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RELATIONSHIP BETWEEN TOXIC METAL CONCENTRATION AND SIZE OF FISH AND TRANSFER FACTOR OF AQUATIC ENVIRONS IN THANLWIN RIVER SEGMENT, MON STATE

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Abstract

Seasonal variations of As, Pb and Cd concentrations in muscle tissues of *Lates calcarifer*, *Otolithoides pama* and *Polynemus paradiseus* captured from Thanlwin River segment of Mon state were investigated during November 2019 to October 2020. Metal concentrations in water and sediment samples of the study sites were also assessed. Metal concentrations in extracts were determined by using Flame Atomic Absorption Spectrophotometry (FAAS) (Perkin Elmer AA Analyst 800 and Winlab – 32 software) at University Research Center (URC) in University of Yangon. Heavy metal concentrations in muscle tissues of all study fish species were below WHO standard limits. Concentration of As in water of the study site I in all seasons as well as those of the study site II also in all seasons were found higher than the WHO standard limits. As concentration in sediment of the study site I in all seasons as well as those of the study site II also in all seasons were found to be higher than the WHO standard limits. Concentration of Pb in water of the study site I in all seasons as well as those of the study site II also in all seasons were found higher than the WHO standard limits. No relationship between sizes of fish and heavy metal concentrations in *L. calcarifer* while negative relationship in *O. pama* and positive relation in *P. paradiseus* were found at the study site I. In the study site II, negative relationships between size of fish and As concentration in *L. calcarifer*, no relationships in *O. pama* and positive relationships between size of fish and As, Pb and Cd in *P. paradiseus* were observed. In the present study, transfer factor from water to muscle tissue of *L. calcarifer* was observed in As and Pb at the study site I and those transfer factor from sediment to muscle tissue of *L. calcarifer* was observed in Pb and Cd at the study site II. Transfer factor from water to muscle tissue of *O. pama* and *P. paradiseus* was observed in Cd at the study site II. However, heavy metal concentrations in muscle tissues of the study fish species were not higher than maximum permissible limits of WHO. Thus, mentioned fish species captured from the study area are generally safe for human consumption.

Keyword fish muscle, arsenic, lead, cadmium, muscle tissue, water, sediment

Introduction

Heavy metal pollution of water has become a major environmental problem almost since the advent of agricultural and industrial revolution and today most water resources are still being contaminated with heavy metals released from domestic, industrial and other man-made activities (Khare and Singh, 2002; Hayat and Javed, 2008). Heavy metal contamination may have devastation impact on the ecological balance of natural water bodies including the loss of aquatic diversity (Vosyliene and Jankaite, 2006; Farombi *et al*., 2007; Hayat and Javed, 2008).

Heavy metals are environmentally ubiquitous, readily dissolved and transported by water and readily taken up by aquatic organisms (Alam *et al*., 2002). Fishes are often at the top of aquatic food chain in water ecosystems and fish living in the polluted water may accumulate toxic trace metals (Mansour and Sidky, 2002).

It is well known that fish, as a regular constituent of the human diet, can represent a dangerous source of certain heavy metals. The discharge of wastewater and industrial effluents whether treated or not can be regarded as constant pollution source that dominate water quality. Water quality parameters can produce an improved understanding of the environmental situation

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and assist policy makers to design priorities for sustainable water management (Hung *et al*., 2010).

Thanlwin River which is one of the distinguished rivers in Myanmar is the study site for the present study. However, due to the natural disasters such as soil erosion and the existence of cement factories, machine cleaning workshop and industrial factories which are located near the study site, there is always a risk for aquatic organisms including fish, water and sediments due to contaminants such as heavy metals. Moreover, as farmers use agricultural fertilizer and pesticides, contamination occurs in water and sediments.

Due to above mentioned reasons, the present study has been carried out with the following objectives; to assess the contents of toxic heavy metal residues (As, Pb and Cd) which bio-accumulated in the muscle tissues of three selected fish species, to identify the toxic metal residue (As, Pb and Cd) concentrations in River water and sediment of River in the study sites, to study the relationship between fish size and toxic level in muscle tissues of three fish species, and to evaluate the transferred factor (TF) of heavy metals from River water and sediment in the muscle tissues of the three fish species.

Materials and Methods

The present study was conducted in two different study sites (Ngan Tae village and Kyauk Tan village) situated on the Thanlwin River segment and its tributaries in Mon states. Ngan Tae village (Lat 16º 28' N and Long, 97º 39' E) and Kyauk Tan village (Lat 16º 24' N and Long, 97º 36' E) were designated as the study site I and II, respectively. Study period lasted from November 2019 to October 2020. *Lates calcarifer*, *Otolithoides pama* and *Polynemus paradiseus*, water and sediment samples were collected monthly in fish landing depots of the study sites. At least seven samples from each fish species were collected. Total length and body weight of specimens were measured. They were dissected using stainless steel scalpels and forceps. A part of the muscle (dorsal muscle) was removed and weighed. Samples were put into an oven (90 ºC) and dried to reach constant weight. After that they were stored at low temperature until digestion. Digestion of the samples was carried out according to dry method by using furnace (Model-L-3383).

