HEAVY METALS ANALYSIS OF SOME FISHES IN AYEYARWADY RIVER SEGMENT OF SALAY ENVIRONS

Cho Cho Thin[1], Myin Zu Minn[2], Min Thu Aung[3]

Abstract

A total of 15 fish species which included two surface dwellers, seven mid-water dwellers and six bottom dwellers were collected from Ayeyarwady River segment of Salay environs to analyze elements content in muscle tissue. Study period lasted from January 2014 to December 2014. The concentration of toxic metals (cadmium, lead and arsenic) in muscle of fish specimens and aquatic environs of study area were analyzed three replicates by Flame Atomic Absorption Spectrometer (FAAS) (Perkin Elmer AAanalyst 800 and Winlab-32 software) in Universities' Research Centre (URC). Seasonal variations of test results were compared with WHO/FAO maximum permissible limits (MPL). In this study, the effects of the seasons on elements accumulation in muscle of fishes were determined. The concentrations of toxic metals in fishes of study area were higher than maximum permissible limits except from rainy season. The concentrations of cadmium and arsenic of water in hot and rainy seasons were higher in the study environs. The concentrations of toxic metal in sediment were lower than the maximum permissible limits (MPL) in all seasons.

Keyword: Toxic Metals, Fish Muscle, Water, Sediment

Introduction

Pollution of the aquatic environments is one of the serious environmental problems in the World (Azizullah *et al*., 2011). Among the several pollutants, heavy metals are known the most usual environmental pollutants. Owing to bioaccumulation in the food chain, long persistence and their toxicity, they are very harmful for the environment (Papagiannis *et al*., 2004). Heavy metals diffuse to aquatic environment from different natural and anthropogenic sources like industrial effluents, agricultural runoffs, burning of fossil fuels, geological structure, mining activities and atmospheric deposition (Papagiannis *et al*., 2004).

The United Nations Environment Programme's World Conservation Monitoring Centre (UNEPWC) lists the Ayeyarwady as one of the world's top thirty high priority river basins due to both its support of high biodiversity and high vulnerability to future pressures.

Fish species are widely used to biologically monitor variations in environmental levels of anthropogenic pollutants (Amundsen *et al*., 1997). Fish are often at the top of the aquatic food chain and may concentrate large amounts of some metals from the water (Farkas *et al*., 2002). In fish toxic effects of heavy metals may influence physiological functions, individual growth rates, reproduction and mortality (Zyadah, 1999). The concentration of heavy metals in tissues are the result of uptake and release processes with characteristics kinetics for the elements and their biological halftime, influence by the age and size of individuals, the feeding habits of the species, their life cycle and life history, and also the seasons (Romeo *et al*., 1999). Heavy metals may enter fish bodies in three possible ways; through the body surface, the gill or the digestive tract (Chi *et al*., 2007). Food may also be an important source for heavy metal accumulation (Dallinger *et al*., 1987).

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Heavy metals have in common relatively high density that causes them to be toxic or poisonous even at low concentrations. Some metals like copper, iron and zinc are essential for metabolism. For normal metabolism, the essential metals must be taken up from water or food, but excessive intake of the essential metals can produce toxic effects (Yousafzai, 2004).

Once metals are accumulated by an aquatic organism, they can be transferred through the upper levels of the food chain. Carnivores at top of the food chain including humans, obtain most of their metal burden from the aquatic ecosystem by way of their food, especially where fish are present so there exists the potential for considerable biomagnifications (Cumbie, 1975; Mance, 1987).

Fish cover a wide range of trophic levels and are an important link of aquatic food chains with human populations (Costa and Kehrig, 2002). These two main features made fish highly suitable for toxic and essential metals contamination studies and monitoring programmes.

Due to these reasons, present study has been conducted with the following objectives; to determine seasonal variation of cadmium, lead and arsenic concentrations in muscle tissue of fish species related to different feeding habits and habitats types and to examine the toxic metals concentrations in water and sediment of study area.

