

ANALYSIS OF HEAVY METALS IN WATER AND FISH (*Tilapia sp.*) SAMPLES FROM TASIK MUTIARA, PUCHONG

(Analisis Logam Berat Dalam Sampel Air dan Ikan (*Tilapia Sp.*)
Tasik Mutiara, Puchong)

Ismaniza Ismail*, Idaliza Mat Saleh

Faculty of Applied Sciences,
Universiti Teknologi MARA, 40450 Shah Alam, Selangor, Malaysia

*Corresponding author: ismaniza@salam.uitm.edu.my

Abstract

The concentrations of seven heavy metals (Al, As, Cd, Cu, Fe, Pb and Zn) were detected in muscle tissues of *Tilapia sp* (black tilapia) collected from the lake of Taman Mutiara, Puchong. Samples were collected for several months in the end of 2009 at three sampling points. Heavy metals in fish and water samples were analyzed by Inductively Coupled Plasma – Optical Emission Spectroscopy (ICP-OES). Only Al, Cu, Fe and Zn were detected in the order Fe > Zn > Al > Cu, whereas concentrations of As, Cd and Pb were below the detection limit. The concentrations of heavy metals in water samples were low and below the detection limit. The levels of heavy metals in the fish samples can be considered as a serious matter of concern as it may be consumed and it signifies the degradation of lake quality. Generally, the sources of heavy metals in the Tasik Mutiara, Puchong could be attributed to the illegal waste dumping activity and discharge from the nearby sewage treatment plant into the lake which promote eutrophication in the lake. It could also be attributed to the Low Dissolved Oxygen (DO) levels in the lake.

Keywords: biomagnification, fish, heavy metals, lake

Abstrak

Kepekatan tujuh jenis logam berat (Al, As, Cd, Cu, Fe, Pb and Zn) telah dikesan di dalam tisu otot ikan *Tilapia sp* (tilapia hitam) yang disampel dari Tasik Taman Mutiara, Puchong. Pensampelan telah dibuat selama beberapa bulan pada penghujung tahun 2009 di tiga 'spot' lokasi tersebut. Kepekatan logam berat di dalam ikan dan air tasik telah dianalisa dengan menggunakan Inductively Coupled Plasma – Optical Emission Spectroscopy (ICP-OES). Didapati kepekatan Al, Cu, Fe dan Zn yang dikesan adalah dalam susunan Fe > Zn > Al > Cu, manakala logam As, Cd dan Pb adalah terlalu sedikit dan tidak dapat dikesan. Jumlah logam berat di dalam sampel ikan boleh dianggap sesuatu yang serius kerana ia mungkin dimakan oleh pemancing-pemancing dan ia menunjukkan kemerosotan kualiti tasik. Kepekatan logam berat di dalam sampel air tasik juga tidak dapat dikesan kerana terlalu sedikit. Secara umumnya, sumber logam berat di Tasik Mutiara, Puchong mungkin berpunca daripada aktiviti pelupusan sisa secara haram dan effluen daripada sistem pengolahan air kumbahan yang berhampiran yang menggalakkan proses eutrofikasi di dalam tasik tersebut. Ia juga boleh dikaitkan dengan nilai Oksigen Terlarut yang rendah di dalam tasik tersebut.

Kata kunci: biomagnifikasi, ikan, logam berat, tasik

Introduction

Fish are often at the top of the aquatic food chain and many concentrate large amount of heavy metals from polluted water that build up by ingestion, ion-exchange of dissolved metals across lipophilic membranes and absorption on tissue and membrane surface [1,2]. For four consecutive years since 2006, six cases of enormous floating dead fish at Tasik Mutiara Puchong have been reported to the Department of Environment (DOE) and Subang Jaya Municipal Council (MPSJ). Besides the concern on biodiversity depletion, the cases also resulted in many complaints from the nearby residents regarding the unsightly phenomenon and unbearable smell.

Despite the fact that metal biomagnification is influenced by metal assimilation, pollutants can still move through the various trophic levels in an ecosystem [3] and results in higher concentrations of the substance than would be expected if water were the only exposure mechanism. At the highest trophic levels, the increased concentrations in tissues may become toxic. This research aims to provide a baseline study to the local authority and the enforcement body on the source of pollution in the lake, hence assisting in the enforcement process. The specific objectives of the project are to identify and quantify the presence of heavy metals in water and fish in the lake. As water is the habitat of fish, there is a significance to measure its quality to assess the possible source of contamination contributing to this problem.