Element concentrations of As, Pb and Cd in extracts were determined by using Flame Atomic Absorption Spectrophotometry (FAAS) (Perkin Elmer AA Analyst 800 and Winlab-32 software) at Universities Research Center (URC) in University of Yangon. Test results were compared with maximum permissible limit (MPL) designated by WHO.

Functional relationship between sizes of fish and heavy metal concentrations were analyzed by using regression method with the following formula (Le ren, 1951) Where,

$Y = a + bX$

a = Y intercept

b = slope of the line

r = regression coefficient

The transfer factor is an approach based on the water-fish transfer factor that provides a straight forward, constructive method for assessing heavy metal accumulation for the purposes of health risk assessment for humans consuming the fish. The water-fish transfer factor (TF) of the biological accumulation coefficient (BAC), which expresses the ratio of contaminant concentration in fish to the concentration in water, was used to characterize quantitatively the transfer of an element from the water to fish (Rodriguez *et al*., 2002 and Tome, V, *et al*., 2003).

To evaluate the bio-accumulation of heavy metals in fish muscle tissue from water or sediment, the transfer factor (TF) was calculated (Kalfakakour and Akrida-Demertzi, 2000; Rased, 2001). The TF formula was given as:

$$\text{TF} = \frac{\text{concentration of metal in fish muscle tissue}}{\text{concentration of metal in environ (water or sediment)}}$$

According to Kalfakakour and Akrida-Demertzi (2000), if the value of TF was is greater than 1, it indicated bioaccumulation of metals in fish muscle tissue.