Materials and Methods

Study area

Salay Township, Magway Region of Ayeyarwady River, situated at 20° 42' N to 20° 51.30' N and 94° 14' E to 97° 47.51' E, was chosen as the area of study. Fish, water and sediment samples were collected from this area and metal content of each sample was determined (Fig. 1).

Study period

Study period lasted from January, 2014 to December, 2014.

Collection and preparation of fish specimens

From the chosen study sites, 24, 27 and 60 specimens of 15 fish species in hot, rainy and cold seasons respectively were collected from local fishermen. Recorded species were categorized as surface dweller, mid-water dweller and bottom dweller according to Fish Base (2011). Feeding habits of recorded fish species were designated in accordance with Talwar and Jhingran (1991). From the collected species, five species of each feeding habit were selected for determination of essential metals. Collected specimens were washed by tap water until the contamination on the body surface was runoff. Total length (cm) and body weight (g) of specimens were measured. After that, the specimens were decapitated, scaled and gutted with a clean stainless steel knife. The metal contents in the dorsal muscle (filet) of each species were analyzed to determine their suitability for human consumption.

Sample Preparation

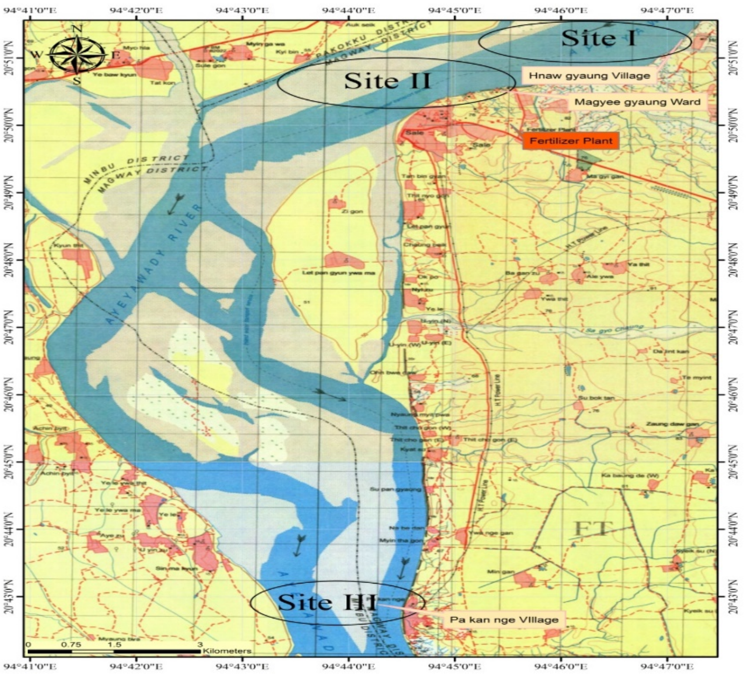
Digestion of the muscle samples was conducted according to the dry method (Plate 1). Muscle samples were dried to a constant weight in an oven and dried samples were weighted and stored in airtight containers. Five grams each, of the dried muscle samples was placed into a crucible and transferred to a furnace (Model-L3383), in which temperature was slowly raised to 500°C over 2 hours. Samples were allowed to ash overnight. Once removed, samples were allowed to cool in room temperature and 5 mL of nitric acid were added and followed by addition of 10mL hydrochloric acid. The digestion was transferred to furnace and the temperature was raised slowly to 450° C and hold at this temperature for 1 hour. The crucible was removed, cooled and 50mL deionized water was added and transferred to volumetric flask.

The sediment samples were sun dried, grounded and sieved with 200 mm sieve to obtain a find powder. A quantity 1.0 g of dried sediment sample in a crucible was placed in a furnace at 200°-250° C for 30 min, and then ashed for 4 hours at 480° C. Then the sample was removed from the furnace, cooled and 2mL of nitric acid was added. The preparation was evaporated to dryness on a sand bath. Subsequently, 2 mL of concentrated HCl was added and transferred to furnace in which the temperature was raised slowly to 450° C and hold at this temperature for 1 hour. The crucible was then removed, cooled and 50mL of deionized water was added. The solution was filtered through Whatman No-42 filter paper and 0.45μm Millipore filter paper (Issac and Kerber, 1971).

