Heavy Metals Contamination in Marine Fish Samples of Bangladesh

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RESEARCH

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ABSTRACT

The objective of the present study is to analyse quantitatively toxic metals such as arsenic (As), cadmium (Cd), lead (Pb), chromium (Cr) and mercury (Hg) using atomic absorption spectrophotometer (AAS) in nineteen marine fish samples of thirteen species. The muscle of fish samples were freeze dried, digested by microwave digestion and finally analysed by AAS. The level of toxic metals varied significantly among fish species and showed that As, Cd, Pb, Cr and Hg levels of mean values were 0.03, 0.04, 0.20, 0.59 and 0.19 mg/kg, respectively. The range of As, Cd, Pb, Cr and Hg in fresh samples were ND-0.04, ND-0.19, 0.06-0.35, 0.42-0.78 and 0.01-0.61 mg/kg fresh weight, respectively. All the values were below the permitted limit set by FAO/WHO standard for each toxic metal except *C. carati* and *L. equulus* those contain Cr in excess and *E. Tetradactylum* that contain Hg in excess level. Quantitative analysis reveals that the marine fish samples are less contaminated than fresh water fish in Bangladesh.

Key Words: Marine fish; Bioaccumulation; Toxic metals; Toxicity; AAS.

Introduction

The Bay of Bengal, one of the largest marine ecosystems in the world is situated at the southern part of Bangladesh. It encompasses about 710 km cost line in south of Bangladesh having about 50 m depth with an area of nearly 37,000 km^2 and is an important source of marine fish. It was reported that 442 marine fishes, 22 amphibians, 17 marine reptiles are available in Bangladesh [1]. Millions of people are consuming marine fish as a vital source of animal based protein all over the world. Toxic metals may enter into human body through contaminated fish food products and will have harmful acute and chronic effects since fish and other food items are the predominant sources (>90%) of heavy metals and chemical contaminants [2]. Although living body required some heavy metals for their normal growth and development but in excess level of essential metals and most of the non-essential metals show toxic effects in living body [3]. So it is essential to know the contamination level of toxic metals in the marine fish samples. The contamination of fresh water as well as the marine environment for the disposal of toxic metals has become a global problem due to the indestructible nature and toxic effect in human body [4]. In many part of the world, waste from both the natural and anthropogenic sources like industries, geochemical structure, steel dust, and mining process of different metals, domestic sewage, discharge, and fossil fuel burning polluting water bodies and accumulate up to a toxic level in fish and create ecological problem [5]. Through the bioaccumulation and bio-concentration process after discharging toxic metals to the aquatic environment, the concentration of different toxic metals is increased in aquatic animal body than in water which shows toxic effect in human body after consumption [6]. Different routes such as adsorption, respiration and ingestion are responsible for the accumulation of toxic metals in the marine fish since they are the most vulnerable animal in the marine environment [7]. The nutrient and the contaminant levels in the marine fish samples are regulated by the age, location, life stage, seasons, diet and species and the bio accumulation level is higher in fish since they are at the top level of aquatic food chain [8]. Bioaccumulation level of toxic metals in marine fish is an indirect measure of the pollution monitoring program in the marine ecosystem [9]. Although a large number of fresh water fish samples were analysed in the previous year in Bangladesh for the presence of toxic metals [10-13] study of marine fish samples from Bangladesh is rarely encountered. Therefore, the objectives of the present study were to determine contamination level of toxic heavy metal in fish samples available in Bangladesh.

Materials and Methods

Sample Collection

Samples were collected randomly from three different markets i.e., Fishery Ghat, Kazir Daori and Reazuddin Bazar in Chittagong near to the coast of the Bay of Bengal (Figure 1). The selected fishes (Table 1) are the most abundant and commercially important species consumed by the people.

Sample Preparation

A clean washed high quality corrosion resistant stainless knife was used to cut off the fish tissue (muscle). After dissection, all the samples were labelled according to their species. The entire samples were separately dried taking 10g of each in freeze drier in the laboratory until the constant weight is obtained. The dried samples were each ground with laboratory ceramic mortar and pestle to powder and stored in aluminium foil paper and kept in desiccators until analysis.