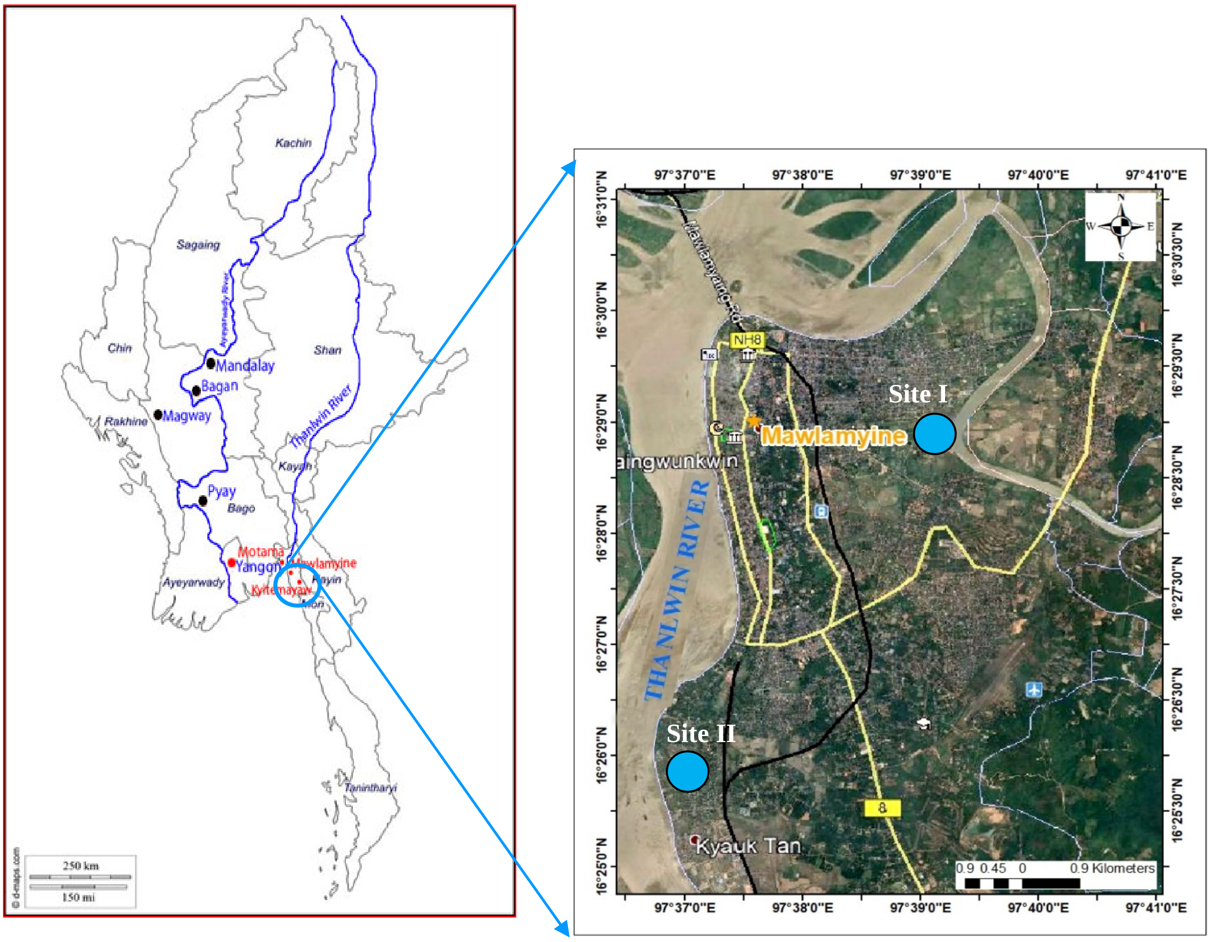

Figure 1 Map of the study sites

A. Cement Factory (Back View) Site I

B. Machine cleaning workshop (Back View) Site II

Plate 1 Environs of the study sites

A. *Lates calcarifer*

B. *Otolithoides pama*

C. *Polynemus paradiseus*

Plate 2 Studied fish species

Results

Mean sizes (total length and body weight) of three fish species, *Lates calcarifer*, *Otholithoides pama* and *Polynemus paradiseus*, which were selected to test metal concentrations in muscle tissues were different. Seasonal variations among mean total lengths of all study species in 2020 were observed (Table.1 and Table. 2).

In metal concentrations in muscle tissue of three selected fish species at the study area, Arsenic concentration in muscle tissue of *Lates calcarifer* collected from study site I was -11.99 mg/L in winter season and it was > -26.45 mg/L in summer season and > -31.43 mg/L in rainy season. Similar results were observed in study site II. The As concentration in muscle tissue of *Otolithoides pama* and *Polynemus paradiseus* was highest in winter season and followed by summer season and rainy season. The As concentrations in muscle tissues of three study fish species collected from study site I were higher than those of study site II in winter season (Table 3).

Pb concentration in muscle tissue of *Lates calcarifer* collected from study I was 0.131 mg/L in summer season, >0.110mg/L in rainy season and >-0.051mg/L in winter season. Similar results were observed in the study site II. The same conditions of Pb concentration were found in muscle tissue of *Otolithoides pama* and *Polynemus paradiseus*. However, Pb concentration in muscle tissues of three study fish species collected from the study site II were higher than those of the study site I in summer seasom (Table 4).

Cadmium concentration in muscle tissue of *Lates calcarifer* at summer season (-0.265 mg/L) was higher than those of rainy season (0.171mg/L) and winter season (-0.274mg/L) in the study site I. Similar results were observed in the study site II. The same conditions of Cd concentration were found in muscle tissue of *Otolithoides pama* and

Polynemus paradiseus. However, Cd concentrations in muscle tissues of *Lates calcarifer*, *Otolithoides pama* and *Polynemus paradiseus* collected from the study site I were higher than those of the study site II (Table 5).

Arsenic concentrations in water and sediment at rainy season (2.965mg/L in water and 109.10mg/L in sediment) were higher than those of summer season (2.114mg/L in water and 87.84mg/L in sediment) and winter season (69.55mg/L in water and 88.01mg/L in sediment) in the study site I. Similar results were observed in the study site II. Arsenic concentrations in water collected from study site I was higher than that of study site II. As concentrations in sediment collected from the study site II was higher than that of the study site I (Table 6 and Table.7).

Lead concentration in water at winter season (0.137mg/L) was higher than those of rainy season (0.114mg/L) and summer season (0.088 mg/L), but in sediment at rainy season was the most higher (0.231 mg/L) than those of summer (0.152mg/L) and winter (0.200mg/L) in the study site I. Although Pb concentration at rainy season (0.468mg/L in sediment) in site II was higher than those of rainy season (0.231mg/L) and winter season (0.200mg/L) in study site I. However, Pb concentrations in water and sediment collected from study site II were higher than those of the study site I in summer season (Table 6 and Table.7).

Cadmium concentration in sediment of summer season (-0.268mg/L) was higher than those of rainy season (-0.291mg/L) and winter season (0.291mg/L) in the study site I. Similar results were observed in the study site II. Cd concentration of water in winter season (0.292mg/L) was higher than those of summer season (0.294mg/L) and rainy season (-0.293mg/L) in site I. However, Cd concentrations in water and sediment collected from the study site I were higher than those of the study site II in all seasons (Table 6 and Table.7).

WHO/FAO maximum permissible limits of As, Pb and Cd in muscle tissue of fish are 0.01 mg/L, 1 mg/L and 0.2 mg/L respectively. Concentrations of As, Pb and Cd in muscle tissues of the study three fish species were found under the maximum levels permitted by WHO/FAO (Table 3,4,5 and Fig. 3,4,5).

In the study for transfer factors of heavy metals from water and sediment to muscle tissues of three fish species, transfer factor (TF) of Cdamium in site I from sediment of aquatic environs to muscle tissues of *L. calcarifer* was (1.29), Cdamium in site II of *L. calcarifer* and *O. pama* were 1.38 and 1.38 respectively and Cadmium in *P. paradiseus* of site II (1.43) was also higher than index value 1 in 2020. (Table 9).

