Species Richness and Metal Concentrations in Some fishes and their Environs of Ayeyarwady River Segment, Salay Township, Magway Region

Cho Cho Thin[1], Myin Zu Min[2], Min Thu Aung[3]

Abstract

A total of 44 fish species belonging to 19 families of six orders including nine herbivores, 18 carnivores and 13 omnivores were recorded from three study sites of Ayeyarwady River segment, Salay region, July 2013 to February 2014. The results of the water quality revealed the pH, conductivity and calcium hardness were within the desirable limits for fish although that of total hardness in all study sites and calcium hardness in study site I were markedly higher than the permissible limits. The toxic metal cadmium concentration was 13.45 ppm in sediment and the ranged from 0.215 – 0.237 ppm in water. Mean values of essential elements in sediment and water of study area were analyzed. Na concentration in sediment was lower than that of water although Ca, Mg and K concentrations in sediments were higher than that of the water in present study area. Na concentration of omnivorous (*Salmostoma sardinella* and *Mastacembellus dayi*) and carnivorous (*Notopterus notopterus* and *Mystus cavasius*) fishes was higher than that of herbivorous fish (*Rhinomugil corsula*). The concentration of Ca in carnivorous fish was the highest followed by omnivorous and herbivorous fishes. Mean values of essential elements Mg in herbivorous fish was lower than that of carnivorous and omnivorous fishes in present study. K concentrations of all study fishes were nearly the same.

Keywords: species richness, water quality, toxic and essential metals

Introduction

Heavy metals are a group of elements between Copper and Bismuth on the Period Table. Doembi (2010) 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.

Toxic metals occur as natural constituents of the earth crust, and are persistent environmental contaminants since they can not be degraded or destroyed. During 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). To a small extent, they enter the human body system through food, air and water and bioaccumulate over a period of time (Lenntech, 2004; UNEP/GPA, 2004).

Some metals like copper, iron and zinc are essential for metabolism. For normal metabolism, the essential metals must be taken up from water or food, but excessive intake of the essential metals can produce toxic effects (Yousafzai, 2004).

Fish are known to be an important exposure pathway of metals to human and considered as one of the most indicative factors in freshwater ecosystems for the estimation of trace metals pollution (Rashed, 2001). There are five potential routes for a pollutant to enter a fish: food, non-food particles, gills, oral consumption of water and the skin (Ayandiran *et al*., 2009).

Once metals are accumulated by an aquatic organism, they can be transferred through the upper levels of the food chain. Carnivores at top of the food chain including humans, obtain most of their metal burden from the aquatic ecosystem by way of their food, especially where

[1] Lecturer, Department of Zoology, University of Yangon
[2] Pro-rector, University of Mandalay
[3] Professor, Department of Zoology, Pathein University

fish are present so there exists the potential for considerable biomagnifications (Cumbie, 1975; Mance, 1987).

Fish cover a wide range of trophic levels and are an important link of aquatic food chains with human populations (Costa and Kehrig, 2002). These two main features made fish highly suitable for toxic and essential metals contamination studies and monitoring programmes. Due to these reasons, the present study was undertaken to examine toxic and essential metals concentration of some fish species and their environs from the study area.

The objectives of present study are followings:

- to know fish species richness in study area
- to evaluate the habit and habitat of recorded fish species
- to check the physical and chemical parameters of aquatic environs
- to examine toxic and essential metals concentration of some fish species and their environs

Materials and Methods

Ayeyarwady River segment of Salay Township, Magway Region situated at 20° 42′ N to 20° 51'.30" N and 94° 14′ E to 97° 47'.51" E were chosen as the study area to examine toxic and essential metals concentration of some fish species and their environs. Near the Hnaw gyaung village, near the Magyee gyaung ward and Pa kan nge were designated as the study site I, II and III, respectively (Fig. 1). Study period lasted from July 2013 to February 2014. Fish species caught from local fishermen were monthly recorded to check the species richness. Identification of recorded fish was carried out followed after Talwar and Jhingran (1991). Feeding habits of recorded fish species were designated in accordance with Talwar and Jhingran (1991). From the collected species, five species were selected for determination of essential metals. The concentration of toxic metals in aquatic environs (water and sediment) of study area such as arsenic, lead and cadmium were analyzed in Myayarpin Engineering and Trading Co., Ltd., and essential metals in some fishes such as Na, Ca, Mg and K was determined by the Flame Atomic absorption spectrometer (FAAS) (Perkin Elmer AAanalyst 800 and Winlab-32 software) Universities’ Research Centre (URC), University of Yangon. Test results were compared with international standards and WHO standards.

