constitute major components of most aquatic habitats and they act as bio-indicator of heavy metal levels in aquatic environment Alinnor and Obiji (2010). Ahmad and Bibi (2010) reported that bioaccumulation studies of metals is an index of pollution status of water body and is useful tool for studying the biological role of metals present at elevated levels in aquatic organisms, especially fish. According to Vermeulen and Wepener (1999); Linnik and Zubenk (2000); Casper *et al*. (2004), aquatic sediments absorb persistent and toxic chemicals to levels many times higher than the water column concentration but according to Soares *et al*. (1999) and Ünlü *et al*. (2008) sediments permit the determination of metals even when their concentrations in water are undetectable. Al-Khashman (2007); Duran *et al*. (2007); Shokrollahi *et al*. (2008); Yetimoglu *et al*. (2007); Cevik *et al*. (2008) and Yildirim *et al.* (2009) reported that bio-monitoring of trace elements is very essential to assess ecosystem health.

Industrial development in Pakistan during past few decades has launched many industrial zones at major cities. These industries are producing tremendous amount of effluents that are drained into nearby rivers like Ravi. River Ravi, being seasonal receives enough rain water during monsoon season while in winter the amount of water decreases significantly. But the industrial effluents and city sewage are produced uninterrupted and enter continuously in the river untreated as reported by Ahmed *et al.* (2011).

Balloki Headworks (Latitude: 31° 13' 10 N, Longitude: 73° 51' 35 E) on river Ravi is located at a distance of about 42 miles from Lahore in the South-West direction. This barrage is very important for commercial fishing but receives 168 cusecs of effluents from nearly 200 industries and 3136 cusecs of domestic waste water from Lahore City as reported by Atlas (2002) without any treatment. As the contaminated water of river Ravi after leaving Lahore City, reaches Head Balloki where its water gets mixed with contaminated water of River Chenab, the pollution level increases many times. Therefore, discharge of untreated industrial and domestic wastewater is a serious threat for aquatic life especially fish. The present study was carried out to determine the concentrations of various trace metals (Fe, Zn, Cu, Cr, Ni) in sediments, water and fishes collected from river Ravi at Balloki Headworks.

MATERIALS AND METHODS

Thirty soil and water samples, fifteen samples in winter and summer each (five samples from each of three sampling site) were collected from river Ravi at Balloki Headworks. Water samples were collected with the help of Van Dorn Bottle Sampler and soil samples were collected with the help of Ekmann Dredge. About 200 ml of water sample was filtered through 0.45 µm glass fiber filter and transferred to acid cleaned 250 ml polypropylene bottle and then acidified with concentrated nitric acid to pH <2.0. All the sediment samples were sealed in polyethylene bags embedded in ice during transportation to the laboratory. They were then air-dried and passed through a 1 mm size sieve to separate the stones, leaves, and dead invertebrates. The sediments were then ground into powder of particle size less than 100 meshes (sieve size = 0.152 mm) using a mortar and a pestle following Adhikari *et al.* (2009). Half a gram tissue samples were taken into digestion tube, 4 ml of HNO_3 (Analar grade, BDH) was added to the samples and left for over night. Samples were heated at 120°C in heating digester (Behr Labor- Technik Gmb H.D- 40599 Dusseidorf) as reported by Yilmaz *et al.* (2007) for 1 hr, cooled, 0.4ml of H_2O_2 (Analar grade, BDH) was added and placed back in heating digester until colorless as done by Tan (2005).

Fifty four specimens of *Labeo rohita, Cirrhina mrigala* and *Catla catla* (3 specimen of each fish species from each sampling site for each season) were collected from Balloki Headworks (table 1) through random commercial catches during winter and summer (Fig. 1). Fish muscles from the dorsal side of the fish, were removed (with plastic knife), washed with distilled water, dried in filter paper, homogenized, packed in polyethylene bags and stored below −20°C until analysis according to the procedures followed by Tabinda *et al*. (2010). Double de-ionized water was used for all aqua dilutions. HNO_3, H_2O_2 were super pure from E. Merck Darmstadt Germany. All glassware were cleaned by soaking in dilute HNO_3 (1/9, v/v) and were rinsed with de-ionized water before use following Uluozlu *et al*. (2007) procedure. Standard solutions of each metal were prepared by diluting a stock solution of 1g/L of each metal (E. Merck. One gram of fish tissue sample was weighed and digested using 6 ml of 65% HNO_3, and 2 ml of 35% H_2O_2. Each sample was gradually heated on hot plate until the sample solutions were clear. The completely digested samples were allowed to cool at room temperature, filtered, transferred into a 25 ml volumetric flask and diluted to the mark with double deionized water as done by Yilmaz *et al.* (2007). After filtration, fish samples were analyzed for Fe, Zn, Cr, Cu, Ni using Perkin-Elmer, AA 400 atomic absorption spectrophotometer but Cu was analyzed using MHS 10 hydride generator assembly. All elements were determined against aqueous standards following the procedures of Karadede *et al*. (2004).The data are presented in µg $g^{-1}$of sample (wet weight). Procedural blanks and metal standards (water: SRM-143d, National Institute of Standards and Technology; sediment: CRM-277, Community Bureau of Reference; fish: DORM-2, National Research Council) were analyzed after every five samples to check accuracy and metal recoveries as done by Yap *et al*. (2004). Recovery rates ranged from 95 to 99% for all elements were investigated.