In the study for relation between size of fish and metals concentrations in muscle tissue of fish, regression coefficient of total length of *L. calcarifer* and concentrations of As (y=-0.1762x-18.685, r = 0.195), Pb (y=0.0021x+0.0086, r= 0.236) and Cd (y=1E-04x-0.2725, r= 0.236) were observed. Total length of *L. calcarifer* and As, Pb and Cd concentrations were found to have no relation in the study site I. In site II, As (y=0.0919x-17.112, r=0.321) Pb (y=-0.0002x-0.0498, r=0.024) and Cd (y=1E-05x-0.2904, r = 0.017) were observed. Total lengths of *L. calcarifer* and As concentrations were found to have negative relation in the study site II (Table 8).

Regression coefficient of total lengths of *O. pama* and concentrations of As (y=1.11x-54.619, r=0.336), Pb (y=0.0149x-0.4214, r=0.374) and Cd (y=0.0014x-0.2962, r=0.372) in muscle tissue of this species in site I were observed. In site II, As (y=-0.2614x-19.106, r= -0.176) Pb (y=-0.0007x-0.0328, r=0.024) and Cd (y=8E-05x—0.2949, r = 0.060) were observed. Total lengths of *O. pama* and As and Pb concentrations were found to be negatively related in the study site I (Table 8).

Regression coefficient of total lengths *P. paradiseus* and concentrations of As (y=-1.7043+13.34, r= -0.429) Pb (y=0.033x-0.5404, r=0.631) and Cd (y= 0.0033x-0.323, r = 0.635) in muscle tissue of this species in site I were observed. In study site II, As (y=3.4211x-87.336, r=0.760) Pb (y=-0.0033x-0.0189, r=-0.501) and Cd (y=-0.002x-0.2611, r=-0.522) were observed. In site I and II, total lengths of fish and As, Pb and Cd concentrations were found to be positively related (Table. 8).

Regression coefficient of body weights of *L. calcarifer* and concentrations of As (y=0.0066x-21.575, r=0.225) Pb (y=9E-05x+0.0397, r=0.314) and Cd (y=5E-06x-0.2713, r = 0.372) in muscle tissue of this species in site I were observed. In study site II, As (-0.0021x-18.977), Pb (y=6E-06x-0.0531, r=0.036) and Cd (y=2E-07x-0.2901, r=0.010) were observed. Body weight of *L. calcarifer* and As concentrations were negatively related in site II (Table 8).

Regression coefficient of body weights of *O. pama* and concentrations of As (y=0.079x-35.91, r=0.404), Pb (y=0.0008x-0.1412, r=0.333) and Cd (y=7E-05x-0.2694, r=0.329) in muscle tissue of this species in site I were recorded. In the study site II, that of As (y=0.1779x-41.001, r=0.408), Pb (y=-0.0058x+0.4742, r=0.728) and Cd (y=-0.0058x-0.4742, r=-0.721) were observed. Positive relation between body weights of *O. pama* and As concentrations was observed in site I and site II. Body weights of *O. pama* and Pb concentrations were negatively related in site I and site II (Table 8).

Regression coefficient of body weights *P. paradiseus* and concentrations of As (y=-0.2811x-7.8548, r=-0.385), Pb (y=0.0058x-0.138, r=0.605) and Cd (y=0.0006x-0.284, r =0.653) in muscle tissue of this species in site I were observed. In study site II, As (y=0.6402x-46.374, r=0.746), Pb (y=-0.0006x-0.0583, r=-0.489) and Cd (y=0.0004x-0.2851, r =-0.510) were observed. Body weights of *P. paradiseus* and As concentrations were positively related in site II and those with Pb and Cd concentrations were positively related in site I (Table 8).

Table 1 Mean total length and body weight of the fish for seasonal analysis of metal concentration in the study site I

Sr No.	Species	Summer		Rainy		Winter	
		TL (cm)	Weight (g)	TL (cm)	Weight (g)	TL (cm)	Weight (g)
1.	*Lates calcarifer*	23.2±10.94	142.8±159.42	28.7±9.35	395.1±408.42	26.5±5.35	236.2±97.87
2.	*Otolithiodes pama*	23.42±1.69	85.42±15.63	25.67±1.89	123.83±23.17	24.5±2.65	114.3±54.58
3.	*Polynemus paradiseus*	14.83±0.53	15.67±1.2	17.44±0.8	30.11±5.23	16.78±1.69	25.44±9.12

Table 2 Mean total length and body weight of the fish for seasonal analysis of metal concentration in the study site II

Sr No.	Species	Summer		Rainy		Winter	
		TL (cm)	Weight (g)	TL (cm)	Weight (g)	TL (cm)	Weight (g)
1.	*Lates calcarifer*	30.10±8.14	418.6±372.09	34.9±14.6	700.6±744.98	26.8±3.31	239.5±93.47
2.	*Otolithiodes pama*	22.08±0.98	77.08±4.69	21.29±6.32	99±8.97	23.17±0.75	95.33±11.12
3.	*Polynemus paradiseus*	16.22±1.13	22.94±5.71	15.78±0.71	20.44±2.88	19.22±0.71	38.39±5.26

Table 3 Seasonal variation of Arsenic concentrations (mg/L) in muscle tissues of fish species in the study sites (2020)

