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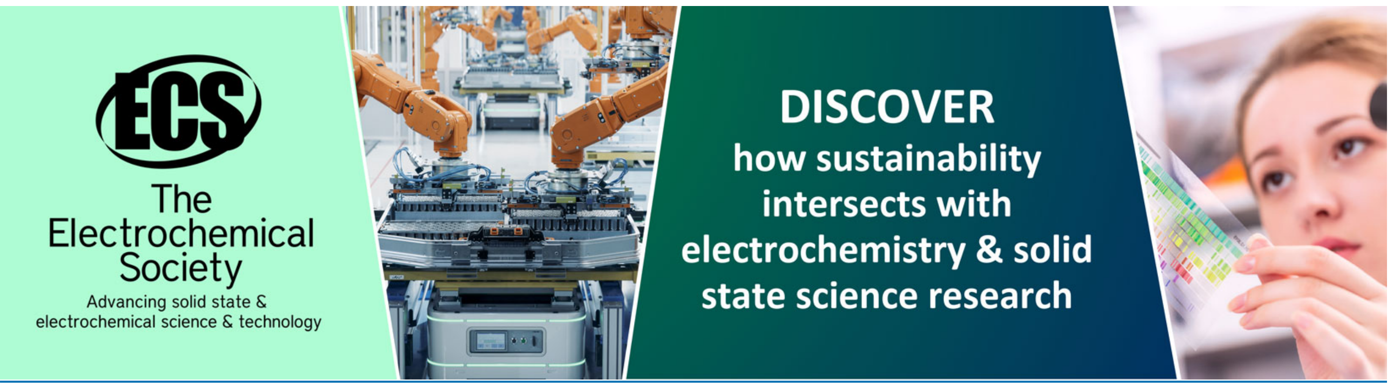

Effect of Heavy Metal Bioaccumulation on Wellbeing of Some Commercial Fishes from Hlaing River Segment Near Industrial Zones of Yangon Region, Myanmar

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Abstract

Possible pollutants from industrial zones such as Aluminium (Al), Chromium (Cr), Cadmium (Cd), Arsenic (As), Nickel (Ni), Mercury (Hg) and Lead (Pb) were analysed in the muscle of some commercial fishes collected from Hlaing River near industrial zones during April 2015 to March 2017. Most of studied fishes were in good condition (K>1). *Illisha megaloptera* was less tolerance of heavy metal pollution than other studied fish species showing under good condition (K<1). Bioaccumulation factors of Al, Cd and As were in high value indicating long term exposure of these heavy metals to fish in the study area. Bioaccumulation factors of Al, Cd, and As were negatively correlated with condition factors of studied fishes, although those of Cr, Ni, Hg and Pb were not negatively correlated with the condition factors. Long term exposure of water pollution may decrease the fecundity of fish populations, and eventually become extinction of aquatic resources. Therefore, regular monitoring of heavy metal pollution should be conducted to prevent impacts on wellbeing of fish species in the aquatic environments.

Key words: Heavy metals, commercial fishes, bioaccumulation, condition factor

1. Introduction

Now a day, heavy metal pollution become major impact in aquatic ecosystems, since some hazardous substances from anthropogenic activities constitute heavy metals which can bioaccumulate in various aquatic life. In the process of bioaccumulation, a chemical pollutant enters into the body of an organism, cannot excrete, and eventually accumulated in the tissue of the organisms. Deposited heavy metals in the aquatic environment may accumulate in the food chain and cause ecological issue, consequently posing a threat to human health. Heavy metal consumption can cause cancer and damage of the nervous system which is documented in humans (Van den Broek, Gledhill and Morgan, 2002).

The principle sources of the heavy metal pollution in aquatic ecosystems are human impacts especially industrial and domestic sewage, agricultural runoff. Heavy metals pollution from these anthropogenic activities entered into the ecosystem especially obvious in sediments and aquatic organisms than surface water (Linnik and Zubenko, 2000). Therefore, pollution of heavy metals in aquatic ecosystems are typically monitored by biological assays using aquatic organisms as bioindicators, especially fish (Burger et al., 2002; Wong and Dixon, 1995).