Materials and Methods

Study area

Fish samples (*Tilapia sp.*) of about the same size (length $\pm 5''$) were collected at three points; near the effluent discharge from the sewage treatment plant (S1), near the wastes dumping area (S2) and far from the sewage treatment plant with little wastes dumping activities (S3) as shown in Figure 2.1. Sampling was conducted at the frequency of twice a month for three consecutive months, in the morning and in the afternoon, as these were the common time of effluent discharge from the sewage treatment plant.



Figure 1. Sampling location at Tasik Mutiara, Puchong.

Sample collection and preparation

Fish samples were caught, placed in plastic bags and immediately preserved on ice prior to heavy metal analysis to meet the analytical holding times. Fish were weighed before and after being cut into small pieces and ground well thoroughly to achieve homogeneity. 5 gram of the sample were put in a 125-mL Erlenmeyer flask, added with 10 mL of concentrated nitric acid and warmed on a hot plate until the tissue solubilized. The temperature of the hot plate was increased to near boiling until the solution turned brown. Then, it was allowed to cool and an additional 5 mL of concentrated nitric acid was added for repeated heating and cooling. Another 2mL of nitric acid was added before being heated again on the hot plate until the volume of the sample reduced to 10 mL. Once cooled, 2 mL of 30% hydrogen peroxide was added. Once again the sample was heated until the volume of the sample reduced to 5 to 10 mL. After allowed to cool, another 2 mL of hydrogen peroxide was added. This step was repeated until a total

of 10 mL of hydrogen peroxide was added. After that the sample was allowed to cool before 2 mL of concentrated hydrochloric acid was added. Then the sample was returned to the hot plate until the volume of the sample is reduced to 5 to 10 mL. The sample was allowed to cool and transferred into a 100-mL volumetric flask. The sample was then topped-up with deionized water to the mark for ICP-OES analysis.

Results and Discussion

Concentrations of heavy metals in fish

All heavy metals bioaccumulated at varying levels on a dry weight basis. Al, Cu, Fe and Zn were detected by the ICP-OES although concentration of As, Cd and Pb were consistently below the detection limit. The concentrations of heavy metals (Al, As, Cd, Cu, Fe, Pb and Zn) in fish at the three different sampling points are given in Table 1.

Apparently, the concentration ranges of the metals detected were: Al: 15.4 to 320.6 mg/kg; Cu: 0.17 to 20.8 mg/kg; Fe: 31.9 to 743 mg/kg; and Zn: 45.5 to 86.1 mg/kg. The highest mean concentration of the heavy metal at all sampling points was Fe, followed by Zn, Al and Cu, as shown in Figure 2.

Table 1. Heavy metals concentration (mg/kg) in fish samples at the three sampling points in throughout the study period

Point	Al	As	Cd	Cu	Fe	Pb	Zn
S 1	41.5-89.7	BDL	BDL	BDL-0.85	66.3-211.1	BDL	56.4-70.7
	57.0-100.3	BDL	BDL	1.19-2.03	74.1-221.3	BDL	52.4-82.9
	32.0-149	BDL	BDL	0.54-1.07	51.3-338.6	BDL	61.1-63.3
	27.7-59.4	BDL	BDL	0.43-20.8	69.2-142.4	BDL	63.3-72.9
	32.6-162.2	BDL	BDL	0.35-2.06	69.4-424.9	BDL	59.1-63.0
	30.4-320.6	BDL	BDL	BDL-5.61	79.7-743.0	BDL	61.1-71.1
S 2	23.1-60.9	BDL	BDL	0.18-1.46	51.6-141.7	BDL	66.2-86.1
	22.8-62.1	BDL	BDL	1.54-0.69	69.5-139.3	BDL	55.6-62.5
	29.1-59.5	BDL	BDL	1.46-0.62	79.6-120.2	BDL	60.5-71.6
	25.1-52.4	BDL	BDL	0.18-0.89	49.7-131.9	BDL	50.3-67.5
	26.2-136.8	BDL	BDL	BDL-0.63	66.7-173	BDL	53.8-65.5
	28.4-69.6	BDL	BDL	BDL-1.34	72.0-148.9	BDL	59.1-63.4
S 3	20.4-48.4	BDL	BDL	BDL-0.17	40.3-108.6	BDL	53.7-64.9
	15.4-51.9	BDL	BDL	BDL-0.29	31.9-139.7	BDL	45.5-59.1
	16.2-35.2	BDL	BDL	BDL-1.31	46.3-96.45	BDL	55.2-54.2
	16.6-43.9	BDL	BDL	BDL-0.01	34.9-141.2	BDL	48.3-47.4
	16.5-69.2	BDL	BDL	BDL-0.31	36.7-302.7	BDL	50.6-45.7
	19.8-47.4	BDL	BDL	0.41-1.18	47.8-126.7	BDL	69.8-46.9

