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Determination of some Heavy Metals in *Clarias batrachus* (Linnaeus, 1758) and *Channa striata* (Bloch, 1793) in Meiktila Lake, Meiktila, Mandalay Region, Myanmar

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Abstract:- A total of 20 fish samples of two fish species; Clarias batrachus (Nga khu) and Channa striata (Nga yant) from the South Lake of Meiktila Lake was analyzed for the concentration of copper (Cu) as an essential metal and lead (Pb) and cadmium (Cd) as nonessential metals during December 2017 to September 2018. The mean body length of Clarias batrachus was 11.88 ± 1.55 cm and its mean body weight 230.34 ± 29.08 g. The mean body length of Channa striata was 13.05 ± 1.59 cm and its mean body weight 186.96 ± 41.60 g. The metal concentration in the water and fish samples were determined by Atomic absorption spectrophotometry (AAS) (AA-6300). In the present study, the mean concentration of copper in Clarias batrachus was 1.045 ± 0.18 ppm (part per million) (range, 0.80 - 1.42 ppm) and that of Channa striata was 0.48 ± 0.11 ppm (range, 0.36 - 0.72 ppm) that was far from permissible limits set down by FAO/WHO (1992). The level of Cu between fish species studied was significantly different ($p < 0.05$). Lead was not found in the water and fish samples analyzed. The mean concentration of Cd in Clarias batrachus was 0.07 ± 0.15 ppm and that in Channa striata 0.053 ± 0.095 ppm. The level of Cd between Clarias batrachus and Channa striata was not significantly different ($p > 0.05$). The accumulation of cadmium in the muscle of fish studied was around the permissible limits set down by EU (0.1 ppm) and FAO/WHO, European Communities (EC), United States Food and Drug Administration (USFDA) (0.05 ppm). The results of this study showed that some of the examined fish samples were not fully safe for human consumption due to high level of cadmium.

***Keywords**:- Channa striata; Clarias batrachus; Meiktila Lake; Cd; Cu; Permissible Limits.*

I. INTRODUCTION

The universal problem is the environmental pollution and the most important pollutants are the heavy metals in aquatic ecosystem because of their toxicity, accumulation and bio-magnification by aquatic creatures. Domestic, industrial, agricultural and anthropogenic activities may broadly become the source of natural aquatic systems contamination of heavy metals (Velez and Montoro, 1998; Conacher and Mes, 1993; Kalay and Canli, 2000). [cited in 1] The rapid development of industry and agriculture has resulted in an increase in the pollution of rivers and lakes with heavy metals, which have been identified as a significant environmental hazard for invertebrates, fish (Uluturhan and Kucuksezgin, 2007) [2] and gives threat to public water supplies and also to consumers of fishery sources (Terra *et al*., 2008). [3]

The World Health Organization (WHO), the Food and Agriculture Organization (FAO) of the United Nations stated that monitoring eight elements in fish- Hg, Cd, Pb, As, Cu, Zn, Fe and Sn is obligatory and monitoring of others is suggested (Riget *et al*., 2004; Kendrick *et al*., 1992; Mansour and Sidky, 2002). [4] Aquatic organisms such as fish and shellfishes accumulate metals to concentration many times higher than present in water (Olaifa *et al*., 2004). [6] The pollutants such as heavy metals bioaccumulate in food chain and cause the antagonistic effects, even death so fish are used to determine the health condition of aquatic ecosystem (Farkas and Salanki, 2002; Al-Yousuf and Shahausi, 1999). [1]