For water, each sample was filtered through a 0.45 micron Whatman filter.

Chemical Analysis

The concentration of three elements (cadmium, lead and arsenic) in muscle tissue samples of the fish specimens as well as in sediment and water samples were analyzed in tri-replicates by Flame Atomic Absorption Spectrometer (FAAS) (Perkin Elmer AAanalyst 800 and Winlab-32 software) in the Universities' Research Centre (URC) at University of Yangon. Seasonal variations of test results were compared with WHO/FAO maximum permissible limits. TEC (threshold effect concentration), MEC (midpoint effect concentration), and PEC (probable effect concentration) were also determined for toxic metal concentrations of sediment samples according to MacDonald *et al.*, (2000).



Source: Universal Transverse Mercator (UTM) Map Sheets, 2004

Figure 1 Map of the study area

(A). Ashing samples in furnace

(B). Filtration of samples

(C). Samples ready for AAS

(D). Analysis by AAS

Plate 1. Apparatus used in sample analysis

Results

A total of 15 fish species which included two surface dwellers, seven mid-water dwellers and six bottom dwellers were collected from Ayeyarwady River segment of Salay Township (Table 1).

Base on literature, a total of 15 fish species which included five species of herbivores, five species of carnivores, and five species of omnivores were collected from this study area. The total length and weight of study species in three seasons were recorded in Table 2 and Table 3.

Cadmium concentrations of *Macrognathus zebrinus* (2.151 mg/L) and *Mastacembelus dayi* (0.265 mg/L) in hot season, and *Salmostoma sardinella* (6.646 mg/L) and *Macrognathus zebrinus* (1.126 mg/L) in cold season were found to be higher than those of the maximum permissible limit 0.2 mg/L. Above mentioned three species were recognized as omnivorous mid-water dwellers. Under limited concentrations of cadmium in all study fish species were observed in rainy season (Table 4 and Fig. 2).

Lead concentrations of *Mastacembelus dayi* (2.076 mg/L) in hot season and those of eight species (*Tenualosa ilisha* (1.388 mg/L), *Labeo rohita* (5.437 mg/L), *Mystus cavasius* (7.252 mg/L), *Oreochromis mossambicus* (2.961 mg/L), *Rhinomugil corsula* (4.342 mg/L), *Channa punctatus* (2.496 mg/L), *Macrognathus zebrinus* (3.835 mg/L) and *Mastacembelus dayi* (2.869 mg/L)) in cold seasons were found to be higher than recommended highest standard 1 mg/L (Table 5 and Fig. 3).

Arsenic concentrations of all studied fish species in all seasons were found to be higher than those of the maximum permissible limits 0.26 mg/L (Table 6 and Fig. 4).

Cadmium (0.056 mg/L in hot and 0.03 mg/L in rainy) and arsenic (2.158 mg/L in hot and 2.034 mg/L in rainy) of water in hot and rainy seasons were higher than the MPL (Table 7 and

Fig. 5). The concentrations of cadmium, lead and arsenic of sediment in three seasons were observed to be lower than those of MPL (Table 8 and Fig. 6).

Table 1 Habitats of studied fish speies

Sr.No.	Species	Habitats		
		Surface	Mid	Bottom
1	*Notopterus notopterus*			√
2	*Tenualosa ilisha*			√
3	*Cirrhinus mrigala*		√	
4	*Labeo boga*		√	
5	*Labeo calbasu*			√
6	*Labeo rohita*		√	
7	*Salmostoma sardinella*		√	
8	*Separata aor*			√
9	*Mystus cavasius*			√
10	*Eutropiichthys vacha*	√		
11	*Oreochromis mossambicus*		√	
12	*Rhinomugil corsula*	√		
13	*Channa punctatus*			√
14	*Macrognathus zebrinus*		√	
15	*Mastacembelus dayi*		√	
	Total	2	7	6

Table 2 Mean total length (cm) of fish species selected to test metal concentration

