Bioaccumulation of Heavy Metals in Some Indigenous Fishes, Water and Sediments from Hinthada Environs, Ayeyarwady Region

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Abstract

Investigations on the accumulation of heavy metals lead (Pb), cadmium (Cd) and arsenic (As) were carried out with three indigenous fishes namely *Puntius sophore* (Nga-khone-ma), *Amblypharyngodon mola* (Nga-beh-phyu) and *Mystus bleekeri* (Nga-zin-yaing) from Nat-Maw Creek, Kyone-tuwn, Hinthada Environs from December 2017 to July 2018. The concentrations of heavy metals were analyzed three replicates by Flame Atomic Absorption Spectrometer (FAAS) (Perken-Elmer AAanalyst 800 and Winlab-32 software) in Universities Research Center (URC). Seasonal variation of heavy metal by comparing with WHO and EC maximum permissible limits (MPL) were analysed. Cadmium (Cd) concentration was high in all studied fish species were analysed, *P.sophore* 0.063 mg/L, *A.mola* 0.056 mg/L and *M.bleekeri* 0.059 mg/L during hot season. The accumulation of heavy metals in *M.bleekeri*; lead, cadmium and arsenic were higher than limit of value in hot season, 0.059 ± 0.010 Cd, 0.52 ± 0.010 Pb and 0.482 ± 0.681 As. Over maximum permissible limit of Cadmium (Cd) 0.035 ± 0.008 mg/L in hot season and 0.032 ± 0.007 in wet season were found in water. Whereas in sediments, 0.046 ± 0.008 mg/L in hot season; 0.036 ± 0.008 mg/L in wet season. Lead (Pb) concentrations of water was found to be low 0 ± 0.029 mg/L in hot season; 0 ± 0.011 mg/L in wet season as compare as in sediments, 0 ± 0.031 mg/L in hot season; 0 ± 0.028 mg/L in wet season were found. Arsenic (As) concentrations of water and sediments were found to be high in all season. Most high arsenic concentrations of water 0.467 ± 0.078 mg/L in hot season and 4.073 ± 0.947 mg/L in cool season were found. In sediment the arsenic concentration was 13.44 ± 0.440 mg/L in hot season and 41.33 ± 11.381 mg/L in cool season. The findings of this study will support to fulfill in partial information to environmental condition of the study area.

Keywords: Indigenous fishes, Water and Sediments, Heavy metals

Introduction

Increased industrialization, urbanization, population growth are a serious threat to all kinds of life in the form of pollution which has now become a global problem. Among all types of pollution, aquatic pollution is of greater concern. The heavy metals are considered as critical toxic contaminants of aquatic ecosystems, due to their high potential to enter and accumulate in food chain (Olojo *et al*., 2005). The main sources of heavy metal pollution of the agriculture, industry and metropolitan cities, the bioaccumulation of toxic heavy metals in fish species from different aquatic systems is dependent on their foreign polluted substances. The distribution of heavy metals in water, sediments and fish play a key role in detecting sources of heavy metal pollution in aquatic ecosystem (Forstner and Wittman, 1981). Of them lead (Pb), mercury (Hg), cadmium (Cd) and arsenic (As) are the top most toxic pollutants of environmental concern entering into aquatic ecosystems through diverse sources including both natural and anthropogenic activities (Leland *et al*.,1978, Mance1987).

As long as industrial and domestic activities, sustained measurements will be needed to assess the effectiveness of set limitation standards by identification and quantification of the state of environmental degradation attributable to the discharged heavy metals. Contaminating elements and compounds are transported by water and gather at the bottom and alluvial sediments. The anthropogenic trace metals released by industries and domestic effluents are incorporated into accumulating sediments (Zerbe *et al*., 1998). Also toxic metals occur as natural constituents of the earth crust, which are persistent environmental

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contaminants since they cannot be degraded or destroyed. Like in mining processes, some metals are left behind as tailings scattered in open and partially covered pits; some are transported through wind and flood, creating various environmental problems (Habashi, 1992).

