A TEMPORAL STUDY OF SELECTED METALS CONCENTRATION IN FISHES OF LAKE CHINI, PENINSULAR MALAYSIA

(Satu Kajian Temporal Kepekatan Logam Terpilih Dalam Ikan di Tasik Chini, Semenanjung Malaysia)

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Abstract

Heavy metals concentration in fishes of Lake Chini was monitored for within a span of the years in 1990, 1999 and 2000. Fishes in the lake are taken by indigenous and local people as part of their diet, therefore necessary to determine metal concentrations in fish. A total of nine fish species were analysed for lead (Pb), zinc (Zn), copper (Cu) and cadmium (Cd) concentration in fish tissues. The extraction procedure follows that carried out by Agemian et al, (1984), while the preparation, extraction and metal determination were done following standard method (APHA, 1985). The metals concentration in fish tissues was lower than the maximum allowable concentration in Malaysian food guideline (Malaysian Food Act, 1983). The mean concentration for Pb, Zn, Cu and Cd in fish tissues are 0.56 ± 0.28 mg/kg, 3.02 ± 0.78 mg/kg, 0.38 ± 0.31 mg/kg and 0.18 ± 0.07 mg/kg respectively. Although little variation of concentrations was detected from different species, the variation was not significant. One-way ANOVA test indicates that metals concentration were not significant different between sampling date ($p > 0.05$). Lake Chini was characterised as having a low Pb, Zn, Cu and Cd concentrations in fish and is considered save for local consumption.

Keywords: Lake Chini, Heavy metal, Aquatic Pollution, Biosentinel

Abstrak

Kepekatan logam berat di dalam ikan di Tasik Chini telah dipantau bermula pada tahun 1990, 1999 dan 2000. Ikan di tasik telah digunakan oleh penduduk asli dan tempatan sebagai sebahagian daripada makanan harian, oleh itu adalah penting untuk menentukan kepekatan logam berat di dalam ikan di tasik ini. Sebanyak sembilan spesies ikan telah ditentukan kepekatan logam berat plumbum (Pb), zink (Zn), kuprum (Cu) dan kadmium (Cd). Kaedah penghadaman tisu ikan dilakukan mengikut Agemian et al., (1984), manakala persediaan, ekstraksi dan penentuan kepekatan logam berat dilakukan mengikut panduan APHA (1985). Kepekatan logam berat kajian didapati lebih rendah berbanding dengan garis panduan kepekatan maksimum yang dibenarkan di dalam makanan di Malaysia (Akta Makanan Malaysia, 1983). Kepekatan purata untuk Pb, Zn, Cu dan Cd dalam ikan adalah are 0.56 ± 0.28 mg/kg, 3.02 ± 0.78 mg/kg, 0.38 ± 0.31 mg/kg and 0.18 ± 0.07 mg/kg. Walaupun terdapat variasi nilai kepekatan logam berat diantara spesies ikan, ianya adalah tidak bermakna. Hasil ujian ANOVA satu hala menunjukkan kepekatan logam berat di dalam ikan adalah tidak berbeza dengan bermakna diantara tarikh persampelan ($p > 0.05$). Tasik Chini boleh dikatakan mempunyai kepekatan Pb, Zn, Cu dan Cd yang rendah dan pengambilan ikan sebagai sumber protein adalah selamat.

Kata kunci: Tasik Chini, logam berat, pencemaran akuatik, biosentinel

Introduction

Freshwater fishes likes marine water fishes play major role in determine citizen diet. In circumstances, some freshwater fishes such as Malaysian masheer (*Tor tambroides*), cat fish (*Pungasius* spp) and (*Hemibragus nemurus*) becoming more demand and expensive than marine fishes.

Recently, heavy metal pollutions in aquatic ecosystem are becoming critical issues. Metals in aquatic ecosystem can be transported and transmits into different media easily. The percolation of rainwater through chat piles mobilizes metals into solution, which flows into local ponds. Fish as second or third consumers in aquatic food web have significant potential to accumulate higher metals in body. The consumption of fish containing elevated levels of metals is a concern because chronic exposure to heavy metals can cause health problems. Chronic lead exposure has been linked to anemia, neurological dysfunction and renal impairment. Chronic cadmium exposure has been

linked to renal damage, hypertension, and cardiovascular effects. Although zinc is an essential nutrient required for proper growth and development, the presence of zinc can affect the body's metabolism of other metals.

