

LEVELS OF HEAVY METALS (CADMIUM, CHROMIUM, COPPER AND LEAD) ON WATER AND SELECTED TISSUES OF *OREOCHROMIS MOSSAMBICUS* FROM DIFFERENT LOCATIONS OF MALIR RIVER, KARACHI

*Raheela Sharmeen, M Zaheer Khan, Ghazala Yasmeen and Syed Ali Ghalib
Department of Zoology (Wildlife Section), University of Karachi, Karachi-75270

ABSTRACT

Heavy metals (Cd, Cr, Cu and Pb) concentrations were determined in surface and deep water samples along with their accumulation in tissues of the fish *Oreochromis mossambicus* from Malir River. Water and fish samples were collected from four locations (Murad Memon Goth, Malir City, Shah Faisal Colony and Qayumabad) of Malir River. Heavy metals concentrations in water and the fish were analyzed by using atomic absorption spectrophotometer. Heavy metal concentration in surface and deep water samples were found in order Cr>Cu>Pb>Cd and in the fish these were in the order Pb>Cu>Cr>Cd. In fish, Cd and Pb concentrations were found higher in gill samples while Cr and Cu concentrations were higher in liver samples, whereas gonads appeared to be the least preferred site for the bioaccumulation of metals. The concentrations of water samples were found to be above the values recommended by FAO/WHO (1993), NEQS (1993) and JECFA (2000) and in fish samples the concentrations of Cr, Cu and Pb were found to be higher than those recommended by WHO (1985), FEPA (2003) and FAO (1983) in fish food.

Keywords: Malir River, heavy metals, bioaccumulation, *Oreochromis mossambicus*.

INTRODUCTION

Freshwater contamination has become a matter of concern over the last few decades (Canli and Kalay, 1998; Dirilgen, 2001; Vutukuru, 2005; Vinodhini and Narayanan, 2008). Among most of the pollutants discharged into the aquatic environment, heavy metals are regarded as one of the most serious pollutants due to their environmental persistence and tendency to accumulate in aquatic environment (Schüürmann and Markert, 1998; Edem *et al.*, 2008; Amisah *et al.*, 2009; Benzer *et al.*, 2013). Heavy metals are known as high density metallic elements or stable metals with density greater than 5.00 to 6.00 g/cm³, which may have hazardous effects on plant and animal ecosystems when present in high concentrations than found naturally (Keepax *et al.*, 2011). Heavy metals can be categorized as potentially toxic (aluminium, arsenic, cadmium, antimony, lead and mercury), semi-essential (nickel, vanadium, cobalt) and essential [copper, zinc, selenium, manganese, iron, etc] (Szentmihalyi and Then, 2007). These essential metals can also cause toxic effects when taken in excessive amounts (Tüzen, 2003; Ellias, 2009). Fishes are most important organisms in the aquatic food chain, which are sensitive to heavy metals contamination, thus fish not only indicate the pollution status of aquatic ecosystem but have significant impact on the food web (Chi *et al.*, 2007). Fishes are one of the main sources of protein-enriched food all over the world (Mansour and Sidky, 2002). Consumption of fish contaminated with heavy metals can have hazardous effects on human health (Mai

et al., 2006). Various studies have been conducted on heavy metal bioaccumulation in the muscle tissues of fish collected from different freshwater aquatic systems in relation to their concentrations in water (Ebrahimpour and Mushrifah, 2008; Batvari *et al.*, 2008; Raja *et al.*, 2009; Biswas *et al.*, 2011).

The objective of the present study was to determine the occurrence and levels of some selected heavy metals (cadmium, chromium, copper and lead) in surface and deep water samples including their accumulation in selected tissues i.e. gills, gonads, liver and muscles of the fish, *Oreochromis mossambicus* collected from four different locations of Malir River (Murad Memon Goth, Malir City, Shah Faisal Colony and Qayumabad) within Karachi.

MATERIALS AND METHODS

Sampling Sites

For the collection of samples four different locations of Malir River were selected viz. (1) Murad Memon Goth (2) Malir City (3) Shah Faisal Colony and (4) Qayumabad.

Preservation of the Samples

The water samples (both surface and deep) and the samples of the fish, *Oreochromis mossambicus* were collected monthly from all four locations during the whole study period from January to December 2010. The water samples were collected with the help of ruttner

*Corresponding author email: raheela_sharmeen@yahoo.com

Table 1. Average concentrations (ppm) of Cd, Cr, Cu and Pb in surface water samples at Locations 1-4.