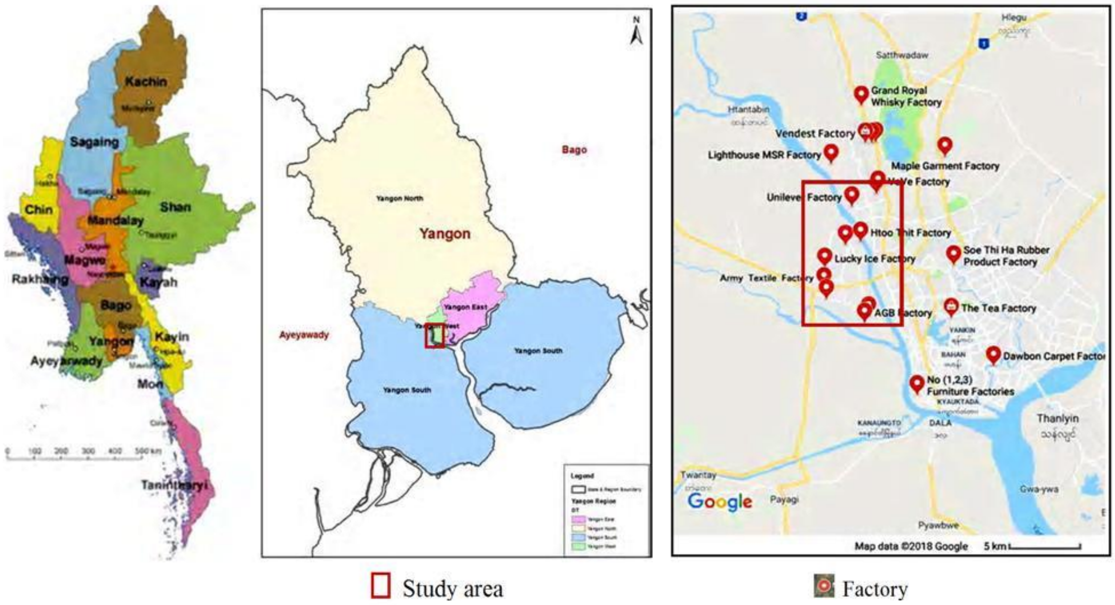
The state of free from pollution in aquatic ecosystems can be assess by using fish as bioindicator (Farkas, Salanki and Specziar, 2002; Yousuf and El-Shahawi, 1999), since they occupy different trophic levels with different sizes and ages (Burger et al., 2002). Fishes serve as good bio-accumulators of organic and inorganic pollutants since they are major components of aquatic habitats (King and Jonathan, 2003). Besides, fish occupy at the top level in the food chain and may accumulate heavy metals in its body. Contaminants are passed through to human by eating fish being in polluted water so as consumers may suffer heavy metal toxicity and can cause chronic or acute diseases (Al-Yousuf, El-Shahawi and Al-Ghais, 2000).

The study area of the segment of Hlaing River situated between the Shwe Pyi Thar Industrial Zone in the east and Hlaing Thar Yar Industrial Zones in the west which are the largest industrial zones in Yangon Region. In the study area, the small fisheries were carried out for selling in the markets of Insein, Shwe Pyi Thar, Hlaing and adjacent townships. A few researches of water pollution were carried out in Hlaing River based on the impact of industrial zones (Department of Medical Research (DMR), 2013; Green Motherland Development Association (GMDA), 2015;Mya Thandar, 2014). Therefore, the present study aimed to investigate the impact of heavy metal pollution by industrial wastes on wellbeing of the fish with following objective:to seek the relationships of heavy metal bioaccumulation in fish muscle and condition factor of commercial fishes in the study area.

2. Materials and Methods

2.1 Study area

Study area was the Hlaing River segment locating between 16° 58' N, 96° 02' E, and 16° 55' N, 96° 04' E near industrial zones of Yangon Region. Total distance of the studied river segment was approximately 10.57 km in length. It is a tidal river which runs into the Gulf of Martaban as marine estuary (Figure 1). Brackish water runs up upper most of the study area during high tide with fluctuating of salinity concentration.



(a) (b) (c)

Figure 1. Map of the study area (Source: Google Map, 2018)

(a) Map of Myanmar, (b) Map of Yangon Region, (c) Location map of study area

2.2 Sample collection

Some commercial fishes were collected such as *Otolithoides pama* (Hamilton, 1822) (Pama croaker), *Polynemus paradiseus* Linnaeus, 1758 (Paradise threadfin), *Illisha megaloptera* (Swainson, 1839) (Bigeye illishar),*Cirrhinus cirrhosus* (Bloch, 1795) (Mrigal carp), *Mystus spp.* (Hamilton, 1822) (Dwarf catfish), *Silonia silondia* (Hamilton, 1822) (Silond catfish) and *Pangasius hypophthalmus* (Sauvage, 1878) (Striped catfish). Species identification was followed after Talwar and Jhingran (1991).