All data were subjected to statistical analysis and correlation matrices were produced to examine the inter-relationships between the investigated metal concentrations in sediment, water and fish tissue samples. T-test was performed to determine the level of significance among various means.

RESULTS AND DISCUSSION

Results

Concentrations of metals in water, sediments and fish: The concentrations of Fe, Zn, Cu, Cr, and Ni in water ranged between 1.490-1.500 mg L^{-1}, 0.172-0.173 mg L^{-1}, 0.145-0.146 mg L^{-1}, 0.071-0.072 mg L^{-1}, and 0.040-0.040 mg L^{-1} in winter and 2.000-2.100 mg L^{-1}, 0.480-0.480 mg L^{-1}, 0.370-.0.371 mg L^{-1}, 0.136-0.136 mg L^{-1}, and 0.075-0.078 mg L^{-1} in summer respectively (Table I). Order of the metal concentrations in the water samples was Fe> Zn >Cu > Cr >Ni.

The concentrations of Fe, Zn, Cu, Cr, and Ni in sediments ranged between 1849.00-1863.00 mg L^{-1}, 125.68-133.16 mg L^{-1}, 38.4-47.93 mg L^{-1}, and 48-51.85 mg L^{-1}, and 23.5-25.21 mg L^{-1} in winter season and 1949'00-1973.28 mg L^{-1}, 138.58-147.20 mg L^{-1}, 55.44-60.13 mg L^{-1}, 61.60-67.30 mg L^{-1}, and 28.99-32.53 mg L^{-1} in summer season respectively (Table II). The metal levels of sediments were in order as; Fe> Zn >*C*u > Cr >Ni.

Results on heavy metal concentrations in the muscle of fish taken seasonally from the Ravi are summarized in Table III. The concentration of Fe, Zn, Cu, Cr, and Ni in *Cirrhina mrigala* ranged as 78.89-90.43 mg L^{-1}, 58.74-65.47 mg L^{-1}, 5.94-6.56 mg L^{-1}, 1.43-1.49 mg L^{-1} and 1.33-1.4 mg L^{-1} in winter and 83.95-109.48 mg L^{-1}, 69.47-77.86 mg L^{-1}, 6.60-7.14 mg L^{-1}, 1.64-1.92 mg L^{-1} and 1.86-2.19 mg L^{-1} in summer respectively. In *Labeo Rohita* the concentration of Fe, Zn, Cu, Cr, and Ni ranged as 64.55-73.19 mg L^{-1}, 48.85-57.53 mg L^{-1}, 4.34-5.39 mg L^{-1}, 1.10-1.21 mg L^{-1} and 0.69-0.83 mg L^{-1} in winter season and 82.99-91 mg L^{-1}, 59.33-68.11 mg L^{-1}, 6.45-6.84 mg L^{-1}, 1.53-1.66 mg L^{-1} and 1.79-2.03 mg L^{-1} in summer season respectively. The concentration of Fe, Zn, Cu, Cr, and Ni in *Catla catla* ranged as 41.91-53.59 mg L^{-1}, 29.24-37.74 mg L^{-1}, 2.79-3.20 mg L^{-1}, 1.06-1.07 mg L^{-1} and 0.35-0.41 mg L^{-1} in winter and 64.38-71.91 mg L^{-1}, 42.97-50.46 mg L^{-1},

Table 1 Concentrations of metals (mg L^{-1}) in water from river Ravi at Balloki Headworks and their comparison with international limits

Water	Winter	Fe	Zn	Cu	Cr	Ni
		1.499±0.0005 [b]	0.172 ±0.0005 [b]	0.145±0.0005[b]	0.071±0.0006 [b]	0.04±0.0 [b]
		(1.490-1.500)	(0.172-0.173)	(0.145-0.146)	(0.071-0.072)	(0.040-0.040)
	Summer	2.060 ± 0.060 [a]	0.480±0.000 [a]	0.370±0.0005[a]	0.136±0.000 [a]	0.076±0.001 [a]
		(2.000-2.100)	(0.480-0.480)	(0.370-.0.371)	(0.136-0.136)	(0.075-0.078)
International values (mg L^{-1})	WHO (1993)	0.200	-	2 .000	0.010	0.020
	EPA (2003)	-	3.000	-	0.010	-
Other studies (concentration mg L^{-1})	Gediz River in west Anatolia, Turkey[1]	-	-	0.034	-	-
	Attaturk Dam Lake, Turkey[2]	-	-	0.220	-	-
	Demirkopru Dam Lake [3]	0.025-5.490	0.012-0.370	0.020	0.001-0.044	-
	River Ganga, west Bengal[4]	-	-	-	3.86 ± 2.12	-
	Balloki Headworks, River Ravi, Pakistan[5]	-	-	-	-	0.012-3.750

1. Uzunoglu (1999); 2 Karadede and Ünlü (2000); 3.; Ozturk *et al*. (2008); 4. Kar *et al*. (2008); 5. Rauf *et al*. (2009a)
Different letters (a, b) within the same column of same species indicate significant difference

Table 2 Concentrations of metals (µg g^{-1}) in sediment from Balloki Headworks and their comparison with international limits