Locations	Data Analysis	Cadmium	Chromium	Copper	Lead
Murad Memon Goth	Average Values (ppm) \pm SD	0.027 \pm 0.005	0.706 \pm 0.010	0.286 \pm 0.010	0.396 \pm 0.014
	Max. and Min. conc.(ppm)	0.030 - 0.020	0.720 - 0.690	0.300 - 0.260	0.420 - 0.380
	95 % Confidence Limit	0.024 - 0.030	0.700 - 0.712	0.281 - 0.300	0.387 - 0.405
Malir City	Average Values (ppm) \pm SD	0.029 \pm 0.003	1.059 \pm 0.011	0.675 \pm 0.018	0.755 \pm 0.005
	Max. and Min. conc.(ppm)	0.030 - 0.020	1.080 - 1.050	0.700 - 0.650	0.760 - 0.750
	95 % Confidence Limit	0.030 - 0.031	1.052 - 1.110	0.664 - 0.690	0.752 - 0.758
Shah Faisal Colony	Average Values (ppm) \pm SD	0.054 \pm 0.005	1.245 \pm 0.010	0.995 \pm 0.005	0.646 \pm 0.005
	Max. and Min. conc.(ppm)	0.060 - 0.050	1.260 - 1.220	1.000 - 0.990	0.650 - 0.646
	95 % Confidence Limit	0.051 - 0.060	1.241 - 1.251	0.992 - 1.000	0.643 - 0.649
Qayumabad	Average Values (ppm) \pm SD	0.056 \pm 0.007	0.937 \pm 0.012	0.579 \pm 0.012	0.523 \pm 0.005
	Max. and Min. conc.(ppm)	0.070 - 0.050	0.950 - 0.920	0.590 - 0.560	0.530 - 0.520
	95 % Confidence Limit	0.052 - 0.060	0.931 - 0.944	0.568 - 0.583	0.520 - 0.526

water sampler and were kept into separate 1 liter tightly packed clean and previously washed rubber bottles (after acidification) and labeled for metals analysis. Fish were captured with the help of gill net and hand net and were kept in clean polythene bags and kept chilled in an ice box.

Preparation and Analysis of Samples

The Whatman filter paper No. 40 was used to filter water samples and the fish were washed with plenty of cold water and taken to laboratory to dissect gills, gonads, liver and muscles for metal analysis. All the tissues were wrapped in aluminum foil separately for complete dryness in a heating oven at 40-50°C upto constant weight. These dried samples and filtered water samples were digested as follows:

Acid digestion of water samples was done according to EPA (1976). 100ml of homogenized samples were taken in a beaker. Three ml of concentrated Analar grade HNO₃ was added. The beaker was placed on hot plate and evaporated to dryness. It was made sure that sample should not boil, then it was cooled and further addition of 3 ml of concentrated HNO₃ was made. Again, the beaker was put on a hot plate. The temperature of hot plate was increased for the occurrence of gentle reflux action. Heating was continued with addition of some more acid as when needed, until the digestion was completed (indicated by light colored residue). Sufficiently distilled 1:1 HCl was added and warmed to dissolve the residue and the sample was filtered to remove silicates and other insoluble materials which may clog the capillary of atomizer. Finally, volumes were adjusted on the basis of expected metal concentration.

Acid digestion of tissue samples was performed according to Benton (1988). Around 0.500 g of dried tissues were transferred to a beaker and 2.5 ml concentrated HNO₃ was added, and it was allowed to stand overnight while

covered, then it was placed on hot plate at 80°C for one hour again, then cooled and 2.5 ml perchloric acid (HClO₄) was added. Covered beaker was placed on hotplate and digested at 180-200°C for 2-3 hours or till clear solution was obtained. The beaker was uncovered and heated at 80°C till removal of fumes. Then it was taken off hotplate and cooled. Little amount of deionized water was added and transferred to volumetric flask. Final volume was made up with distilled water.

Preparation of Standard Solutions

All working standards were prepared by subsequent dilution of available stock reference solution having 1000ppm metal in 5N HNO₃.

Procedure

Standards and samples were analyzed by aspirating into Atomic absorption spectrophotometer (Perkin Elmer AA 3100) for Cd, Cr, Cu and Pb using Hollow Cathode lamps at air acetylene flame.