Moreover, water reservoirs are collectors of all materials spread by human, industrial and agricultural activities. Heavy metals penetrate into water reservoirs via atmosphere, drainage, soil waters and erosion (Riget *et al*., 2004; Kendrick *et al*., 1992; Mansour and Sidky, 2002). [4] Land disposal of municipal and industrial wastes automobiles emissions, mining activity and application of fertilizers and pesticides for agriculture have contribute to a continuous accumulation of heavy metals in soils (Nosri *et al*., 2008; Tu *et al*., 2000; Selene *et al*., 2003). Phosphate fertilizer application in agricultural lands can cause increased levels of Cd, As, Cr and Pb in soil and dramatically decreased soil pH that cause desorption of heavy metals from the soil matrix (Allow, 1995). [7] Heavy metals in fish come mainly from their diet and levels of bioaccumulation of contaminants are higher in fish which can higher in food chain (EFSA, 2005). [4]

Fish is a basic and important food for human nutrition such as omega-3 fatty acid that can reduce the risk of heart diseases and stroke due to their contribution in lowering the cholesterol levels in blood, which are incredibly important for our body and brain and also provides minerals and vitamins. [8] Therefore, fish consumption should increase for the supplement of proteins. On the other hand, the contamination of freshwater fish with heavy metals (HMs) is a recognized environmental problem. Fish is an important link of aquatic food chain to human and other fish feeding animals with its contamination by toxic metals causes a direct threat, not only to the entire aquatic food chain and but also to terrestrial food chain via the fish feeding habit. [9] The presence of heavy metal in fish gives impact to the human health (Livingstone, 2003 and Batvari *et al*., 2007). [10] Besides, fish is a very suitable bioindicators of heavy metal contaminations (Simon, 2000). [6].

In Myanmar, traditional people prefer freshwater fish than marine fish and it is certainly recognized the fish are the second only to rice in the diets. Meiktila Lake is located in Meiktila, Mandalay Region. It is 7 miles (11 km) long, average 0.5 mile (0.80 km) wide and covers an area of 3.5 square miles (9.1 km^2). It has been the only water resource for the residents of Meiktila and for the peasants for about 1000 years. It is very important for local people. It provides sufficient water not only for growing summer paddy and the other crops like tomato, onion, chili, sun-flower and grapes but also to recreation and public water supplies. It contributes immensely to aquatic biodiversity and also provides breeding grounds of many lacustrine fish species, and act as sources of fish and edible aquatic life to the local communities. Meiktila Lake is divided by a bridge into two parts, North Lake and South Lake (hppts://www. Wikipedia.org > wiki > Meiktila-Lake). [27] Mon-Dai Dam supplies water to the Meiktila Lake and Nyaung kone Dam only to South Lake of Meiktila Lake. The water supplies of Lake may be contaminated with chemical residues due to the long term use of synthetic pesticides and overuse of fertilizers in farms around Mondai Dam and Nyaungkone Dam and inflowing municipal waste water to the lake may also be the reason. Local researchers worked out on the species composition and abundance of some fishes in Meiktila environs. However, the research work in which the assessment of metal content in lake water and fish is very limited.

For the above reasons, the present study was undertaken to determine the level of some heavy metals in selected fish from South Lake of Meiktila Lake, Meiktila. The objectives of the research work are to determine the level of copper, lead and cadmium in water and fish samples and to analyze the level of copper, lead and cadmium in fish muscles of *Clarias batrachus* (Nga khu) and *Channa striata* (Nga yant).

II. MATERIALS AND METHODS

Meiktila Lake was located at 20˚ 53' 0" N and 95 ˚ 53' 0" E. The lake is 0.80 km wide and 11 km long and its surface area is about 9.1 km^2 (Fig. 1). Study period lasted from December 2017 to September 2018.

A. Sample Collection

Fishes were purchased from local fishermen near the South Lake of Meiktila Lake. Two fish species; *Clarias batrachus* and *Channa striata* were chosen for metal analysis according to the preference of local people (market survey). Then, fishes were measured in length (cm) and weight (g) and taken photo before dissecting the fish muscle tissue.

Water sample was collected about 6.10 m (20 ft. or 0.006 km) from the west bank of the lake at the depth of 3.05 m (10 ft. or 0.003 km) with pre-cleaned plastic bottles. The samples were then transported to laboratory of Department of Zoology, Meiktila University.