	Winter	Fe	Zn	Cu	Cr	Ni
Sediment		1861.00±11.14 [b]	128.84±3.87 [b]	43.65±4.84 [b]	50.37±2.07 [b]	24.12±0.95[b]
		(1849.00-1863.00)	(125.68-133.16)	(38.4-47.93)	(48-51.85)	(23.5-25.21)
	Summer	1958.29±13.10 [a]	143.38± 4.55 [a]	58.69±1.35 [a]	65.03±3.02 [a]	31.15±1.89[a]
		(1949'00-1973.28)	(138.58-147.20)	(55.44-60.13)	(61.60-67.30)	(28.99-32.53)
International values (mg kg^{-1})	Dutch Target Limit	-	140.00	36.00	100.00	35.00
Other studies (concentration mg kg^{-1})	Demirkopru Dam Lake, Gediz River in west Anatolia, Turkey[1]	-	-	-	-	60.50
	Lake Texoma marinas, Red River , USA[2]	-	-	-	-	-
	Danube River, Serbia and Montenegro[3]	-	70.00-230.00	11.00-35.00	28.00-54.00	17.00
	Almendares River, Cuba[4]	-	86.1-708.8	71.60-420.80	84.40-209.70	16.00-39.00
	Mengkabong Lagoon, Sabah, Malaysia[5]	1434 .00- 1836.00	-	-	-	-
	Orogodo River, Agbor, Delta state, Nigeria[6]	0.01-33.70	-	-	151.60	-
	Karasu Creek, Nigde, Turkey[7]	-	0.01-1.67	0.01-3.73	0.01-1.42	-
	Absar Dam Lake, Turkey[8]	22734.00 –	-	-	-	0.01-0.93
	Balloki Headworks, River Ravi, Pakistan[9]	25268.00	-	3.38 -159.79	4.60 - 57.40	-
		-				-

1. Uzunoglu (1999); 2. An and Kampbell (2003); 3. Milenkovic *et al*. (2005); 4. Olivares-Rieumont *et al*. (2005) ; 5. Praveena *et al*. (2007);
6. Puyate *et al* . (2007) ; 7. Yalcin *et al*. (2007); 8 Ozturk *et al*. (2009); 9 Rauf *et al*. (2009b)
Different letters (a, b) within the same column of same species indicate significant difference

Table 3 Concentrations of metals (μg g^{-1}) in fish species from Balloki Headworks and their comparison with other studies

Fish Species	Season	Metal Concentration				
		Fe	**Zn**	**Cu**	**Cr**	**Ni**
Cirrhina mrigala	Winter	84.32±5.70 ^{b}	61.74±3.42 ^{b}	6.24±0.31 ^{a}	1.46±0.02 ^{b}	1.37±0.04 ^{b}
		(78.89-90.43)	(58.74-65.47)	(5.94-6.56)	(1.43-1.49)	(1.33-1.4)
	Summer	96.53±12.76 ^{a}	73.97±4.22 ^{a}	6.89±0.27 ^{a}	1.78±0.14 ^{a}	1.99±0.1 ^{a}
		(83.95-109.48)	(69.47-77.86)	(6.60-7.14)	(1.64-1.92)	(1.86-2.19)
Labeo rohita	Winter	69.69±4.55 ^{b}	51.84±4.9 ^{b}	4.89±0.52 ^{b}	1.16±0.05 ^{b}	0.74±0.07 ^{b}
		(64.55-73.19)	48.85-57.53	(4.34-5.39)	(1.10-1.21)	(0.69-0.83)
	Summer	87.17±4.02 ^{a}	63.65±4.39 ^{a}	6.62±0.2 ^{a}	1.61±0.07 ^{a}	1.91±0.12 ^{a}
		(82.99-91)	(59.33-68.11)	(6.45-6.84)	(1.53-1.66)	(1.79-2.03)
Catla catla	Winter	48.01±5.86 ^{b}	34.02±4.35 ^{b}	3.02±0.2 ^{b}	1.07±0.005 ^{b}	0.38±0.03 ^{b}
		(41.91-53.59)	(29.24-37.74)	(2.79-3.20)	(1.06-1.07)	(0.35-0.41)
	Summer	68.11±3.76 ^{a}	46.33±3.80 ^{a}	4.50±0.13 ^{a}	1.62±0.09 ^{a}	1.76±0.16 ^{a}
		(64.38-71.91)	(42.97-50.46)	(4.41-4.64)	(1.53-1.72)	(1.62-1.94)
International limits	Canadian Food Standard (Papagiannis *et al*. 2004)	-	100	100	-	-
(mg kg^{-1})	USEPA (2000)	-	-	-	0.491	1.00
Oth Other studies	Freshwater Reservoirs, Indus River, Pakistan[1]	0.620	2.670	0.589	0.930	0.155
(concentration mg μg	Rawal Lake, Pakistan[2]	-	-	-	1.53-	-
g^{-1} μg	Manila Bay, Philippines[3]	-	39-124	1.11- 5.45	-	-
	Sır Dam Lake, Kahramanmaraş, Turkey[4]	0.99 (nd -2.87)	-	-	-	0.787(nd -1.93)
	Portugal[5]	6.4 -16	14 - 22	0.9-1.4	0.66-1.3	0.11 – 0.25
	Ponds, Tamilnadu, India[6]	-	-	-	1.083±0.21	0.63±0.015
	Avsar Dam Lake, Turkey [7]	16.55±6.99	-	3.85±2.1	1.18±0.73	1.27±1.18
	Kayseri, Tukey[8]	-	19.59 – 79.71	nd -1.67	nd -1.94	nd-16.07
	river Ravi, Pakistan[9]	-	19.00-79.00	-	1.48±0.51	-
	Keti Bunder, Thatta, Pakistan[10s]	0.247± 0.002	1.490± 0.109	0.001± 0.001	0.209± 0.003	0.149± 0.002
	aricay stream turkey[11s]	(0.223- 0.249)	(1..345-1.612)	(0.000-0.003)	(0.191-0.213)	(0.138-0.152)
	Alexandria Region, Egypt[12]	4.24-172	6.3-28.55	-	-	Nd
	Sicily , Italy*l*[13]	-	16.50-40.50	6.9-15.4	-	-
		-	-	0.13-5.20		0.63

