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Heavy metal concentration and its toxicity assessment in some market fishes of Dhaka city

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Abstract
In the present study, concentration of some bio-accumulated heavy metals (Cd, Cr, Ni, Fe, Mn and Pb) in four farm raised species of fishes, namely *Pangasius hypophthalmus, Anabas testudineus, Oreochromis niloticus* and *Wallago attu* were investigated collecting from different markets of Dhaka city. Among the six heavy metals tested, Fe was maximally accumulated, followed by Ni, Mn, Cr and Cd in flesh and liver of fishes. The concentration of Pb was below the detectable level (BDL) in all fishes. The overall highest concentration (mg/kg) of metals in flesh of all examined fishes were- Cd (0.775 mg/kg) and Cr (12.675 mg/kg) in *A. testudineus*, Ni (221.792 mg/kg), Fe (331.050 mg/kg) and Mn (17.842 mg/kg) in *O. niloticus* respectively. In liver, the highest concentration of five heavy metals were- Cd (1.433 mg/kg) and Cr (51.590 mg/kg) in *O. niloticus*, Ni (278.966 mg/kg) in *W. attu*, Fe (666.262 mg/kg) in *O. niloticus* and Mn (50.317 mg/kg) in *A. testudineus*. The values of all selected metals in fish samples considerably exceeded the maximum permissible limits of heavy metals for fish tissues as prescribed by various international agencies (FAO, WHO and IAEA) which indicate the acute heavy metal contamination in studied fishes. Therefore, the biological monitoring of the water and fish for heavy metal contamination should be done regularly and necessary steps must be taken to mitigate this contamination considering the human health safety issues.

Keywords: Heavy metals. Toxicity test, Market fishes.

1. Introduction
Fishes are major part of the human diet and therefore the studies on metal pollution in different species of edible fish are very essential regarding the fish consumption by human being. The heavy metals gain access into the aquatic environment from natural and anthropogenic sources and bio-accumulate in fish and other aquatic animals and rather than sedimentations in water [1]. Toxic heavy metals in the aquatic environment enters either directly from drinking water or indirectly through the food chain and have been implicated in many human health problems such as cancer, brain damage and various behavioral problems [2]. Studies carried out on fish have shown that heavy metals may have toxic effects, altering physiological activities and biochemical parameters both in tissue and in blood of fish [3]. The consequence of heavy metal pollution can be hazardous to human being by consuming such contaminated food. Therefore, it is important to monitor heavy metal in aquatic environments (water, sediment and biota).
Recent reports have shown that farmed salmon, trout and shrimp can be contaminated with a range of contaminants including heavy metals, polychlorinated dibenzo-p-dioxins and –furans (PCDD/Fs), polychlorinated biphenyls (PCBs), organochlorine pesticides (OCPs) and polybrominated diphenyl ethers (PBDEs), hexabromocyclododecane (HBCD), and residues of antibiotics [4-8]. There have been remarkable numbers of studies done on heavy metal contamination in water, sediments and fish throughout the world. Some research works related to this works have been done in different part of the world [9-16]. In Bangladesh the concentration of heavy metals in fish, water and sediment has been studied by some authors but some works are prominent [17-24]. They investigated the concentration of different heavy metals in specific rivers or in specific organisms but there is no complete study on heavy metal concentration in market fishes. There is limited information available on the contamination of heavy metals in farmed raised fish which are cultured using polluted water and different types of artificial feeds.
Therefore, the present study was conducted to determine the concentrations of Lead (Pb), Cadmium (Cd), Chromium (Cr), Nickel (Ni), Iron (Fe) and Manganese (Mn) in selected farm-

raised fishes from different markets of Dhaka city regarding their consumption by human being to formulate the health safety measures. The specific objectives of the present study were -1. To determine the concentrations of Lead (Pb), Cadmium (Cd), Chromium (Cr), Nickel (Ni), Iron (Fe) and Manganese (Mn) in fish from three markets of Dhaka city. 2. To identify the level of heavy metals accumulated in flesh and liver of fish frequently consumed by the city dwellers. 3. To detect the level of toxicity due to higher concentration in selected fishes. 4. To determine the prevalence of chemical hazards caused by heavy metals in farmed fish. 5. To assess the risks associated with farmed fish addressing human health safety issues regarding the fish consumption.