Otolithoides pama, *P. paradiseus*, *I. megaloptera*and *Cirrhinus cirrhosus*are scaled fishes while *Mystus spp.*, *S. silondia* and *P. hypophthalmus*are scaleless fishes. All studied fishes are brackish water tolerant species.

A total of 231 specimens as a ratio of three specimens for each commercial fish species per month were collected. Collected specimens were kept in the ice box and bring to the laboratory of Zoology Department, West Yangon University for further study.Study period lasted from April 2015 to March 2017.

2.3 Preparation for heavy metal test

Collected fish specimens were skinned and approximately 50g of the axial muscles were cut out from the fish and weighted. Then, flesh of fish was cut into slices for dry rapidly. Consequently, fish slices were dried in drying oven at 60˚C overnight. Each dry specimen was weighted again and kept in separate polyethylene bag and stored in the refrigerator at 20˚C before heavy metal test. Code number of each specimen, collection date, wet weight and dry weight were labelled on the respective bag. Each specimen was homogenized by using electric blander before conducting heavy metal test.

2.4 Method of heavy metal test

Method of heavy metal test was followed after Koleleni and Haji (2014) by applying energy dispersive X-ray Fluorescence (EDXRF) analysis. Altogether 50 mg of homogenized fish power for each sample was thoroughly mixed with 10 mg of cellulose binder (SpectroBlend®) using clean porcelain mortar and pestle. After that, mixture was put into aluminum sample cups and compressed at 20 tones by using 25 T Atlas® Power Press and a 40 mm Apex™ Quick Release Die. Quantitative and qualitative elemental analyses of sample pellets were carried by using Energy Dispersive X-ray Fluorescence spectrophotometer (EDX-8000, Shimadsu®) according to manual of the spectrophotometer. Quantitative (spectral peaks) and qualitative data (concentration in ppm) were automatically reported by running PCEDX Navi software from the attached computer. The suspected waste from industrial zones such as Aluminium (Al), Chromium (Cr), Cadmium (Cd), Arsenic (As), Nickel (Ni), Mercury (Hg) and Lead (Pb) were marked in computer output for further analysis. Heavy metal analysis was conducted at Department of Physics, University of Mandalay.

2.5 Bioaccumulation factor

The bioaccumulation factor (BAF) is the ratio between the accumulation of a given pollutant in any organ and dissolved concentration in water according to Authman and Abbas (2007).

$$BAF = Con_{fish} / Con_{water}$$

Con_{fish} = pollutant concentration in fish tissue (mg/kg)

Con_{water} = pollutant in water (mg/l)

The parameter is zero if the element accumulates only from the water. If the BAF is greater than 1.0 then bioaccumulation for metals occurs by fish species (Aboul Ezz and Abdel-Razek, 1991).

2.6 Condition factor

Fulton's condition factor (K) was calculated according to Bagenal (1978) as follows:

$$K = 100\ W/L^3$$

Where W is the total body weight in grams and L the standard length in centimeters.

2.7 Statistical analysis

Recorded data were statistically analyzed using SPSS Version 16. Concentrations of heavy metals were presented as mean and standard deviation. Relation of heavy metal concentrations and bioaccumulation factor with condition factor was analyzed using Pearson's correlation coefficient test.

3. Results

Heavy metal concentrations in the muscle varied considerably among studied fish species. The concentration of aluminium was found to be highest in *Illisha megaloptera* (Big eye illisha) as 522.15±44.58 ppm in wet weight, followed by *Mystus spp.* (Dwarf catfish), *Cirrhinus cirrhosus*(Mrigal carp), *Silonia silondia* (Silond catfish), *Otolithoides pama* (Pama croaker), *Polynemus paradise* (Paradise threadfin), and the least value was observed in *Pangasius hypophthalmus* (Striped catfish) as 306.12±84.33 ppm in wet weight (Table 1).