RESULTS AND DISCUSSION

Analysis of Water Samples

In the surface water samples from Location No. 1 (Murad Memon Goth), the average concentrations of Cd, Cr, Cu and Pb were 0.027 \pm 0.005, 0.706 \pm 0.010, 0.286 \pm 0.010 and 0.396 \pm 0.014 ppm, respectively (Table 1). While the average concentrations of Cd, Cr, Cu and Pb in deep water samples were 0.018 \pm 0.004, 0.640 \pm 0.013, 0.308 \pm 0.009 and 0.398 \pm 0.013 ppm, respectively (Table 2).

It was measured that in surface water samples from Location No. 2 (Malir City), the average concentrations of Cd, Cr, Cu and Pb were 0.029 \pm 0.003, 1.059 \pm 0.011, 0.675 \pm 0.018 and 0.755 \pm 0.005 ppm, respectively (Table 1), while in deep water samples, the average concentrations of Cd, Cr, Cu and Pb were 0.028 \pm 0.005, 1.003 \pm 0.014, 0.575 \pm 0.016 and 0.818 \pm 0.006 ppm, respectively (Table 2).

Table 2. Average concentrations (ppm) of Cd, Cr, Cu and Pb in deep water samples at Locations 1-4.

Locations	Data Analysis	Cadmium	Chromium	Copper	Lead
Murad Memon Goth	Average Values (ppm) \pm SD	0.018 \pm 0.004	0.640 \pm 0.013	0.308 \pm 0.009	0.398 \pm 0.013
	Max. and Min. conc.(ppm)	0.020 - 0.010	0.650 - 0.620	0.320 - 0.300	0.420 - 0.380
	95 % Confidence Limit	0.016 - 0.021	0.632 - 0.648	0.302 - 0.313	0.389 - 0.406
Malir City	Average Values (ppm) \pm SD	0.028 \pm 0.005	1.003 \pm 0.014	0.575 \pm 0.016	0.818 \pm 0.006
	Max. and Min. conc.(ppm)	0.030 - 0.020	1.020 - 0.980	0.600 - 0.550	0.820 - 0.800
	95 % Confidence Limit	0.025 - 0.030	0.994 - 1.011	0.565 - 0.585	0.814 - 0.821
Shah Faisal Colony	Average Values (ppm) \pm SD	0.053 \pm 0.005	1.208 \pm 0.008	1.001 \pm 0.029	0.695 \pm 0.008
	Max. and Min. conc.(ppm)	0.060 - 0.050	1.220 - 1.200	1.050 - 0.950	0.710 - 0.680
	95 % Confidence Limit	0.050 - 0.055	1.203 - 1.214	0.983 - 1.019	0.690 - 0.700
Qayumabad	Average Values (ppm) \pm SD	0.052 \pm 0.007	0.961 \pm 0.033	0.584 \pm 0.014	0.618 \pm 0.006
	Max. and Min. conc.(ppm)	0.060 - 0.040	1.010 - 0.900	0.600 - 0.560	0.620 - 0.600
	95 % Confidence Limit	0.047 - 0.056	0.940 - 0.982	0.575 - 0.593	0.614 - 0.621

It was calculated that in surface water samples from Location No. 3 (Shah Faisal Colony), the average concentrations of Cd, Cr, Cu and Pb were 0.054 \pm 0.005, 1.245 \pm 0.010, 0.995 \pm 0.005 and 0.646 \pm 0.005 ppm, respectively (Table 1), while the average concentrations of Cd, Cr, Cu and Pb in deep water samples were 0.053 \pm 0.005, 1.208 \pm 0.008, 1.001 \pm 0.029 and 0.695 \pm 0.008 ppm, respectively (Table 2).

In surface water samples from Location No. 4 (Qayumabad), the average concentrations of Cd, Cr, Cu and Pb were 0.056 \pm 0.007, 0.937 \pm 0.012, 0.576 \pm 0.012 and 0.523 \pm 0.005 ppm, respectively (Table 1), while the average concentrations of Cd, Cr, Cu and Pb in deep water samples were 0.052 \pm 0.007, 0.961 \pm 0.033, 0.584 \pm 0.014 and 0.618 \pm 0.006 ppm, respectively (Table 2).

