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Bioaccumulation of Mercury in Fish Species from Different Trophic Level

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Abstract: Mercury (Hg) is an environmental pollutant, and can bioaccumulate and biomagnify in the food web. Twenty four fish samples of different tropic level i.e., Herbivore, Omnivore and Carnivore were collected from two contaminated rivers, the Megna and the Buriganga which surround the Dhaka division for the assessment of toxic Hg. Fourteen samples were found to contain Hg in the range of 0.01-0.09 mg/kg. The highest Hg (0.09 mg/kg) was found in the Carnivore, Bele (*Glossogobius giuris*). However, all fish species had lower amount of Hg than the maximum Hg limit (0.5 mg/kg for fish) set by World Health Organization (WHO). Among all the fish species, the order of bioaccumulation was carnivore > omnivore > herbivore. Kajoli (*Ailia coila)*, Shing (*Heteropnuestes fossilis)*, Rui (*Labeo rohita)*, Chewa (*Tryauchen vagine)*, Rita (*Rita rita*), Hilsha *(Tenualosa ilisha)*, Small Puti (*Puntius sophore)*, Bacha (*Eutropiichthys vacha)* and Chingri (*small prawn*) were not found to contain any Hg which indicated that fish species from these rivers are safe for human consumption.

Key words: Bioaccumulation, biomagnification, chemical contaminant, food chain and Atomic Absorption Spectroscopy (AAS).

1. Introduction

Mercury (Hg), a natural element, has been considered as environmental pollutants due to its high toxicity even at low concentration [1, 2] and its toxicity includes neurotoxicity, nephrotoxicity and genotoxicity [3, 4]. The sources of mercury are volcanoes, forest fires and fossil fuels. However, anthropogenic activities like discharge from hydroelectric, gold mining, e-waste, pulp and paper industries; incineration of municipal and medical waste and emissions from coal-using power plants also increase the level of Hg in the environment [5, 6]. It has capacity to bioaccumulate in living organism and biomagnify in the food chain [3]. In the environment Hg is transformed into methylmercury by microbial mediation to the water column and the sediments. Methylmercury which accounts for the most toxic forms of all mercury is ingested by fish and is bioaccumulated in the food web [7]. Human exposure to mercury occurs mainly through the consumption of fish and seafood [8]. The World Health Organization (WHO) sets the maximum concentration of mercury of 0.5 mg/kg in fish for human consumption [9].

Fish is the main protein sources for a population of 160 million of Bangladesh. It also gives high-value amino acids, vitamins and minerals, and is an excellent source of essential omega-3 fatty acids [10]. The fishery industry also plays an important role in the national economy and contributes about 2.73% to the total export earning, 3.69% to GDP and 22.60% to agricultural sector [11]. The Meghna river, a major river forming the Ganges Delta and the Buriganga river surrounds the Dhaka city, the capital of Bangladesh and plays an important role in the economy of 120 million people as there are many small and medium sized industries on the bank of the rivers. The chemical waste of mills and factories, household waste, medical waste, sewage, dead animals, plastics, and oil are discharged into these rivers from the city and create pollution in the aquatic environment. These environmental pollutants especially mercury can potentially bioaccumulate in

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the fatty tissues of fish and biomagnified from one trophic level to the higher trophic levels. Consumption of contaminated fishes with mercury can have adverse effects on human health. There is no report on the assessment of Hg in fresh water fish from Bangladesh. The present study reports bio-accumulation of mercury in twenty four fish samples of different trophic level i.e., Omnivore, Herbivore and Carnivore.

2. Materials and Methods

2.1 Sample Collection

Twenty four fish samples of different trophic level i.e., Omnivore, Herbivore and Carnivore were collected from two contaminated rivers, the Buriganga and the Megna surrounding the Dhaka city during June-July in 2014 and 2015 (Fig. 1). The collected fish samples were kept in jip-locked plastic bag with label in chill-box then transported to the laboratory and stored in the freezer at -20 °C until extraction carried out. Name, position in the food chain and place of collection are given in Table 1. Each fish was weighed (whole ± 0.1 g). A small portion of muscle tissue of each fish was removed and freeze dried (Table 1).

2.2 Mercury Analysis

Freeze-dried samples (0.5 ± 0.01 g) were digested by Microwave Digestion (HNO_3-H_2O_2; 4:1 mixture, 10 mL each) maintaining temperature between 140-180 °C for 30 min and finally analyzed by Atomic Absorption Spectroscopy (AAS) [13].