Sr. No.	Species	No.	Hot	Rainy	Cold
Herbivore	*Cirrhinus mrigala*	5	25±3.08	51.8 ± 4.82	29.4 ± 17.31
	Labeo boga	5	13.8±1.15	16.8 ± 1.64	15±3.32
	Labeo calbasu	5	18.5±3.20	12 ± 6.71	10.7 + 1.48
	Labeo rohita	3	27.33±4.04	25.67±25.42	13 ± 1.73
	Oreochromis mossambicus	6	13.83±7.9	14.42±1.69	10.17 ± 0.41
Carnivore	*Notopterus notopterus*	5	22.6 ± 4.81	14.42±1.69	25.2 ± 4.71
	Separata aor	5	22.4 ±1.95	22.6±2.19	32.2 ± 2.77
	Mystus cavasius	7	16.27 ± 3.11	12 ± 1	12.71±4.86
	Eutropiichthys vacha	5	18.8 ± 0.91	13.8±0.45	15.2 ± 1.15
	Channa punctatus	5	16.2 ±1.64	18.4 ±5.37	17.8 ± 6.53
Omnivore	*Tenualosa ilisha*	5	21.4 ± 4.98	22.2 + 3.56	17.8 ± 6.53
	Salmostoma sardinella	35	9.63 ± 1.37	9.64 + 1.04	9.14 ± 0.85
	Rhinomugil corsula	10	11.7 ± 0.79	12.5 + 2.88	13.1±1.71
	Macrognathus zebrinus	5	28 ± 5.43	25.6 + 10.06	20.3±6.99
	Mastacembelus dayi	5	25.5 ± 5.45	18.6 + 5.37	26.2 ±6.26

Table 3 Mean body weight (g) of fish species selected to test metal concentration

Sr. No.	Species	No.	Hot	Rainy	Cold
Herbivore	*Cirrhinus mrigala*	5	211.6±82.30	1674 ± 98.7	147±51.19
	Labeo boga	5	99±60.77	49 ± 12.94	41 ± 15.68
	Labeo calbasu	5	83±42.22	36 ± 58.14	9 ± 1.22
	Labeo rohita	3	306.67±120.99	34 ± 3.54	35 + 34.64
	Oreochromis mossambicus	6	64.17±9.70	60±23.66	26 ± 0.63
Carnivore	*Notopterus notopterus*	5	92 ± 55.18	38 ± 2.74	127 ± 62.79
	Separata aor	5	80.2 ± 22.80	83 ± 25.88	199.6 ±25.51
	Mystus cavasius	7	35 ± 19.79	14.86±1.68	28.43±9.13
	Eutropiichthys vacha	5	40 ± 6.12	22.4 ± 0.89	25.8±1.48
	Channa punctatus	5	48.6 ± 7.99	70 ± 53.62	77.6 ± 57.72
Omnivore	*Tenualosa ilisha*	5	23 ± 4.30	109 ± 56.61	119 ± 64.36
	Salmostoma sardinella	35	3 ± 0.33	3.72 ± 0.18	3.36 ±0.13
	Rhinomugil corsula	10	16.5 ± 1.41	28.5±9.56	30.6±.64
	Macrognathus zebrinus	5	65 ± 20	50 ± 42.72	22.4±1.33
	Mastacembelus dayi	5	42 ± 17. 89	23 ± 9.75	40±12.73

Table 4 Seasonal variation of cadmium concentration (mg/L) in different fish species