1. Ashraf *et al*. (1991); 2 Ashraf *et al*. (1992); 3. Prudent *et al*. (1997); 4. Erdoğrul and Erbilir (2007) ; 5 Carvalho *et al*. (2005) ; 6 Vinodhini and Narrayan (2008);7 Ozturk *et al*. (2009); 8 Yildrim *et al* (2009); 9 Rauf *et al*. (2009b); 10 Tabinda *et al*. (2010); 11 Yilmaz (2007); 12 Nabwi *et al* (1987); 13 Licata *et al* (2005)

Different letters (a, b) within the same column of same species indicate significant difference

4.41-4.64 mg L^{-1}, 1.53-1.72 mg L^{-1} and 1.62-1.94 mg L^{-1} during summer respectively. Metal accumulation in three species of Indian major carp at Balloki Headworks during winter and summer followed the order Fe> Zn> Cu> Cr> Ni (except Ni in three species during summer). Highest concentrations of all the metals were detected in *Cirrhina mrigala* whereas *Catla catla* showed lowest accumulation among the three species analysed.

Table 4 Correlation analysis for fish

	Fe	Zn	Cu	Cr	Ni
Zn	0.984				
Cu	0.981	0.964			
Cr	0.665	0.581	0.582		
Ni	0.708	0.622	0.659	0.964	

Table 5 Correlation analysis for water

	Fe	Zn	Cu	Cr	Ni
Zn	0.986				
Cu	0.986	1.00			
Cr	0.986	1.00	1.00		
Ni	0.987	0.998	0.998	1.00	

Table 6 Correlation analysis for sediment

	Fe	Zn	Cu	Cr	Ni
Zn	0.818				
Cu	0.926	0.855			
Cr	0.933	0.955	0.899		
Ni	0.927	0.699	0.899	0.790	

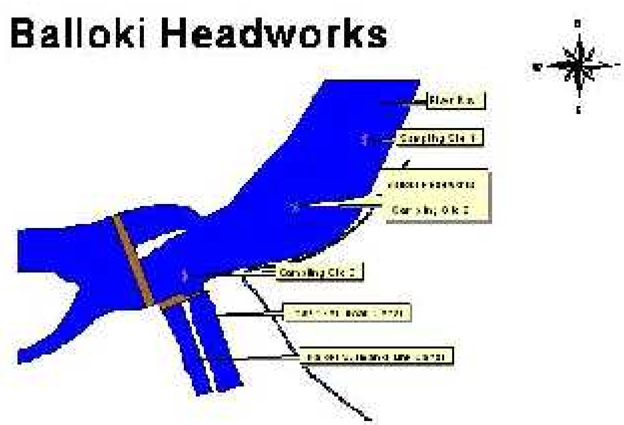

Fig. 1 Map of the study area.