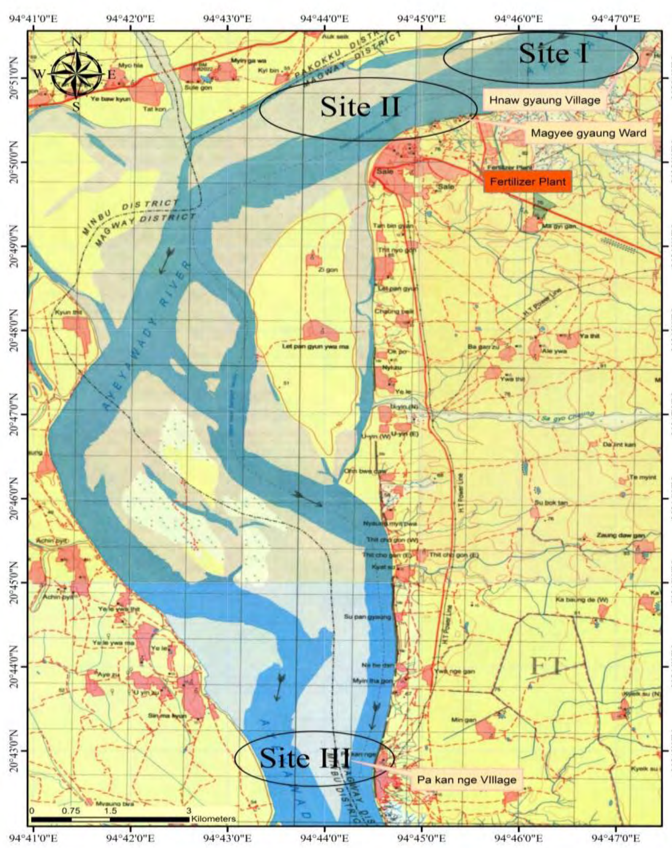


Fig. 1 Map of the study area and study site

Results

A total of 44 fish species belonging to 19 families of six orders were recorded from three study sites of Ayeyarwady River segment, Salay Environs. The fish species composition of order Siluriformes (36%) was the largest followed by order Cypriniformes (15%) and Perciformes (9%) although that of order Osteoglossiformes and order Cyprinodontiformes were the lowest (1% each) in present study (Table 1 and Fig. 2). Fish species richness in these three study sites were not different (42 species in site I, 41 species in site II and 44 species in site III) (Table 2 and Fig. 3(A)).

Nine species of herbivores, 18 species of carnivore and 13 species of omnivore were also categorized (Table 3 and Fig. 3(B)).

Physical and chemical parameters of three study sites were found to be varied. Water temperature, turbidity and DO were not different in three study sites. The value of pH ranged from 7.9 - 8.2, that of conductivity ranged from 80 – 120 us/cm, that of total hardness ranged from 42 – 104 ppm, that of calcium hardness ranged from 36 – 84 ppm, that of M-alkalinity ranged from 62 – 98 ppm and that of chloride ranged from 5 – 8.5 ppm. P-alkalinity was not observed (Table 4).

The concentration of arsenic and lead were not investigated in the sediment of study area however the cadmium concentration was 13.45 ppm (Table 5). Similarly, arsenic and lead were not investigated in the water of all study sites however the cadmium concentration ranged from 0.215 – 0.237 ppm (Table 6).

Mean values of essential elements in sediment and water of study area were analyzed. Na was 1.797 ±0.015 ppm in sediment and 17.37 ±0.047 ppm in water, Ca was 14.14 ±0.167 ppm in sediment and 11.00 ±0.069 ppm in water, Mg was 10.97 ±0.167 ppm in sediment and 9.486 ±0.007 ppm in water and K was 16.20 ±0.082 ppm in sediment and 1.463 ±0.025 ppm in water (Table 7).