*Below detection limit

Fe recorded the highest concentration among the other heavy metals, with 207.61 mg/kg at S1 which was near the sewage treatment plant and paint factory, followed by 103.67 mg/kg at S2 (near the waste dumping area) and 96.10 mg/kg at S3. All the readings were very high compared to a similar study in Egypt [4] of 42.81 mg/kg. Dependent on species, individuals, habitats and sampling period, Fe concentrations were measured in species with more affinity

for rocky bottoms and species with more affinity to sandy or muddy bottom. This situation explains why the Fe concentrations were high at S1. The water condition was very muddy caused by the effluent discharge into the lake.

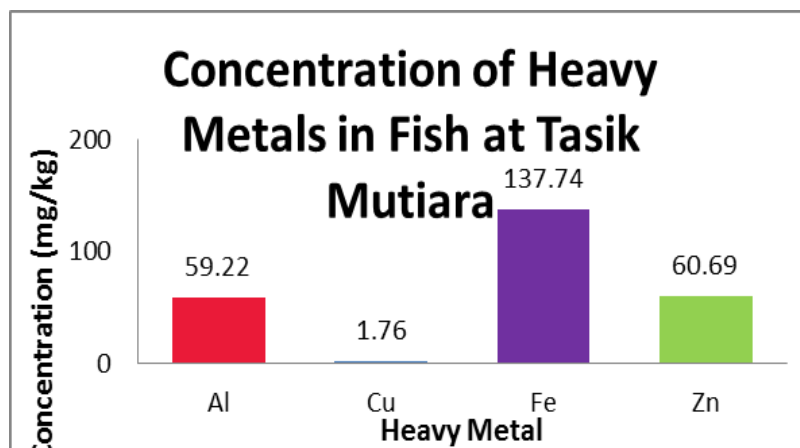


Figure 2. Mean concentrations of Al, Cu, Fe and Zn at the sampling location.

The Zn concentrations in *Tilapia sp.* sampled did not differ much, with 64.78 mg/kg, 63.51 mg/kg and 53.42 mg/kg. Similar to the amount of Zn in *Tilapia zilli* [4] that was 55.88 mg/kg, they were all found higher than the permissible level (40 mg/kg) recommended by Western Australian Food and Drink Regulations. However, they were still below the maximum allowable concentration (100 mg/kg) specified by the Malaysian Food Act, 1983 (Malaysian Food and Drug Regulation). Zn appears to have a proactive effect against toxicity of both Cd and Pb [5].

The highest concentration of Al was indicated at S1, followed by S2 and S3 with the concentration 91.87, 49.66 and 33.42 mg/kg respectively. Industrial waste, erosion, dissolution of minerals and salts, atmospheric dust pollution and rain are the major activities that promote the presence of Al. A previous study observed the fish mortality in mixing zones of rivers with difference acidizes and elevated levels of Al [6].

Cu was found highest S1 followed by S2 and S3 with the concentration 3.49, 0.89 and 0.53 mg/kg respectively. Although it was still below the permissible level (30 mg/kg) of the Malaysian Food Act, 1983 (Malaysian Food and Drug Regulation 1985), they were higher than of those in *Tilapia zilli* [4,7]. The toxicity of Cu however depends upon the hardness and pH of water, and therefore, it is more toxic in soft water and in water with low alkalinity. In this study, As, Cd and Pb concentrations were below the detection limit where the concentrations were very low. All these three heavy metal are toxic elements which have no known biological function and show their carcinogenic effect on aquatic biota and humans [8]. Although Cd detected in low concentration, it normally contained in the most mobile fraction in sediment and therefore can easily enter or transported to the food chains [9].

