HEAVY METALS IN BIOTIC AND ABIOTIC COMPONENTS IN SERI SERDANG LAKE IN DIFFERENT WEATHER CONDITIONS

KHAIRUNNISA BINTI ABDUL RAHMAN

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By

KHAIRUNNISA BINTI ABDUL RAHMAN

Thesis Submitted to School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Master of Science

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Chairman: Hishamuddin bin Omar, PhD
Faculty: Science

The threat from heavy metal pollution to living organisms is real and heavy metal is known to cause health issues to human particularly. In Malaysia most of the heavy metal studies mainly on the heavy metal content in the tissues but seldom involving the food chain and food web. Therefore a study was carried out to assess the concentration of heavy metals (lead, cadmium, nickel, copper, iron and zinc) in abiotic (water, sediment, rain water) and biotic (phytoplankton, *Vallisneria*, *Valvata tricarinata*, small and big *Oreochromis mossambicus*, Chironomid larvae and *Ardea alba*) components in Seri Serdang Municipal Lake. These components were collected from the inlet (other sources channel into the lake) and outlet (lake water channel to river) of this lake in three different weather conditions which are dry, wet and mixed season. After acid digestion, analysis of metal concentration in these components were assessed by using atomic absorption spectrophotometer (AAS). The highest concentration of metal during dry weather conditions for rain water and lake water were Fe and Ni with concentration of 0.24 µg/g and 5.02 µg/g. Contrast with sediment that has highest concentration of metal (Fe) in wet weather conditions with concentration of 2015.99 µg/g.

In biotic components, aquatic macrophytes, *Vallisneria* is the highest component that has high value of metals; Fe, than other components with concentration of 1775.81 µg/g during dry weather conditions. Furthermore, the highest concentration of metals in big *Oreochromis mossambicus* was Fe with value of 335.18 µg/g during weather conditions. *Ardea alba* also has highest concentration of metal in dry weather condition which was Fe (166.75 µg/g).

In general the results showed that heavy metal in the dry conditions were significantly higher than wet and mixed condition, while components from inlet have higher concentrations than the outlet. The sequence of metal concentration in sediment at inlet point during dry condition was Fe>Zn>Cu>Ni>Pb>Cd. From the food web of this lake, three of food chain were identify. In food chain 1, from *Vallisneria* to small and big

Oreochromis mossambicus are mostly the metals experiencing dilution in both inlet and outlet point. However for non essential metals; Pb, Ni and Cd have the higher value especially Cd and most of it occurred at the outlet point during dry, wet and mixed conditions. Furthermore, from small and big *Oreochromis mossambicus* to *Ardea alba*, all metals concentration were increased at inlet and outlet point for all these weather conditions. This magnified pattern in *Ardea alba* also occurred in food chain 2 and 3 for dry, wet and mixed weather conditions respectively. Confirmation with experimental data showed the higher organism (*Ardea alba*) in trophic level in food chain has been carrying the metals from lower level by biomagnification process. In actual ecosystem or environment, biomagnification and biodilution can happen concurrently or sequentially affecting the relationship and distribution pattern. The concentration of metals were significantly higher during dry weather conditions compared to the other weather conditions. Water temperature has some affects on aquatic organisms; high water temperatures can increase solubility and therefore toxicity of certain compounds. Therefore when the heavy metals in Seri Serdang Lake ecosystem increased biomagnification process through food chain/food web caused the organism at the higher trophic level to have elevated heavy metal.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia
sebagai memenuhi keperluan untuk ijazah Sarjana Sains