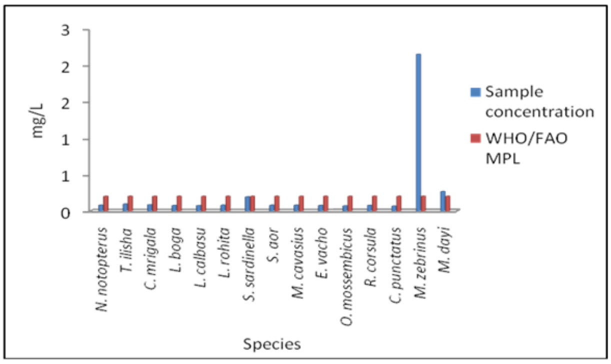
Sr.No.	Species	Concentration (mg/L)			WHO/FAO MPL
		Hot	Rainy	Cold	
1	*Notopterus notopterus*	0.078	0.040	0.073	0.2
2	*Tenualosa ilisha*	0.094	0.047	0.149	0.2
3	*Cirrhinus mrigala*	0.083	0.037	0.060	0.2
4	*Labeo bogo*	0.074	0.036	0.201	0.2
5	*Labeo calbasu*	0.071	0.030	0.067	0.2
6	*Labeo rohita*	0.079	0.049	0.135	0.2
7	*Salmostoma sardinella*	0.192	0.035	6.646	0.2
8	*Separata aor*	0.078	0.044	0.051	0.2
9	*Mystus cavasius*	0.078	0.050	0.078	0.2
10	*Eutropiichthys vacha*	0.075	0.049	0.036	0.2
11	*Oreochromis mossambicus*	0.068	0.038	0.033	0.2
12	*Rhinomugil corsula*	0.075	0.040	0.140	0.2
13	*Channa punctatus*	0.065	0.033	0.048	0.2
14	*Macrognathus zebrinus*	2.151	0.028	1.126	0.2
15	*Mastacembelus dayi*	0.265	0.026	0.141	0.2

Table 5 Seasonal variation of lead concentration (mg/L) in different fish species

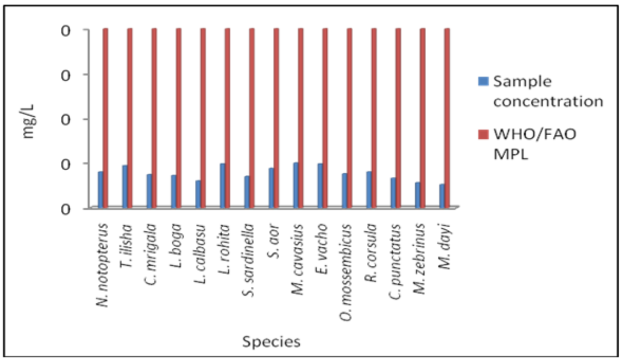
Sr.No.	Species	Concentration (mg/L)			WHO/FAO MPL
		Hot	Rainy	Cold	
1	*Notopterus notopterus*	0.028	−0.233	0.066	1
2	*Tenualosa ilisha*	0.07	−0.261	1.388	1
3	*Cirrhinus mrigala*	0.042	−0.167	0.656	1
4	*Labeo bogo*	0.102	−0.302	−0.081	1
5	*Labeo calbasu*	−0.102	−0.318	−0.070	1
6	*Labeo rohita*	−0.024	−0.222	5.437	1
7	*Salmostoma sardinella*	0.28	−0.264	−0.128	1
8	*Separata aor*	−0.062	−0.270	0.659	1
9	*Mystus cavasius*	−0.024	−0.265	7.252	1
10	*Eutropiichthys vacha*	−0.057	−0.241	0.275	1
11	*Oreochromis mossambicus*	−0.077	−0.298	2.961	1
12	*Rhinomugil corsula*	−0.072	−0.293	4.342	1
13	*Channa punctatus*	−0.102	−0.307	2.496	1
14	*Macrognathus zebrinus*	0.664	−0.325	3.835	1
15	*Mastacembelus dayi*	2.076	−0.292	2.869	1

Table 6 Seasonal variation of arsenic concentration (mg/L) in different fish species