When fish are exposed to elevated metal levels in an aquatic environment, they can absorb the bioavailable metals directly from the environment via the gills and skin or through the ingestion of contaminated water and food, thus accumulates them in their tissues and enter the food chains and extent to many other problems to humans [10]. On the other hand, a study on *Synodontis clarias* concluded that the highest heavy metal concentration was at Station 1 (rural and agricultural runoff, continuous discharge of oily wastewaters from the flow station) [2]. In conclusion, the levels of Zn, Cd, Ni, Pb and Mn observed would have harmful effect on the health of the rural community in the study area.

Sampling sites near large cities usually have significant amount of metal levels, unlike fish tissues from bog lakes that have very low metal levels, possibly because of the high concentrations of natural organic matter in these

waters [11]. This fact is somehow consistent with other studies in which the varied presence of heavy metals throughout the lake sites was due to variations in the quantity, sources and mobility of the sediments [12].

In Malaysia, the consumption of fish is estimated to be 21 kg/person/year or 0.06 kg/day [13]. Many countries monitor the levels of toxic element in food due to heavy metal toxicity and other serious contamination of foods. However, the potential hazards of metals transferred to humans are probably dependent on amount of muscle consumed by an individual.

Concentration of heavy metals in water sample

The water samples at each sampling point were also taken and analyzed by using ICP-OES. The physio-chemical properties of the water samples were recorded in the Table 2.

Table 2. The physio-chemical properties of water of lake of Taman Mutiara, Puchong

Sampling point	pH	Temperature (°C)	Dissolved Oxygen (%)
S1	7.44 - 8.01	31.51-32.17	0.37-0.43
S2	7.38 - 7.85	30.35-31.28	0.75-0.83
S3	7.28 - 8.47	31.55-31.88	1.08-1.27

The pH values of this study (7.28 to 8.01) were in the range of a previous study in Bhopal [8] where the pH values of water were alkaline (7.2 - 9.8). According to the report, these pH values might be attributed to sewage water discharge into the lake, which was similar to this study (discharge from the sewage treatment plant). The temperatures were in the range of 30.42 °C to 32.17°C and varied at the three points depending on the surrounding factors such as vegetation. The dissolved oxygen concentrations of the water were very low where the value ranges from 0.37 to 1.27 mg/L, which were lower than of those in the previous studies at 2.2 to 13.6 mg/L and 7.11 to 8.33 mg/L respectively [8, 14]. Oxygen depletion might suffocate the fish and other oxygen-consuming organisms, hence resulting in devastating effects on fish populations.

Equivocally, the concentration of Al, As, Cd, Cu, Fe, Pb and Zn was very low and below the detection limit. This however is in agreement with a study in Turkey, where the concentration of heavy metals in fish was high even the concentration of heavy metals in the water was low [15]. In normal metabolism, fish may uptake heavy metals from water, food or sediment. However, the efficiency of metal uptake from contaminated water may differ in relation to ecological needs, metabolisms, and the contamination gradient of water, food and sediment as well as other environmental factors such as salinity, temperature and interacting agent. Ecological factors such as season, place of development, nutrient availability and temperature of water may cause inconsistency of metals concentration in the flesh of the fish [13].

Other factors that affect the fish mortality

Besides heavy metals from the previous mining operation, the nearby sewage treatment plant and the illegal waste dumping near the lake were the plausible causes of the dead fish cases. Inorganic tin compounds may be bioconcentrated by organisms, but data are limited [16]. Toxic compound from the treatment plant could also be the culprit, that originates from industrial and commercial sources, stormwater, and inflow and infiltration from cracked pipes and leaky manhole covers.

The sampling location also showed signs of eutrophication during the study, in which it was covered by dead aquatic vegetations. Nutrients and organic matter could be from the treated sewage flowing into the lake. This somehow affected the availability of dissolved oxygen and pH.

Conclusion

The highest concentration of heavy metals determined in the (*Tilapia sp.*) fish samples from the lake of Taman Mutiara, Puchong was Fe (31.93 to 743 mg/kg) followed by Al (15.39 to 320.6 mg/kg), Zn (Zn: 45.52 to 86.08 mg/kg) and Cu (0.17 to 20.78 mg/kg). However, the concentrations of As, Cd and Pb determined were very low and below the detection limit. Apparently, the heavy metals concentrations were determined highest at S1 followed by S2 and S3, which showed that the discharge from the sewage treatment plant to the lake might be the contributor of heavy metal accumulation and other possible pollutants in the fish samples. The concentrations of heavy metals in the water were very low and below the detection limit. The dissolved oxygen concentrations were very low (1.20 – 1.48 mg/L) and the pH was between 7.28 to 8.47, presumably due to the sewage discharge into the lake.