B. Sample Preparation

For fish sample, two or three pieces (about 160 g) of muscle tissue were dissected into small pieces and sundried for about five days. Then the dried fish were ground by pestle into fine pieces. After that samples were sun dried again, powdered finely by pestle and sieved. Finally, dried fish powder was stored in airtight plastic container.

C. Acid Digestion

Acid digestion procedure was used following [11] with slight modifications. About four grams of sample (dry weight) was weighed by electric balance and added into polyethylene glass tube. Four ml of concentrated nitric acid (HNO_3) (65%) were added into the sample and then four ml of concentrated sulphuric acid (H_2SO_4) (80%) added. The reaction was allowed to proceed and the tubes were placed in room temperature overnight. Next day, the tubes were placed in a water bath and heated up to temperature 80˚C for about five hours. All the samples were totally dissolved. And then the tubes were removed from the water bath and allowed to cool. Next day, about four ml of hydrogen peroxide (H_2O_2) (80%) was added and heated again in the water bath to about 98˚C for four and half hours until the sample was cleared. Finally, the samples were cooled again to room temperature and the volume was adjusted to 20 ml of deionized water. For water samples, two to three drops of concentrated nitric acid

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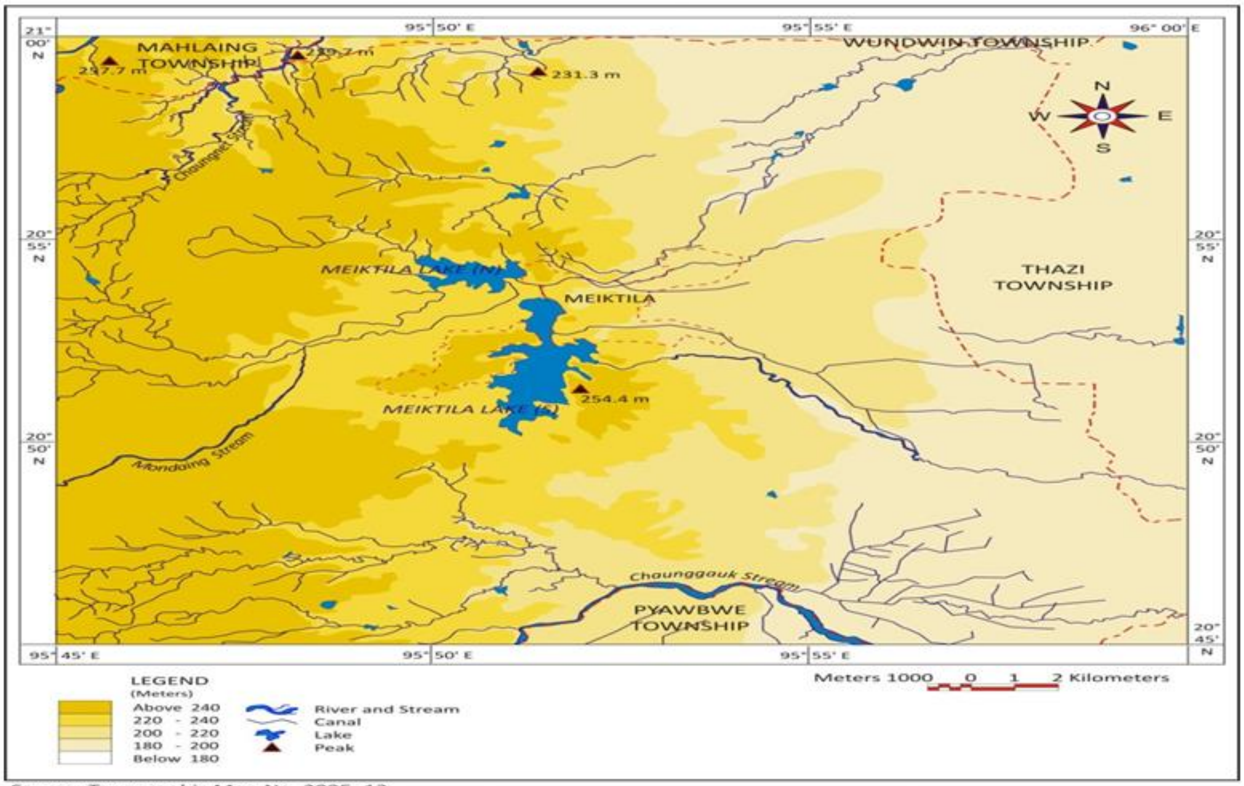
(70%) was added to water samples that was ready to analyze metals.