2. Materials and Methods

The present study was conducted jointly at the Fisheries Laboratory, Department Zoology, and University of Dhaka and at the Soil Agronomy and Environment Laboratory of BCSIR, Dhaka, Bangladesh (a South Asian Country) following standard methods as laid down in APHA, AWWA, WPCF [25] using Atomic Absorption Spectrophotometer (AAS). Samples from each of the four species (*Pangasius hypophthalmus, Anabas testudineous, Oreochromis niloticus* and *Wallago attu*) were collected from three markets viz. Hatirpool Bazar, Ananda Bazar, Kathalbagan Bazar on monthly basis for half a year from January, 2013 to June, 2013. Fish samples of uniform size were collected into ice-box, from three different bazaars, and taken to the laboratory at the same days, cleaned with sterile distilled water and then dissected. Samples (flesh and liver) were taken from fish for digestion method. The digests prepared in triplicate with blank digestion to quantify possible contamination during sample preparation and analysis. The diluted digests of samples of flesh and liver of selected fish were analyzed for Pb Cd, Cr, Ni, Fe and Mn, with flame Atomic Absorption Spectrophotometer (Model AA-7000F) equipped with dual background correction system using aqueous calibration standards prepared from standard solutions of the respective elements. The final concentration of each heavy metal was estimated multiplying the actual concentration of machine reading with the primary dilution factor. All statistical analyses were performed using a statistical software namely SPSS (version 15).

3. Results and Discussions

The present study investigated the level of concentrations of Pb, Cd, Cr, Ni, Fe and Mn accumulated in flesh and liver of four species of fish along with their toxicity due to higher concentration and the risks associated with those fishes addressing human health safety issues. The average concentration of Cd, Cr, Ni, Fe and Mn in *P. hypophthalmus*, *A. testudineus, O. niloticus* and in *W. attu* has been presented in Tab. 1. The orders of fish containing different heavy metals in flesh can be sequenced as for Cd (*A. testudineus* > *O. niloticus* > *P. hypophthalmus* > *W. attu*), Cr (*A. testudineus* > *O. niloticus* > *W. attu*> *P. hypophthalmus*), Ni (*O. niloticus*> *P. hypophthalmus* > *A. testudineus* > *W. attu*), Fe (*P. hypophthalmus* > *W. attu* > *A. testudineus* > *O. niloticus*) and for Mn (*O. niloticus* > *W. attu* > *P. hypophthalmus* > *A. testudineus*). This orders were found in liver as for Cd (*O. niloticus* > *W. attu* > *A. testudineus* >*P. hypophthalmus*), Cr (*O. niloticus* > *P. hypophthalmus* > *A. testudineus* > *W. attu*), Ni (*W. attu* > *O. niloticus* > *P. hypophthalmus* > *A. testudineus*), Fe (*A. testudineus* > *P. hypophthalmus* > *W. attu* > *O. niloticus* and for Mn (*A. testudineus* > *W. attu*> *O. niloticus*> *P. hypophthalmus*). The order of metal concentration was same both in flesh and liver of fishes that found as Fe> Ni> Mn> Cr> Cd. Fig. 1 and 2 showing the average concentration of selected metals in flesh and liver found in *P. hypophthalmus*, *A. testudineus, O. niloticus* and *W. attu*.

Table 1: Average heavy metal concentration (mg/kg) in different parts of fishes collected from different markets.