Most of the metal levels were lower than the maximum permissible limits of Malaysian Food Act, 1983 (Malaysian Food and Drug Regulation). The heavy metals concentrations in the fish sample might not be the cause of the massive floating fish. However, bioaccumulation process may cause the concentration of the heavy metals in the fish muscle become higher in the future and may kill the fish in the lake. Another possible factor that contributes to the dead fish in the lake is eutrophication, in which the lake surface was covered by aquatic plants within two months, hence causing lower concentrations of dissolved oxygen in the water bodies.

Acknowledgement

The authors would like to thank the Subang Jaya Municipal Council (MPSJ) for providing information and resources to carry out the study.

References

1. Mendil, M., Uluozlu, O.D, Hasdemir, E, Tuzen, M, Sari, H and Suicmez, M. (2005) Determination of trace metal levels in seven fish species in lake in Tokat, Turkey, *Food Chemistry*, 90 (1-2), pg. **175-179**.
2. Agbozu, I.E, Ekweozor, I.K.E, Opuene, K (2007) Survey of heavy metals in the catfish *Synodontis clarias*. *Int. J. Environ. Sci. Tech.*, 4 (1): 93-97, 20.
3. Wang, W.X (2002) Interactions of trace metals in different marine food chains, *Marine Ecology Progress Series* 243, 295-309.
4. Mohamed, F.A.S and Gad N.S (2008) Environmental pollution-induced biochemical changes in tissues of *Tilapia zilli*, *Solea vulgaris* and *Mugil capito* from Lake Qarun, Egypt. *Global Veterinaria* 2(6), 327-336.
5. Al-Weher, S.M (2008) Levels of heavy metals (Cd, Cu and Zn) in three fish species collected from Northern Jordan Valley, Jordan, *J of Biological Sciences*, Vol 1, pp 41-46.
6. Reitz, B., Heydorn, K., Pritzl, G. (1996). Determination of aluminium in fish tissues by means of INAA and ICP-MS. *J of Radioanalytical and Nuclear Chemistry* 216(1), 113-116.
7. Zyadah, M.A (1999) Accumulation of some heavy metals in *Tilapia zilli* organs from Lake Manzalah, Egypt. *J.Zoology*, 23, 365-372.
8. Malik, N; Biswas, A.K.; Qureshi, T.A; Borana, K and Virha, R. (2008) Bioaccumulation of heavy metals in fish tissues of a freshwater lake of Bhopal, *Environ Monit Assess*, 160(1-4):267-276.
9. A.K. Ahmad and M. Shuhaimi-Othman, 2010. Heavy Metal Concentrations in Sediments and Fishes from Lake Chini, Pahang, Malaysia. *J of Biological Sciences*, 10: 93-100.
10. Nussey, G., Vuren, J., and Preez, H. (2006). Bioaccumulation of chromium, manganese, nickel and lead in the tissues of moggel, *Labeo umbratus* (Cyprinidae), from Withbank Dam, Mpumalanga. *Water SA*. 26 (2) 269-284.
11. Klavins M., Potapovics O., Rodinov V. (2009) Heavy Metals in Fish from Lakes in Latvia: Concentrations and Trends of Changes. *Bulletin of Env Contamination and Toxicology*. Vol. 82, pp 96–100.
12. Abdel-Satar, A.M and Geneid, Y.A., (2009) Evaluation of Heavy Metal Status in Ecosystem of Lake Manzalah, Egypt. *Global Journal of Environmental Research* 3 (3): 194-204.
13. Irwandi, J and Farida, O (2009) Mineral and heavy metal contents of marine fin fish in Langkawi Island, Malaysia. *International Food Research Journal* 16: 105-112.
14. Olaifa, F. G.; Olaifa, A. K.; Onwude, T. E., (2004). Lethal and sublethal effects of copper to the African Cat fish (*Clarias gariepinus*). *Afr. J. Biomed. Res.*, 7, 65-70.

15. Öztürk,M., Özözen,G., Minareci,O., Minareci, E. (2009) Determination of heavy metals in fish, water and sediments of Avsar Dam Lake in Turkey, *Iran. J. Environ. Health. Sci. Eng.*, 2009, Vol. 6, No. 2, pp. 73-80.
16. Howe, P and Watts, P. (2005) Tin and inorganic tin compounds. United Nations Environment Programme, International Labour Organisation, World Health Organization.

Uncorrected Proof