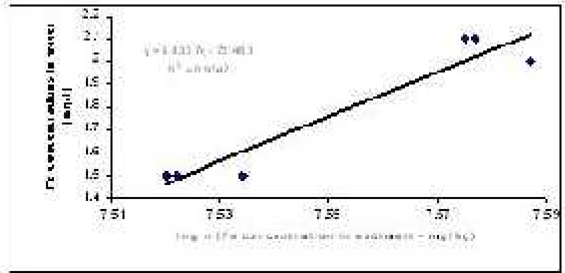

Fig 2a. Relationship between sediment and water for Fe concentration

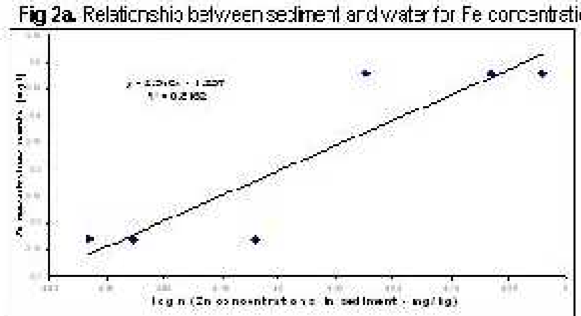

Fig 2b. Relationship between sediment and water for Zn concentration

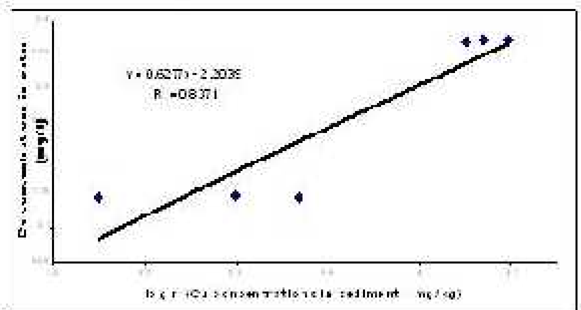

Fig 2c. Relationship between sediment and water for Cu concentration

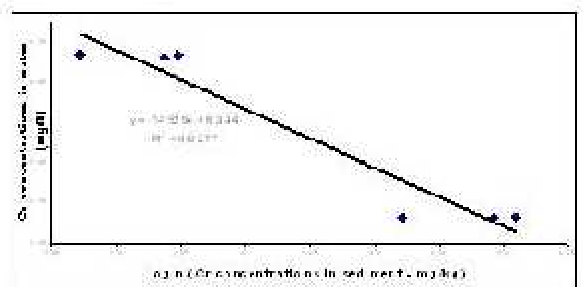

Fig 2d. Relationship between sediment and water for Cr concentration

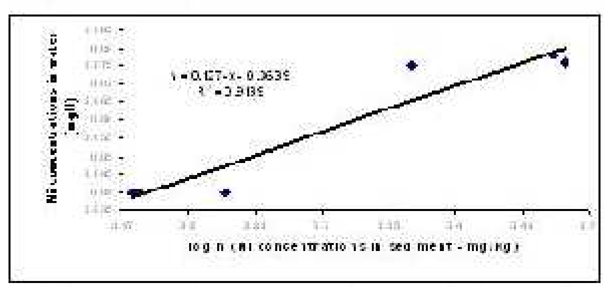

Fig 2e. Relationship between sediment and water for Ni concentration

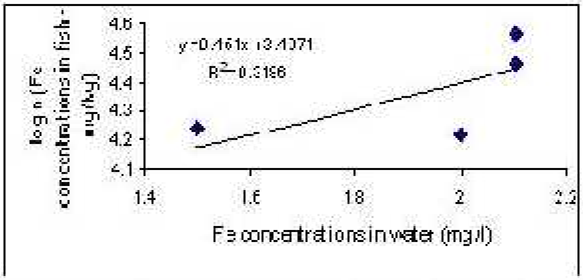

Fig. 3a Relationship between fish and water for Fe concentration

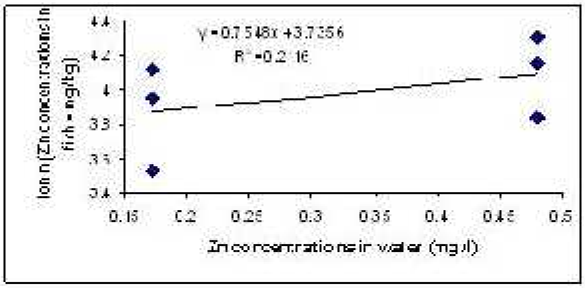

Fig. 3b Relationship between fish and water for Zn concentration

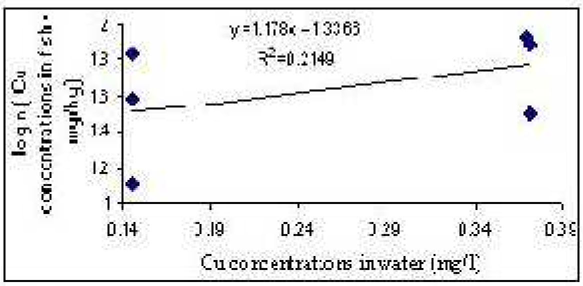

Fig. 3c Relationship between fish and water for Cu concentration

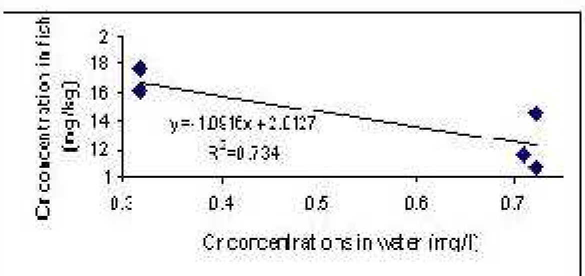

Fig. 3d Relationship between fish and water for Cr concentration

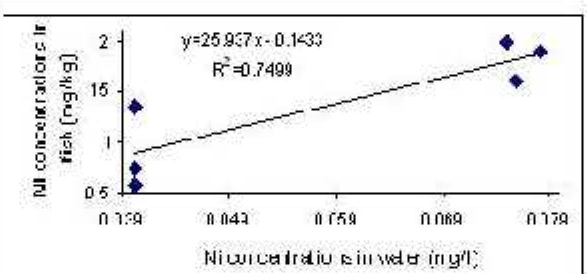

Fig. 3e Relationship between fish and water for Ni concentration

DISCUSSION

The concentration of iron in water of river Ravi at Balloki Headworks during winter season was 7.4 times higher but during summer 10.3 times in excess than the WHO standard of 0.2 mg/L. Zinc concentration during winter and summer seasons was within the EPA permissible standard of 3.0 mg/L. Similarly copper concentration during both the seasons was well below the WHO limit of 2.0 mg/L. But chromium value was 7.0 times higher during winter season while 13.6 times in excess during summer season as compared to EPA standard of 0.010 mg/L. Nickel concentration during winter was twice while during summer 3.8 times higher than WHO limit of 0.020 mg/L. Comparison of metals concentrations detected during present studies and their values found in literature for other rivers is presented in Table I. Range of nickel in water of river Ravi at Balloki Headworks found during present studies during both winter and summer seasons was very low than it's value reported by Rauf *et al*. (2009). According to them the main sources of pollution in River Ravi are municipal sewage, scientific laboratories, paper and pulp industries, steel factories and electroplating workshops (Rauf *et al*. 2009).