Mean values of essential elements in five fish species were analyzed. In herbivorous fish *Rhinomugil corsula*, the concentration of Na was 32.04 ±0.134 mg/kg that of Ca was 77.99 ±9.307 mg/kg, that of Mg was 10.53 ±0.025 mg/kg and that of K was 107.0 ±0.006 mg/kg. In carnivorous fish *Notopterus notopterus* and *Mystus cavasius*, the concentration of Na was not available and 41.32 ±0.000 mg/kg, that of Ca was 128.5 ±1.351 mg/kg and 129.0 ±0.270 mg/kg, that of Mg was 10.78 ±0.015 mg/kg and 10.84 ±0.010 mg/kg, and that of K was 107.1 ±0.002 mg/kg and 107.6 ±0.009 mg/kg, respectively. In omnivorous fish *Salmostoma sardinella* and *Mastacembellus dayi*, the concentration of Na was 33.42 ±0.088 mg/kg and 41.32 ±0.000 mg/kg, that of Ca was 94.70 ±7.347 mg/kg and 128.0 ±0.988 mg/kg, that of Mg was 10.71 ±0.006 mg/kg and 11.04 ±0.033 mg/kg, and that of K was 107.1 ±0.006 mg/kg and 108.2 ±0.005 mg/kg, respectively (Table 8).

Table 1. Fish species composition of respective orders in study area

Sr. No.	Order	Family	No. of species
1	Osteoglossiformes	1	1
2	Clupeiformes	1	2
3	Cypriniformes	2	15
4	Siluriformes	7	16
5	Cyprinodontiformes	1	1
6	Perciformes	7	9
	Total	19	44

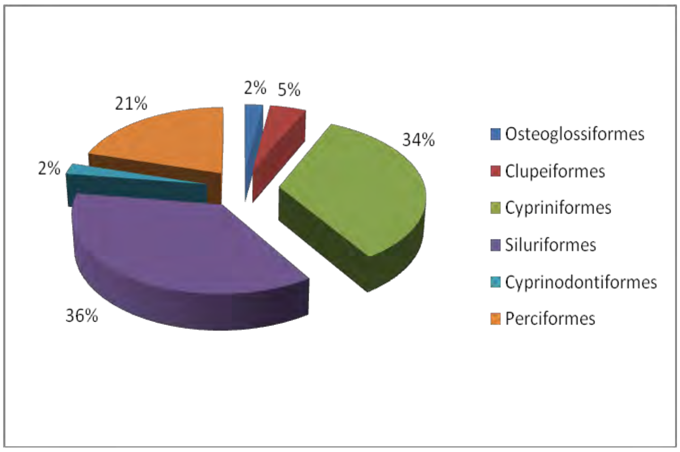


Fig. 2 Fish species composition of respective orders

Table 2. Recorded fish species from three study sites

Sr. No.	Species	Study site		
		I	II	III
1	*Notopterus notopterus*	√	√	√
2	*Tenualosa ilisha*	√	√	√
3	*Gudusia variegata*	√	√	√
4	*Catla catla*	√	√	√
5	*Cirrhinus mrigala*	√	√	√
6	*Gonoproktopterus curmuca*	√	√	√
7	*Labeo boga*	√	√	√
8	*Labeo calbasu*	√	√	√
9	*Labeo rohita*	√	√	√
10	*Osteobrama belangeri*	√	√	√
11	*Osteobrama cunma*	√	√	√
12	*Puntius sophore*	√	√	√
13	*Salmostoma sardinella*	√	√	√
14	*Cabdio morar*	√	√	√
15	*Raiamas guttatus*	√	√	√
16	*Crossochelus burmanicus*	√	√	√
17	*Acantopsis chairorhynchus*	√	√	√
18	*Botia histrionica*	Nil	Nil	√
19	*Separata aor*	√	√	√
20	*Mystus cavasius*	√	√	√
21	*Mystus leucophasis*	Nil	Nil	√
22	*Rita sacerdotum*	√	√	√

