Contents of Heavy Metals in *Notopterus notopterus* (Pallas, 1769) from Inle Lake, Nyaung Shwe Township, Shan State

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Abstract

This study aimed to determine the concentrations of heavy metals (Pb, Cr, Cd, Mg and Cu) skin, muscle and gill of *Notopterus notopterus* from the Inle Lake. Nyaung Shwe Township, Shan State during the hot season of 2019. The fish samples were examined by Flame Atomic Absorption Spectrometer (FAAS) (Perkin Elmer AAanalyst 800 and Winlab-32 software) in the Universities' Research Centre (URC). Recorded results were compared with FAO standard range and WHO limits. The present findings indicated that the concentrations of heavy metals in each tissue of fish were as follow: muscles > skin > gills for Pb; gill > muscle > skin for Cr and Cd; muscle >gill >skin for Mg and Cu. The mean concentration of Cadmium (Cd), Magnesium (Mg) and Copper (Cu) were within the maximum permissible limit of FAO/WHO (2011) except for the concentration of lead (Pb) and Chromium (Cr) which showed beyond the acceptable limits. Daily consumption in a large number of studied fish species caught from Inle lake may cause serious health complications if the successive amassing of heavy metals continues at the same rate without taking effective management for pollution in the lake.

Keywords: Heavy metals, Fish, Inle Lake, *Notopterus notopterus*

Introduction

Heavy metals in the biosphere are the most dangerous air pollutants because of their rapid diffusion and their cumulative concentration. They infiltrate the environment into the biological cycle and penetrate in various ways, disrupting the biological functions of organisms and causing toxicity (Smalinskienė, *et al.,* 2001). The World Health Organization (WHO) and the Food and Agriculture Organization (FAO) recommend monitoring the content of heavy metals (HMs) while regulating ingredients in food products. Fish are one of the most precious aquatic treasures and Agriculture and industrial activities are intensifying that directly contributing to the pollution of reservoirs, and affecting water quality. Heavy metals penetrate water reservoirs via the atmosphere, drainage, soil waters and soil erosion. As the concentration of heavy metals in the environment increases, chemicals inevitably enter the biochemical cycle. (Kominkova D., Nabelkova J., 2007).

Inle Lake is the second largest lake in Myanmar with an estimated surface area of 44.9 square miles (116 km2), and one of the highest at an elevation of 2,900 feet (880 m). During the dry season, the average water depth is 7 feet (2.1 m), with the deepest point being 12 feet (3.7 m). During the rainy season, this can increase by 5 feet (1.5 m). The floating gardens of Inlay Lake are a valuable inland wetland for local ecosystems in Myanmar and lie between 2 mountain ranges in the Shan State. It is the most essential for its environmental, social and agricultural activities. (M. Su, and A. D. Jassby, 2000). It is one of Myanmar's freshwater biodiversity hotspots and a freshwater lake inhabited by a wide range of animal species including many rare snails and fish. (*Allen, D.J.; K.G. Smith; W.R.T. Darwall, eds.* (2012). In floating gardens, the farmer’s overuse of organic fertilizers and pesticides is one of the main sources of water pollution.

The fertilizers and pesticides from the floating gardens and sewage from the catchment are also reaching the lake in addition to sediments and nutrient causing the lake to eutrophic, a trophic state which is indicative of the deteriorated state of lake health (Lwin, Z., & Sharma,

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M. P., 2012). Pollution of heavy metals in the waters will cause a decrease in water quality and the life of aquatic organisms will also be disrupted. However, there is still little research on the content of heavy metals in fish organs in Inle Lake. The present work aimed to determine the content of heavy metals (Pb, Cr, Cd, Mg and Cu) in the skin, muscle and gill of bronze featherback fish *Notopterus notopterus* from Inle Lake.

Materials and Methods

Study Area

Inle lake (Lat 20°39.573' N; Long 96° 55.136' E) located on the Shan plateau in the Southern Shan State of east Myanmar and in Thanlwin river basin was chosen as the study area. (Fig 1)

Study period

The study was conducted during the hot season of 2019.