Sr. No.	Species	Site I			Site II			MPL
		Summer	Rainy	Winter	Summer	Rainy	Winter	
1.	*Lates calcarifer*	-26.45	-31.43	-11.99	-19.47	-23.77	-16.53	0.26
2.	*Otolithoides pama*	-22.21	-21.81	-38.16	-28.20	-16.97	-29.54	0.26
3.	*Polynemus paradiseus*	-13.26	-22.75	-7.578	-27.86	-38.95	-18.97	0.26

Table 4 Seasonal variation of Lead concentrations (mg/L) in muscle tissues of fish species in the study sites in 2020

Sr. No.	Species	Site I			Site II			MPL
		Summer	Rainy	Winter	Summer	Rainy	Winter	
1.	*Lates calcarifer*	0.131	0.110	-0.051	0.059	-0.110	-0.116	1
2.	*Otolithoides pama*	0.071	-0.104	-0.138	0.097	-0.116	-0.125	1
3.	*Polynemus paradiseus*	0.036	0.078	-0.114	-0.059	-0.080	-0.086	1

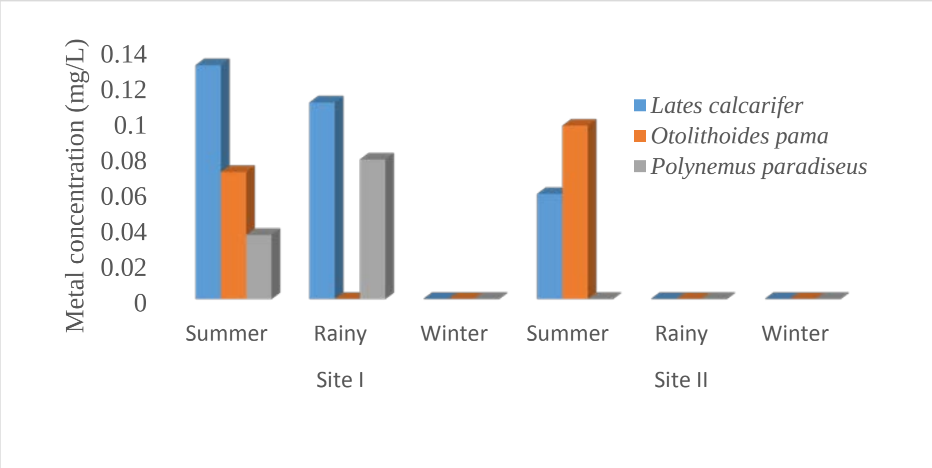

Figure 2 Lead concentrations (mg/L) in three fish species at two different study sites

Table 5 Cadmium concentrations (mg/L) in three fish species at two different study sites

Sr No.	Species	Site I			Site II			MPL
		Summer	Rainy	Winter	Summer	Rainy	Winter	
1.	*Lates calcarifer*	-0.265	-0.271	-0.274	-0.279	-0.294	-0.297	0.2
2.	*Otolithiodes pama*	-0.249	-0.266	-0.269	-0.286	-0.299	-0.294	0.2
3.	*Polynemus paradiseus*	-0.258	-0.271	-0.278	-0.286	-0.298	-0.302	0.2

MPL = Maximum permissible limit

Table 6 Heavy metal concentrations in water of two different study sites

Sr No.	Elements	Site I			Site II			MPL
		Summer	Rainy	Winter	Summer	Rainy	Winter	
1.	Arsenic	2.114	2.956	69.55	2.682	4.620	2.698	0.01
2.	Lead	0.088	0.114	0.137	0.120	0.078	0.125	0.01
3.	Cadmium	-0.294	-0.293	-0.292	-0.300	-0.317	-0.309	0.003