Table 1. Heavy metal concentrations in the muscle of some commercial fishes in the study area during the study period (ppm in wet weight)

Species	Heavy metal concentrations in wet weight (ppm) (Mean±SD)						
	Al	Cr	Cd	As	Ni	Hg	Pb
Otolithoides pama	354.09 ± 41.68	1.43 ± 0.17	0.33 ± 0.04	0.98 ± 0.12	0.04 ± 0.01	0.31 ± 0.04	0.20 ± 0.02
Polynemus paradiseus	335.78 ± 40.14	1.74 ± 0.20	0.21 ± 0.02	0.91 ± 0.10	0.11 ± 0.01	0.55 ± 0.06	1.14 ± 0.13
Illisha megaloptera	522.15 ± 44.58	1.18 ± 0.10	0.43 ± 0.04	0.47 ± 0.04	0.06 ± 0.01	0.37 ± 0.03	0.21 ± 0.02
Cirrhinus cirrhosus	393.06 ± 92.95	1.70 ± 0.04	0.21 ± 0.05	0.12 ± 0.03	0.12 ± 0.03	0.40 ± 0.09	0.24 ± 0.06
Mystus spp.	421.61 ± 56.48	1.71 ± 0.23	0.12 ± 0.02	0.34 ± 0.05	0.17 ± 0.02	0.48 ± 0.06	0.22 ± 0.03
Silonia silondia	381.44 ± 56.35	1.94 ± 0.27	0.49 ± 0.07	0.32 ± 0.29	0.10 ± 0.01	0.53 ± 0.08	0.25 ± 0.03
Pangasius hypophthalmus	306.12 ± 84.33	1.62 ± 0.45	0.45 ± 0.12	0.38 ± 0.11	0.07 ± 0.02	0.41 ± 0.11	0.45 ± 0.12

Among the tested fishes, chromium concentration was the highest in *S. silondia* as 1.94±0.27 ppm in wet weight, followed by *P. paradiseus*, *Mystus spp.*, *C. cirrhosus*, *P. hypophthalmus*, *O. pama*. The lowest concentration was observed in *I. megaloptera* as 1.18±0.10 ppm in wet weight (Table 1).

Cadmium concentration was the highest in *S. silondia* as 0.49 ±0.07 ppm in wet weight and followed by *P. hypophthalmus*, *I. megaloptera*, *O. pama*, *P. paradiseus*, *C. cirrhosus*, and the least cadmium concentration was found in *Mystus spp.* as 0.12±0.02 ppm in wet weight (Table 1).

Among the studied fish species, the highest arsenic concentrations were found to be in *O. pama* as 0.98±0.12 ppm in wet weight followed by *P. paradiseus*, *I. megaloptera*,*P. hypophthalmus*, *Mystus spp.* and *S. silondia.* The lowest arsenic concentration was found in *C. cirrhosus* as 0.12± 0.03 ppm in wet weight (Table 1).

The highest nickel concentration was observed in *Mystus spp.* as 0.17 ± 0.02 ppm in wet weight, followed by *C. cirrhosus*, *P. paradiseus*, *S. silondia*, *P. hypophthalmus*, *I. megaloptera.* The least nickel concentration was recorded in *O. pama* as 0.04 ± 0.01ppm in wet weight (Table 1).

Mercury concentrations were found to be highest in *P. paradiseus*0.55±0.06 ppm in wet weight and followed by *S. silondia*, *Mystus spp.*, *P. hypophthalmus*, *C. cirrhosus*, *I. megaloptera.* The least mercury concentration was observed in *O. pama* as 0.31±0.04 ppm in wet weight (Table 1).

The highest concentration of Lead was observed in *P. paradiseus* as 1.14±0.13 ppm in wet weight, and followed by *P. hypophthalmus*, *S. silondia*, *C. cirrhosus*, *Mystus spp.*,*I. megaloptera.* The least lead concentration was found in *O. pama* as 0.20±0.02 ppm in wet weight (Table 1).

Condition factor of studied fishes

Condition factor of studied fish species indicated that majority of studied fishes were in good condition (K> 1.00). Exception was observed in *I. megaloptera* which showed under good condition criteria as 0.82 was observed (Figure 2).