Studied Fish	Investigated Part of fish	Cadmium (Cd)	Chromium (Cr)	Nickel (Ni)	Iron (Fe)	Manganese (Mn)
P. hypophthalamus	Flesh	0.641	6.350	144.683	247.800	9.4167
	Liver	0.616	7.450	231.500	572.017	20.708
A. testudineus	Flesh	0.775	12.675	130.550	188.800	8.775
	Liver	0.941	5.800	118.592	438.125	50.317
O. niloticus	Flesh	0.758	10.200	221.792	331.050	17.842
	Liver	1.433	51.590	238.583	666.262	25.875
W. attu	Flesh	0.578	6.953	101.488	132.708	10.095
	Liver	1.321	16.779	278.966	523.775	28.558
Concentration in flesh(Mean ± SD)		0.688±0.094	9.045±2.952	149.628±51.359	225.089±84.84	11.532±4.240
Concentration in liver(Mean ± SD)		1.078±0.372	20.405±21.344	216.910±68.799	550.0448±95.228	31.365±13.048

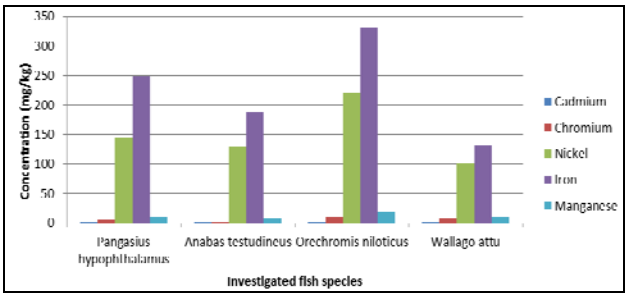

Fig 1: Heavy metal concentration in flesh of investigated fishes collected from three markets of Dhaka city

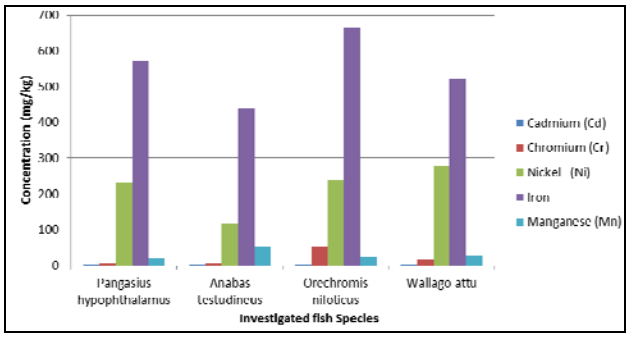

Fig 2: Heavy metal concentration in liver of investigated fishes collected from three markets of Dhaka city.

3.1 Variation of metal concentration in flesh and liver of selected fishes

The concentration of heavy metals in all the fish organs investigated in the present study showed their (Cd, Cr, Ni, and Mn) acute toxic levels in flesh and liver of four species of fishes collected from three markets from Dhaka city. Among the studied metal, only Pb was below the detection level in all fishes. The overall concentration of Cd, Cr, Ni, and Mn both in flesh and liver of all fishes exceeded the maximum permissible limits recommended by different international organization.

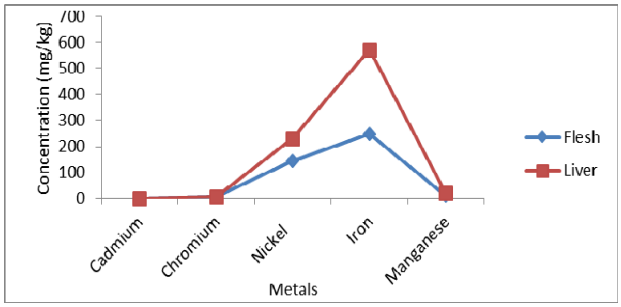

Fig 3: Co-relation of metals in flesh with the corresponding concentration in liver of *P. hypophthalmus*

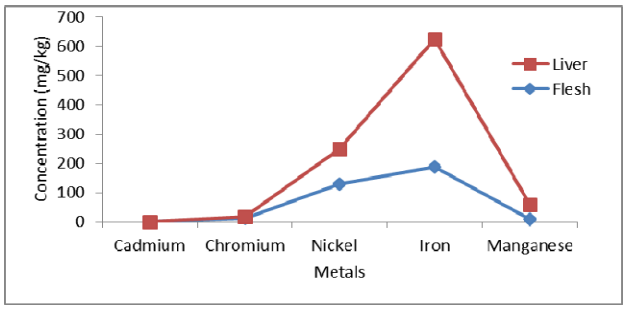

Fig 4: Co-relation of metals in flesh with the corresponding concentration in liver of *A. testudineus*