Sample Digestion Procedure

A certain amount of dried fish was taken in a tarred silica dish and put in a furnace consecutively at 100, 200, 300, 400 and 500 ºC temperatures each for 1 hour until the sample become ash. Toxic metals (As, Cd, Pb, Cr and Hg) were analysed after digesting the definite amount (5-10g) of homogenized samples in a mixture of concentrated HNO3 (20 mL) and H_2O_2 (10mL) and heat it on a hot plate until a transparent clear solution is obtained. The solution was made up to the mark in 50 mL volumetric flask. After filtration the solution was analysed in AAS. For As analysis, the ash was dissolved in 1:1 HNO_3: H_2O_2 solution. The sample was then taken at hot plate to remove acid vapour. Again it was heated directly at 500ºC temperature until full ashing. 5-10 mL HNO_3 was added to the sample and heated in normal burner. While heating, a little amount of water was added and cooled. The sample was then taken into a 25 mL volumetric flask by filtering and made up to the mark. 5 mL of the sample was taken in another 25 mL volumetric flask and 2.5 mL of conc. HCl and 0.1% KI was added to it. It was then made up to the mark with deionized water and kept overnight.

After developing yellow color the solution was used for analysis in AAS. The toxic metals detection was performed by following standard methods APHA, AWWA, WPCF [14] using Atomic Absorption Spectrophotometer (AAS). After preparing the standard solution of different metals, each solution was run in AAS.

Using these data and the concentration of each standard solution five calibration curves were made for five different toxic metals. All curves gave straight line with their respective correlation coefficient (R^2). The limit of detection (LOD) was calculated by taking peak height (concentration of the standard) three times of noise level (S/N; 3:1; Table 2). Following these curves the amount of different toxic metals was determined quantitatively (Table 3) where ND indicates not detectable amount.

Results and Discussion

Concentrations of As, Cd, Pb, Cr and Hg in muscle tissue of marine fish samples are shown in Table 3. A graphical representation of heavy metals content is also shown in Figure 2. A comparison between mean value and MRL value is represented in figure 3.

Arsenic Content

Arsenic is a naturally occurring element that is common in soils, water and living organisms. Fish can accumulate considerable amounts of organic arsenic from environment. Most As in our diet is present in organic form. The present study shows As content was in between ND-0.04 mg/kg. Comparatively higher concentration (0.04 mg/kg) of arsenic accumulation was observed in Chingri (*M. monoceros*) and Poa (*B. loach*). Lakkaha (*E. tetradactylum*), koral (*L. calcarifer*), kalochanda (*P. chinensis*), undurabaila (*P. indicus*), loitta (*H. nehereus*) and shadhachanda (*P. argenteus*) contain arsenic in very low level. The maximum recommended levels permitted for As in sea fish as 2.00 mg/kg [15]. Comparing the analytical data for As content in marine fish sample with the recommended value, it is clear that the consumption of these marine fish may not any health hazard risks and their consumption may not risky at all. But gradual bioaccumulation due to frequent exposure to arsenic can cause several chronic and acute diseases [19].

Cadmium Content

Cd concentrations in marine fishes were ND-0.19 mg/kg and of mean value 0.04 mg/kg. The highest amount of Cd content was found in the chingri (*M. monoceros*) fish (0.19 mg/kg).This is because the fact that the chingri (*M. monoceros*) habitually prefer to live at the sandy and muddy bottoms of the marine ecosystem where toxic and hazardous substances are deposited [20]. Cd was below detection level in koral (*L. calcarifer*) and tekchanda (*P. chinensis*). The maximum recommended levels permitted for Cd in sea fish is 0.5-0.6 mg/kg [15]. Thus, all the fish samples analysed in this study may be safe for the public consumption. Long period of accumulation of Cd in fish may pose health hazards. Cd shows no indication of being an essential element in biological processes, instead it is toxic. Cd causes several toxic effects in human body including bone demineralization, renal dysfunction, and lung damage and lung cancer [21]. It competes with the Fe in the body and creates iron deficiency causes slight anaemia [22].