Doembi Ucla Edu (2011) listed 31 heavy metals, none of these are essential elements in biological systems and additionally, most of the better known elements are toxic in fairly low concentrations. Heavy metals are high pollutants because of their relative high toxicity and persistent nature in the environment. Therefore, the knowledge of the changing concentrations and distribution of heavy metals and their compounds in various compartments of the environment is a priority for good environment management programmes all over the world (Don-Pedro *et al*., 2004).

Of these toxic heavy metals can impact human health. Eight common heavy metals are arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver. Generally, humans are exposed to these metals by ingestion (drinking or eating) or inhalation (breathing). Working in or living near an industrial site, where these of metals have been improperly disposed. As a result of human activities, such as fossil fuel burning, mining, and manufacturing, lead and lead compounds can be found in all parts of our environment. This includes air, soil and water. Lead is used in many different ways such as the production of batteries, ammunition and X-ray shielding devices. As the effects on human health, lead is a highly toxic metal as a result of related health concerns which is used in several products like gasoline, paints, and pipe solder. Cadmium is a very toxic metal which is also produced by batteries, pigments, metal coatings, and plastics. It is used extensively in electroplating. Also the arsenic can be released in larger quantities through volcanic activity, erosion of rocks, forest fires, and human activity. Arsenic is also found in paints, dyes, metals, drugs, soaps and semi-conductors. Animal feeding operations, fertilizers and pesticide can release high amounts of arsenic to the environment as the industry practices (Martin and Griswold, 2009).

Small indigenous species of fish are valuable and easily available source of food which are rich in protein, vitamin and minerals. By eaten of many Small Indigenous Fish Species (SIS) calcium, phosphorous and vitamins could be contributed in the body of consumers. Therefore in the small fish occupy an important position as a popular food stem (Costa and Kehrig, 2002).

Nat-Maw Creek is situated between Kyone-Pha-Inn and Pyin-Ma-Gone creek in Hinthada Township. Nat-Maw town is located along the bank of this creek. It is also one of the chief fishing grounds in Hinthada environs that provides an important food source for villagers along the creek. The villager get their earning by selling fishes at the local and Hinthada's markets.

The present study has been carried out with the following objectives.

- to examine seasonal variation of heavy metals such as Lead, Cadmium, and Arsenic concentrations in three fish species from study site
- to examine heavy metals concentration in water and sediment from study site

Materials and Methods

Study area and study period

Kyone-tuwn village of Nat-Maw Creek in Hinthada Township, Ayeyarwady Region locating at 17°35' 21.02" N and 95°25' 39.96" E were chosen as the study area (Fig.1). Study period lasted from December 2017 to July 2018. The three seasons were expressed that March to May as hot season; June to September as wet season and October to February as cool season.

Figure (1). Map of specimen collection in the study site, (Source: Google Map)

Sample collection and identification of fish species

Three species was collected from local fishermen in the study site. There were *Mystus bleekeri, Puntius sophore* and *Amblypharygodon mola*. Totally ten specimens of each fish species were collected seasonally (Plate 1). The identification of examined fishes were carried out follow after Talwar and Jhingran (1991).

Sample preparations

Sample preparation of fishes

The collected specimens were washed by the tap water to run off the contamination on the body surface of fish. Total length (cm) and body weight (g) of specimens were measured. After that, the specimens were dissected using stainless steel scalpels and forceps. These samples were dried at 90°C to constant weight in an oven. The dried samples were weight and stored in airtight containers. After that, they were stored at low temperature until digestion. Digestion of the sample was conducted according to dry method using furnace (Model-L-3383). Each 5 g dry weight of samples was placed into crucible and then transfer to a furnace and slowly raises temperature to 500°C for 2 hours. Obtained ash was passed through overnight and it was cool to room temperature. Ash was added with 5mL nitric acid and swirl and then add 10 mL HCl. Again those ashes were transferred to furnace and the temperature was slowly raised to 500°C and hold at this temperature for one hour. Then, crucible was removed and cold at room temperature. Dilution of prepared sample was applied with 50 mL deionized water and transferred to volumetric flask and filtered with filter paper to examine by AAS. The concentration of elements (Lead, Cadmium and Arsenic) in each specimens was analyzed three replicates by FAAS. Seasonal variations of test results were compared with WHO and EC maximum permissible limits. Samples of water and sediment were also collected seasonally from study area (Plate 2).