MPL = Maximum permissible limit

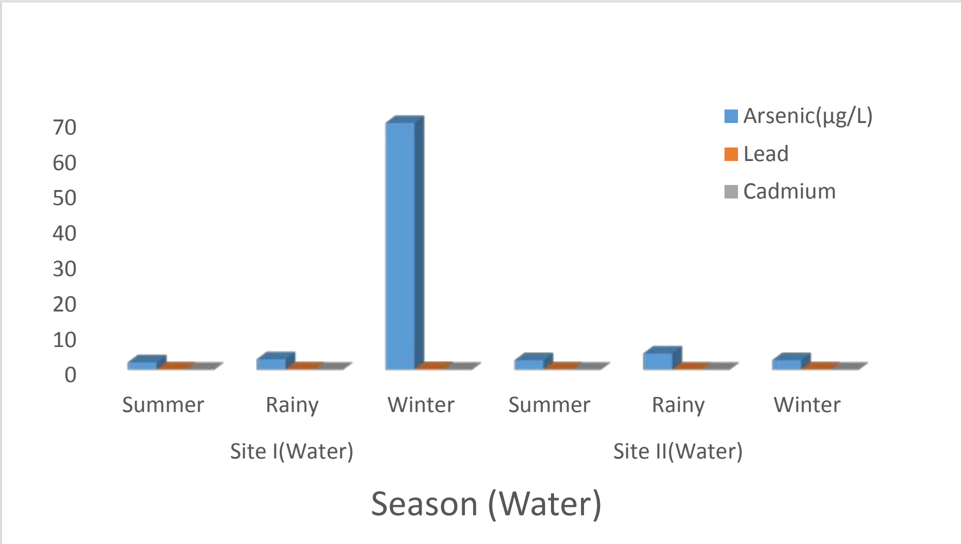

Figure 3 Heavy metal concentrations in water of two different study sites

Table 7 Heavy metal concentrations in sediment of two different study sites

Sr No.	Elements	Site I			Site II			MPL		
		Summer	**Rainy**	**Winter**	**Summer**	**Rainy**	**Winter**	**TEC**	**MEC**	**PEC**
1.	Arsenic	87.84	109.10	88.01	93.97	162.10	226.90	9.8	21.4	33
2.	Lead	0.152	0.231	0.200	0.216	0.468	0.024	36	83	130
3.	Cadmium	-0.286	-0.291	-0.291	-0.293	-0.294	-0.045	0.99	3	5

MPL = Maximum permissible limit
TEC = Threshold effect concentration
MEC = Midpoint effect concentration
PEC = Protable effect concentration

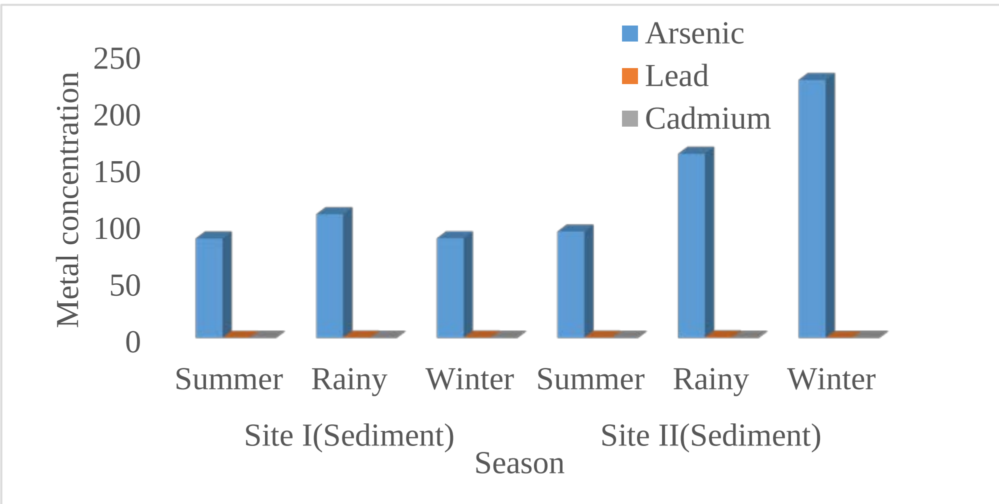

Figure 4 Heavy metal concentrations in sediment of two different study sites

Table .8 Relationship between body length (cm) and weight (g) of fish and heavy metal concentrations in muscle tissue of fish at study Site I and Site II

Species	Heavy metals	Site I				Site II			
		Length	Remark	Weigth	Remark	Length	Remark	Weigth	Remark
		Linear equation		Linear equation		Linear equation		Linear equation	
Lates calcarifer	As	y = -0.1762x - 18.685 R^2 = 0.0382 r=-0.195	No relation	y=-0.0066x - 21.575 R^2=0.0508 r=-0.225	No relation	y=-0.0919x - 17.112 R^2=0.1028 r=-0.321	Negative relation	y= -0.0021x - 18.977 R^2=0.1333 r=-0.365	Negative relation
	Pb	y=0.0021x + 0.0086 R^2=0.0556 r=0.236	No relation	y=9E-05x + 0.0397 R^2=0.0988 r=0.314	Negative relation	y= -0.0002x - 0.0498 R^2=0.0006 r=-0.024	No relation	y=-6E-06x - 0.0531 R^2=0.0013 r=-0.036	No relation
	Cd	y=1E-04x - 0.2725 R^2=0.0555 r=0.236	No relation	y=5E-06x - 0.2713 R^2=0.1386 r=0.372	Negative relation	y=1E-05x - 0.2904 R^2=0.017 r=0.017	No relation	y= 2E-07x - 0.2901 R^2=0.0001 r=0.010	No relation
Otolithoides pama	As	y=1.11x - 54.619 R^2=0.113 r=0.336	Negative relation	y=0.079x - 35.91 R^2=0.1635 r=0.404	Positive relation	y= -0.2614x - 19.106 R^2=0.031 r=-0.176	No relation	y=0.1779x - 41.001 R^2=0.1666 r=0.408	Positive relation
	Pb	y=0.0149x - 0.4214 R^2=0.14 r=0.374	Negative relation	y=0.0008x - 0.1412 R^2=0.1106 r=0.333	No relation	y= -0.0007x - 0.0328 R^2=0.0006 r=-0.024	No relation	y= -0.0058x + 0.4742 R^2=0.5293 r=-0.728	Negative relation
	Cd	y= 0.0014x - 0.2962 R^2=0.1387 r=0.372	No relation	y=7E-05x - 0.2694 R^2=0.1085 r=0.329	Negative relation	y= 8E-05x - 0.2949 R^2=0.0036 r=0.060	No relation	y== -0.0058x + 0.4742 R^2=0.5198 r=-0.721	Negative relation
Polynemus paradiseus	As	y=-1.7043x + 13.34 R^2=0.1838 r=-0.429	Negative relation	y=-0.2811x - 7.8548 R^2=0.1484 r=-0.385	Negative relation	y=3.4211x - 87.336 R^2=0.5778 r=0.760	Positive relation	y= 0.6402x - 46.374 R^2=0.556 r=0.746	Positive relation
	Pb	y=0.033x - 0.5404 R^2=0.3984 r=0.631	Positive relation	y=0.0058x - 0.138 R^2=0.3659 r=0.605	Positive relation	y= -0.0033x - 0.0189 R^2=0.2514 r=-0.501	Positive relation	y=-0.0006x - 0.0583 R^2=0.2392 r=-0.489	Negative relation
	Cd	y=0.0033x - 0.3236 R^2=0.4027 r=0.635	Positive relation	y= 0.0006x - 0.284 R^2=0.427 r=0.653	Positive relation	y= -0.002x - 0.2611 R^2=0.2724 r=-0.522	Positive relation	y=-0.0004x - 0.2851 R^2=0.2596 r=-0.510	Negative relation