Heavy metals transported into lakes through various sources such as through air and streams and sink to the bottom and are deposited on the lake bed. New pollution is deposited on top of layers of older sediments. This will affect all aquatic organisms that live within the ecosystem. Fish as higher consumers in aquatic food web have high risk to be exposed to the metal pollutions. Metals can be taken into fish through respiration, direct absorption and feeding. They provide a picture of emission trends at different time periods.

Lake Chini is one of natural formed lakes in Malaysia and is located in the state of Pahang. The lake connected with Pahang River through Chini River and serve as important wetland ground for fish breeding and nursery. It has been reported to support approximately 84 freshwater fishes [4]. Fish caught from this lake constitute a significant portion of the diets especially for native peoples. Since Lake Chini is one of famous tourism destination, it possible to be exposed to the pollution due to human activities.

This study was initiated to determine temporal metals concentration trend in fishes of Lake Chini. The first study was done in 1990 and repeated by another studies in 1999 and 2000. The aim of this study was to determine the level of Pb, Zn, Cu and Cd in fish tissue to estimate the metals pollution and safety of taking the fish as part diet.

Experimental

Study Area

Lake Chini is the second largest natural lake in Peninsular Malaysia, which located in the state of Pahang. The lake connected to the nearest river (Pahang River) through Chini River that is approximately 4.8 km length (Figure 1). The area of the lake is ranges from 150 ha to 300 ha depend on the season. Lake Chini has approximately 4 x 10^6 to 7 x 10^6 m^3 volume of water and means inflow is from 0.46 to 3.53 m^3/s [1]. This lake is surrounded by undulating land and receives water sources from seven feeder rivers. Some areas of forest have been developed for the oil palm plantation, mining and small scale agriculture. Recently, many parts of the Lake Chini's forest have been cleared to enhance the oil palm plantation and recreational activities. Several major potential pollution sources to this lake are come from agricultural, ex-mining, logging, tourism and local communities' activities. Pollutants likes heavy metals which contributed from previous mentioned sources could be transported through various feeder rivers or directly contributed into the lake. Boating activity for tourism for example, could lead to introduction to input of lead (Pb) into the lake. Study was undertaken within the whole lake for duration of ten years.

Method

Sampling was done using either gill net or cast net, wherever is possible. Gill net was setup at the open water (deeper water) and casting was used at the shallow water. Collected fish was measured for the physical characteristic namely weight and length to estimate their age. Fish samples from various species were grouped into the same age according to their size and weight.

A sufficient number of fish was prepared for each species (more than 5 individuals) and three replicates were set for each species. Prior to analysis, all fishes were rinsed thoroughly with deionised water to remove any dirt and mucus since metals are found in both the mucus and scales of fish. Only stainless steel cutting were used and preparation surfaces were sheeted in polyethylene. All materials used in this procedure were acid soaked (10% nitric acid) for at least 24 hours and rinse thoroughly with deionised water.

Fishes were skinned and filleted. Only boneless tissues were collected for the analysis. Some of freshwater fish have small bone within the tissues and care was given not to include this part. The collected tissues were than mixed using commercial grade food grinder to produce homogeneous mix tissues. Each species has been prepared for three replicates.