Sample preparation of water and sediments

Water sample was filtered through a 0.45 micron Whatman filter. The samples were analyzed directly by AAS. The sediment sample was dried, grounded and sieved with 200mm sieve to obtain a find powder. 1.0 g dried sediment sample in a crucible was placed into a furnce and heating at 200-250°C for 30 min, and then slowly raised the temperature to reached 500°C for ash at 4 hours. Then the sample was removed from the furnace and cool down, 2 mL of concentrated HCl was added and swirled. The solution was filtered through whatman No-42 filter paper and 0.45 m Millipore filter paper and then transferred to 25 mL volumetric flask by adding distilled water and analyzed by FAAS (Plate 2).

A. *Puntius sophore*

B. *Amblypharygodon mola*

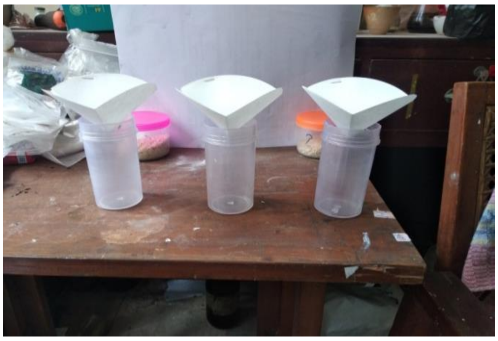
C. *Mystus bleekeri*

Plate (1). The examined fish species

A. *Specimens preparation*

B. Incubator and crucible

C. Dry method by using furnace



D. Filteration of samples

Plate (2). Sample preparation and apparatus used for metals analysis

Results

The systematic position of examined fish species was shown in table (1). The mean total length and weight were 7.38 ± 0.57 cm to 5.00 ± 1.27 g in *Puntius sophore*; 9.72 ± 0.54 cm to 9.65 ± 1.68 g in *Amblypharyngodon mola*; 7.83 ± 0.57 cm to 4.45 ± 0.92 g in *Mystus bleekeri* in hot season. The mean total length and weight were 8.82 ± 0.83 cm to 9.43 ± 2.69 g in *P.sophore;* 8.90 ± 1.35 cm to 8.28 ± 4.37 g in *A.mola* ; 8.46 ± 0.95 cm to 5.46 ± 1.54 g *M.bleekeri* in wet season. The mean total length and weight were 8.98 ± 0.53 cm to 10.00 ± 2.02 g in *P.sophore*; 8.01 ± 1.08 cm to 5.08 ± 2.18g in *A.mola;* 6.37 ± 0.78 cm to 4.08 ± 0.84 g in *M.bleekeri* in cool season. 0.588 ± 0.043 mg/L in cool season (Table 2).

Table (1). Systematic position of studied fish species

Sr No.	Species	Local Name	Family	Order	Class	Phylum
1	*Puntius sophore*	Nga-Khone-ma	Cyprinidae	Cypriniformes	Osteichthyes	Chordata
2	*Amblypharyngodon mola*	Nga-beh-phyu				
3	*Mystus bleekeri*	Nga-zin-yaing	Bagridae	Siluriformes		

Table (2). Mean total length and weight of studied fishes

Sr No	species	Total Length (cm)			Body Weight (g)		
		Hot (n=10)	Wet (n=10)	Cool (n=10)	Hot (n=10)	Wet (n=10)	Cool (n=10)
1	*Puntius sophore*	7.38 ± 0.57	8.82 ± 0.83	8.98 ± 0.53	5.00 ± 1.27	9.43 ± 2.69	10.00 ± 2.02
2	*Amblypharyngodon mola*	9.72 ± 0.54	8.90 ± 1.35	8.01 ± 1.08	9.65 ± 1.68	8.28 ± 4.37	5.08 ± 2.18
3	*Mystus bleekeri*	7.83 ± 0.57	8.46 ± 0.95	6.37 ± 0.78	4.45 ± 0.92	5.46 ± 1.54	4.08 ± 0.84

Heavy metal concentrations in fishes

Cadmium (Cd)