In freshwater, cadmium is generally present in concentrations of between 0.1 and 10 μ g/l (Friberg *et al.*, 1974). The maximum acceptable concentration of cadmium in drinking water is 0.005 mg/l (5 μ g/l) (FAO/WHO, 1993) this value was lowered to 0.003 mg/l in the 1993 Guidelines, based on the PTWI set by JECFA (JECFA, 2000). While in the present work, the highest cadmium concentration in surface water samples was found 0.056 \pm 0.007 ppm at Qayumabad followed by 0.054 \pm 0.005 at Shah Faisal Colony whereas the lowest concentration were observed as 0.027 \pm 0.005 at Murad Memon Goth. Thus, the values recorded at all study areas in surface and deep water samples were found above the acceptable limits of cadmium in drinking water prescribed by FAO/WHO (1993) and JECFA (2000).

Chromium (Cr) is a relatively scarce metal, the occurrence and amounts in aquatic ecosystems is generally very low i.e. 0.001 to 0.002 mg/l (Moore and Ramamoorthy, 1984; Kupchella and Hyland, 1993; DWAF, 1996). The concentration of Cr was found in the

ranges of 0.0001-0.0082 μ g/l and 3.62-41.81 μ g/l in industrial effluents of NWFP and ground water of Korangi industrial area (KIA) Karachi, respectively (Iqbal *et al.*, 1998; Mahmood *et al.*, 1998). While in present study, chromium had high concentration level in surface and deep water samples i.e. 1.245 \pm 0.010 ppm and 1.208 \pm 0.008 ppm, respectively at Shah Faisal Colony. The chromium concentrations were found higher i.e. 0.961 \pm 0.033 ppm in deep water samples and 0.937 \pm 0.012 ppm in surface water samples at Qayumabad. The values observed as 1.059 \pm 0.011 ppm and 1.245 \pm 0.010 ppm at Malir City and Shah Faisal Colony exceed the permissible limits of chromium i.e. 1.00 mg/l set by NEQS (1993). Thus the values of all samples at all study areas were found above the prescribed range of chromium in drinking water i.e. 0.05 mg/l set for Cr (WHO, 1996).

Copper is one of the most abundant trace metal and an essential micronutrient for almost all organisms (Duffus, 1980). Natural concentrations of copper in surface water are at <5 mg/l (Alabaster and Lloyd, 1980). In the present work, the concentration of copper in surface and deep water samples had high concentrations level i.e. 0.995 \pm 0.005 and 1.001 \pm 0.029 ppm at Shah Faisal Colony whereas in deep water samples the copper concentration levels of 0.584 \pm 0.014 ppm were recorded higher as compared to surface water samples i.e. 0.579 \pm 0.012 at Qayumabad. Thus the samples obtained from all study areas were found under the permissible concentration of copper in drinking water i.e. 2 mg/l set by WHO (1996), whereas the copper concentrations in deep water samples at Shah Faisal Colony i.e. 1.001 \pm 0.029 ppm were found above the desirable level i.e. 1.0 mg/l recommended by NEQS (1993).

Lead (Pb) is a general toxicant and a cumulative poison which is present in water to some extent as a result of its dissolution from natural sources, but the excessive lead may be primarily from house hold plumbing. Several

Table 3. Average concentrations (ppm) of Cd, Cr, Cu and Pb in the gills of *Oreochromis mossambicus* at Locations 1-4.

Locations	Data Analysis	Cadmium	Chromium	Copper	Lead
Murad Memon Goth	Average Values (ppm) \pm SD	0.368 \pm 0.011	0.803 \pm 0.011	0.942 \pm 0.009	3.082 \pm 0.009
	Max. and Min. conc.(ppm)	0.380 - 0.350	0.820 - 0.780	0.950 - 0.920	3.090 - 3.060
	95 % Confidence Limit	0.360 - 0.374	0.795 - 0.810	0.936 - 0.948	3.076 - 3.088
Malir City	Average Values (ppm) \pm SD	0.650 \pm 0.010	1.220 \pm 0.013	2.696 \pm 0.010	4.096 \pm 0.011
	Max. and Min. conc.(ppm)	0.680 - 0.640	1.240 - 1.200	2.710 - 2.680	4.110 - 4.080
	95 % Confidence Limit	0.643 - 0.666	1.211 - 1.229	2.690 - 2.702	4.089 - 4.102
Shah Faisal Colony	Average Values (ppm) \pm SD	0.818 \pm 0.008	1.472 \pm 0.011	3.979 \pm 0.013	3.935 \pm 0.016
	Max. and Min. conc.(ppm)	0.830 - 0.800	1.480 - 1.450	4.000 - 3.960	3.950 - 3.900
	95 % Confidence Limit	0.813 - 0.823	1.464 - 1.479	3.971 - 3.998	3.925 - 3.945
Qayumabad	Average Values (ppm) \pm SD	0.277 \pm 0.010	1.079 \pm 0.010	2.478 \pm 0.017	2.289 \pm 0.016
	Max. and Min. conc.(ppm)	0.290 - 0.200	1.090 - 1.060	2.500 - 2.450	2.310 - 2.260
	95 % Confidence Limit	0.270 - 0.283	1.073 - 1.085	2.467 - 2.488	2.279 - 2.299