Table 9 Transfer factors of toxic metals from water and sediment to muscle tissue of different fish species in 2019-2020

Species	**Metals**	**2019-2020**			
		Site I		**Site II**	
		TF from water	**TF from sediment**	**TF from water**	**TF from sediment**
	As	0.94	-0.25	-5.98	-0.12
Lates calcarifer	Pb	0.55	0	-0.55	0.21
	Cd	0.93	**1.29**	0.94	**1.38**
	As	-1.1	-0.29	-7.48	-0.15
Otolith0ides pama	Pb	-0.55	0	-0.45	-0.21
	Cd	0.9	0.9	0.94	**1.38**
	As	-0.58	-0.15	-8.59	-0.18
Polynemus paradiseus	Pb	0	0	-0.73	-0.33
	Cd	0.93	0.93	0.97	1.43

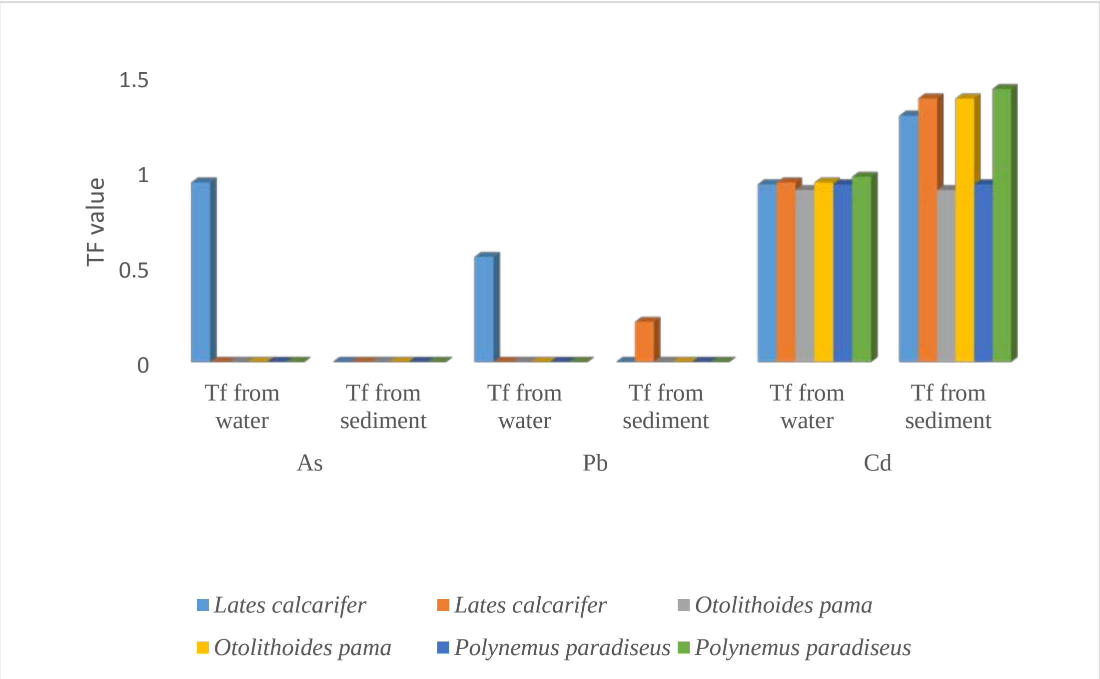

Figure 5 Transfer factors of heavy metals from water and sediment in muscle tissue of different fish species in 2019-2020

Discussion

Heavy metals (As, Pb and Cd) in muscle tissues of three fish species (*Lates calcarifer*, *Otolithoides pama* and *Polynemus paradiseus*) collected from the catch in Ngan Tae village and Kyauk Tan village situated on the Thanlwin River segment and its tributaries of Mon states were analyzed seasonally during the period from November 2019 to October 2020. Metal concentrations in water and sediment of aquatic environs of the study sites were also assessed. Arsenic is released in the environment through natural processes such as weathering, and may circulate in natural ecosystems for long time (Mol *et al*., 2010).