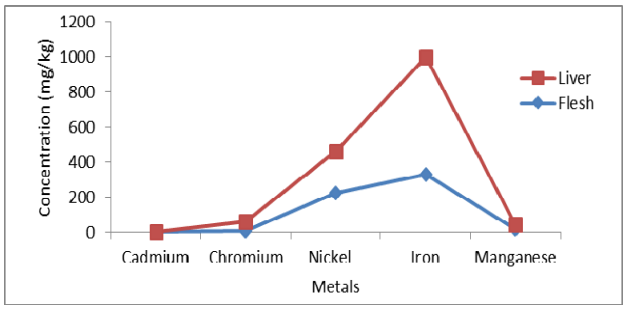

Fig 5: Co-relation of metals in flesh with the corresponding concentration in liver of *O. niloticus*

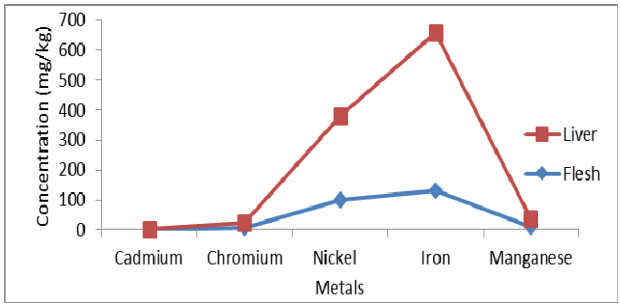

Fig 6: Co-relation of metals in flesh with the corresponding concentration in liver of *W. attu.*

Figure (3-6) shows the overall variation of Cd, Cr, Ni, Fe and Mn in flesh and liver of *P. hypophthalmus*, *A. testudineus, O. niloticus* and in *W. attu*. The overall concentration of each metal significantly varied between flesh and liver of fishes ($P<0.05$). The accumulation of metals in liver was higher than that flesh of fishes as Liver > Flesh. The average concentration (mg/kg) of selected metals in flesh was found as in *O. niloticus* (Cd: 0.758± 0.375, Cr: 10.200±1.260, Ni: 221.792±113.89, Fe: 331.050 ± 284.974 and Mn: 17.842±14.061) where Kebede [26] found the concentration (mg/kg) in same fish as Cd (0.44-1.43), Ni (7.80-15.9), Fe (18.7-53.0), Mn (1.03-6.78) that was lower than the levels of present investigation.

Edward *et al.* [27] have found the level of concentration (mg/kg) in different fish tissues as Fe (1.09)> Mn (0.82)> Pb (0.09)> Cd (0.04) but the order of heavy metals studied in the present investigation was as Fe (225.089)>Ni(149.628)>Mn (11.532)>Cr (9.045)>Cd (0.688) in flesh and in liver as Fe (550.0048)>Ni(216.910)>Mn (31.365)>Cr (20.405)>Cd (1.078). This comparison clearly shows the differences in concentration and the order of heavy metals between two studies except the highest position of iron (Fig.1-2). Kumar [28] had also observed the order of concentration in different species of pond fishes as Fe >Mn>Ni>Cd which is somewhat similar to present study accumulating position Mn and Ni. The concentration of metals (Cd: 0.642±0.275, Cr: 6.350±4.070, Ni: 144.683±54.548, Fe: 247.800±75.840 and Mn: 9.417±5.760) in *P. hypophthalmus* and in *A. testudineus* (Cd: 0.775± 0.175, Cr: 12.675± 2.652, Ni: 130.550±82.344, Fe: 188.800±136.416 and Mn: 8.775±5.112), was higher than maximum permissible limit of WHO, FAO and IAEA [29, 30, 31] but the levels of Pb and Cd were below the toxic limit in Pangas and Climbing Perch in study of Monalisa *et al.* [10]. In the present study metal accumulating organ of fish can be arranged as Liver >flesh which is also similar to the findings of Ambedkar and Muniyan [11] who studied on different freshwater fish species.