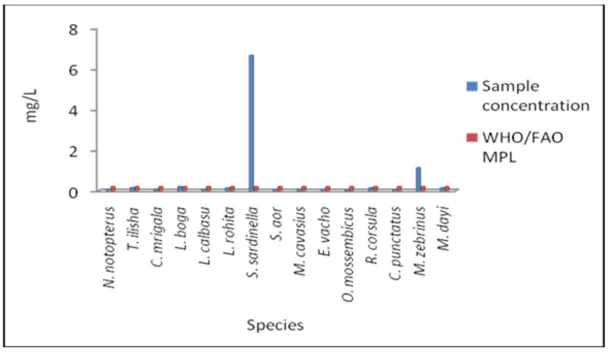
Sr.No.	Species	Concentration (mg/L)			WHO/FAO MPL
		Hot	Rainy	Cold	
1	*Notopterus notopterus*	1.446	1.221	2.274	0.26
2	*Tenualosa ilisha*	1.047	0.973	1.947	0.26
3	*Cirrhinus mrigala*	1.858	2.651	3.411	0.26
4	*Labeo bogo*	1.744	2.352	2.021	0.26
5	*Labeo calbasu*	2.830	1.941	2.772	0.26
6	*Labeo rohita*	2.476	1.466	2.148	0.26
7	*Salmostoma sardinella*	4.872	2.923	4.068	0.26
8	*Separata aor*	2.741	2.231	2.089	0.26
9	*Mystus cavasius*	1.274	2.645	2.113	0.26
10	*Eutropiichthys vacha*	2.350	3.016	2.553	0.26
11	*Oreochromis mossambicus*	2.206	2.639	1.379	0.26
12	*Rhinomugil corsula*	3.659	2.748	2.556	0.26
13	*Channa punctatus*	3.192	2.523	1.867	0.26
14	*Macrognathus zebrinus*	3.289	1.875	4.284	0.26
15	*Mastacembelus dayi*	2.829	3.393	2.144	0.26



(A) Hot season

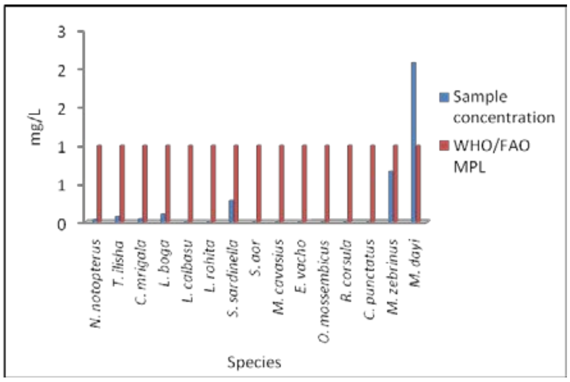


(B) Rainy season

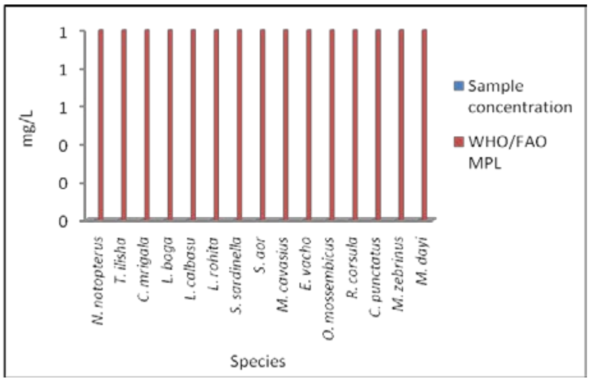


(C) Cold season

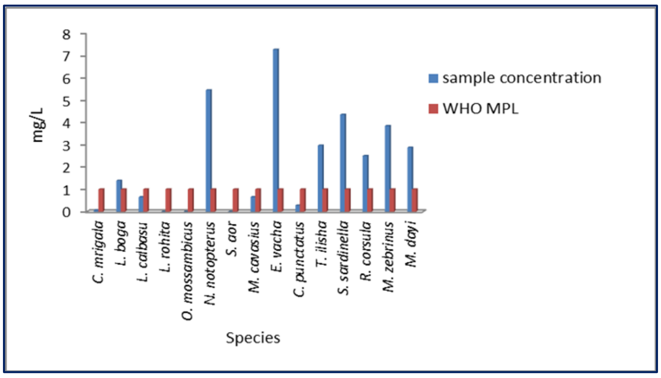
Figure 2 Seasonal variation of cadmium concentration in different fish species