D. Metal Analysis

The water and fish samples prepared were sent to AMTT Co., Ltd., Yangon, Myanmar for analysis of metals. The concentration of copper (Cu), Lead (Pb) and Cadmium (Cd) was determined by atomic absorption spectrophotometry (AAS) (AA-6300). This method is reliable for determination of trace metals in aqueous solution. The value of mean metal concentration was expressed as milligram per liter (mg/l) or part per million (ppm).



Source: Topographic Map No. 2095_13.

Fig 1:- Map of study area (South Lake of Meiktila Lake), Meiktila, Mandalay Region

E. Statistical Analysis

Data obtained was analyzed using Microsoft Excel (2013). Descriptive statistics, the mean and standard deviation were presented. Student t test was used to determine the difference ($p<0.05$) of statistical means of the heavy metal concentration between two fish species studied.

III. RESULTS

A. The Water Samples and Fish Samples Pretested

The concentration of copper (Cu), lead (Pb) and cadmium (Cd) in two water samples, each from South lake and North lake of Meiktila Lake and that in two fish samples (*Clarias batrachus* and *Channa striata*) were pretested during December 2017 to April 2018. The Cu, Pb and Cd in water samples pretested was not detected. In fish samples, the concentration of Cu was 0.132 ppm in *Clarias batrachus* and 0.087 ppm in *Channa striata*.

B. The Concentration of Copper, Lead and Cadmium in Fishes

In the present study, a total of 20 fish samples of two fish species studied; *Clarias batrachus* and *Channa striata* from the South lake of Meiktila Lake was analyzed for the concentration of Cu, Pb and Cd during April to July 2018. Cu was detected in all fish samples analyzed. On the other hand, Pb was non-detected in all fish sample. Cd was not detected in three of ten samples of *Clarias batrachus,* and in one of ten samples of *Channa striata*.

The mean body length of *Clarias batrachus* was 11.88 ± 1.55 cm and the mean body weight 230.34 ± 29.08 g. In *Clarias batrachus*, the mean concentration of Cu was 1.045 ± 0.18 ppm and the mean concentration of Cd was 0.07 ± 0.15 ppm (Table 1). The mean concentration of Cu and Cd in the samples of *Clarias batrachus* was compared with International Standards (Fig. 2 and Fig. 3).

Sr. No.	Fish Sample	Length (cm)	Weight (g)	Cu (ppm)	Cd (ppm)
1	Sample 1	13.2	262.4	1.40	0.45
2	Sample 2	10.0	196.8	0.89	0.02
3	Sample 3	10.5	213.2	1.09	0.05
4	Sample 4	11.0	204.4	1.13	0.04
5	Sample 5	14.5	270.6	0.97	0.05
6	Sample 6	12.1	245.9	0.99	0.03
7	Sample 7	10.0	188.6	1.15	0.001
8	Sample 8	11.5	221.4	0.80	ND
9	Sample 9	13.5	254.2	0.90	ND
10	Sample 10	12.5	245.9	1.11	ND
	Mean ± SD	11.88 ± 1.55	230.3 ± 29.08	1.045 ± 0.18	0.07 ± 0.15

Table 1:- The concentration of copper and cadmium in *Clarias batrachus* in April to July 2018

ppm = part per million
ND = not detected (< LOD)
LOD = limit of detection
Cu < 0.01 ppm
Pb < 0.006 ppm

The mean body length of *Channa striata* was 13.05 ± 1.59 cm and the mean body weight 186.96 ± 41.60 g. In *Channa striata*, the mean concentration of Cu was 0.48 ± 0.11 ppm and the mean concentration of Cd was 0.053 ± 0.095 ppm (Table 2).