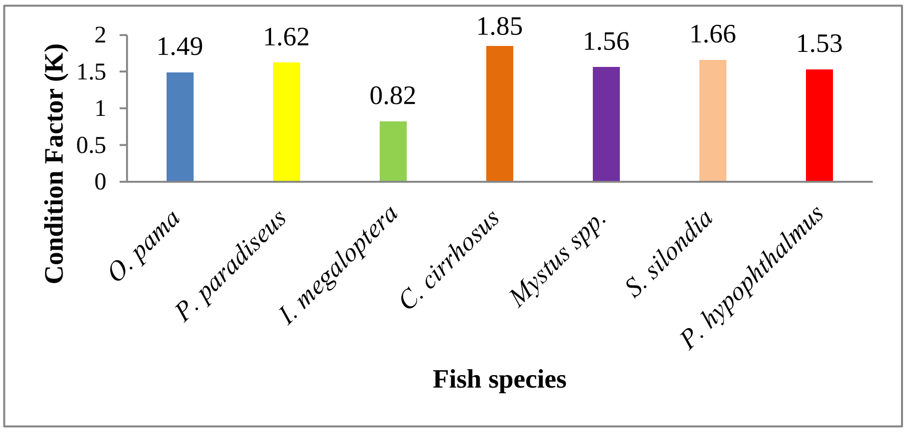


Figure 2. Condition factors of studied fish species

Correlation between BAF and condition factors of studied commercial fishes

In *Otolithoides pama*, highest bioaccumulation factor was observed in Al, followed by Cd, As, Hg, Pb, and Ni (Table 2). Significant negative correlation was observed between condition factor and heavy metal bioaccumulation factor of studied fish (r= -0.7719, $p<0.05$) (Figure 3).

Table 2. Bioaccumulation factors of studied fish species

Species	Bioaccumulation factors						
	Al	Cr	Cd	As	Ni	Hg	Pb
Otolithoides pama	11.80	2.38	11.00	**8.91**	1.33	3.88	1.67
Polynemus paradiseus	11.86	2.89	6.85	8.30	3.81	**6.85**	**9.51**
Illisha megaloptera	**17.41**	1.97	14.33	4.27	2.00	4.63	1.75
Cirrhinus cirrhosus	13.10	2.83	7.00	1.09	4.00	5.00	2.00
Mystus spp.	14.05	2.85	4.00	3.09	**5.67**	6.00	1.83
Silonia silondia	12.71	**3.23**	**16.33**	2.91	3.33	6.63	2.08
Pangasius hypophthalmus	10.20	2.70	15.00	3.45	2.33	5.13	3.75