The cadmium concentration in fishes were 0.063 ± 0.013 mg/L in hot season; 0.035 ± 0.012mg/L in wet season, and 0.037 ± 0.006 mg/L in cool season of *Puntius sophore*. In *Amblypharyngodon mola*, 0.056 ± 0.007 mg/L in hot season ; 0.048 ± 0.014 mg/L in wet season, and 0.010 ± 0.014 mg/L in cool season. Whereas in *Mystus bleekeri*, 0.059 ± 0.010 mg/L in hot season, 0.025 ± 0.008 mg/L in wet season, and 0.026 ± 0.006 mg/L in cool season.Cadmium concentration of studied fish species were higher above the maximum permissible limits recognized by WHO and EC at three fish species in hot seasons (Table 3, Fig. 2).

Lead (Pb)

The Lead concentration in fishes were 0 ± 0.017 mg/L in hot season; 0 ± 0.018 mg/L in wet season and 1.832 ± 0.094 mg/L in cool season of *Puntius sophore.* In *Amblypharyngodon mola*, 0 ± 0.029 mg/L in hot season; 0 ± 0.017 mg/L in wet season, 0.521 ± 0.032 mg/L in cool season. Whereas in *Mystus bleekeri*, 0.526 ± 0.018 mg/L in hot season; 0 ± 0.022 mg/L in wet season, concentration of water was found to be low in hot and wet seasons. Lead concentration of water was high above limit value in cool season. Arsenic concentration of water was high in all seasons. (Table 3, Fig. 2).

Arsenic (As)

The arsenic concentration in fishes were 0 ± 0.528 mg/L in hot season; 0.007 ± 0.349 mg/L in wet season, and 0 ± 2.363 mg/L in cool season of *Puntius sophore*. In *Amblypharyngodon mola*, 0 ± 0.678 mg/L in hot season; 0 ± 0.629 mg/L in wet season, and 0 ± 3.306 mg/L in cool season. Whereas in *Mystus bleekeri*, 0.482 ± 0.681 mg/L in hot season; 0.001 ± 0.641 mg/L in wet season, and 0 ± 5.108 mg/L in cool season. Arsenic concentration in *P.sophore* and *A.mola* were found to be lower in all seasons. Arsenic concentration in *M.bleekeri* was high in hot season and then these fish species arsenic concentration was found to be low in wet and cool seasons. (Table 3, Fig. 2).

Heavy metals concentration in water and sediments

Water

The cadmium concentration in water were 0.035 ± 0.008 mg/L in hot season; 0.032 ± 0.007 mg/L in wet season, and 0.019 ± 0.005 mg/L in cool season. In Lead concentration of water, 0 ± 0.029 mg/L in hot season; 0 ± 0.011 mg/L in wet season, and 0.331 ± 0.046 mg/L in cool season. Whereas in arsenic concentration of water, 0.467 ± 0.078 mg/L in hot season, 0.075 ± 0.070 mg/L in wet season, and 4.073 ± 0.947 mg/L in cool season. Cadmium concentration of water at study site was high during hot and wet seasons. Lead concentration of water was found to be low in hot and wet seasons. Lead concentration of water was high above limit value in cool season. Arsenic concentration of water was high in all seasons (Table 4).

Sediments

The cadmium concentration in sediment was 0.046 ± 0.008 mg/L in hot season, 0.036 ± 0.008 mg/L in wet season, and 0.007 ± 0.005 mg/L in cool season. In Lead concentration in sediment, 0 ± 0.031 mg/L in hot season, 0 ± 0.028 mg/L in wet season, and 0.277 ± 0.024 mg/L in cool season. Whereas in Arsenic concentration in sediment, 13.44 ± 0.440 mg/L in hot season, 0.077 ± 0.44 mg/L in wet season, and 41.33 ± 11.381 mg/L in cool season. Cadmium concentrations in sediment was higher above limit value in hot and wet season but lower than limit value in cool season. Lead concentrations in sediment was found to be low in hot and wet seasons. Lead concentrations in sediment was high above limit value in cool season. Arsenic concentration in sediment was high in all seasons (Table 4).