Sample collection and identification

The fish samples were collected from the local fishermen at the landing site. The external morphology of the studied fish was examined in the fresh state and taken the photograph. The total length (cm) of collected fish samples was measured. The size of the fish was categorized as small size (<10cm), medium size (>10cm - <20cm) and large size (>20cm). The collected fifteen samples (five individuals of each category) were kept in the ice box and brought to the Department of Zoology, University of Yangon for further analysis. Identification of fish species was followed after Talwar and Jhingran (1991) using the key characters described in the literature.

Sample preparation

Fifteen fish samples of different sizes (five of each small size, medium size, and large size) were washed thoroughly with tap water and then with distilled water to remove the contaminants and dissected. At least five grams of skin, muscle and gill were taken from each size for the analysis of heavy metal concentration.

Heavy metal concentrations analysis

The concentrations of heavy metals such as lead (Pb), chromium (Cr), cadmium (Cd), Magnesium (Mg) and copper (Cu) in the skin, muscle and gill of sampled fish were analyzed triplicate using the Flame Atomic Absorption Spectrometer (FAAS) (Perkin Elmer AA Analyst 800 and Winlab-32 software) at Universities" Research Center (URC) in University of Yangon. Mean values of test results were compared with WHO/FAO maximum permissible limits. The measured values were expressed as milligrams per litre (mg/L).

Fig.1 Map of the study area showing Inle Lake. (Source from Google Map)

Results

The mean concentration of five heavy metals such as lead (Pb), chromium(Cr), cadmium (Cd), Magnesium (Mg) and copper (Cu) in the skin, muscle and gill of the of *Notopterus notopterus* with different sizes were analyzed triplicate by using the Flame Atomic Absorption Spectrometer (FAAS).

The present findings indicated that the concentrations of heavy metals in each tissue of fish were as follow: muscles > skin > gills for Pb; gill > muscle >skin for Cr and Cd; muscle >gill >skin for Mg and Cu. The results showed that the concentration of lead (Pb), chromium (Cr), was found to be higher than WHO/FAO maximum permissible limits (Table 1,2,3,4,5).

Heavy Metal Concentration

Lead (Pb)

Among the skin of fish analyzed, the highest mean value of lead (Pb) concentrations was found to be at 2.607±0.018 mg/L in small-size fish, followed by 2.590±0.009 mg/L in medium size fish and 2.582±0.025 mg/L in large-size fish respectively.

Regarding the muscles of fish analyzed, the highest mean value of lead (Pb) concentration was found to be at 2.610±0.006 mg/L in small-size fish, followed by 2.563±0.022 mg/L in medium-size fish and 2.541±0.018 mg/L in large-size fish respectively.

In the case of the gill of the fish analyzed, the highest mean value of lead (Pb) concentration was found to be at 2.604±0.020 mg/L in small-size fish, followed by 2.553±0.008 mg/L in medium-size fish and 2.535±0.028 mg/L in large-size fish respectively.

Concentrations of lead (Pb) in all the samples of skin, muscle and gill of *Notopterus notopterus* with different sizes were found to be higher than those of MPL (1 mg/L) recommended by WHO/ FAO. The highest mean value of lead (Pb) concentration (2.607±0.018 mg/L) was found to be in the muscle of the small-size fish (Table 1).

Chromium (Cr)

Among the skin of fish analyzed, the highest mean value of chromium (Cr) concentration was found to be at 0.660±0.006 mg/L in small-size fish, followed by 0.654±0.011mg/L in medium-size fish and 0.589±0.015mg/L in large-size fish respectively.

For the analysis in the muscle of fish, the highest mean value of chromium (Cr) concentration was found to be at 0.702±0.085 mg/L in small-size fish, followed by 0.674±0.059 mg/L in medium-size fish and 0.633±0.052mg/L in large-size fish respectively.

Concerning the analysis in the gill, the highest mean value of chromium (Cr) concentration was found to be at 0.769±0.039 mg/L in small-size fish, followed by 0.667±0.049 mg/L in medium-size fish and 0.626±0.085 mg/L in large-size fish respectively.