In sediments metals concentrations during summer season were higher as compared to winter season. Akin and Unlu (2007); Kassim *et al*. (1997); Rauf *et al*. (2009) reported similar results**.** Zinc concentration in sediments during winter was within the Dutch permissible limit and in summer almost similar to the Dutch limit of 140µg/g. Copper concentration in sediments was about 1.2 times higher during winter and 1.6 times in excess as compared to the Dutch standard of 36µg/g. The chromium and nickel concentration in sediments during both winter and summer seasons was within the Dutch permissible limits of 100µg/g and 35µg/g respectively. Sediments accumulate the metals from water so high amount of metals were recorded in sediments as compared to water and fish tissue (Akin and Unlu, 2007).

Concentration of iron in tissue of all fish species analysed was higher in summer season as compared to winter season. The concentration of zinc and copper in tissues of all fish species analysed during both seasons was within the Canadian permissible standard of 100µg/g. The concentration of chromium in *Cirrhina mrigala* was 3.5 and 4.2, in *Labeo rohita* 2.3 and 3.2 times, in Catla catla 2.1 and 3.2 times higher in winter and summer seasons than the USEPA permissible limit of 0.491µg/g. Nickel concentration in muscle of *Cirrhina mrigala* was approximately 1.4 and 1.9 times higher, in *Labeo rohita* below and 1.9 times higher, in *Catla catla* below and 1.7 times higher during summer and winter as compared to USEPA standard of 1.0µg/g. Presence of metal concentration in fish tissue may be due to their contact with water and sediments contaminated with these metals. Rauf *et al*. (2009) reported that contaminated sediments also introduce heavy metals in the above lying column. Highest concentration of all metals was detected in tissues of *Cirrhina mrigala* followed by *Labeo rohita* and *Catla catla*. Muscle of *Cirrhina mrigala* was more contaminated among the three species analysed. According to Zoumis *et al*. (2001) sediments are sinks for the heavy metals, pesticides and aquatic species are directly exposed to these chemicals through contact with sediments. The release of metals from sediments to the water and fish in aquatic habitat is dependent upon chemical characteristics of water, solubilization, absorption, precipitation and complexation behavior of metals (Javed, 2003). It may be due to the fact that *Cirrhina mrigala* it is a bottom dweller and its contact with sediments is high. *Labeo rohita* and *Catla catla* has less metals concentrations as compared to *Cirrhina mrigala* as *Labeo rohita* is a mid water column dweller and *Catla catla* is a upper water column dweller as they are in less or no contact with contaminated sediments. However, some metals concentrations were found in their tissues because metals are re-suspended in the water column by the bottom dwelling fish.

Inter-elemental correlation analysis: From the correlation of sediment (Table 5), Fe is highly correlated with Cu, Cr and Ni but Cr is highly correlated with Zn. Cu has significant correlation with Zn, Cr and Ni; Fe has significant correlation with Zn but relationship of Ni is positive with Zn and Cr. Other relationships are not significant. Correlation of water (Table 6) indicates that Zn is highly correlated with Cu and Cr; Cu is highly correlated with Cr and Ni; Ni is highly correlated with Cr and Zn; Fe is positively correlated with Zn, Cu, Cr and Ni. Other relationships are not significant. Correlation of fish (Table 7) indicates that Fe is strongly correlated with Zn; Cu is strongly correlated with Fe and Zn. Other relationships are not significant.

Relationship of sediment and water (Fig. 2a-2e) indicates positive correlation between log n Fe in sediment and Fe in water; log n Zn in sediment and Zn in water; log n Cu in sediment and Cu in water, but negative correlation between log n Cr in sediment and Cr in water; log n Ni in sediment and Ni in water.

Relationship of water and fish (Fig. 3a-3e) indicates non-significant or negative relationships.

REFERENCES

Adhikari, S., L. Ghosh, S. P. Rai, and S. Ayyappan (2009). Metal concentrations in water, sediment, and fish from sewage-fed aquaculture ponds of Kolkata, India. Environ. Monitor. Assess. 159:217–230.

Adnano, D. C. (1986). Trace metals in the terrestrial environment. New York: Springer Verlag. Limits.

Ahmed, M. S. and S. Bibi (2010). Uptake and bioaccumulation of water-borne lead (Pb) in the fingerlings of a freshwater cyprinid, *Catla catla.* The J. Anim. Plant Sci. 20 (3): 201-207.

Ahmed, M. S., Y. Aslam, and W. A. Khan (2011). Absorption and bioaccumulation of water-borne inorganic mercury in the fingerlings of grass carp, C*tenopharyngodon idella*. The J. Anim. Plant Sci. 21(2): 176-181.

Akin, H.K. and Unlu, E. 2007. Heavy Metal Concentrations in Water, Sediment,Fish and Some Benthic Organisms from Tigris River, Turkey. Environ Monit Assess, 131:323–337.