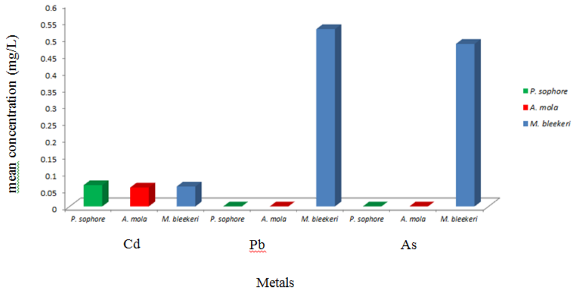
Table (3). Seasonal variation of heavy metals concentration in studied fish species

Metals	Species	Concentration (mg/L)			
		Hot	Wet	Cool	MPL
Cd	*Puntius sophore*	0.063 ± 0.013	0.035 ± 0.012	0.037 ± 0.006	0.05
	Amblypharygodon mola	0.056 ± 0.007	0.048 ± 0.014	0.010 ± 0.014	0.05
	Mystus bleekeri	0.059 ± 0.010	0.025 ± 0.008	0.026 ± 0.006	0.05
Pb	*Puntius sophore*	0 ± 0.017	0 ± 0.018	1.832 ± 0.094	0.2
	Amblypharygodon mola	0 ± 0.029	0 ± 0.017	0.521 ± 0.032	0.2
	Mystus bleekeri	0.526 ± 0.018	0 ± 0.022	0.588 ± 0.043	0.2
As	*Puntius sophore*	0 ± 0.528	0.007 ± 0.349	0 ± 2.363	0.01
	Amblypharygodon mola	0 ± 0.678	0 ± 0.629	0 ± 3.306	0.01
	Mystus bleekeri	0.482 ± 0.681	0.001 ± 0.641	0 ± 5.108	0.01

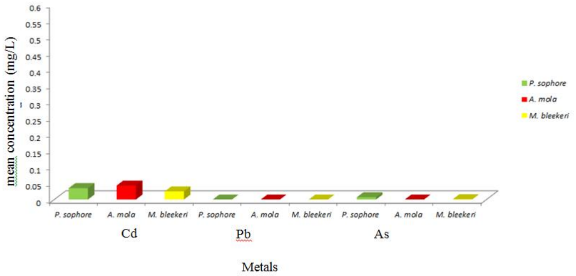
Table (4). Seasonal variation of heavy metals concentration in water and sediments

MPL= maximum permissible limit of WHO & EC

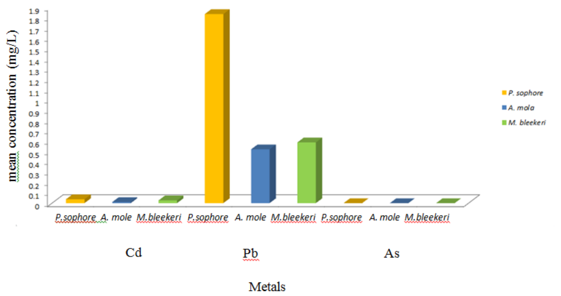
Metals	Source	Hot	Wet	Cool	MPL
Cd	Water	0.035± 0.008	0.032± 0.007	0.019 ± 0.005	0.01
	Sediment	0.046 ± 0.008	0.036 ± 0.008	0.007 ± 0.005	0.01
Pb	Water	0 ± 0.029	0 ± 0.011	0.331 ± 0.046	0.05
	Sediment	0 ± 0.031	0 ± 0.028	0.277 ± 0.024	0.05
As	Water	0.467± 0.078	0.075 ± 0.070	4.073 ± 0.947	0.01
	Sediment	13.44± 0.440	0.077 ± 0.044	41.33 ± 11.381	0.01



A. Hot season



B. Wet season



C. Cool season

Figure (2). Seasonal variation of heavy metals residues in different fish species

Discussion

Metals bioaccumulations through aquatic food webs to fish, human and other piscivorous animals are of environmental and human health concern. Heavy metals concentration in indigenous three fish species, *Puntius sophore* (Nga-khone-ma), *Amblypharyngodon mola* (Nga-beh-phyu), *Mystus bleekeri* (Nga-zin-yaing) were assessed seasonally during December 2017 to July 2018. A total of ten individuals of each fish species were seasonally tested the metal residues.