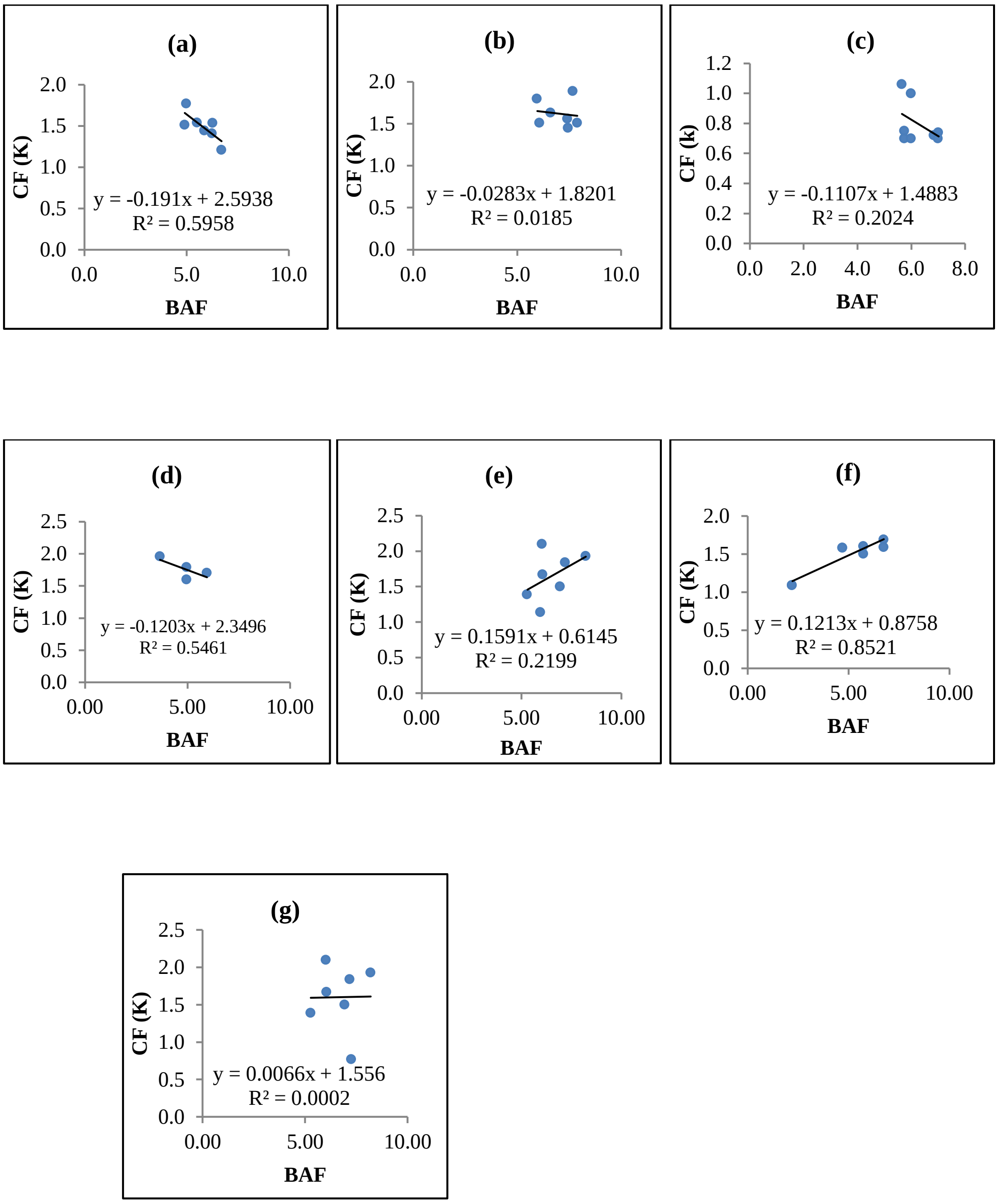


Figure 3. Correlation between bioaccumulation factor of all tested heavy metals and condition factor of each studied fish: (a) *Otolithoides pama*,(b)*Polynemus paradiseus*,(c) *Illisha megaloptera*, (d) *Cirrhinus cirrhosus*,(e) *Mystus spp*, *(f) Pangasius hypophthalmus*,(g) *Silonia silondia*

In *Polynemus paradiseus*, bioaccumulation factor was found to be highest in Al, followed by Pb, As, Cd, Hg, Ni, and Cr (Table 2). Condition factor and heavy metal bioaccumulation factor of studied fish was found to be negative correlation (r= -0.1359, p>0.05) (Figure 3).

Bioaccumulation factor value of Al in *Illisha megaloptera* showed the highest and followed by Cd, Hg, As, Ni, Cr, and Pb (Table 2). Negative correlation between condition factor and heavy metal bioaccumulation factor of studied *I. megaloptera* was observed (r= -0.4499, p>0.05) (Figure 3).

In *Cirrhinus cirrhosus*, bioaccumulation factor was found to be highest in Al, followed by Cd, Hg, Ni, Cr, Pb, and As (Table 2). Condition factor of studied fish was significantly negative correlation with heavy metal bioaccumulation of all tested heavy metals (r= -0.8667, p<0.05) (Figure 3).

In *Mystus spp.*, highest bioaccumulation factor was observed in Al, folowed by Hg, Ni, Cd, As, Cr, and Pb (Table 2). Condition factor of studied fish was not negatively correlated with bioaccumulation of all tested heavy metals (r= 0.4690, p>0.05) (Figure 3).

In *Silonia silondia*, bioaccumulation factor was highest in Cd. followed by Al, Hg, Cr, Ni, As, and Pb (Table 2). Condition factor of studied fish was not negatively correlated with bioaccumulation of all tested heavy metals (r= 0.5968, p>0.05) (Figure 3).

In *Pangasius hypophthalmus*, bioaccumulation value was highest in Cd, followed by Al, Hg, Pb, As, Cr, and Ni (Table 2). Condition factor of studied fish was not negatively correlated with heavy metal bioaccumulation factor (r= 0.2028, p>0.05) (Figure 3).

Among the tested heavy metals, condition factors of studied fishes were negatively correlated with the bioaccumulation factors of Al (r=-0.3783), Cd (r= -0.0893), and As(r= -0.195). The bioaccumulations of other tested metals, Cr, Ni, Hg and Pb showed no negative correlation with the condition factors of studied fishes (Figure 4).