Lead Content

The concentration of Pb in the marine fish samples were found from 0.06-0.35 mg/kg and average Pb in fish is 0.20 mg/kg. The maximum acceptable limit for fish is 2.00 mg/kg [15].Present study indicated that the concentration of Pb levels was lower than permissible limits. Thus, this study confirmed that the consumption of marine fish samples is safe in the context of Pb contamination. Pb exists in nature mainly as lead sulfide. This metal is extremely insoluble and is readily absorbed by organic matter, especially under reducing conditions. Several anthropogenic sources like municipal and industrial wastes, mining, gasoline combustion, smelting and reprocessing action are responsible for the lead contamination in the environment [23]. Several symptoms such as intestinal cramps, fatigue, children mental disorder, hyper tension in expectant women and enzymatic inhalation are caused in human body due to the consumption of highly Pb contaminated fish [24].

Chromium Content

Cr concentration in marine fishes was found from 0.42-0.78 mg/kg of mean value 0.59 mg/kg. In the present study, Cr was found excess than maximum tolerable limit in Ulua (*C. carati*) 0.78 mg/kg and Teckchanda (*L. equulus*) 0.76 mg/kg where the lowest amount was in the Shadhachanda (*P. argenteus*) 0.42 mg/kg. A tolerance level of Cr concentrations in fish is 0.73 mg/kg in fish [17]. Since fish is at the top level of food chain, a higher quantity of Cr bio accumulate in the fish disposed from leather, steel and textile industries including tobacco product where Cr [VI] harmful to human health causing skin diseases, lung cancer, kidney and liver damage, ulcer and mutation in genetic materials [25].

Mercury Content

Hg is one of the most toxic elements. Hg was found from 0.01-0.61 mg/kg in the fish samples and of mean value is 0.19mg/kg. The highest amount (0.61 mg/kg) of Hg content was found in lakkha fish (*E. tetradactylum*) and lowest amount (0.01 mg/kg) was found in loitta fish (*H. nehereus*).The joint FAO/WHO expert committee on food additives [16] and ANHMRC (Australian National Health and Medical Research Council) set the standard for Hg in seafood to 0.50 mg/kg. The result indicate that mean Hg level in marine fishes is below FAO/WHO (2011) and ANHMRC permissible limit. After disposal of Hg from different natural (volcanoes, forest fire and fossil fuel) and anthropogenic sources (gold mining, incineration of municipal, hydroelectric, e-waste, pulp and paper industries and medical waste) it deposited in water body where it bioaccumulates in the fish tissues which create toxicity like neurotoxicity, nephrotoxicity and genotoxicity in human body after consuming such fish [26].

Conclusion

The present study reveals several information about the toxicity level of heavy metals bioaccumulation in marine fish of Bay of Bengal. The toxic metals content trend is like Cr >Pb> Hg > Cd > As. The analysed marine fish samples are at the safe level of consumption in the context of As, Cd, Pb, Cr and Hg contamination except Ulua (*C. carati*) and Teckchanda (*L. equulus*) fish where only Cr contamination level exceed permissible limit (0.73 mg/kg). Again, this study was compared with the previous study of fresh water fish which implies that the toxic metal contamination of marine fish is lower than fresh water fish and this is may be due to the high dilution factor of marine water. From this study it is seen that the consumption of these species is still in safe level but frequent and excessive consumption of these fish may result in chronic non-carcinogenic effect in human body. Finally it is recommended that a continuous observation should ensure to control the pollution of Bay of Bengal so that toxicity level of heavy metals does not exceed the global permissible limit.

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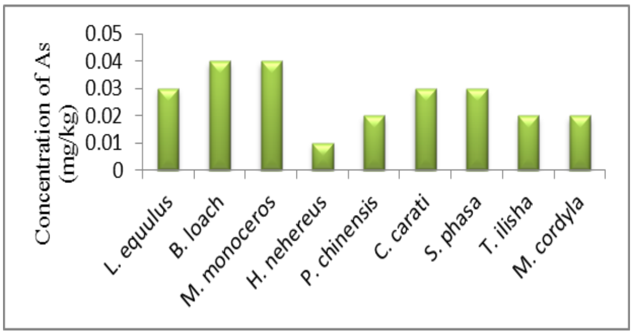
PEER REVIEW