Concentrations of Chromium (Cr) in all the samples of skin, muscle and gill of *Notopterus notopterus* with different sizes were found to be also higher than those of MPL (0.5 mg/L) recommended by WHO/ FAO. The highest mean chromium (Cr) concentration (0.769±0.039 mg/L) was found to be in the gill of the small-size fish (Table 2).

Cadmium (Cd)

Among the skin of fish analyzed, the highest mean value of cadmium (Cd) concentrations was found to be at 0.177±0.013 mg/L in small-size fish, followed by 0.184±0.015 mg/L in medium-size fish and 0.177±0.022 mg/L in large-size fish respectively.

For the analysis in the muscle of fish, the highest mean value of cadmium (Cd) concentrations was found to be at 0.198±0.006 mg/L in large-size fish, followed by 0.197±0.008 mg/L and 0.184±0.010 mg/L in small-size fish respectively.

Concerning the analysis in gill, the highest mean value of cadmium (Cd) concentrations was found to be at 0.197±0.007 mg/L in medium-size, followed by 0.182±0.009 mg/L in small -size fish and 0.177±0.007 mg/L in large-size fish respectively.

Concentrations of cadmium (Cd) in all the samples of skin, muscle and gill of *Notopterus notopterus* with different sizes were found to be within those of MPL (0.2 mg/L) recommended by WHO/ FAO. The highest mean cadmium (Cd) concentration 0.198±0.006 mg/L was found in the muscle of the large-size fish (Table 3).

Magnesium (Mg)

Among the skin of fish analyzed, the highest mean value of Magnesium (Mg) concentration was found to be at 3.798±0.005mg/L in large-size fish, followed by 3.676±0.005mg/L in medium-size fish and 2.861±0.035mg/L in small-size fish respectively.

For the analysis in the muscle of fish, the highest mean value of Magnesium (Mg) concentrations was found to be at 4.671±0.007 mg/L in large-size fish, followed by 3.591±0.008 mg/L in medium-size fish and 2.887±0.010 mg/L in small-size fish respectively.

Concerning the analysis in gill of the fish, the highest mean value of Magnesium (Mg) concentrations was found to be at 4.746±0.007 mg/L in medium-size, followed by 4.515±0.007 mg/L in medium-size fish and 3.062±0.018 mg/L in small-size fish respectively.

Concentrations of Magnesium (Mg) in all the samples of skin, muscle and gill of *Notopterus notopterus* with different sizes were found to be within those of MPL (4.5-452 mg/L) recommended by WHO/ FAO. The highest mean value of Magnesium (Mg) concentration was found to be in the muscle of the large-size fish (Table 4).

Copper (Cu)

Among the skin of fish analyzed, the highest mean value of Copper (Cu) concentrations was found to be at 0.047±0.002 mg/L in large-size fish, followed by 0.025±0.004mg/L in medium-size fish and 0.009±0.001 mg/L in small-size fish respectively.

For the analysis in the muscle of fish, the highest mean value of Copper (Cu) concentrations was found to be at 0.193±0.001mg/L in large-size fish, followed by 0.009±0.002 mg/L and 0.007±0.001 mg/L in small-size fish respectively.

Concerning the analysis of gill the of the fish, the highest mean value of Copper (Cu) concentrations was found to be at 0.169±0.003mg/L in large-size, followed by 0.009±0.001mg/L in medium-size fish and 0.005±0.001 mg/L in small-size fish respectively. (Table 5)

Concentrations of Copper (Cu) in all the samples of skin, muscle and gill of *Notopterus notopterus* with different sizes were found to be within the limit of MPL (3 mg/L) recommended by WHO/ FAO. The highest mean Copper (Cu) concentration was found to be in the muscle of the large size fish (Table 5).