Table 2. (Continued)

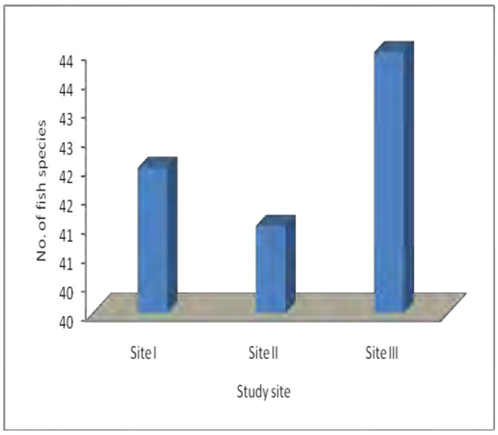
Sr. No.	Species	Study site		
		I	II	III
23	*Ompok bimaculatus*	√	√	√
24	*Ompok pabo*	√	√	√
25	*Wallago attu*	√	√	√
26	*Clupisoma prateri*	√	√	√
27	*Eutropiichthyes vacha*	√	√	√
28	*Silonia silondia*	√	√	√
29	*Pangasius pangasius*	√	√	√
30	*Bagarius yarrelli*	√	√	√
31	*Gagata cenia*	√	√	√
32	*Glyptothorax dorsalis*	√	√	√
33	*Clarias batrachus*	√	Nil	√
34	*Hemipimelodus jatius*	√	√	√
35	*Xenentodon cancila*	√	√	√
36	*Pseudambassis ranga*	√	√	√
37	*Pama pama*	√	√	√
38	*Oreochromis mossambicus*	√	√	√
39	*Rhinomugil corsula*	√	√	√
40	*Glossogobius giuris*	√	√	√
41	*Channa punctatus*	√	√	√
42	*Macrognathus zebrinus*	√	√	√
43	*Mastacembelus armatus*	√	√	√
44	*Mastacembelus dayi*	√	√	√
	Total	42	41	44

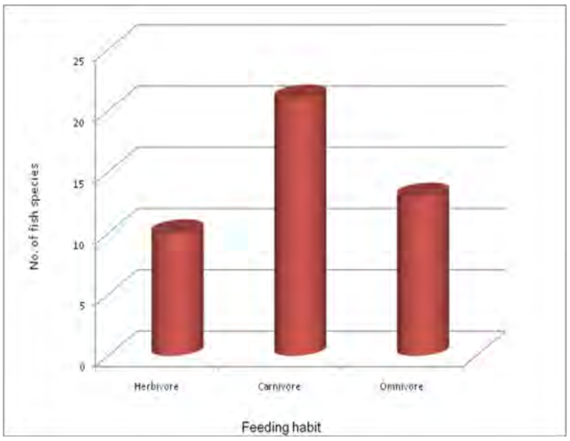
Table 3. Feeding habitats of recorded fish speies

Sr. No.	Species	Feeding habit		
		Herbivore	Carnivore	Omnivore
1	*Notopterus notopterus*		√	
2	*Tenualosa ilisha*			√
3	*Gudusia variegata*			√
4	*Catla catla*	√		
5	*Cirrhinus mrigala*	√		
6	*Gonoproktopterus curmuca*			
7	*Labeo boga*	√		
8	*Labeo calbasu*	√		
9	*Labeo rohita*	√		
10	*Osteobrama belangeri*	√		
11	*Osteobrama cunma*	√		
12	*Puntius sophore*			√
13	*Salmostoma sardinella*			√
14	*Cabdio morar*			√
15	*Raiamas guttatus*		√	
16	*Crossochelus burmanicus*	√		
17	*Acantopsis chairorhynchus*		√	
18	*Botia histrionica*			√
19	*Separata aor*		√	
20	*Mystus cavasius*		√	
21	*Mystus leucophasis*		√	
22	*Rita sacerdotum*			

Table 3. (Continued)