Tressou *et al*.,(2004) stated that metals which are toxic even a minute quantity include Pb, Cd and As. These metals are concentrated in the food chain. Harrison (2001)described that cadmium is emitted on air from by mine, metal smelter, cadmium compound for alloys, battery, pigments and plastic, many countries control these. WHO (2007) stated that cadmium exposurses are associated with kidney and bone damage. Dehn *et al*., (2006) described that cadmium has also been identified as a potential human carcinogen, causing lung cancer. Seinn Moh Moh Paing and Min Thu Aung (2016) stated that cadmium concentrations is over maximum permissible limit in the hot and wet seasons were found in most *N. notoptenus* and least in *M. zebrinus*.

In the present results, the concentrations of cadmium in studied fish species were beyond the limit value proposed by WHO and EC in hot season. Cadmium concentrations of 0.063 mg/L in *P.sophore*, 0.056 mg/L in *A. mola* , 0.059 mg/L in *M. bleekeri* were found to be higher than the maximum permissible limit 0.05 mg/L in hot season. This result pointed out that the studied fish species may become a health problem for consumers especially in hot season.

Kiran *et.al.,* (2011) stated that lead is toxic metal and non–essential element for human body as it causes a rise in blood pressure, kidney damage and miscarriage. For instance, neurotoxic as it reduces mental development in children and causes cardiovascular diseases in adults (Liu *et.al.,* 2008).

According to the previous literatures, Seinn Moh Moh Paing and Min Thu Aung (2016) state that lead concentrations in the fish muscle tissued are high in cool seasons. Cho Cho Thin (2017) state that lead concentrations were high in muscle tissues of carnivorous and omnivorous fishes in cool season. In the present result, lead concentrations of 1.832 mg/L in *P. sophore*, 0.527 mg/L in *A. mola* and 0.588 mg/L in *M. bleekeri* were found to be higher than permissible limit 0.02 mg/L of WHO and EC in cool season. The results was coincided with these references Sein Moh Moh Paing and Min Thu Aung (2016) and Cho Cho Thin (2017) who also stated high lead concentration in cool season.

Martin and Griswold (2009) stated that arsenic toxicity can be either acute or chronic and chronic arsenic toxicity is termed as arsenicosis. Most of the reports of chronic arsenic toxicity in man focus on skin manifestations because of its specificity in diagnosis. Pigmentation and keratosis are the specific skin lesions that indicate chronic arsenic toxicity. Smith *et.al*., (2000)described that lower levels of arsenic exposure can cause nausea and vomiting, reduced production of erythrocytes and leukocytes, abnormal heart beat, pricking sensation in hands and legs, and damage to blood vessels. Long-term exposure can lead to the formation of skin lesions, internal cancers, neurological problems, pulmonary disease, peripheral vascular disease, hypertension and cardiovascular disease and diabetes mellitus.

In the present result, the value of arsenic concentrations were high observed in *M. bleekeri* (0.482 mg/L) during hot season but cadmium and lead were lower than maximum permissible limit.

Ayodele and Abubakar (2001) stated that the present of metals pollution in freshwater is known to disturb the balance of aquatic ecosystem and has been noticed to manifest in the presence of irrigularities in fish physiology as fishes tend to concentrate some metal in their body tissue. Health (1987) stated that the present of metals in river, lake or any aquatic environment can change both aquatic species diversity and ecosystem due to toxicity and accumulative behavior. Ayandiran *et.al.*,(2009) described that there are five potential routes for a pollutant to enter a fish: food, non-food particles, gills, oral consumption of water and the skin. Knowledge of heavy metal concentrations in fishes are important for both human consumption and natural management.

In the present study area, cadmium concentrations of water and sediments were higher in hot and wet seasons than the permissible limit. Lead concentrations were higher to cool season beyond the maximum. Arsenic concentrations were found to be higher than permissible limit in all seasons. It may be due to effect of agricultural activities along the Nat-Maw Creek.

In conclusion, the cadmium concentrations were higher in hot season; the lead concentrations were higher in cool season and the arsenic concentrations were lower in all season than the maximum permissible limit of WHO and EC. These indicate that heavy metals concentration do not reach a harmful level and hence local people can confidently consume the fish products of Hinthada environs so far.

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