STATUS LOGAM BERAT ABIOTIK DAN BIOTIK KOMPONEN DI TASIK SERI SERDANG DALAM KEADAAN PERBEZAAN CUACA

Oleh

KHAIRUNNISA BINTI ABDUL RAHMAN

Januari 2018

Pengerusi: Hishamuddin bin Omar, PhD
Fakulti: Sains

Ancaman dari pencemaran logam berat kepada organisma hidup adalah nyata dan logam berat diketahui punca terutamanya masalah kesihatan kepada manusia. Di Malaysia kebanyakan kajian logam berat terutamanya mengenai kandungan logam berat dalam tisu tetapi jarang melibatkan rantaian makanan dan web makanan. Oleh itu, satu kajian dijalankan untuk menilai kepekatan logam berat (plumbum, kadmium, nikel, tembaga, besi dan zink) dalam abiotik (air, sedimen, air hujan) dan biotik (phytoplankton, *Vallisneria, Valvata tricarinata, Oreochromis mossambicus,* kecil dan besar , larva Chironomid dan *Ardea alba*) di Tasik Perbandaran Seri Serdang. Komponen ini dikumpulkan dari saluran masuk (saluran sumber lain ke dalam tasik) dan saluran keluar (saluran air tasik ke sungai) tasik ini dalam tiga keadaan cuaca yang berbeza, musim kering, basah dan campur. Selepas penghadaman asid, analisis kepekatan logam dalam komponen ini dinilai dengan menggunakan spektrofotometer serapan atom (AAS). Kepekatan tertinggi logam semasa keadaan cuaca kering untuk air hujan dan air tasik ialah Fe dan Ni dengan kepekatan 0.24 µg / g dan 5.02 µg / g. Berbanding dengan sedimen yang mempunyai kepekatan tertinggi iaitu logam (Fe) dalam keadaan cuaca basah dengan kepekatan 2015,99 µg / g.
Dalam komponen biotik, makrofiit akuatik, *Vallisneria* adalah komponen yang mempunyai nilai logam yang paling tinggi; Fe, daripada komponen lain dengan kepekatan 1775.81 µg / g semasa keadaan cuaca kering. Selain itu, kepekatan tertinggi logam dalam *Oreochromis mossambicus* besar adalah Fe dengan nilai 335.18 µg / g semasa keadaan cuaca. Ardea alba juga mempunyai kepekatan tertinggi logam dalam keadaan cuaca kering iaitu Fe (166.75 µg / g).

Secara umum keputusan menunjukkan bahawa logam berat dalam keadaan kering jauh lebih tinggi daripada keadaan basah dan campuran, manakala komponen dari saluran masuk mempunyai kepekatan yang lebih tinggi daripada saluran keluar. Urutan kepekatan logam dalam sedimen pada saluran masuk semasa keadaan kering ialah Fe> Zn> Cu> Ni> Pb> Cd. Dari web makanan tasik ini, tiga rantaian makanan telah dikenalpasti. Dalam rantaian makanan 1, dari *Vallisneria* ke *Oreochromis mossambicus*

kecil dan besar kebanyakannya logam yang mengalami pencairan di kedua-dua saluran masuk dan keluar. Walau bagaimanapun untuk logam *non essential*; Pb, Ni dan Cd mempunyai nilai yang lebih tinggi terutamanya Cd dan kebanyakannya berlaku di saluran keluar semasa keadaan kering, basah dan bercampur. Tambahan pula, dari *Oreochromis mossambicus* kecil dan besar ke *Ardea alba*, semua kepekatan logam meningkat di saluran masuk dan keluar bagi semua keadaan cuaca ini. Corak yang diperbesarkan di *Ardea alba* juga berlaku dalam rantaian makanan 2 dan 3 untuk keadaan cuaca kering, basah dan bercampur. Pengesahan dengan data eksperimen menunjukkan organisma yang lebih tinggi (*Ardea alba*) di peringkat trofik dalam rantaian makanan telah membawa logam dari tahap yang lebih rendah melalui proses biomagnifikasi. Dalam ekosistem atau persekitaran sebenar, biomagnifikasi dan biodilution boleh berlaku secara serentak atau menjejaskan corak hubungan dan pengedaran. Kepekatan logam adalah lebih tinggi semasa keadaan cuaca kering berbanding dengan keadaan cuaca yang lain. Kesan suhu air memberi kesan kepada organisma akuatik di mana suhu air yang tinggi dapat meningkatkan kelarutan dan oleh itu keracunan sebatian tertentu. Logam berat di Tasik Seri Serdang ini telah meningkat kepada ekosistem melalui proses biomagnifikasi di rantai makanan di mana organisma yang tertinggi di rantai makanan akan mempunyai kepekatan logam berat yang lebih tinggi.

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This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Master of Science.

The members of the Supervisory Committee were as follows:

Hishamuddin bin Omar, PhD
Senior Lecturer
Faculty of Science
Universiti Putra Malaysia
(Chairman)

Ahmad bin Ismail, PhD
Professor
Faculty of Science
Universiti Putra Malaysia
(Member)

____
ROBIAH BINTI YUNUS, PhD
Professor and Dean
School of Graduate Studies
Universiti Putra Malaysia

Date:

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Signature: ___________________________
Name of
Chairman of Supervisory Committee: Dr. Hishamuddin Bin Omar

Signature: ___________________________
Name of
Member of Supervisory Committee: Prof. Dr. Ahmad Bin Ismail

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%	Percent
°C	Celcius
Ag	Silver
Al 3^{+} ,	Aluminium (III) ion
AMD	Acid mine drainage
As	Arsenic
Au $^{+}$	Gold (I) ion
BAF	Bioaccumulation factor
BMF	Biomagnification factor
Cd	Cadmium
Cd 2^{+}	Cadmium (II) ion
CI	Confidence intervel
cm	centimeter
Co	Cobalt
Co 2^{+}	Cobalt (II) ion
Cr	Cromium
Cr 3^{+}	Cromium (III) ion
Cu	Copper
Cu $^{+}$	Copper (I) ion
Cu 2^{+}	Copper (II) ion
Fe	Ferum
Fe 2^{+}	Ferum (II) ion
Fe 3^{+}	Ferum (III) ion
g	Gram
$HCIO_4$	Perchloric acid
Hg	Mercury
Hg 2^{+}	Mercury (II) ion
HNO_3	nitric acid
kg/ha/year	kilogram/hectare/year
L	Liter
LC_{50}	Lethal Concentration
mg	miligram