Sr. No.	Species	Feeding habit		
		Herbivore	Carnivore	Omnivore
23	*Ompok bimaculatus*			√
24	*Ompok pabo*			√
25	*Wallago attu*		√	
26	*Clupisoma prateri*			√
27	*Eutropiichthyes vacha*		√	
28	*Silonia silondia*		√	
29	*Pangasius pangasius*		√	
30	*Bagarius yarrelli*		√	
31	*Gagata cenia*		√	
32	*Glyptothorax dorsalis*			
33	*Clarias batrachus*		√	
34	*Hemipimelodus jatius*		√	
35	*Xenentodon cancila*		√	
36	*Pseudambassis ranga*		√	
37	*Pama pama*			
38	*Oreochromis mossambicus*	√		
39	*Rhinomugil corsula*			√
40	*Glossogobius giuris*		√	
41	*Channa punctatus*		√	
42	*Macrognathus zebrinus*			√
43	*Mastacembelus armatus*			√
44	*Mastacembelus dayi*			√
	Total	9	18	13





(A) Fish species richness (B) Feeding habitats of recorded fish speies

Fig. 3 Species richness, habits and habitats of recorded fish speies in study area

Table 4. Water parameter of different study sites

Sr. No.	Water parameters	Study site			Desirable limit for fish	Reference
		I	II	III		
1	Temperature (°C)	26	26	27		
2	Turbidity	trace	trace	trace		
3	pH(Scale)	7.9	8.2	8	6.0 - 9.0	Osman *et al*., 2010
4	DO(mg/L)	12	12	12	>5	Water Quality,2006
5	Conductivity (us/cm)	100	80	120	20 – 1500	Boyd, 1979
6	Total hardnes (ppm)	104	82	42	25 – 250	Willsam and Durborow, 1992
7	Calcium hardness (ppm)	84	40	36	8 - 45.0	UNEP Water Programme, 2006
8	P-alkalinity (ppm)	Nil	Nil	Nil		
9	M-alkalinity (ppm)	98	80	62		
10	Chloride (ppm)	8	8.5	5		

Table 5 Analytical results of heavy metal in sediment of study area

Sample	Test items	Test result
Sediment	Arsenic	Nil
	Lead	Nil
	Cadmium	13.45

Table 6 Analytical results of heavy metal in water of study sites

Samples	Test items	Test results			WHO Guideline
		Site I	Site II	Site III	
Water	Arsenic	Nil	Nil	Nil	0.01
	Lead	Nil	Nil	Nil	0.01
	Cadmium	0.215	0.218	0.237	0.015

Table 7 Analytical result of essential elements in sediment and water of Ayeyawady River segment of Sale Township

Sr. No.	Test items	Test results of essential elements			
		Na	Ca	Mg	K
1	Sediment	1.797 ±0.015	14.14 ±0.167	10.97 ±0.167	16.20 ±0.082
2	Water	17.37 ±0.047	11.00 ±0.069	9.486 ±0.007	1.463 ±0.025

Table 8 Analytical result of essential elements in some fish species of Ayeyawady River segment of Sale Township

Sr. No.	Test items	Test results of essential elements			
		Na	Ca	Mg	K
1	*Notopterus notopterus*	Nil	128.5 ±1.351	10.78 ±0.015	107.1 ±0.002
2	*Salmostoma sardinella*	33.42 ±0.088	94.70 ±7.347	10.71 ±0.006	107.1 ±0.006
3	*Mystus cavasius*	41.32 ±0.000	129.0 ±0.270	10.84 ±0.010	107.6 ±0.009
4	*Rhinomugil corsula*	32.04 ±0.134	77.99 ±9.307	10.53 ±0.025	107.0 ±0.006
5	*Mastacembellus dayi*	41.32 ±0.000	128.0 ±0.988	11.04 ±0.033	108.2 ±0.005

Discussion

A total of 44 fish species belonging to 19 families of six orders were recorded from three study sites of Ayeyarwady River segment, Salay Environs. Fish species richness in these three study sites was not different. Among the recorded fish species, nine herbivores, 18 carnivores and 13 omnivores were included. Khin Myint Mar (2011) reported that a total of 25 fish species including five herbivores, 12 carnivores and eight omnivores were recorded from Gaw wein fish landing of Ayeyarwady River of Mandalay segment. The United Nations Environment Programme's World Conservation Monitoring Centre (UNEPWC) lists the Ayeyarwady as one of the world's top thirty high priority river basins due to both its support of high biodiversity and high vulnerability to future pressures. The river is home to 79 known fish species and as of 2002 there were four known endemic bird areas in the basin (Pelow (1999) cited in Duruibe *et al*., 2007).