Sr. No.	Fish Sample	Length (cm)	Weight (g)	Cu (ppm)	Cd (ppm)
1	Sample 1	13.0	147.6	0.58	0.32
2	Sample 2	14.0	221.4	0.72	0.01
3	Sample 3	13.5	164.0	0.39	0.04
4	Sample 4	13.3	155.8	0.53	0.03
5	Sample 5	10.0	147.6	0.50	0.04
6	Sample 6	13.8	180.4	0.44	0.03
7	Sample 7	12.0	213.2	0.41	0.01
8	Sample 8	11.1	147.6	0.49	0.02
9	Sample 9	15.0	262.4	0.36	ND
10	Sample 10	14.8	229.6	0.36	0.03
	Mean ± SD	13.0 ± 1.59	186.96 ± 41.60	0.48 ± 0.11	0.053 ± 0.095

Table 2:- The concentration of Cu and Cd in *Channa striata* in April to July 2018

The mean concentration of Cu and Cd in the samples of *Channa striata* was compared with International standards (Fig. 4 and 5). Lead was not detected in all of 20 fish samples analyzed.

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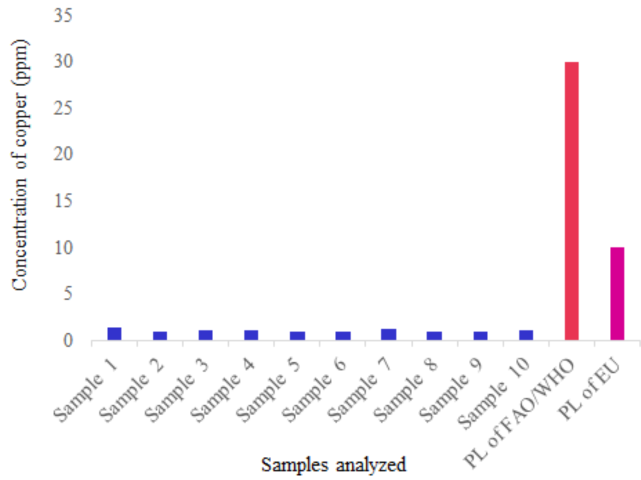

Fig. 2 Accumulation of Cu in muscle tissue of *Clarias batrachus* compared with International Standards

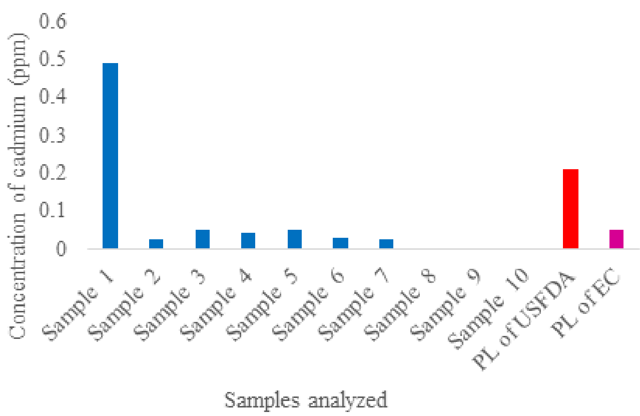

Fig. 3 Accumulation of Cd in muscle tissue of *Clarias batrachus* compared with International Standards

The metal accumulation in the muscle tissues of two fish studied was assessed by maximum permitted level (PL) in fish and shellfish enforced by various International Organizations (Table 3). In the present study, the mean concentration of Cu in *Clarias batrachus* was 1.045 ± 0.18 ppm (range, 0.80 - 1.42 ppm) and that of *Channa striata* was 0.48 ± 0.11 ppm (range, 0.36 - 0.72 ppm) that was far from permissible limits set down by FAO/WHO (1992). The concentration of Cu was significantly different between *Clarias batrachus* and *Channa striata* ($p < 0.05$).