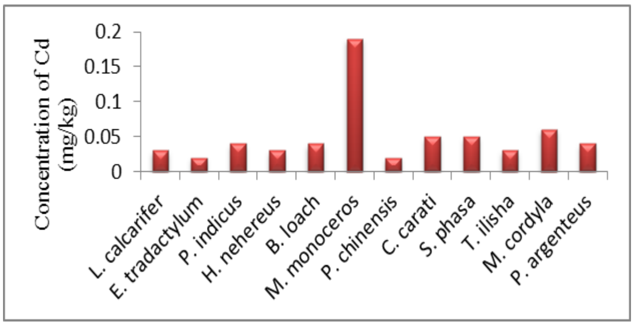
Not commissioned. Externally peer reviewed.

FIGURES

Figure 1: Sampling Area.



a)



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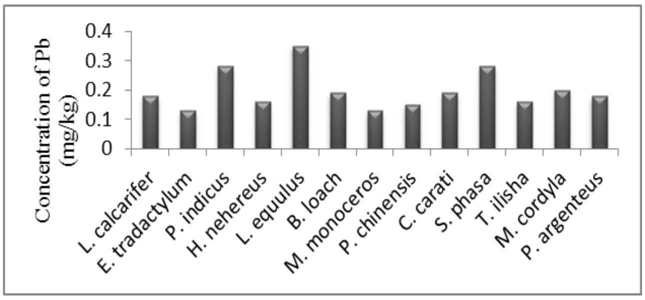

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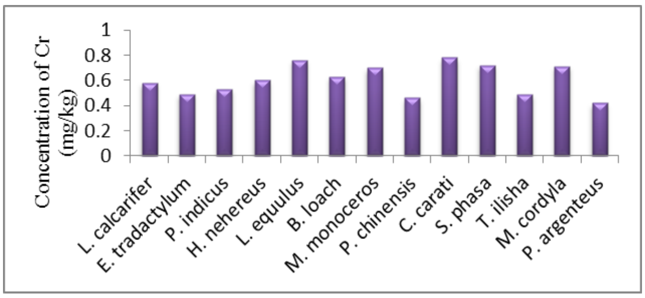

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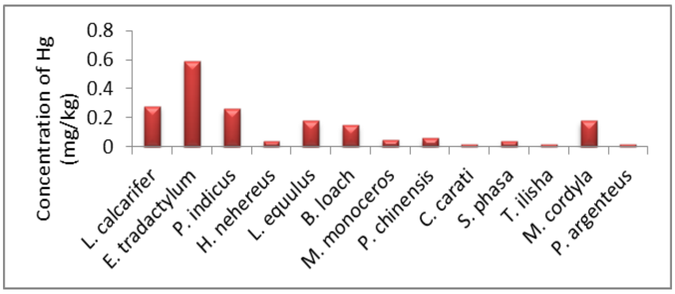

e)

Figure 2. Graphical presentation of a) As, b) Cd, c) Pb, d) Cr e) Hg content in marine fish samples.

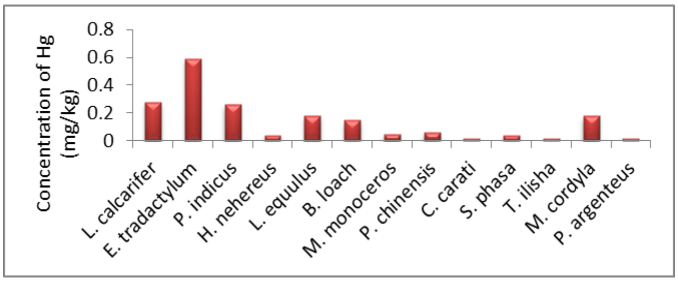

Figure 3: Comparison between mean value and MRL value.

Table 1. Samples with local name, scientific name and their behaviour.