2.3 Calibration Curve, Limit of Detection (LOD) and Limit of Quantification (LOQ)

The standard calibration curves of mercury were made by measuring solutions at concentration 0.1, 0.5, 1.0, 2.5, 5.0 and 10.0 µg/kg of the certified standard mercury into the AAS (Fig. 2). The curve gave straight line with correlation coefficient (r^2) equal to 0.998. The LOD and LOQ were calculated by taking peak height (concentration of the standard) three times of noise level (S/N; 3:1) and S/N ratio, 10:1, respectively. The LOD and LOQ of mercury were 0.1452 µg/kg and 0.0484 µg/kg, respectively.

3. Results and Discussion

Mercury was detected in 14 samples out of 24 fish species within the range of 0.01-0.36 mg/kg (Table 2). The highest amount of Hg was found in carnivore *G.*

G. giuris (Bele) *M. Tengra* (Bujuri) *T. ilisha* (Hilsha)

W. attu (Bowal) *C. soborna* (Kachki) *M. rosenbergii* (Chingri)

Fig. 1 Some fish samples.

Table 1 Fish samples from two rivers.

Scientific name	Local name	Position in food chain	Collection	Dry weight (%)
Labeo rohita	Rui	Herbivore	Buriganga	21.46
Ailiacoila	Kajoli	Omnivore	Buriganga	20.36
Heteropnuestes fossilis	Shing	Omnivore	Buriganga	17.27
Corica soborna	Kachki	Omnivore	Megna	19.83
Tryauchen vagine	Chewa	Carnivore	Megna	17.71
Glossogobius giuri	Bele	Carnivore	Megna	21.27
Heteropnuestes fossilis	Shing	Omnivore	Megna	17.27
Tryauchen vagine	Chewa	Carnivore	Megna	19.94
Channa marulius	Gojar	Carnivore	Megna	20.00
Corica soborna	Kachki	Omnivore	Megna	19.83
Mastacembelus armatus	Baim	Carnivore	Megna	22.32
Mystus tengra	Bojuri	Omnivore	Megna	22.28
Notopterus notopterus	Foli	Omnivore	Megna	20.68
Nandus nandus	Meni	Carnivore	Megna	22.20
Labeo rohita	Rui	Herbivore	Megna	17.20
Wallogonia attu	Bowal	Carnivore	Megna	17.36
Rita rita	Rita	Carnivore	Megna	19.39
Tenualosa ilisha	Hilsha	Plankivore	Megna	29.88
Puntius sophore	Small Puti	Herbivore	Megna	19.31
Channa punctatus	Taki	Carnivore	Megna	20.28
Puntius sarana	Swor Puti	Omnivore	Megna	21.00
Otolithoides pama	Powa	Carnivore	Megna	22.68
Eutropiichthys vacha	Bacha	Carnivore	Megna	29.15
Macobrachium rosernbergii	Chingri	Omnivore	Megna	21.20

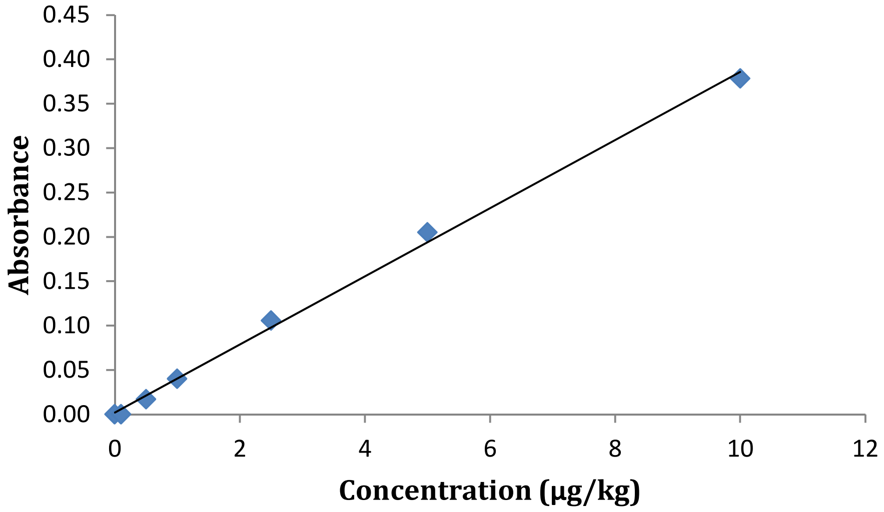

Fig. 2 Standard calibration curve of mercury.

Table 2 Amount of Hg (mg/kg) in fish samples (wet weight basis).