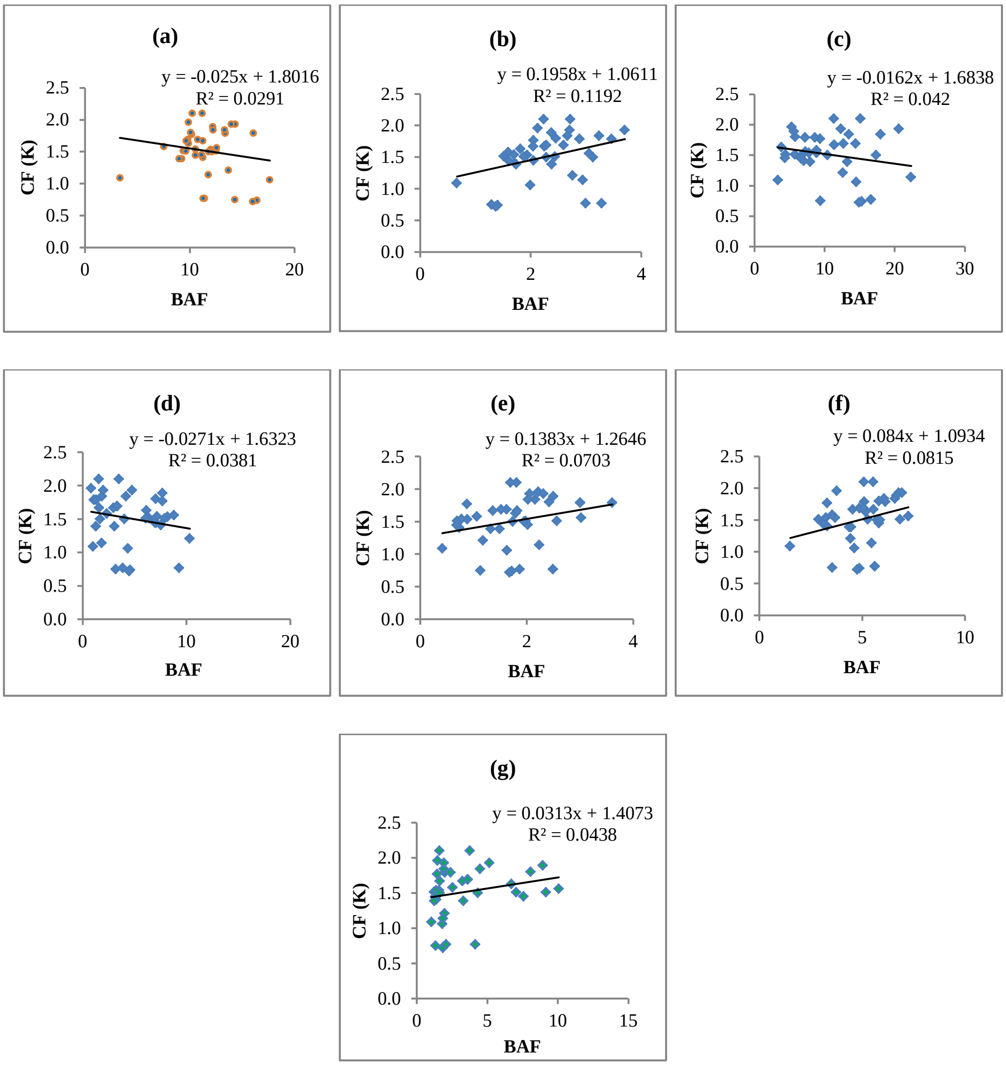


Figure 4. Relationship between condition factor of all studied fish species and bioaccumulation factor of each heavy metal: (a) Aluminium, (b) Chromium, (c) Cadmium, (d) Arsenic, (e) Nickel, (f) Mercury, (g) Lead

Discussion

The main sources of the heavy metal pollution in aquatic ecosystems are due to anthropogenic activities especially industrial and domestic sewages. It is often most obvious in sediments, macrophytes and aquatic animals via elevated concentrations in water (Linnik and Zubenko, 2000). Therefore, typical monitor of aquatic ecosystems are essential for pollution of heavy metals using biological assays (Wong and Dixon, 1995).

Many aquatic organisms are used as bioindicators, especially fish (Burger *et al.*, 2002). In the present study, heavy metal analysis was conducted in edible muscle tissues of 231 specimens belonging to seven commercial fish species were analysed for accessing the impact of heavy metal pollution by industrial wastes on wellbeing of the fish in the study area.