Table 4. Average concentrations (ppm) of Cd, Cr, Cu and Pb in the gonads of *Oreochromis mossambicus* at Locations 1-4.

Locations	Data Analysis	Cadmium	Chromium	Copper	Lead
Murad Memon Goth	Average Values (ppm) \pm SD	0.023 \pm 0.005	0.204 \pm 0.014	0.071 \pm 0.009	0.286 \pm 0.011
	Max. and Min. conc.(ppm)	0.030 - 0.020	0.220 - 0.180	0.080 - 0.060	0.300 - 0.260
	95 % Confidence Limit	0.020 - 0.025	0.195 - 0.213	0.065 - 0.0766	0.279 - 0.292
Malir City	Average Values (ppm) \pm SD	0.027 \pm 0.005	0.243 \pm 0.008	0.096 \pm 0.007	0.506 \pm 0.010
	Max. and Min. conc.(ppm)	0.030 - 0.020	0.250 - 0.230	0.100 - 0.080	0.520 - 0.489
	95 % Confidence Limit	0.0235 - 0.030	0.238 - 0.248	0.0916 - 0.100	0.500 - 0.512
Shah Faisal Colony	Average Values (ppm) \pm SD	0.032 \pm 0.006	0.243 \pm 0.020	0.112 \pm 0.006	0.389 \pm 0.011
	Max. and Min. conc.(ppm)	0.040 - 0.020	0.300 - 0.220	0.120 - 0.100	0.400 - 0.370
	95 % Confidence Limit	0.028 - 0.035	0.230 - 0.255	0.108 - 0.115	0.382 - 0.396
Qayumabad	Average Values (ppm) \pm SD	0.028 \pm 0.004	0.168 \pm 0.013	0.088 \pm 0.005	0.308 \pm 0.006
	Max. and Min. conc.(ppm)	0.030 - 0.020	0.180 - 0.150	0.090 - 0.080	0.320 - 0.300
	95 % Confidence Limit	0.026 - 0.031	0.160 - 0.176	0.085 - 0.090	0.305 - 0.312

scientists reported the concentration of Pb in the following ranges, 0.0-0.52, 0.0-0.6, 0.013-0.16, 0.0-0.00083 mg/l and 6.97-30.73 μ g/l, respectively (Ipinmoroti, 1993; Khan *et al.*, 1995; Tariq *et al.*, 1996; Iqbal *et al.*, 1998; Mahmood *et al.*, 1998). While in present study the highest concentrations level of lead in surface water samples were recorded as 0.755 \pm 0.005 ppm at Malir City. In the deep water samples the lead concentrations were recorded higher as compared to surface water samples from all study areas. All the samples collected from all study areas exceeded the guideline value of cadmium in drinking water i.e. 0.01mg/l set by WHO (1996) and the desirable level i.e. 0.5 mg/l set by NEQS (1993).

Analysis of Heavy Metals in Fish Tissues

Heavy metal contamination has been reported in aquatic organisms and considered to be serious pollutants inducing their toxic effects on aquatic fauna (Farkas *et al.*, 2002).

The present work was carried out on fish *Oreochromis mossambicus* because this indigenous South African species is relatively easy to manage, accessible throughout the year, inexpensive and serves as an excellent indicator of water quality and on large scale serves by local inhabitants.

In the samples from Location No. 1 (Murad Memon Goth), the average concentrations of Cd, Cr, Cu and Pb in gills samples were 0.368 \pm 0.011, 0.803 \pm 0.011, 0.942 \pm 0.009 and 3.082 \pm 0.009 ppm, respectively (Table 3), while the average concentrations of Cd, Cr, Cu and Pb in gonads samples were 0.023 \pm 0.005, 0.204 \pm 0.014, 0.071 \pm 0.009 and 0.286 \pm 0.011 ppm, respectively (Table 4). The average concentrations of Cd, Cr, Cu and Pb in liver samples were 0.160 \pm 0.010, 0.999 \pm 0.008, 5.073 \pm 0.010 and 1.713 \pm 0.008 ppm, respectively (Table 5), while the average concentrations of Cd, Cr, Cu and Pb in muscles samples were 0.045 \pm 0.005, 0.193 \pm 0.009, 0.224 \pm 0.008 and 0.452 \pm 0.007 ppm, respectively (Table 6).