The mean concentration of Cd in *Clarias batrachus* was 0.07 ± 0.15 ppm (range, ND - 0.49 ppm) and that of *Channa striata* was 0.053 ± 0.095 ppm (range, ND - 0.32 ppm). This concentration was around the permissible limits set down by International standards; (0.05 ppm) set down by FAO/WHO, 1992 and EC, 2005 and (0.01- 0.21 ppm) set down by (USFDA, 1993). The results showed that the concentration of Cd was not statistically significant difference between *Clarias batrachus* and *Channa striata* ($p > 0.05$).

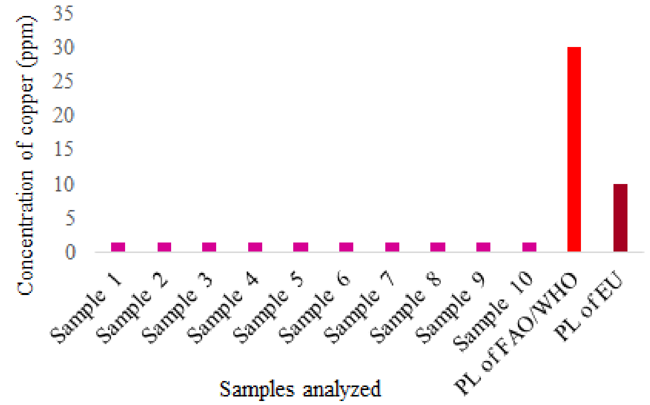

Fig. 4 Accumulation of Cu in muscle tissue of *Channa striata* compared with International Standards

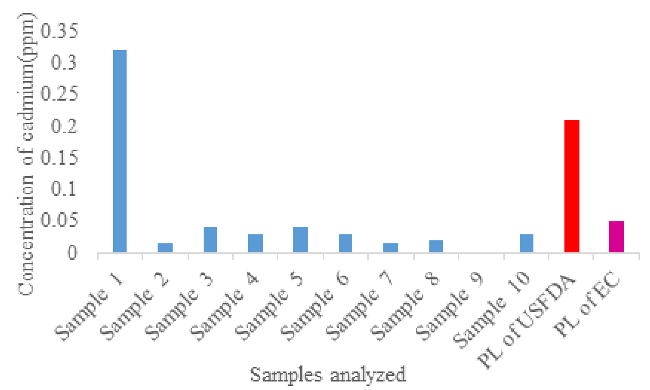

Fig. 5 Accumulation of Cd in muscle tissue of *Channa striata* compared with International Standards

IV. DISCUSSION

Knowledge of metal concentration in fish is important to management for various purposes such as risk of taking fish as part of diet and metal pollution control strategies. [15] The metals such as copper are essential and occur in most natural diet in sufficient quantities to satisfy the metabolic requirements of fishes. Lead and cadmium are nonessential and toxic and therefore only a small amount in fishes is harmful to consumers in the long-term exposure. [14].

Like other animals, heavy metals are not destroyed by human. They tend to accumulate within the human body and can be stored in soft and hard tissues such as liver, muscles and bone and threaten the health of humans. Therefore, the heavy metals are among the pollutants which received the most attention and considered to be in the most dangerous category of pollutants. An early example of environmental problem due to chronic cadmium poisoning (itai-itai disease) occurred in Fugawa, Japan, in 1955 (Dual *et al.*, 2007). [16].