Toxic effects appear when arsenic is ingested in excess for long periods resulting in cancer, cutaneous malignancies, etc. Lead is toxic metal and non-essential element for human body as it causes a rise in blood pressure, kidney damage and miscarriage Cadmium injures the kidney, poor reproductive capacity, hypertension, tumors and hepatic dysfunction. (Kiran *et al*., 2011).

In the present study, concentrations of Pb in muscle tissues of *L. calcarifer*, *O. pama*, and *P. paradiseus* were found to be higher in summer and rainy seasons than those of winter in site I.

Similar findings of Pb concentrations in muscle tissues of *L. calcarifer* and *O. pama* were observed to be high in summer of site II. As and Cd concentrations in this species were lower than MPL limit in all season.

Thus, concentrations of As, Pb and Cd in muscle tissues of three study fish species collected from the study site I and II were not higher than the MPL recommended by WHO.

Khin Thida Kyaw (2008) stated that seasonal variation of toxic metals (As,Pb and Cd) concentrations in three fish species were higher in summer and rainy season than those of winter.

However, Cho Cho Thin (2017) stated that the level of As in fish muscle was found above the WHO standard limit but Khin Myint Mar(2011) found that the concentrations of heavy metals in studied species were lower than WHO standard limit.

Thus, present findings were not agreed with the findings of above authors and potential danger may not occur for the consumption of the study fish species from the present study area.

In relationship between fish size and toxic level, length and weight of *P. paradiseus* and As, Pb and Cd concentrations were positively related in the study site I and site II. Lengths and Pb and Cd concentrations as well as weight and Pb and Cd concentrations of three fish species in site I were positively related. Lengths and weights of *P. paradiseus* and As concentrations were positively related in the study site II. Cho Cho Thin (2017) observed that relationship between As concentrations in muscle tissues of carnivorous and omnivorous fishes and their body lengths and body weights were significant.

In the present study, transfer factor from sediment to muscle tissue of *L. calcarifer* was observed in Cd at site I and site II. Similar case of *O. pama* was observed in Cd at site II. Transfer factor from sediment to muscle tissue of *P. paradiseus* was observed in Cd at site II. Sein Moh Moh Paing (2019) stated that Cd and As concentrations in water and sediment of the study area were found above the WHO standard limits in all seasons.

Excessive releases of heavy metals into the environment due to industrialization and urbanization has posed a great problem worldwide. Water contaminants in those habitats were being discharged by industries affecting the ecosystem of the aquatic organisms including fish species. Sustainable use, public awareness, and conservation activities are important to maintain healthy aquatic environs.

The effects of pollutants may be also detected on land as a result of their bioaccumulation and bioconcentration in the food chain (Zhang *et al*., 2004; Stara *et al*., 2013). Fish cover a wide range of trophic levels and are an important link of aquatic food chains with human populations (Costa and Kehrig, 2002).

On the basis of results of present study, the levels of As, Pb and Cd concentration in three fish species were lower than those of limits recommended by WHO. However, in water of both study sites, levels of As and Pb concentration were higher than maximum permissible limits of WHO. Cd concentration level was lower than maximum permissible limit of WHO. In sediments, the level of As concentration was higher than maximum permissible limit of WHO whereas the levels of Pb and Cd concentration were lower than maximum permissible limits of WHO. Therefore the studied fish species are generally safe for human consumption. Water and sediment of the study area were not safe due to heavy metals contaminations and are therefore in alarm state for human drinking, and other domestic uses.

Conclusion

The results of this research based on the investigation of metal concentrations in *L. calcarifer*, *O. pama*, *P. paradiseus,* water and sediment of aquatic environs in Thanlwin River lower segment of Mon State revealed the heavy metal contaminations of water and sediment. In the present study As, Pb and Cd concentrations of water and sediment in all seasons during the study period were observed to be higher than the maximum permissible limits and guide line limits of WHO/FAO. Transfer factors of Pb and Cd in *Lates calcarifer, Otolithoides pama and Polynemus paradiseus* were found to be from sediment of their aquatic environs. In the present study, it might be due to soil erosion, agricultural runoff of fertilizers and pesticides, industry effect composed of organic and inorganic materials which are oxidized. People should have awareness that environment is degraded and contaminated due to human activities. Three fish species, *Lates calcarifer*, *Otholithoides pama* and *Polynemus paradiseus,* were selected from the catch of Ngan Tae village and Kyauk Tan village situated on the Thanlwin River segment and its tributaries of Mon State to test metal concentrations in their muscle tissues. In the present study, arsenic, lead and cadmium concentrations in muscle tissues of all studied fish species in all three seasons at two study sites were found under the WHO maximum permissible limits. However, As concentrations in water and sediment were higher than maximum permissible limit.

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