Table 1. Concentrations of Lead (Pb) (mg/L) in the skin, muscle and gill of *Notopterus notopterus*

Sr. No	**Size**	**Concentration (mg/L)**			**WHO/FAO MPL**
		Skin	Muscle	Gill	
1	Small	2.607±0.018	2.610±0.006	2.604±0.020	1
2	Medium	2.590±0.009	2.563±0.022	2.553±0.008	1
3	Large	2.582±0.025	2.541±0.018	2.535±0.028	1

MPL = maximum permissible limit

Table 2. Concentrations of Chromium (Cr) (mg/L) in the skin, muscle and gill of *Notopterus notopterus*

Sr. No	**Size**	**Concentration (mg/L)**			**WHO/FAO MPL**
		Skin	Muscle	Gill	
1	Small	0.660±0.006	0.702±0.085	0.769±0.039	0.5
2	Medium	0.654±0.011	0.674±0.059	0.667±0.049	0.5
3	Large	0.589±0.015	0.633±0.052	0.626±0.085	0.5

MPL = maximum permissible limit

Table 3. Concentrations of Cadmium (Cd) (mg/L) in the skin, muscle and gill of *Notopterus notopterus*

Sr. No	**Size**	**Concentration (mg/L)**			**WHO/FAO MPL**
		Skin	Muscle	Gill	
1	Small	0.177±0.013	0.184±0.010	0.182±0.009	0.2
2	Medium	0.184±0.015	0.197±0.008	0.197±0.007	0.2
3	Large	0.177±0.022	0.198±0.006	0.177±0.007	0.2

MPL = maximum permissible limit

Table 4. Concentrations of Magnesium (Mg) in the skin, muscle and gill of *Notopterus notopterus*

Sr. No	Size	Concentration (mg/L)			WHO/FAO MPL
		Skin	Muscle	Gill	
1	Small	2.861±0.035	2.887±0.010	3.062±0.018	4.5-452
2	Medium	3.676±0.005	3.591±0.008	4.515±0.007	4.5-452
3	Large	3.798±0.005	4.671±0.007	4.746±0.007	4.5-452

MPL = maximum permissible limit

Table 5. Concentrations of copper (Cu) in the skin, muscle and gill of *Notopterus notopterus*

Sr. No	Size	Concentration (mg/L)			WHO/FAO MPL
		Skin	Muscle	Gill	
1	Small	0.009±0.001	0.007±0.001	0.005±0.001	3
2	Medium	0.025±0.004	0.009±0.002	0.009±0.001	3
3	Large	0.047±0.002	0.193±0.001	0.169±0.003	3

MPL = maximum permissible limit

Discussion

The concentration of five heavy metals such as lead (Pb), chromium(Cr), cadmium (Cd), Magnesium (Mg), and copper (Cu) in the skin, the muscle and gill of *Notopterus notopterus* were analyzed triplicate using the Flame Atomic Absorption Spectrometer (FAAS) (Perkin Elmer AA Analyst 800 and Winlab-32 software) at Universities Research Center (URC) in University of Yangon.

Fish is one of the most important sources of animal protein and micronutrients in Myanmar with average consumption levels estimated to be 30 kg/person/year (WorldFish. 2017). Fish caught from Inle Lake has been a staple of the local diet. Today Inle Lake's environment is under serious pressure due to pollution, siltation, eutrophication, overfishing and introduced species, including the highly invasive water hyacinth (Allen *et al*, 2012). In the present study, the concentrations of heavy metals in the skin, muscle and gill of *Notopterus notopterus* were analyzed to determine whether the studied fish species is suitable for consumption or not because bronze featherback fish, *Notopterus notopterus* is one type of fish that is commonly found and caught in Inle Lake.

Budijono, *et al.* (2020) studied the concentrations of heavy metals (Cd, Cr, Pb, Zn, Fe, and Cu) in gills, muscles, kidneys, bones, liver and reproductive organs of *Notopterus notopterus* from the Sail River. The average metal concentrations of Pb (35.62 mg/kg), Zn (88.47 mg/kg), and Fe (2.35 mg/kg) were highest in the gills. The estimated concentrations of Cd, Cr, Pb, Fe were higher and Zn, Cu were lower than the limits permitted. In the present study, concentrations of lead (Pb) in all the samples of skin, muscle and gill of *Notopterus notopterus* with different sizes were found to be higher than those of MPL (1 mg/L) recommended by WHO/ FAO. The highest mean value of lead (Pb) concentration (2.607±0.018 mg/L) was found to be in the muscle of the small size fish. The high

concentration of lead (Pb) in the muscle of fish may be due to the fact that one of the businesses of Inle Lake is gold silversmithing.