In the present study, heavy metal concentrations in studied fish muscles and those of the surface water in the study area were significantly correlated. It indicated that the pollutant heavy metals in the water enter the Hlaing River ecosystem and bioaccumulation took place in the studied fishes. The tested heavy metals assumed to enter the study area by anthropogenic activities such as industrial wastes, chemical fertilizers and pesticides used in agricultures, sand and gravel digging in the river and storage at the river bank, fuel discharged from large vessels, etc. This finding is in agreement with the statement of Zeitoun and Mehana (2014) that industrial wastes are potential source of heavy metal pollution in aquatic environments. In recent years, the anthropogenic pollution of aquatic ecosystems increased and need to identify the impact of heavy metals on the species living there. Monitoring programs for bioaccumulation measurements in fish serve as a biomarker from contaminated places and provide information about the environmental conditions. Therefore, the studied commercial fishes were served as the biomarkers of heavy metal pollutions in the study area.

In the study area, majority of studied fish species were in good condition showing condition factor values exceeding the critical value (K=1), although condition factors of those fishes were found to be negatively correlated with the heavy metal bioaccumulation factor in their muscles. They seem to be healthy with no obvious sign of illness, but they may be attrition due to long term exposure of heavy metals. This finding is in accordance with the finding of previous authors (Dupuy, Galland, Pichereau, Sanchez and Riso, 2014; Hashim, Song, Muslim, and Yen, 2014). They stated that long term exposure of heavy metal pollutions may decrease the fecundity leading to decline the population of fishes and eventual extinction of these natural resource.

In the present study, the low level of condition factor (K<1) was observed in *Illisha megaloptera* incorporated with the significant negative correlation of heavy metal bioaccumulation especially Al, Cd, As, Ni, and Hg. Although other studied fishes showed significant negative correlation of heavy metal bioaccumulation, they were in good condition factor. Therefore, it could be assumed that *I. megaloptera* was less tolerance of heavy metal contamination than other studied fish species. Dupuy et al. (2014) reported that the fish in some polluted ecosystems have a lower condition showing poor health status.

Hlaing River is used for transportation, irrigation in agriculture, small scale fishing and extraction of sand and gravel by digging diesel powered suction pumps.

Besides, many factories in industrial zones such as glass, pharmaceutical, steel, chemical, electrical, engineering, paint, food processing and garment factories are situated near the river bank. Both treated and untreated wastes from these factories discharged into the river directly or indirectly and become polluted day to day. The previous researchers (GMDA, 2015;Kyi Wai, 2009) also mentioned that Hlaing River is becoming polluted nearly hazarded levels.

The previous authors mentioned that the scaled fishes were more resistance of water parameters than scaleless fishes because of the thick layer protection of the skin (Abedi, et al. 2012). The impact of heavy metal bioaccumulation was not obviously influence on the wellbeing of studied scaleless fishes as *Mystus spp.*, *S. silondia* and *P. hypophthalmus*in the study areabecause condition factor of these fishes showed no negative correlation with those of bioaccumulation factors. It is considered that the scaleless fishes were less tolerance of the salinity than scaled fishes and they assumed to be dwelling in upper portion of the study area where brackish water has low salinity. Fluctuation of the salinityis a barrier for these fishes to reach the lower portion of the study area where most of the waste water of the factories runs off into the river. Therefore, the studied scaleless fishes were less suffered the impact of heavy metal contamination than scaled fishes in the study area. However, it is need to be confirmation because other factors can influence on the wellbeing of fishes in the complex ecosystem.

In all studied fish species, high bioaccumulation factor values were observed and greater than critical value (BAF=1). Therefore, tested heavy metals especially Al, Cd and

As were accumulated by fish showing long term exposure of heavy metals to fish in its surrounding. Since condition factors of *O. pama*, *P. hypophthalmus*, *I. megaloptera* and *C. cirrhosus*were found to be significant negative correlation with heavy metal bioaccumulation factors, these fishes were assumed to be the direct impact of heavy metal bioaccumulation on their wellbeing since long been.

4. Conclusion

In conclusion, the bioaccumulation factor values of heavy metals were found to be high in the muscle of all studied commercial fishes showing long term exposure of heavy metal pollution in the study area. Heavy metals are not destroyed by organism including humans (Hassaan, Al-Kahali and Al-Edres, 2007). Consequently, they tend to accumulate within the body and can affect the health of fish and fish consumers. Pollution was increasing by anthropogenic activities of industrial zones in the study. This impact is seemed to be threatened aquatic ecosystem not only in the study area but also downstream along the Hlaing River. Therefore, regular monitoring of heavy metal pollution should be conducted to prevent long term impacts on wellbeing of fish species in the Hlaing River.

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