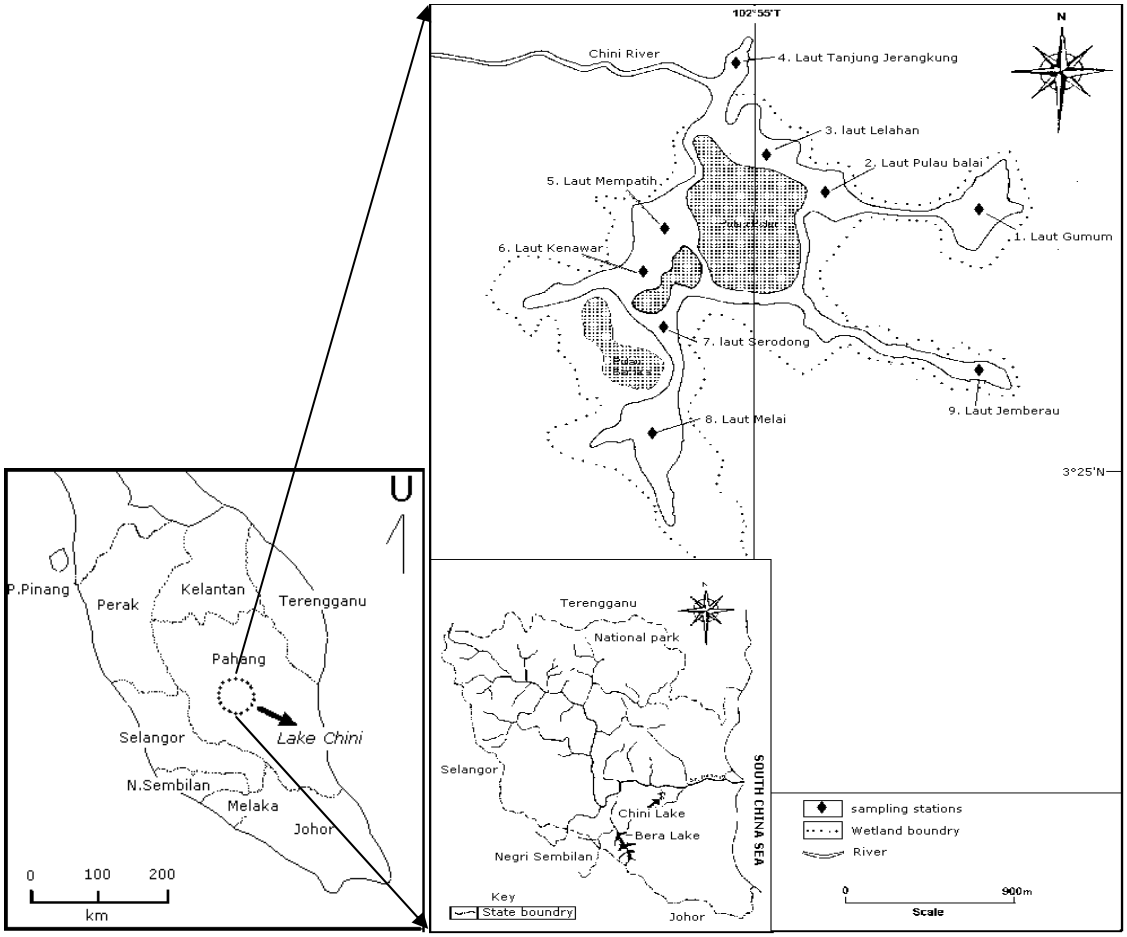


Figure 1: Malaysia Peninsular and location of Lake Chini

The tissues extraction was undertaken according to the Agemian et al [2]. The wet digestion was undertaken on the hot plate. 10 grams of fish tissues were digested with concentrated nitric acid (70%) in PTFE beaker and heated on the hot plate at 80°C until a clear yellowish solution produced. All tissues at that time were dissolved into the HNO_3. The mixture allowed reaching room temperature prior to the filtration. The mixtures were filtered through 0.45 µm pore size filter paper and final solutions were set for 100 ml. Lead (Pb), zinc (Zn), copper (Cu) and cadmium (Cd) were determined using atomic absorption spectrophotometric AAS 1100B model Perkin Elmer. The unit used is mg/kg wet weight.

For the quality assurance purpose, standard reference materials were analysed prior to the analysis. The lobster sample (TORT-2)(National Research Council Canada) was used to confirm the recovery of digestion and analysis. The recovery of preliminary test using above standard reference materials for Pb, Zn, Cu and Cd were 92%, 90%, 95% and 92% respectively.