Table 5. Average concentrations (ppm) of Cd, Cr, Cu and Pb in the liver of *Oreochromis mossambicus* at Locations 1-4.

Locations	Data Analysis	Cadmium	Chromium	Copper	Lead
Murad Memon Goth	Average Values (ppm) \pm SD	0.160 \pm 0.010	0.999 \pm 0.008	5.073 \pm 0.010	1.713 \pm 0.008
	Max. and Min. conc.(ppm)	0.180 - 0.150	1.010 - 0.990	5.080 - 5.050	1.720 - 1.700
	95 % Confidence Limit	0.153 - 0.167	0.994 - 1.004	5.066 - 5.079	1.708 - 1.717
Malir City	Average Values (ppm) \pm SD	0.175 \pm 0.008	2.095 \pm 0.011	3.643 \pm 0.014	3.012 \pm 0.008
	Max. and Min. conc.(ppm)	0.190 - 0.160	2.120 - 2.080	3.660 - 3.620	3.020 - 3.000
	95 % Confidence Limit	0.170 - 0.180	2.088 - 2.101	3.633 - 3.652	3.006 - 3.017
Shah Faisal Colony	Average Values (ppm) \pm SD	0.222 \pm 0.007	2.358 \pm 0.005	5.076 \pm 0.012	2.096 \pm 0.007
	Max. and Min. conc.(ppm)	0.230 - 0.210	2.360 - 2.350	5.090 - 5.050	2.110 - 2.090
	95 % Confidence Limit	0.217 - 0.226	2.354 - 2.360	5.068 - 5.083	2.091 - 2.100
Qayumabad	Average Values (ppm) \pm SD	0.113 \pm 0.008	1.333 \pm 0.013	2.063 \pm 0.010	1.816 \pm 0.007
	Max. and Min. conc.(ppm)	0.120 - 0.100	1.350 - 1.320	2.080 - 2.050	1.820 - 1.800
	95 % Confidence Limit	0.109 - 0.118	1.324 - 1.341	2.056 - 2.069	1.812 - 1.820

Table 6. Average concentrations (ppm) of Cd, Cr, Cu and Pb in the muscles of *Oreochromis mossambicus* at Locations 1-4.

Locations	Data Analysis	Cadmium	Chromium	Copper	Lead
Murad Memon Goth	Average Values (ppm) \pm SD	0.045 \pm 0.005	0.193 \pm 0.009	0.224 \pm 0.008	0.452 \pm 0.007
	Coefficient of Variation (%)	0.050 - 0.040	0.200 - 0.180	0.230 - 0.210	0.460 - 0.440
	95 % Confidence Limit	0.042 - 0.048	0.187 - 0.198	0.219 - 0.229	0.447 - 0.456
Malir City	Average Values (ppm) \pm SD	0.056 \pm 0.005	0.353 \pm 0.011	0.337 \pm 0.008	0.958 \pm 0.005
	Coefficient of Variation (%)	0.060 - 0.050	0.360 - 0.330	0.350 - 0.320	0.960 - 0.950
	95 % Confidence Limit	0.053 - 0.059	0.345 - 0.360	0.332 - 0.342	0.955 - 0.960
Shah Faisal Colony	Average Values (ppm) \pm SD	0.063 \pm 0.005	0.546 \pm 0.005	0.367 \pm 0.017	0.818 \pm 0.006
	Coefficient of Variation (%)	0.070 - 0.060	0.550 - 0.540	0.400 - 0.350	0.830 - 0.810
	95 % Confidence Limit	0.060 - 0.065	0.543 - 0.549	0.356 - 0.377	0.815 - 0.822
Qayumabad	Average Values (ppm) \pm SD	0.048 \pm 0.009	0.177 \pm 0.008	0.197 \pm 0.005	0.517 \pm 0.009
	Coefficient of Variation (%)	0.060 - 0.030	0.180 - 0.160	0.200 - 0.190	0.530 - 0.500
	95% Confidence Limit	0.0424 - 0.054	0.172 - 0.182	0.194 - 0.200	0.511 - 0.522