(A) Hot season

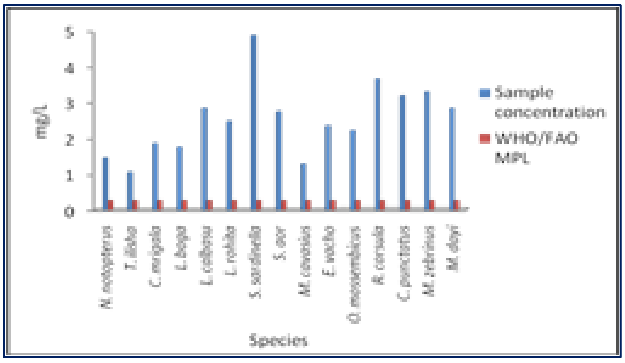


(B) Rainy season

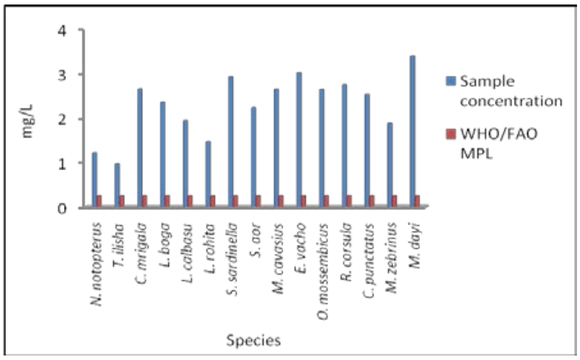


(C) Cold season

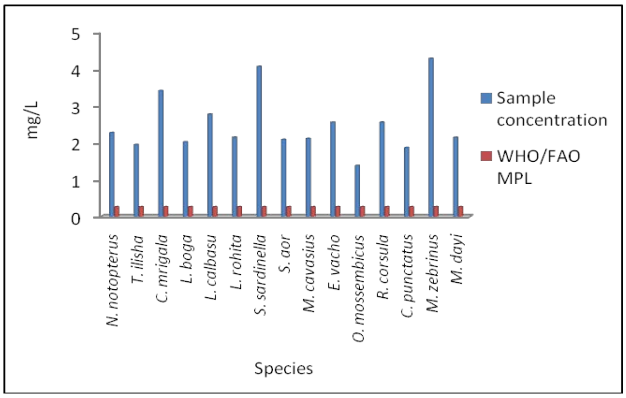
Figure 3 Seasonal variation of lead concentration in different fish species



(A) Hot season



(B) Rainy season



(C) Cold season

Figure 4 Seasonal variation of arsenic concentration in different fish species

Table 7 Seasonal variation of elements (mg/g) in water of study area

Particular	Elements	Concentration (mg/L)			WHO/FAO MPL
		Hot	Rainy	Cold	
Water	Cadmium	0.056	0.03	0.004	0.01
	Lead	−0.228	−0.330	−0.371	0.05
	Arsenic	2.158	2.034	−0.731	0.01

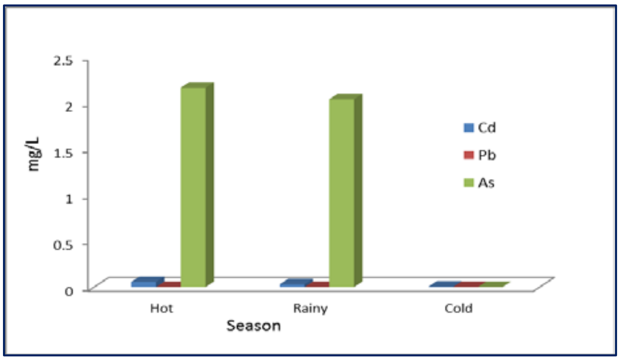


Figure 5 Seasonal variation of elements in water of study area

Table 8 Seasonal variation of elements (mg/g) in sediment of study area

Particular	Element	Concentration (mg/g)			MPL		
		Hot	Rainy	Cold	TEC	MEC	PEC
Sediment	Cadmium	0.063	0.063	0.015	0.99	3	5
	Lead	0.117	−0.229	−0.236	36	83	130
	Arsenic	2.319	2.278	2.264	9.8	21.4	33

TEC = Threshold effect concentration, MEC = Midpoint effect concentration
PEC = Portable effect concentration, MPL = maximum permissible limit