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The present study determined the accumulation of some heavy metals; copper as essential metal and lead and cadmium as non-essential and toxic metals in water samples and fish muscle tissues of *Clarias batrachus* and *Channa striata* from South Lake of Meiktila Lake, Meiktila. The muscle tissues of two fish studied (*Clarias batrachus* and *Channa striata*) were used as bioindicator to determine the metal contamination in lake ecosystem of Meiktila Lake, Meiktila. In the present study, the concentration of Cu, Pb and Cd in water samples and two fish samples from North Lake and South Lake of Meiktila Lake was pretested. In the pretest study, these metals analyzed in water samples were not detected or lower than detection limit but only copper was detected in fish samples.

Copper occurs in foods as many chemical forms and has important role in the physiological activities of living bodies. Cu considered as public health hazard if abnormal high level of Cu is ingested (Abou-arab *et al.*, 1996; Underwood, 1997). If abnormal high level of Cu was found in human, it may cause Mediterranean anemia, hemochromatosis, liver cirrhosis and Wilson's disease (Underwood, 1997). [17] In the present study, Cu was detected in all samples of two fish species studied. The mean concentration of Cu in *Clarias batrachus* was 1.045 ± 0.18 ppm and that in *Channa striata* 0.48 ± 0.11 ppm.

Gathumbi *et al.* (2013) recorded the concentration of Cu in catfish from Kirinyaga South District, Kenya was 3.63 ± 5.20 ppm. [5] Nurwijayanti *et al*. (2017) determined that the concentration of Cu in *Channa striata* and *Clarias* sp. in Sunter River, Indonesia was 6.84 ppm and 4.11 ppm respectively. (19) Friday *et al.* (2013) found that Cu in the tissues of *Tilapia zilli* of Owubu Creek, Niger Delta, Nigeria was 4.29 ± 1.22 ppb. [18] The present findings were lower than the results of Gathumbi *et al*. and Nurwijayanti *et al.* but higher than the results of Friday *et al.*, 2013.

The results of the present study was compared with that of other studies by local researchers. In Myanmar, Khin Nwe Yi (2012) recorded that the concentration of Cu in the muscle tissues of six freshwater fishes (*Labeo rohita*, *Salmostomata sardinella*, *Clupisoma prateri*, *Ompok bimaculatus*, *Wallago attu* and *Mystus cavasius*) from Ayeyawady River Segment, Magway Region was 0.176-0.281 ppm. [25] In the present study, Cu in the muscle tissue of two fish species studied was slightly higher than the findings of Khin Nwe Yi. The data obtained in the present study revealed that the level of Cu between *Clarias batrachus* and *Channa striata* was significantly different ($p < 0.05$).

Nevertheless, the concentration of Cu in the muscle tissues of two fish studied was very much less than the permissible limits of International guidelines (Table 3); (30 ppm) set down by Food and Agriculture Organization (FAO/WHO, 1992) [22] and (10 ppm) by European Community Regulation (EU, 2001). [20]

With respect to lead (Pb), the metals analyzed were not found in all fish samples of two species studied in Meiktila Lake. In 2014, Theik Htet Aung assessed the concentration of Pb in water and fish samples of Ayeyarwady River near Salay fertilizer Industry, Chauk Township in which lead was not detected in the water sample but detected in fish sample. [13] It was agreed with the present study in which copper (Cu), lead (Pb) and cadmium (Cd) were not detected in water samples from North and South Lake of Meiktila Lake during the study period. Therefore, it was suggested that the level of lead in Meiktila Lake water seems to be lower than the detection limit.