The overall Cr levels (9.045 ±2.952) in fish flesh under present study is higher than that of Ahmad *et al*., [23] who have studied the concentration of Cr in six species of fish of Buriganga River that varied from 5.27 to 7.38 mg/kg, respectively. Ahmed *et al.* [24] have investigated the average bioaccumulation levels of Cr in Ayre fish, *Sperrata aor* from Daleswari River of Dhaka as 1.458 mg/kg which was also lower than the average concentration in fishes under present study. Haque *et al.* [20] found the Ni concentration in *Puntius sophore* as 0.94 to 4.59 mg/kg and in *Mystus vittatus* as 1.17 to 8.68 mg/kg which is lower than the average value (149.628 mg/kg) of Ni in the studied fishes. Sharif *et al.* [17] recorded it in different fish species ranging from 1.20 to 6.10 mg/kg. Ahmad *et al.*, [23] have studied the concentration of Ni in six species of fish, which varied seasonally from 8.25 to 11.21 mg/kg that was higher than the results of present investigation.

The average concentration of Cd (0.688± 0.094) in present investigation is higher than that of Haque *et al.* [20]who have studied the Cd concentration in *P. sophore* as 0.24 to 0.41mg/kg and in *M. vittatus* as 0.24 to 0.58 mg/kg which is nearer to the average value of Ni prevailed presently in the fishes of selected rivers. Mn concentrations in different fish species ranging from 4.76 to 71.61 mg/kg recorded by Sharif *et al.* [17] shows little similarity with Mn concentration (11.532±4.240) of present study. Significant differences ($P<0.05$) in the concentrations of heavy metal were noticed between the flesh and liver of studied fishes collected from different markets of Dhaka city (Fig.3-6). The differences in

the level of accumulation in the different organs of the test fishes can primarily be attributed to the differences in the physiological role of each organ [32]. This high level of metals in the liver tissues for all the fishes is due to the fact that, the liver is a target organ for the accumulation of these elements. Considerable variation in the concentration of metals found in sample fishes of three markets might be associated with the place of collection from different farms or pond or water bodies located in different polluted prone regions of the country. It is reported that artificially fish feeds (supplied to the intensive and semi-intensive fish farm) are being manufactured mixing with different tannery and some industrial by products. The highest value of Fe in studied fish might be due to use of shallow ground waters in the farm ponds and it also associated with the usage of iron made pipe for water supply in the pond. The toxic concentration of Cd, Cr, Fe, and Mn of the present study might be attributed to this fact. Moreover, polluted water entering from different polluted sources may cause the higher concentration of these metals in farm reared fishes those frequently consumed by human beings. As, the present investigation explored the abnormal accumulation of selected heavy metals (Cd, Cr, Ni, Fe and Mn,) in studied species of market fishes in Dhaka city; so, there is high health risk to consumers of the fishes in the area for heavy metal toxicity.

4. Conclusion

When considering the heavy metals concentrations in fish species, the most important aspect is their toxicity to humans suitable for human consumption. The results of this study showed that extreme higher concentrations of heavy metal elements (Cr, Mn, Ni, Cd) in selected market fish of Dhaka city. The results revealed that frequently consumed fishes are harmful to consumers because observed values of heavy metals were higher (2-100 times) than the permissible limits issued by FAO/WHO/IAEA for human consumption. So, it is a matter of concern in fish accumulation. As the fish is one of the main protein sources to diet of human, it is necessary that biological monitoring of the water and fish meant for consumption should be done regularly. Laws enacted to protect our environment should be enforced. More intensive study is needed in order to determine the bioaccumulation of heavy metals in fishes from the different markets of Dhaka city. Further study on accumulation of other heavy metals (Hg, Zn, As, Cu etc.) organochlorine pesticides, and other toxins in fish tissues should be undertaken considering human health safety issues in Bangladesh.

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