Result

General

A total of nine species of freshwater fishes were analysed for heavy metals concentration and results were summarised in Table 1. Results are summary of three replicates. Fish collected demonstrates various metals concentration in tissue. Although samples were grouped to approximate similar age (based on weight and length), metal concentrations were varies significantly between species. There are many other factors that influence the rate of accumulation such as locality, type of food and feeding behaviour. Bottom feeding species (demercial) normally accumulate higher rate than pelagic species and times. Sediment is well known act as a sink for metals deposition and these metals easily taken by demercial fishes compared to the pelagic species. All fishes used for the analysis were about at middle age. Their age was estimated using Malaysian Peninsular fish biology book [3].

Lead and zinc were found highest in 1990, in *Labiobarbus festiva* that are 1.06 ± 0.01 mg/kg and 7.41 ± 0.05 mg/kg respectively. Copper and cadmium were found highest in 1999, however in different species. Copper was highest in *Exyleotris marmoratus* (1.40 ± 1.55 mg/kg), and cadmium was in *Notopterus notopterus* (0.31 ± 0.01 mg/kg).

Temporal Variation

Each metal exhibits different temporal pattern, but with approximately similar range of concentration (Figure 2). The fluctuation of metal concentrations temporally may explain the process occurs within the ecosystem. Generally, Pb, Zn and Cu exhibit consistence range of concentration between sampling but Cd was increased gradually.

Lead (Pb)

Lead average concentrations was the lowest in 1999 but increased in 2000 (Figure 2). Although raw data exhibited high variation, lead mean concentration found to be the least in 1999 followed by 1990 and the year of 2000. Although Pb mean concentrations was determined highest in the year of 2000, one-way ANOVA test (Tukey Post-Hoc test) indicates that Pb concentrations was not differ significantly between sampling period ($p > 0.05$, $\alpha = 0.05$).

Zinc (Zn)

The Zn concentration in fish tissues exhibits different pattern as compared to Pb. The concentration of Zn gradually reduce from 1990 to 2000 (Figure 2). The maximum mean concentration is 3.91 mg/kg (1990) and reduced to 1.96 mg/kg (2000). The one-way ANOVA test (Tukey Post-Hoc test) indicates that Zn was only differ significantly between year 1990 to 2000 ($p = 0.004$, $\alpha = 0.05$).

Copper (Cu)

The Cu concentration does not differ clearly between sampling. Although the concentration was less varies between sampling, the minimum concentration was recorded in the year of 2000. The highest mean concentration was recorded in the year of 1999 with the value 0.22 mg/kg. The one-way ANOVA test indicates that Cu was not significantly differ between the sampling occasions ($p > 0.05$, $\alpha = 0.05$).

Cadmium (Cd)

Only Cd was found exhibited increment from 1990 to 2000 and highest in 1999 (Figure 2). The lowest Cd recorded was 1.22 mg/kg in the year of 1990 and the highest was 0.27 mg/kg. The box Whiskes plot demonstrates the isolation of data between sampling date (Figure 2). The result demonstrates the potential of Cd pollution in the lake. The one-way ANOVA test indicates that Cd concentrations was significantly differ between three sampling dates ($p < 0.05$, $\alpha = 0.05$).