Alinnor I. J. and I. A. Obiji (2010). Assessment of trace metal composition in fish samples from Nworie River. Pakistan J. Nutr. 9 (1): 81-85: 2010

Al-Khashman, O. A. (2007). Determination of metal accumulation in deposited street dusts in Amman, Jordan. Environ. Geochemistry and Health, 29, 1–10.

An, Y. J. and D. H. Kampbell (2003). Total, dissolved, and bioavailable metals at Lake Texoma marinas. Environ. Pollut. 122: 253–259.

Ashraf M., J. Tariq and M. Jaffar (1991). Contents of trace metals in fish, sediment and water from three fresh water reservoirs on the Indus River, Pakistan. Fish. Res. 12(4): 355-364.

Ashraf, M., M. Jaffar and J. Tariq (1992). Annual variation of selected trace metals in freshwater lake fish, *Labeo rohita*, as an index of environmental pollution. Toxic. Environ. Chem. 35(1): 1 – 7.

Carvalho, M. L., E. S. Santiago and E. S. Nunes (2005). Assessment of the essential element and heavy metal content of edible fish muscle. Anal. Bio-anal Chem. 382: 426–432.

Casper, S. T., A. Mehra, M. E. Farago and R. A. Gill (2004). Contamination of surface soils, river water and sediments by trace metals from copper processing industry in the Churnet River Valley, Staffordshire, UK. Environ. Geochem. Health**.** 26: 59-67.

Cevik, U., N. Damla, B. Koz and S. Kaya (2008). Radiological characterization around the afsin-elbistan coal-fired power plant in Turkey. En. Fuel. 22(1): 428–432.

Duran, M., Y. Kara, G. K. Akyildiz, and A. Ozdemir (2007). Antimony and heavy metals accumulation in some macroinvertebrates in the Yesilirmak River (N Turkey) near the Sb-mining area. Bull. Environ. Contam. Toxicol. 78(5): 395–399.

Dutch Ministry. Sediment quality assessment. Review and discussion of current methods. http:// www. life-m3.eu/ fileadmin/ M3-life/ downloads/ presentations-workshop 2010/M3-Session5-Fl%FCck.pdf

Erdoğrul, O. and F. Erbilir (2007). Heavy metal and trace elements in various fish samples from Sır Dam Lake, Kahramanmaraş, Turkey. Environ. Monit. Assess. 130: 373–379.

EPA (Environmental Protection Agency), (2003). Risk assessment: Technical background information. RBGTable. Available from http://www.epa.gov. /reg3hwmd/risk(online update: 23.03.2009).

Javed, M., (2003). Relationships among water, sediments and plankton for the uptake and accumulation of metals in the river Ravi. Indus J. Plant. Sci., 2: 326–331

Kassim, T. I., Al-SaadiI, H. A., Al-lami, A. A. and Al-Jaberi, H. H. (1997). Heavy metal in water, suspended particles, sediments and aquatic plants of the upper region of Euphrates River, Iraq. J. Environ. Science and Health. Part A, 32, 2497 – 2506.

Kar, D., P. Sur, S. K. Mandal, T. Saha and R. K. Kole (2008). Assessment of heavy metal pollution in surface water. Int. J. Environ. Sci. Technol. 5(1): 119-124.

Karadede, H. and E. Unlu, E. (2000). Concentrations of some heavy metals in water, sediment and fish species from The Ataturk Dam Lake (Euphrates), Turkey. Chemosphere, 41: 1371–1376.

Karadede, H., S. A. Oymak and E. Unlu (2004). Heavy metals in mullet, Liza abu and Cat fish, Silurus triostegus, from the Atatürk Dam Lake (Euphrates), Turkey. Environ. Internat. 30(2): 183–188.

Licata, P., D. Trombetta, M. Cristani, C. Naccari, D. Martino, M. Calo and F. Naccari (2005). Heavy metals in liver and muscle of bluefin tuna (*Thunnus thynnus*) caught in the straits of messina (Sicily, Italy). Environ. Monitor. Assess. 107(1-3): 239–248.

Linnik, P. M. and B. Zubenko (2000). Role of bottom sediments in the secondary pollution of aquatic environments by heavy-metal compounds, Lakes and Reservoirs Research and Management, 5: 11-16.

Mendil, D., Ö. Uluözlü., E. Hasdemir, M. Tüzen, H. Sari and M. Suiçmez (2005). Determination of trace metal levels in seven fish species in lakes in Tokat, Turkey, Food Chem. 90 (1-2): 175-179.

Milenkovic, N., M. Damjanovic and M. Ristic (2005). Study of Heavy Metal Pollution in sediments from the Iron Gate (Danube River), Serbia and Montenegro. Polish J. Environ. Stud. 14(6): 781-787.

Olivares-Rieumont, S., D. de La Rosa, L. Lima, D. W. Graham, K. D. Alessandro, J. Borroto, F. Öztürk, M., G. Özözen, O. Minareci and E. Minareci (2008). Determination of heavy metals in of fishes, water and sediment from the Demirköprü Dam Lake(Turkey). J. App. Bio. Sci. 2(3): 99–104.

Öztürk, M., G. Özözen, O. Minareci and E. Minareci (2009). Determination of heavy metals in fish, water and Sediments of Avsar Dam lake in Turkey. Iran J. of Environ. Health Sci. and Eng. 6 (2): 73-80.

Papagiannis, I., I. Kagalou, J. Leonardos, D. Petridis and V. Kalfakakou (2004). Copper and zinc in four freshwater fish species from Lake Pamvotis (Greece). Environ. Intern. 30 (3): 357-362.