Mn	Manganese
$Mn\ 2^{+}$	Manganase (II) ion
Mo	Molybdenum
Ni	Nickel
$Ni\ 2^{+}$	Nickel (II) ion
Pb	Lead
$Pb\ 2^{+}$	Lead (II) ion
Sb	Antimony
$Sn\ 2^{+}$	Tin (II) ion
t/per/year	tonne per year
U	Uranium
V	Vanadium
W	Tungsten
Zn	Zinc
$Zn\ 2^{+}$	Zink (II) ion

CHAPTER 1

INTRODUCTION

1.1 Study Background

In recent times, mother earth is facing serious environmental issues such as various kinds of pollution, environmental degradation and global warming. All the above does not act alone but work in cycle creating even more devastation effect to the environment. For example air pollution and soil pollution eventually ends up in water adding the effect of water pollution. Global warming produces acid rain which then turns leached out mineral and heavy metals from the soil and substrates and eventually ends up in water (Horne and Goldman, 1994). The water will become more acidic and contains more minerals and heavy metals. The acidic nature of water will affect the speciation of heavy metal, its characteristic and availability to the flora and fauna in the water bodies (Taweel *et al*. 2013).

Heavy metals can be categorized as essential and non essential heavy metals. The most dangerous heavy metals is non essential heavy metals such as Pb, Cr, Hg, Ni, Cd and etc (Tongesayi et al., 2013). Though heavy metals can occur naturally, some of them accumulated to high level due to human activities that have deleterious effect to living organisms (Tongesayi et al. 2013). These heavy metals are readily available to the organisms, transferred across the trophic level and magnified through food chain (Kidd et al. 2012).

Some of amounts of heavy metal from drinking water, food and the air with very low levels generally have no adverse effect and some cases can be beneficial, example essential to maintain the metabolism of the human body (Kidd et al., 2012). However, human activities from industry (such as smelting, mining), commercial, agricultural land-use and run-off from urban increase the concentration of metals in the environment, and potentially to high levels and could have adverse effects related in food chain.

1.2 Problem Statement

The most disturbing issues are how this metal is accumulated, magnified and transferred to upper trophic levels. As seen, all those activities closely related in food web where are influenced by the trophic level of organism and it is a serious issue that must be to consider. Although the initial concentration in the environment might be low but through biomagnifications, the levels can reach to dangerous level that might harm the biological function of organism. Additionally, heavy metal is stable and cannot be destroyed (Kidd et al., 2012), so they tend to accumulate in water, sediment, benthos and the atmosphere, and it is affect to biotic and abiotic components.

However the heavy metals in food chain are less studied. Most of the present study concern with heavy metal in organism, soil, water, plant and sediment only but a few that concern about heavy metals in food chain. The study of heavy metal in food chain includes how metal transfers in organism and increases in biomagnification that effect and spreads particularly in food chain of organisms, benthos, humans, environmental surroundings and an in ecosystem. Another study is using organism as biological indicator.

Concentration of heavy metal will be increase when the biomagnification increase, and the higher organism in food chain have higher concentration of this toxicity. The effects of this contaminated can be acute and chronic effect depends to concentration or dose and also time scale of toxicity react in organism. The biomagnification factor of heavy metal in each trophic level may identify and measure to know the status of concentration of heavy metal.

Environmental health study is used to indicate whether the environment is healthy or not which includes water, air, land, animals and also human. In this study, it is important to identify the water quality and factors those affecting environmental health which are aquatic life and also ecosystem related particularly in food chain. This problem occurs due to pollution in the ecosystem that have adverse effect whether acute or chronic effect.

Distribution of heavy metal in food chain could be identified which the concentration of heavy metal in each biotic and abiotic will be defined and both are related in an ecosystem (EPA, 2014). This study differs from previous studies especially in Malaysia because its take into account the heavy metals content in the water, sediment, phytoplankton, fish, aquatic plant and benthos in the study area. This is the beginning of heavy metal study in the food chain of a particular ecosystem although still at the early stages.

Therefore, we must look heavy metal in a holistic way especially the introduction of heavy metal to the environment, how much is deposited to the substrate and how many is uptake by the flora and fauna.

1.3 Objectives

The objectives of this study are

1) To assess the concentration of selected heavy metals (lead, cadmium, nickel, copper, iron and zinc) in abiotic and biotic components in Taman Seri Serdang Municipal Lake.
2) To identify heavy metals status in food web of Seri Serdang Municipal Lake.
3) To identify transformation of heavy metals, laboratory study of heavy metal transport in freshwater food chain.
4) To identify selected biotic and abiotic components of the lake in relation to the influence of weather conditions

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