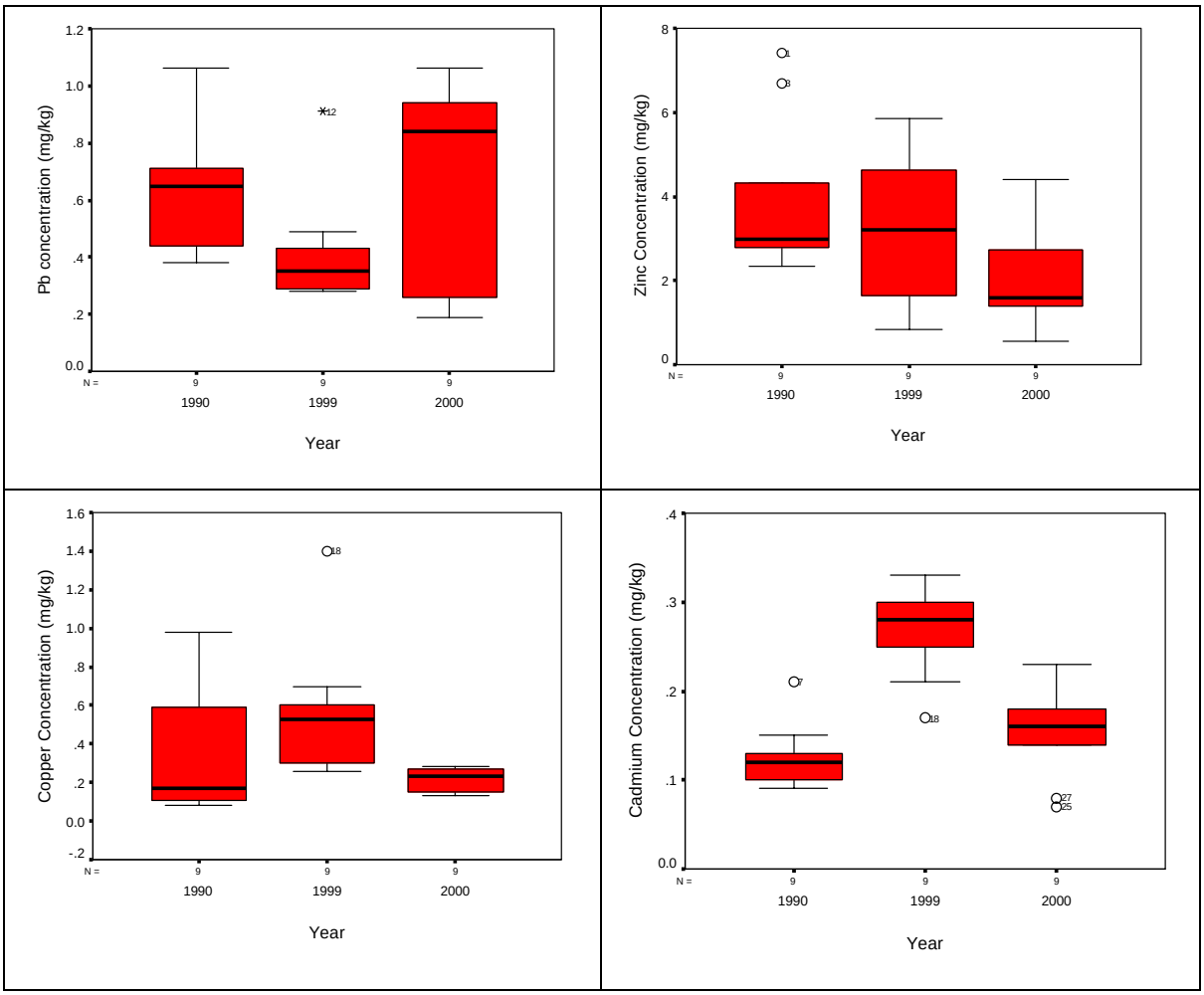
Table 1: Summary of heavy metals concentration in fish tissues