Collecting area	**Local name**	**Scientific name**	**Behavior**
Reazuddin Bazar	Koral	*Latescalcarifer*	Carnivore
	Lakkha	*Eleutheronemate teradactylum*	Varies seasonally
	Undurabailla	*Platycephalusindicus*	Demersal
	Loitta	*Harpodonnehereus*	Benthopelagic
	Tekchanda	*Leiognathusequulus*	Benthopelagic
	Poa	*Burmeseloach*	Benthopelagic
Fishery Ghat	Chingri	*Metapenaeusmonoceros*	Benthic
	surma	*Megalapsiscordyla*	Pelagic
	Hilsha	*Tenualosailisha*	Pelagic-neritic
	Loitta	*Harpodonnehereus*	Benthopelagic
	Kalochanda	*Pampuschinensis*	Benthopelagic
	Ulua	*Coiliaramcarati*	Pelagic
	Koral	*Latescalcarifer*	Carnivore
	Faissha	*Setipinnaphasa*	Pelagic
	Undurabailla	*Platycephalusindicus*	Demersal
Kazir Daori	Undurabailla	*Platycephalusindicus*	Demersal
	Koral	*Latescalcarifer*	Carnivore
	Lakkha	*Eleutheronematetradactylum*	varies seasonally
	Shadachanda	*Pampusargenteus*	Benthopelagic

Table 2. Analytical parameters for the measurement of toxic metals.

Heavy Metals	Limit of Detection (LOD) (mg/L)	correlation coefficient (*R²*)	Straight line Equation	Wavelength (nm)
Arsenic (As)	0.002×10^{-6}	0.993	y = 0.018x	193.7
Cadmium (Cd)	0.001	0.998	y = 0.321x	228.8
Lead (Pb)	0.010×10^{-6}	0.995	y = 0.0312x	283.3
Chromium (Cr)	0.005	0.998	y = 0.089x	357.9
Mercury (Hg)	0.005	0.999	y = 0.013x	253.7

Table 3. Concentration of heavy metals (mg/kg fresh weight) in the tissues of marine fish and their Maximum Tolerable Limit.

Local name	Collecting area	As	Cd	Pb	Cr	Hg
Koral	Reazuddin bazar	ND	ND	0.06	0.55	0.23
Lakkha		ND	0.02	0.12	0.45	0.61
Undurabailla		ND	0.04	0.28	0.59	0.08
Loitta		ND	0.03	0.21	0.51	0.07
Tekchanda		0.03	ND	0.35	0.76	0.18
Poa		0.04	0.04	0.19	0.63	0.15
Chingri	Fishery Ghat	0.04	0.19	0.13	0.70	0.05
Loitta		0.01	0.04	0.12	0.69	0.01

Kaloch anda		0.02	0.02	0.15	0.46	0.06
Ulua		0.03	0.05	0.19	0.78	0.02
Faissha		0.03	0.05	0.28	0.72	0.04
Undura bailla		ND	0.05	0.27	0.45	0.21
Koral		ND	0.03	0.27	0.59	0.32
Ilish		0.02	0.03	0.16	0.49	0.02
surma		0.02	0.06	0.20	0.71	0.18
Lakkha	Kazir Daori	ND	0.02	0.15	0.54	0.58
Undura bailla		ND	0.04	0.28	0.56	0.50
Koral		ND	0.03	0.22	0.59	0.28
Shadac handa		ND	0.04	0.18	0.42	0.02
Range		ND-0.04	ND-0.19	0.06 - 0.35	0.42 - 0.78	0.01 - 0.61
Mean		0.03	0.04	0.20	0.59	0.19

Toxic Metals	Maximum Tolerable Limit (mg/kg)	Reference
As	2.00	[15]
Cd	0.5-0.6	[15]
Pb	2.00	[15]
Hg	0.50	[16]
Cr	0.73	[17]

Table 4. Comparison of toxic metals between fresh and marine fish of Bangladesh (mg/kg).

Sampling Region	As	Cd	Pb	Cr	Hg	Reference
Bay of Bengal	ND-0.04	ND-0.19	0.06-0.35	0.42-0.78	0.01-0.61	Present work
Bangshi River	1.97-6.24	0.09-0.87	1.76-10.27	0.47-2.07	-	[10]
Gumti River	ND	ND	0.5-4.05	ND		[10]
Dhaka city	-	0.578-01.433	-	5.800-51.590	-	[11]
Rajshahi	0.10-0.15	0.22-2.11	1.44-23.99	0.42-1.23	-	[12]
Buriganga river	-	0.73-1.25	8.03-13.52	5.27-7.38	-	[18]