With regard to Cd, human being takes Cd mainly through food. Cd has effects on fish and their consumers. It acts as a fish stressor, leading to metabolic alterations and decreasing to total protein concentrations while in human it can be associated with salivation, choking attacks, persistent vomiting, abdominal pains, spasms of the anal sphincter, vertigo and loss of consciousness (Elinder, 1986). [17]

Sr. No.	Elements	International Organizations				
		FAO/ WHO (1992)	EC (2005)	USFDA (1993)	EU (2001)	Present Study
1	Copper	30	-	-	10	0.80-1.42 *Clarias batrachus* 0.36-0.72 *Channa striata*
2	Cadmium	0.05	0.05	0.01-0.21	0.1	ND-0.49 *Clarias batrachus* ND-0.32 *Channa striata*
3	Lead	0.5	0.2	0.5	0.1	ND

Table 3 Maximum acceptable level of heavy metals in fish muscle (µg/g, ppm) enforced by various International Organizations compared with the present study

In the present work, Cd was detected in 70% of fish samples in *Clarias batrachus* and 90% of fish samples in *Channa striata*. The mean concentration of cadmium (Cd) in *C. batrachus* was 0.07 ± 0.15 ppm and that in *C. striata* 0.053 ± 0.095 ppm.

Paudel *et al*. (2016) reported that the concentration of Cd in *Clarias batrachus* in fish markets of Kathmandu Valley, Nepal was 0.53±0.33ppm [16] while Ahmad *et al.* (2016) recorded that the accumulation of Cd in the tissues of *C.striata* and *C.batrachus* from Wang Mengkuang abandoned Tin Mine, Malaysia was 0.10 ± 0.00 ppm and 0.12±0.01 ppm respectively. [17] The results of present study were lower than the findings of the above authors.

In Myanmar, Aye Aye Mu (2011) recorded the accumulation of Cd in the muscle of *Channa striata* in Hinthada Township, was 0.077 ± 0.025 ppm. [12] In 2012, Khin Myint Mar analyzed the cadmium in the muscle of *C. striata* in Ayeyawady River Segment, Mandalay Region, was 0.073 ± 0.007 ppm. [26] Theik Htet Aung (2014) recorded that the cadmium level in *Mystus cavasius*, *Mystus leucophasis* and *Wallago attu* in Ayeyawady River Segment near Salay fertilizer Industry, Chauk Township was ND - 0.07 ppm. [13] The present findings agree with the results of the above authors. In the present study, the level of Cd between two fish species studied was not significantly different ($p > 0.05$). The accumulation of cadmium in the muscle of fish studied was around the permissible limit set down by EU, 2001 (0.1 ppm) and FAO/WHO (1992), European Communities (EC, 2005), United States Food and Drug Administration (USFDA, 1993) (0.05 ppm). [20, 21, 22, 23]

According to Kutty and Al-Mahaqeri (2016), *Clarias batrachus* and *Channa striata* are bottom feeders and carnivores and have a greater capacity for metal bioaccumulation than the other fish species. [24] Therefore, it was probably that high level of Cd was found in the muscle of fish chosen for the present study. The present work suggests that the high level of cadmium in the muscle tissues of fish species studied may be due to the overuse of fertilizers and pesticides on farms around the Mondai Dam and Nyaung kone Dam and also probably the disposal of waste water and domestic wastes near the lake.

The present work gives information of the concentration of metals in the fishes analyzed in the study area. The data obtained in the present study indicate that it seems not to be threat to Cu and Pb poisoning for consumption of fish studied in South Lake of Meiktila Lake. In contrast, the concentration of Cd in *Clarias batrachus* and *Channa striata* in South Lake of Meiktila Lake seems to be risk for local consumers. The results of this research work showed that some of the examined fish samples were not fully safe for human consumption due to high level of cadmium. Therefore, this study suggests that it may be urgently needed to control the accumulative effect of cadmium and to monitor the water quality of Meiktila Lake.

V. CONCLUSION

There is a varying degree of the phosphate fertilizer application in the cultivated areas around the Mondai Dam and Nyaung kone Dam, Meiktila, Mandalay Region, Myanmar. Long term and heavy use of phosphate fertilizer and municipal waste disposal near the lake may be the potential sources of cadmium in lake water. So, strict legislation is required to prevent water pollution with heavy metals. Community awareness programme and educational interventions should be conducted about the risk of long term effects of chemical fertilizer.

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