Physical and chemical parameters of water in three study sites were found to be varied. The results revealed the pH, DO, conductivity and calcium hardness were within the desirable limits for fish although that of total hardness in all study sites and calcium hardness in study site I were markedly higher than the permissible limits.

Arsenic and lead concentration were not investigated in the soil of study area and in the water of all study sites however the cadmium concentration was 13.45 ppm in soil and the ranged from 0.215 – 0.237 ppm in water. Thus, the cadmium concentration is higher than the permissible limit of 0.015 ppm set down by WHO (1990) guideline. WHO (2007) stated that cadmium exposures are associated with kidney and bone damage. Cadmium has also been identified as a potential human carcinogen, causing lung cancer. Forstner and Wittmann (1981) reported that aquatic organisms such as fish are capable of accumulating met also in their living cells to concentrations much higher than those present in water, sediments and microflora in their environment. Metal content of fish increases with the increment of the metal level in water, sediment and food organism (Arvind, 2002). Selected metals (Na, Ca, Mg, K) were determined in the muscle tissue of five freshwater fish species, *Notopterus notopterus, Salmostoma sardinella, Mystus cavasius, Rhinomugil corsula* and *Mastacembellus dayi*.

Mean values of essential elements in sediment and water of study area were analyzed. Na concentration in sediment was lower than that of water although Ca, Mg and K concentrations in sediments were higher than that of the water in present study area.

In the present study, Na concentration of omnivorous and carnivorous fishes was higher than that of herbivorous fish. As the RDA of Na for women and men ranges within 500-625 mg per person (Ziemlanski, 2001).

The concentration of Ca in carnivorous fish was the highest followed by omnivorous and herbivorous fishes. The recommended daily allowance (RDA) of Ca for women and men aged 25 years and younger is 1200 mg per day and for women over 60 years of age 1100 mg per day (due to progressing loss in bone mineral mass) (Ziemlanski, 2001).

According to Kunachowicz *et al*. (2005), fish tissue contains 12 to 49 mg of Mg per 100 g edible portion. Mean values of essential elements Mg in herbivorous fish was lower than that of carnivorous and omnivorous fishes in present study. The recommended daily allowance of Mg for girls and adult women ranges with 300-380 mg per person, while for boys and adult men within 290-400 mg per person (Ziemlanski, 2001).

In the present study, K concentrations of all study fishes were nearly the same. The recommended daily allowance (RDA) of K for women and men ranges within 2000-3500 mg per person (Ziemlanski, 2001).

Human demand for minerals depends on age (which is related to body mass), physiological condition, (pregnancy, lactation) and in the case of Mg, Fe and Zn, also on gender. Fish meat contains more P, K and Mg comparing to meat from livestock, and in the case of pickled fish or fish with edible bones also more Ca. Toxic effect of metals depends on the site of their deposition within the body (Witeska and Jezierska (2001) cited in Kazmierkiewicz *et al*., 2009). Fish muscle, comparing to the other tissues, usually contain low levels of metals but are often examined for metal content due to their use for human consumption (Witeska and Jezierska, 2001 cited in Kazmierkiewicz *et al*., 2009).

Conclusion

A total of 44 fish species belonging to 19 families of six orders were recorded from three study sites of Ayeyarwady River segment, Salay Environs. Fish species richness in these three study sites was not different. In the present study, metal concentrations of water and sediment were not higher than WHO limits except the concentration of Cd concentrations. The concentrations of Na, Ca, Mg, and K in studied species were within the recommended limits. The fish were found to be safe for consumers' health.