The mean concentrations of elements. Cd, Cr, Ni, Pb, Sb and Zn were lower than the threshold effect level (TEL) of ISQGs values. Inle lake sediments may be minimal enrichment to moderate enrichment with metals such as Cd, Pb and Bi while moderate enrichment to signifying significant enrichment in sediments by As and Sb.(Aung, P. P., Mao, Y., Hu, T., Qi, S., Tian, Q., Chen, Z., & Xing, X., 2019).

Khin Myint Mar (2011) stated that Cd and Pb concentrations of all studied fish species in Ayeyawady River, Mandalay and Magway Segments were markedly lower than the permissible limit. WHO (2007) stated that Cd exposures are associated with kidney and bone damage. In the present study, although the concentration of Pb and Cr was exceeding the maximum permissible limit recommended by WHO/FAO 2007, concentrations of cadmium (Cd) in all the samples of skin, muscle and gill of *Notopterus notopterus* with different sizes were found to be within those of MPL (0.2 mg/L).

The concentration of the essential metals Mg, and toxic metals Pb and Cd in the muscle of *Notopterus notopterus* with different feeding habits were found within FAO standard ranges for all seasons (Thin, C. C., Minn, M., & Aung, M. T. 2019). In the present study, concentrations of (Cd, Mg and Cu) in all the samples of skin, muscle and gill of *Notopterus notopterus* with different sizes were found to be within those of MPL (4.5-452 mg/L) recommended by WHO/ FAO (2007) except Pb which exceeded beyond MPL (1mg/L)

The water from Inlay Lake is not suitable for drinking anymore. The fertilizers and pesticides from the floating gardens and sewage from the catchment are also reaching the lake in addition to sediments and nutrients causing the lake to eutrophic (Thida Swe, 2013). Poor management of fertilizers usage has had a negative effect on the water quality of the lake. (Khaung, T., Iwai, C. B., & Chuasavathi, T., 2021). In some areas of Inlay Lake, poison has been found in some fish and vegetables, especially in tomatoes, which constitute the main product of Inlay Lake. This poses a danger both to the people who live in Inlay Lake and to the customers who eat tomatoes and fish from this source. (Weng, L., 2010). The ovarian and hepatic protein, lipid and cholesterol content were estimated in the fish, *N. notopterus* after exposing it to heavy metals at sublethal concentrations. The protein, lipid and cholesterol content of the ovary and liver got reduced. (Sindhe, V. R., Veeresh, M. U., & Kulkarni, R. S., 2002).

Fish caught from the lake has been a staple of the local diet. Today the lake's environment is under serious pressure due to pollution, siltation, eutrophication, overfishing and introduced species, including the highly invasive water hyacinth. (Allen, D.J.; K.G. Smith; W.R.T. Darwall, eds. (2012). Community awareness programmes and educational talks concerning the risk of long-term effects of chemical fertilizer and heavy metals should be given to the inhabitants of Inle Lake.

Conclusion

In the present study, the mean concentrations of heavy metals in the studied organs of *Notopterus notopterus* were found to be lower than the maximum permissible limits of FAO/WHO (2011) except the lead and chromium. The muscle of small size fish was more likely to be found in the heavy metal contents. Daily consumption of a large number of studied fish species caught from Inle lake may cause serious health complications if the successive amassing of heavy metals continues in the same rate without taking effective management for pollution in Inle lake. Further research should be done to ensure the source of heavy metal contamination in all the species in the lake, sediments and natural water bodies of Inle lake.

The authority concerned with Inle lake should pay more attention to identify the source of contamination, and take the necessary steps to avoid bioaccumulation of heavy metals in fish.

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