In the samples from Location No. 2 (Malir City), the average concentrations of Cd, Cr, Cu and Pb in gill samples were 0.650 \pm 0.010, 1.220 \pm 0.013, 2.696 \pm 0.010 and 4.096 \pm 0.011 ppm, respectively (Table 3), while the average concentrations of Cd, Cr, Cu and Pb in gonads samples were 0.027 \pm 0.005, 0.243 \pm 0.008, 0.096 \pm 0.007 and 0.506 \pm 0.010 ppm, respectively (Table 4). The average concentrations of Cd, Cr, Cu and Pb in liver samples were 0.175 \pm 0.008, 2.095 \pm 0.011, 3.643 \pm 0.014 and 3.012 \pm 0.008 ppm, respectively (Table 5), while the average concentrations of Cd, Cr, Cu and Pb in muscles samples were 0.056 \pm 0.005, 0.353 \pm 0.011, 0.337 \pm 0.008 and 0.958 \pm 0.005 ppm, respectively (Table 6).

In the samples from Location No. 3 (Shah Faisal Colony), the average concentrations of Cd, Cr, Cu and Pb in gills samples were 0.818 \pm 0.008, 1.472 \pm 0.011, 3.979 \pm 0.013 and 3.935 \pm 0.016 ppm, respectively (Table 3), while the average concentrations of Cd, Cr, Cu and Pb in gonads samples were 0.032 \pm 0.006, 0.243 \pm 0.020, 0.112 \pm 0.006 and 0.389 \pm 0.011 ppm, respectively (Table 4). The average concentrations of Cd, Cr, Cu and Pb in liver

samples were 0.222 \pm 0.007, 2.358 \pm 0.005, 5.076 \pm 0.012 and 2.096 \pm 0.007 ppm, respectively (Table 5), while the average concentrations of Cd, Cr, Cu and Pb in muscles samples were 0.063 \pm 0.005, 0.546 \pm 0.005, 0.367 \pm 0.017 and 0.818 \pm 0.006 ppm, respectively (Table 6).

In the samples from Location No. 4 (Qayumabad), the average concentrations of Cd, Cr, Cu and Pb in gill samples were 0.277 \pm 0.010, 1.079 \pm 0.010, 2.478 \pm 0.017 and 2.289 \pm 0.016 ppm, respectively (Table 3), while the average concentrations of Cd, Cr, Cu and Pb in gonads samples were 0.028 \pm 0.004, 0.168 \pm 0.013, 0.088 \pm 0.005 and 0.308 \pm 0.006 ppm, respectively (Table 4). The average concentrations of Cd, Cr, Cu and Pb in liver samples were 0.113 \pm 0.008, 1.333 \pm 0.013, 2.063 \pm 0.010 and 1.816 \pm 0.007 ppm, respectively (Table 5), while the average concentrations of Cd, Cr, Cu and Pb in muscles samples were 0.048 \pm 0.009, 0.177 \pm 0.008, 0.197 \pm 0.005 and 0.517 \pm 0.009 ppm, respectively (Table 6).

Cadmium (Cd) is a non-essential and toxic element. It can easily cause chronic toxicity even when present in low

amount, below 1.00 µg/g. The permissible limit set for cadmium (Cd) is 2.00 µg/g (FAO, 1983). In the present work, cadmium concentrations were found higher in gills 0.818±0.008 ppm, gonads 0.032±0.006 ppm, liver 0.222±0.007 ppm and muscles 0.108±0.155 ppm at Shah Faisal Colony. The levels of Cd (0.023 – 0.818 ppm) recorded in fish samples were lower than the maximum recommended limits of 2.00 ppm (WHO, 1985; FEPA, 2003) in fish food.

Chromium (Cr) is an essential trace element and plays an important role in fish metabolism (Sthanadar *et al.*, 2013). Chromium concentrations in gills, liver and muscles tissues were found higher i.e. 1.472±0.011 ppm, 2.358±0.005 and 0.546±0.005 ppm at Shah Faisal Colony. The gonads had same concentration of chromium i.e. 0.243±0.020 ppm and 0.243±0.008 ppm at Shah Faisal Colony and Malir City, respectively. Presently the mean concentration of chromium (Cr) in the gills and liver tissue were found higher than the permissible limit (1.00 µg/g) of FAO (1983). Vinodhini and Narayanan (2008) have reported a low level of chromium (Cr) deposition in the fish liver with a mean value of 0.863 ± 0.015 (µg/g.d.wt). Contrarily, Yousafzai (2004) recorded a high level of chromium (Cr) in *Tor putitora* liver with a mean value of 3.2± 0.05 µg/wet weight of the body. This was in fact a high level of chromium (Cr) in the fish liver. Similarly, Rauf *et al.* (2009) have recorded a high level of Chromium in the liver of fish species, *Catla catla*, *Labeo rohita* and *Cirrhina mrigala* caught from the River Ravi in Pakistan.