Praveena, S. M., A. Ahmed, M. Radojevic, M. H. Abdullah and A. Z. Aris (2007). Factor-cluster analysis and enrichment study of mangrove sediments-an example from Mengkabong, Sabah. Malaysian J. Anal. Sci. 11 (2): 421

Prudente, E.Y. Kim, S. Tanabe and R. Tatsukawa (1997). Metal levels in some commercial fish species from Manila Bay, the Philippines. Mar. Poll. Bull. 34 (8): 671–674.

Puyate, Y.T., A. Rim-Rukeh and J. K. Awatefe (2007). Metal Pollution Assessment and Particle Size Distribution of Bottom Sediment of Orogodo River, Agbor, Delta State, Nigeria. J. Appl. Sci. Res. 3(12): 2056-2061Rauf, A., M. Javed, M. Ubaidullah. (2009 a). Heavy metal levels in three major carps (C*atla catla, Labeo rohita* and *Cirrhina mrigala*) from the river Ravi, Pakistan. Pakistan Vet. J. 29(1): 24-26.

Rauf, A., M. Javed, M. Ubaidullah and S. Abdullah (2009b). Assessment of heavy metals in sediments of the river Ravi, Pakistan. Int. J. Agri. Biol. 11(2): 197–200.

Shokrollahi, A., M. Ghaedi, M. S. Niband and H. R. Rajabi (2008). Selective and sensitive spectrophotometric method for determination of sub-micro-molar amounts of aluminium ion. J. Hazard. Mat. 151(2–3): 642–648.

Soares, H. M. V. M., R. A. R. Boaventura, A. A. S. C. Machado, and J. C. G. Esteves Da Silva (1999). Sediments as monitors of heavy metal contamination in the Ave river basin (Portugal): multivariate analysis of data. Environ. Poll. 105(3): 311–323.

Tabinda, A. B., M. Hussain, I. Ahmed and A. Yasar (2010). Accumulation of toxic and essential trace metals in fish and prawns from Keti Bunder Thatta District, Sindh. Pakistan J. Zoo. 42(5): 631-638.

Tan K. H. (2005). Soil sampling, preparation and analysis. CRC press Taylor and Francis group. 6000 Brokan sound parkway. NW, Suite 300 Boca Raton FL 3348-2742.

Uluozlu, O. D., M. Tuzen, D. Mendil and M. Soylak (2007). Trace metal content in nine species of fish from the Black and Aegean Seas, Turkey. Food Chem. 10(2): 835-840.

Ünlü, S., S. Topçuoğlu, B. Alpar, C. Kırbaşoğlu and Y. Z. Yılmaz (2008). Heavy metal Pollution in surface sediment and mussel samples in the Gulf of Gemlik. Environ. Monitor. Assess. 144: 169–178.

USEPA (2000). Guidance for assessing chemical contaminant data for use in fish advisories: 1, Fish Sampling and Analysis 3rd Edition, Office of Science and Technology Office of Water USPA Washington, DC EPA 823-B-00-007: 1-200.

Uzunoğlu, O. (1999). Gediz nehrinden alınan su ve sediment örneklerinde bazı ağır metal konsantrasyonlarının belirlenmesi. Yüksek lisans tezi. Celal Bayar Üniversitesi Fen Bilimleri Enstitüsü, Manisa, Türkiye. (In Turkish)

Vermeulen, L. A. and V. Wepener (1999). Spatial and temporal variations of metals in Richards Bay Harbour (RBH), South Africa. Mar. Poll. Bull. 39(1); 304-307.

Vinodhini, R. and M. Narayanan (2008). Bioaccumulation of heavy metals in organs of fresh water fish *Cyprinus carpio* (Common carp). Inter. J Environ. Sci. Technol. 5 (2): 179-182.

WHO (World Health Organization), (1993). Guidelines for drinking water quality. Recommendations, 1, 2nd ed., Geneva

Yalcin, M. G., I. Narin and M. Soylak (2007). Heavy metal contents of the Karasu Creek Sediments, Nigde, Turkey. Environ. Monit. Assess. 128:351–357.

Yap, C. K., A. Ismail and S. G. Tan (2004). Heavy metal (Cd, Cu, Pb and Zn) concentrations in the green-lipped mussel *Perna viridis* (Linnaeus) collected from some wild and aquacultural sites in the west coast of Peninsular Malaysia. Food Chem. 84 (4): 569-575.

Yetimoglu, E. K., O. Ercan and K. Tosyali (2007). Heavy metal contamination in street dusts of Istanbul (Pendik to Levent) E-5 Highway. Annales de Chimie. 97: 227–235.

Yildirim, Y., Z. Gonulalan, I. Narin and M. Soylak (2009). Evaluation of trace heavy metal levels of some fish species sold at retail in Kayseri, Turkey. Environ. Monitor. Assess. 149: 223–228.

Yilmaz, F., N. Özdemir, A. Demirak, and A. L. Tuna (2007). Heavy metal levels in two fish species *Leuciscus cephalus* and *Lepomis gibbosus*. Food Chem. 100 (2): 830-835.

Zoumis, T., A. Schmidt, L. Grigorova and W. Calmano, (2001). Contamination in sediments: remobilization and demobilization. Sci. Total Environ., 266: 195–202