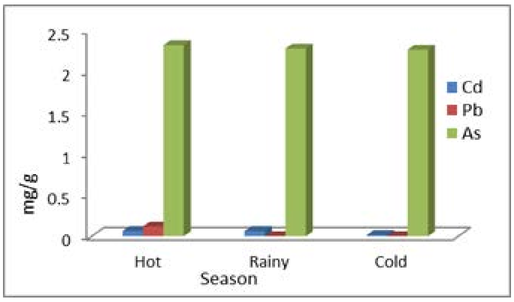


Figure 6 Seasonal variation of elements (mg/g) in sediment of study area

Discussion

A total of 15 fish species of different feeding habits which included two surface dwellers, seven mid-water dwellers and six bottom dwellers were collected from study area to analyze toxic elements content in muscle tissues.

Fish are known to be an important exposure pathway of metals to human and considered as one of the most indicative factors in freshwater ecosystems for the estimation of trace metals pollution (Rashed, 2001). There are five potential routes for a pollutant to enter a fish: food, non-food particles, gills, oral consumption of water and the skin (Ayandiran *et al*., 2009). Knowledge of element concentrations in fish is important for both human consumption and natural management.

Aye Aye Mu (2011), As concentration in muscle tissue of *Lates calcarifer* were high in hot > rainy > cold season.

Khin Myint Mar (2011) detected that Pb and Cd concentrations in different feeding type of fish were found lower the recommended limit of WHO/FAO in Gaw Wein Landing Sites, Ayeyarwady River Segment, Mandalay.

Damodharan *et al*., (2013) observed that Cd concentration in the muscle tissue of *O. mossambicus* showed little variable in dry and wet season.

In the present study, cadmium concentrations in three species (*Macrognathus zebrinus*, *Mastacembelus dayi* and *Salmostoma sardinella*) of omnivorous mid-water dwellers were observed to be higher in hot and cold season. WHO (2007) stated that cadmium exposures are associated with kidney and bone damage. Cadmium has also been identified as a potential human carcinogen, causing lung cancer.

In the present study, lead concentrations in one species at hot season and eight species in cold season were higher. Most of higher lead concentrated species were bottom and mid-water dwellers and they were also carnivores and omnivores. Lead is toxic metal and non-essential element for human body as it causes a rise in blood pressure, kidney damage and miscarriage (Kiran *et al*., 2011). In the present study, the overall mean values for arsenic recorded in the all sample fish species in all seasons were higher than the maximum permissible limit. Toxic effects appear when arsenic is ingested in excess for long periods, resulting in cancer, cutaneous malignancies, etc. Toxic metals are very harmful because of their potential to accumulate in different body parts.

In present study, cadmium and arsenic concentration of water in hot and rainy seasons were higher in study environs. The concentrations of toxic metal in sediment were lower than the maximum permissible limits in all seasons. Forstner and Wittmann (1981) reported that aquatic organisms such as fish are capable of accumulating metals also in their living cells to concentrations much higher than those present in water, sediments and micro flora in their environment. Metal content of fish increases with the increment of the metal level in water, sediment and food organism (Arvind, 2002). The present of metals in river, lake or any aquatic environment can change both aquatic species diversity and ecosystem due to their toxicity and accumulative behavior (Heath, 1987).

In this study, the effects of the seasons on elements accumulation in muscle of fishes were determined. From above mentioned results, it is clear that the concentration of toxic metals of fishes in study environs is high. A number of serious health problems may develop as a result of excessive uptake of dietary heavy metals in human body. Furthermore, the consumption of heavy metal-contaminated food can seriously deplete some essential nutrients in the body (Rafiqul Islam *et al*., 2013).

Conclusion

The result of this research based on toxic elements concentration of 15 fish species of different feeding habits and habitats, water and sediment of Ayeyarwady river segment of Salay environs. In the present study, toxic metal concentrations of all studied fish species were lower than the maximum permissible limits except the lead in cold season and arsenic in all seasons. Toxic metal concentrations of water were found lower than the maximum permissible limits except the arsenic in hot and rainy season and sediment were also found to be lower than the maximum permissible limits. Based on the results, it could be concluded that the study fish species were not suitable for human health.

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