Copper had high concentrations in gills, muscles and gonads i.e. 3.979±0.013, 0.367±0.017 and 0.112±0.006 ppm at Shah Faisal Colony, whereas approximately the same concentrations of copper were found 5.076±0.012 and 5.076±0.010 ppm in liver samples at Murad Memon and Shah Faisal Colony, respectively. Cu can induce respiratory distress in fish, and it is striking that the most hypoxia sensitive species are also the most Cu sensitive. The levels of Cr (0.177–2.358 ppm) recorded in fish samples were higher than the maximum recommended limits of 0.15-1.0 ppm (FAO, 1983; WHO, 1985; FEPA, 2003) in fish food.

The increased level of industrialization is continuously increasing the risk and damages of lead (Pb) to humans via different types of food chains. It is quite considerable that industrial effluents and domestic sewage should approach the main flow after its proper treatment (Sthanadar *et al.*, 2013). Lead had high level concentrations in the gills, gonads, liver and muscles i.e. 4.096±0.011, 0.506±0.010, 3.012±0.008 and 0.958±0.005 ppm at Malir City. The levels of Pb (0.286-4.096 ppm) recorded in fish samples were lower than the maximum recommended limits of 2.0 ppm (FAO, 1983; WHO, 1985; FEPA, 2003) in fish food.

The overall concentrations of cadmium, chromium and copper in gills, gonads, liver and muscles tissues of *Oreochromis mossambicus* were found higher in this pattern Shah Faisal Colony> Malir City> Qayumabad> Murad Memon Goth, whereas the concentration of lead in gills, gonads, liver and muscles of *Oreochromis mossambicus* were found higher in this pattern Malir City> Shah Faisal Colony> Qayumabad> Murad Memon Goth.

The concentration of heavy metals i.e. cadmium and lead were found higher in gills tissues whereas chromium and copper concentrations were found higher in liver tissues. The lowest concentrations of all selected heavy metals were found in gonads. However, the muscle had the least concentration of the heavy metals compared with gills and liver in the fish samples. This is in agreement with previous study by Ishaq *et al.* (2011) which showed that muscle is not an active organ in the accumulation of heavy metals. Gills, on the other hand, has been reported as metabolically active site and can accumulate heavy metals in higher level.

STATISTICAL ANALYSIS

Minitab (version 15) has been used for the analysis of trace metals concentration. It was observed that the concentrations of Cd, Cr, Cu and Pb in surface water samples were not significantly higher ($p>0.05$) than those of deep water samples. The concentrations of metals i.e. Cd, Cr and Cu were significantly higher at Shah Faisal Colony ($p<0.05$) whereas the concentrations of Pb was significantly higher at Malir City ($p<0.05$).

CONCLUSION

This study revealed that the concentrations of selected heavy metals cadmium, chromium, copper and lead in water samples were found higher than the values recommended in drinking water by FAO/WHO (1993), NEQS (1993), WHO (1996) and JECFA (2000). But fortunately the water of Malir River is not used for drinking purposes. It has highly polluted water due to the effects of incoming drains and effluents. In fish organs, the concentrations of cadmium and lead were found higher in gills samples, whereas the concentrations of chromium and copper were found higher in liver tissues. The levels of Cd, Cr and Cu in fish organs were found higher than the maximum recommended limits set by WHO (1985), FEPA (2003) in fish food, whereas the concentrations of lead were found lower than the recommended values set by WHO (1985), FAO (1983) and FEPA (2003). The total metals accumulation were found highest in liver and gills whereas the lowest concentrations were found in muscles and gonads. During the study period, the water samples and fishes collected from Shah Faisal Colony were found highly contaminated

with studied heavy metals as compared to other sampling locations. The results of this research should be brought to the notice of the Fisheries Department for proper actions to be taken about consumption of river fishes. There is also a need to study the overall fish fauna of Malir River to record the edible species and the level of their exploitation for human use. The relevant agencies should find ways for managing the quality of water resources.

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