Acknowledgements

We are much indebted to Dr. Thida Lay Thwe, Professor/Head, Department of Zoology, and Yangon University for her kind encouragement. We would like to specially thank Dr. Aye Mi San, Professor, Department of Zoology, and Yangon University for her invaluable help in this work. Our profound gratitude goes to Dr. Nyan Tun, Associate Professor, Department of Chemistry, Bago University, for his invaluable help in this research work.

References

Arvind, K., 2002. *Ecology of polluted waters*. A.P.H Publishing Corporatio, New delhi.

Ayandiran, T. A., Fawole, O. O., Adewoye, S. O., Ogundiran, M. A., 2009. Bioconcentration of metals in the body muscle and gut of *Clarias gariepinus* exposed to sublethal concentration of soap and detergent effluent. *J. cell. Anim. Biol.*, 3(8): 113-118.

Costa, M., Kehrig, H., 2002. Fish species used as bioindicators of mercury pollution along the Brazilian Coast. Rio de Janeiro. *Marine Pollution Bulletin*, 44: 1018-1023.

Cumbie, P. M., 1975. Mercury levels in Goergia otter, mink and freshwater fish. *J. Bull. Environ. Contam. Toxicol*., 14(2): 193-196.

Doembi Ucla Edu, 2010. Eisenbergy Lab Heavy Metals List, Available from www.doembi.ucla.edu/-librry/heavy- handling2.pd (Accessed 11 October 2011). .

Forstner, U., Wittman, G. T. W., 1981. *Metal pollution in aquatic environment*. Spring Verlag Berlin, heides Berg, New York, 336 pp.

Habashi, F., 1992. Environmental issues in the Metallurgical Industry-Progress and problems, environmental issues and waste management in energy and mineral production. *Balkama Rotherdam*, 78: 1143-1153.

Kazmierkiewicz, M. L., Pokorska, K., Protasowicki, M., Rajkowska, M., Wechterowicz, Z., 2009. Content of selected essential and toxic metals in meat of freshwater fish from West Pomerania, Poland. *Pol. J. Food Nutr. Sci*. 2009, 59(3): 219-224.

Khin Myint Mar, 2011. Uptake of heavy metals and its relationship to feeding habit of selected fish species in Ayeyawady River, Mandalay and Magway segments. PhD dissertation. Department of Zoology, University of Mandalay.

Kunachowicz, H., Nadolna, I., Prygoda, B., Iwanow, K., 2005. Tabele skladu i wartosci odzywczej zywnosci. PZWI., Warszawa (in Polish).

Lenntech Water Treatment and Air Purification, 2004, Water treatment. Published by Lenntech, Rotterdamseweg, Netherlands. Available from: http://www.excelwater.com/thp/filters/ Water-Purification. htm. (Accessed 23 November 2010).

Mance, G., 1987. *Pollution threat of heavy metals in aquatic environment*. Isevier Applied Science Publishers Ltd. London and New York. 372 pp.

Rashed, M. N., 2001. Monitoring of environmental heavy metals in fish from Nasser Lake. *Envion. Int.*, 27: 27-33.

Talwar, P. K., Jhingran, A. G., 1991. *Inland fishes of India and adjacent countries*. Oxford and IBH Publishing Co. PVT. Ltd., Calcutta.

UNEP/GPA, 2004. (United Nations Environmental Protection/Global Programme of Action) The marine environment protection from heavy metals, 2004. UNEP/GPA Coordination Office. Available from http://www. oceansatlas.org.unatlas/uses/uneptextsph/wastesph/260 2gpa. (Accessed 8 September 2010).

WHO, 2007. *Health risks of heavy metals from long-range transboundary air pollution*. WHO, Geneva.

Yousafzai, A. M., 2004. Toxicological effects of effluents dumped in River Kabul on Mahaseer, Torputitora at Aman Garh industrial area Nowshera, Peshawar, Pakistan. *PhD dissertation*, Department of Zoology, University of the Punjab, New Campus, LahorePakistan.

Ziemlanski, S., 2001. Normy zywienia czlowieka. Fizjologiczne podstawy. 2001, *PZWL Warszawa*, p 532 (in Polish).