Scientific name (local name)	Amount (mg/kg)	Position in food chain
L. rohita (Rui)	ND*	Herbivore
L. rohita (Rui)	ND	Herbivore
T. ilisha (Hilsha)	ND	Plankivore
P. sophore (Small Puti)	ND	Herbivore
A. coila (Kajoli)	ND	Omnivore
H. fossilis (Shing)	ND	Omnivore
M. rosernbergii (Chingri)	ND	Omnivore
T. vagine (Chewa)	ND	Carnivore
R. rita (Rita)	ND	Carnivore
E. vacha (Bacha)	ND	Carnivore
N. notopterus (Foli)	0.01	Omnivore
T. vagine (Chewa)	0.02	Carnivore
C. soborna (Kachki)	0.02	Omnivore
O. pama (Powa)	0.03	Carnivore
M. tengra (Bojuri)	0.03	Omnivore
C. soborna (Kachki)	0.03	Omnivore
H. fossilis (Shing)	0.03	Omnivore
C. punctatus (Taki)	0.07	Carnivore
M. armatus (Baim)	0.08	Carnivore
N. nandus (Meni)	0.09	Carnivore
P. sarana (Swor Puti)	0.09	Omnivore
W. attu (Bowal)	0.10	Carnivore
C. marulius (Gojar)	0.18	Carnivore
G. giuris (Bele)	0.36	Carnivore

*ND = Not detected.

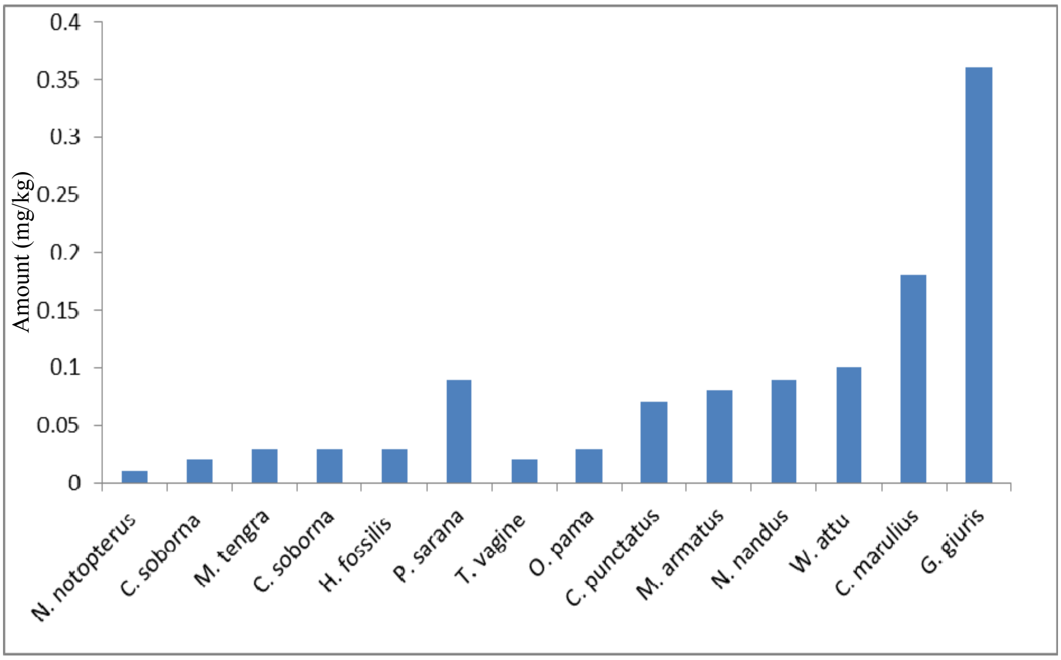

Fig. 3 Graphical comparison of Hg in fish samples.

giuris (0.36 mg/kg) as the fish mainly feed on various types of fishes, insects and mollusks and also it is cannibalistic in nature [13]. Bacha (*E. vacha)* and rita (*R. rita*) of carnivore were not found to contain any Hg. Among 8 omnivore fish species only 6 samples were found to contain Hg within the range of 0.01-0.09 mg/kg. In the case of 3 herbivore and one plankivore fish samples Hg was not found in any species as they occupy in lower trophic level of food chain. The present study revealed that all fish samples contained lower amount of Hg than the maximum Hg limit (0.5 mg/kg for fish) set by WHO [9]. These results can be accounted that the bioaccumulation process may increase the concentration of Hg in their bodies. Among all the fish species, the order of bioaccumulation was carnivore > omnivore > herbivore (Fig. 3). Bioaccumulation of Hg in these trophic levels correlates the finding reported by Lima et al. [14]. These results indicated that fishes from these contaminated rivers are safe for human consumption.

4. Conclusions

Fish is one of the main protein sources in Bangladesh. Contamination with mercury was found in 14 samples out of 24 fish species within the range of 0.01-0.09 mg/kg. However, the level of mercury in these samples was lower (except only one sample) than the maximum allowable concentration of mercury in fish set by WHO (0.5 mg/kg).

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