Species	**Year**	**Heavy Metals (mg/kg)**			
		Pb	Zn	Cu	Cd
Labiobarbus festiva	1990	1.06±0.01	7.41±0.05	0.18±0.01	0.12±0.02
	1999	0.28±0.06	0.83±0.01	0.60±0.04	0.28±0.07
	2000	0.19±0.00	1.52±0.01	0.15±0.02	0.16±0.02
Helostoma temmincki	1990	0.39±0.02	4.32±0.14	0.11±0.00	0.09±0.00
	1999	0.49±0.03	1.65±0.04	0.30±0.05	0.29±0.00
	2000	0.84±0.20	0.55±0.00	0.26±0.02	0.23±0.04
Notopterus notopterus	1990	0.74±0.00	6.69±0.15	0.17±0.02	0.15±0.00
	1999	0.91±0.18	4.62±0.11	0.28±0.02	0.31±0.01
	2000	1.06±0.05	0.59±0.03	0.22±0.01	0.15±0.00
Ompok bimaculatus	1990	0.71±0.03	3.23±0.01	0.08±0.01	0.13±0.00
	1999	0.35±0.09	3.12±0.27	0.25±0.03	0.21±0.03
	2000	0.19±0.01	1.40±0.09	0.27±0.00	0.16±0.01
Osphronemus goramy	1990	0.44±0.07	2.79±0.05	0.98±0.01	0.13±0.04
	1999	0.28±0.06	0.83±0.05	0.60±0.14	0.28±0.07
	2000	0.26±0.01	2.75±0.01	0.15±.008	0.20±0.01
Thynnichthys thynnoides	1990	0.45±0.02	2.85±0.02	0.89±0.00	0.10±0.02
	1999	0.29±0.00	5.86±0.08	0.70±0.15	0.30±0.03
	2000	0.88±0.00	1.60±0.00	0.23±0.03	0.18±0.02
Osteochilus haseltii	1990	0.65±0.09	2.62±0.01	0.11±0.01	0.21±0.00
	1999	0.43±0.09	4.65±0.01	0.53±0.01	0.33±0.04
	2000	0.61±0.02	4.40±0.22	0.13±0.01	0.07±0.00
Puntius bulu	1990	0.69±0.01	2.33±0.08	0.17±0.02	0.11±0.01
	1999	0.33±0.12	3.20±3.69	0.31±0.01	0.25±0.04
	2000	0.98±0.005	2.73±0.07	0.28±0.07	0.14±0.01
Oxyleotris marmoratus	1990	0.38±0.01	2.98±0.00	0.59±0.02	0.10±0.00
	1999	0.35±0.02	4.12±0.03	1.40±1.55	0.17±0.13
	2000	0.94±0.01	2.10±0.03	0.28±0.00	0.08±0.00
Maximum Allowable Limits (mg/kg) (Malaysian Food and Drug Regulation, 1985)		2.00	100	30	1.00

Discussion

Result from nine fish species exhibits fluctuation in metals concentration between sampling occasions. Factors such as fish age, feeding behaviour, migration and species could contribute to high data variation. Mean metal concentrations were compared to the Malaysian Food Act, 1983 (Malaysian Food and Drug Regulation 1985). The guideline was produced as guideline for metals concentrations in fish and fish based food. According to the Malaysian Food and Drug Regulation, 1985, maximum allowable concentrations of Pb, Zn, Cu and Cd in food and fish product foods are 2.00 mg/kg, 100 mg/kg, 30 mg/kg and 1.00 mg/kg respectively (Table 1). As far as this study was concerned, none of studied metals exceed the maximum allowable concentrations.

Figure 2: Pb, Zn, Cu and Cd variation in nine fish species from Lake Chini



However, concern should be given to Cd that found increased from 1990 to 2000. Cadmium could contributed into the lake ecosystem by various sources such agriculture (chemical fertiliser), mining and industrial. Unlikely relatively little information is available to confirm the input of Cd into this lake ecosystem. However, a large oil palm plantation surrounding the lake could possibly contribute through seepage, feeder rivers or surface runoff during rainy season [5]. Lake Chini is also receives water from Pahang River during flood season. There are various agricultural and industrial activities along the Pahang River, which could contribute to Cd load. During the monsoon season, water level of Pahang River normally higher than Lake Chini and water flows into the lake and may contribute Cd pollution to the lake.

Cadmium is unessential metal and it presence in ecosystem creates risk of exposure. Although Cd detected in low concentrations, it normally contained in the most mobile fraction in sediment (either exchangeable or carbonate bound) and therefore can easily enter or transported to the food chains [6]. Demercial fishes such as cat fish has high risk to accumulate metals through feeding which finally transported to the human as final consumers. However, more detail study is required to determine metals fate in lake ecosystem. This study reveal that metals such as Cd could contaminate lake ecosystems through various uncontrolled sources and give risk to the aboriginal people that catch fish for their routine meal.

Conclusion

Lake Chini which is one of the natural lake in Malaysia responded to the input of metals pollution from various sources. Although studied metals still below the allowable limit that proposed by Malaysian Government, a continuoul input could possible to cause risk of exposure. The drastic developments of oil palm plantation and other agriculture, logging activities and tourism could possibly enhance metals load into the lake. In addition, the revival of abundance mine nearby could also enhance metals pollution risk in this lake. A continual monitoring and strategic planning by local stake holder will gain the protection of metal pollution into this natural lake.

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