CONCENTRATION OF NICKEL AND CADMIUM IN TWO AQUATIC PLANTS, *TYPHA* SP. AND *EICHORNIA CRASSIPES*, IN THE LIKAS LAGOON WETLANDS, KOTA KINABALU

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I hereby declare that this dissertation is based on my original work, except for quotations and summaries each of which have been fully acknowledged.

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ABSTRACT

The concentration of nickel and cadmium in *Typha* sp. and *Eichornia crassipes* and the parts of the macrophytes which concentrate the highest level of heavy metal were studied. The concentration of the heavy metals in macrophytes and various plant parts of macrophytes were determined using the atomic absorption spectroscopy (AAS). The average concentration of nickel in *Typha* sp. was 184.0mg/100g dry wt and in *E. crassipes* was 80.7mg/100g dry wt. The average concentration of cadmium in *Typha* sp. was 81.4mg/100g dry wt and in *E. crassipes* was 25.6mg/100g dry wt. The average concentration of nickel in *Typha* sp. roots was 223.8 mg/100g dry wt and in its leaves was 184.5 mg/100g dry wt, and in *E. crassipes* roots was 78.0 mg/100g dry wt and in its leaves was 64.0 mg/100g dry wt. The average concentration of cadmium in *Typha* sp. roots was 90.5 mg/100g dry wt and in its leaves was 69.5 mg/100g dry wt, and in *E. crassipes* roots was 28.9 mg/100g dry wt and its leaves was 5.4 mg/100g dry wt. In summary, *Typha* sp. accumulated higher nickel and cadmium concentration than *Eichornia crassipes*. *Typha* sp. roots accumulated higher nickel and cadmium concentration than its leaves and *E. crassipes* roots and its leaves.

KANDUNGAN NIKEL DAN KADMIUM DALAM DUA TUMBUHAN AKUATIK, TYPHA SP. DAN EICHORNIA CRASSIPES, DI LIKAS LAGOON, KOTA KINABALU

ABSTRAK

Kajian analisis penentuan kandungan nikel dan kadmium dalam Typha sp. *dan Eichornia crassipes dan bahagian-bahagian tumbuhan tersebut telah dijalankan. Kandungan nikel dan kadmium dikaji dengan menggunakan spektroskopi penyerapan atomik (*AAS*). Hasil kajian menunjukkan bahawa Typha* sp. *mengandungi purata kandungan nikel sebanyak 184.0 mg/ 100g dry wt. dan E. crassipes mengandungi 80.7 mg/ 100g dry wt. Hasil kajian juga menunjukkan bahawa Typha* sp. *mengandungi purata kandungan kadmium sebanyak 81.4 mg/ 100g dry wt. dan E. crassipes mengandungi 25.6 mg/ 100g dry wt. Purata kandungan nikel dalam akar Typha* sp. *ialah 223.8 mg/ 100g dry wt., dalam daunnya ialah 184.5 mg/ 100g dry wt., dan akar E. crassipes ialah 78.0 mg/ 100g dry wt. dan dalam daunnya ialah 64.0 mg/ 100g dry wt. Purata kandungan kadmium dalam akar Typha* sp. *ialah 90.5 mg/ 100g dry wt., dan dalam daunnya ialah 69.5 mg/ 100g dry wt., dan akar E. crassipes ialah 28.9 mg/ 100g dry wt. dan dalam daunnya ialah 5.4 mg/ 100g dry wt. Pendek kata, Typha* sp. *mempunyai kandungan nikel dan kadmium yang lebih tinggi daripada E. crassipes. Akar Typha* sp. *mempunyai kandungan nikel dan kadmium lebih tinggi daripada daunnya, dan akar E. crassipes dan daunnya.*

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LIST OF SYMBOLS

m^2	meter square
m^3	meter cube
cm	centimeter
mg	milligram
kg	kilogram
dry wt	dry weight
v/v	volume of solution per volume of water
1+1	volume of solution plus volume of water
mL	milliliter
g	gram
µg	microgram
ppm	parts per molecule
AAS	Atomic Absorption Spectroscopy
Zn	Zinc
Cd	Cadmium
Ni	Nickel
Cu	Copper
Etc	et cetera.
Pb	Lead
Mn	Mangan
Cr	Chromium
Ag	Silver
Co	Cobalt

CHAPTER 1

INTRODUCTION

1.1 Background

1.1.1 Heavy Metals in Water Bodies

Heavy metals mostly are chemical waste or factory waste from industry that will pollute our water bodies like lake, river, streams, lagoon and others. Normally, heavy metals include copper (Cu), nickel (Ni), cadmium (Cd), lead (Pb) and others. The heavy metals normally exist as solvent or ion in water bodies such as copper sulfate. Heavy metals mostly come from factory of all fields. Heavy metals cannot be biodegraded easily and they will exist in water bodies as long as possible until they have been absorb, eaten by other organism, adsorb in sediment or rocks, go through redox process to change to other molecule or others (Shutes *et al.*, 2001). Most of the heavy metals are toxic and dangerous that will lead to multiple dreadful side effects to organism because they are lethal. The side effect will become serious through series of food chain magnification (Miretzky *et al.*, 2004). The highest user in the food chain or the user in the highest position of the food chain will be affected the most because they will accumulate the heavy metals through all kind of media and food. This incident become more serious and many chemical and biological methods have been done to purify and remediate the polluted water bodies to remove heavy metals from water bodies.

1.1.2 Phytoremediation

There are many methods that can be used to remediate polluted water bodies and one of the most efficient and effective way is phytoremediation. Phytoremediation is a method to remove heavy metals by using aquatic plants or macrophytes to remove pollutant from water bodies (Osmolovskaya & Kurilenko, 2005). Phytoremediation uses plants to absorb or remove pollutants from targeted areas such as water bodies or change the pollutants into harmless elements. This method has a minimum cost because it only needs the most suitable species of plants to do the job of remediation. It is also more efficient and effective because more than 75%-90% of heavy metals can be extracted and remove from the water bodies (Sinha & Chandra, 1990). It is also environmentally friendly because it does not produce any harmful byproducts to the environment (Gonzaga *et al.*, 2006). They are three kinds of phytoremediation namely phytoextraction, phytostabilization and phytoimmobilisation (Gonzaga *et al.*, 2006).

(i) Phytoextraction: This method uses plants as hyperaccumulators to absorb and translocate the pollutant into plant units and store them. They have very high tolerance abilities to store high concentration of certain heavy metals (Gonzaga *et al.*, 2006).

(ii) Phytostabilization: This method uses plants that have very high tolerance abilities to stabilize pollutants mechanically and turn the pollutants into harmless and non-toxic elements (Gonzaga *et al.*, 2006).

(iii) Phytoimmobilisation: This method uses plants to reduce the mobility and bioability of the pollutants by combining the pollutants with other elements to immobilize those heavy metals (Gonzaga *et al.*, 2006).

1.1.3 Macrophytes as hyperaccumulator

Macrophytes are effective phytoremediation agents and they are mostly very effective and efficient hyperaccumulators (Blake, 1994). Aquatic plants such as duckweed have been used as experimental subject by many scientists (Blake, 1994). In some countries, they practice phytoremediation by using duckweed to do water treatment and heavy metals removal works. This is because duckweed is easy to culture and they can grow very fast and a lot. Duckweeds are tolerant to serious water quality (Blake, 1994). Macrophytes can be categorized into three main categories according to their location in the water bodies. They are submerged, emerged and free-floating macrophytes (Williams, 1983).

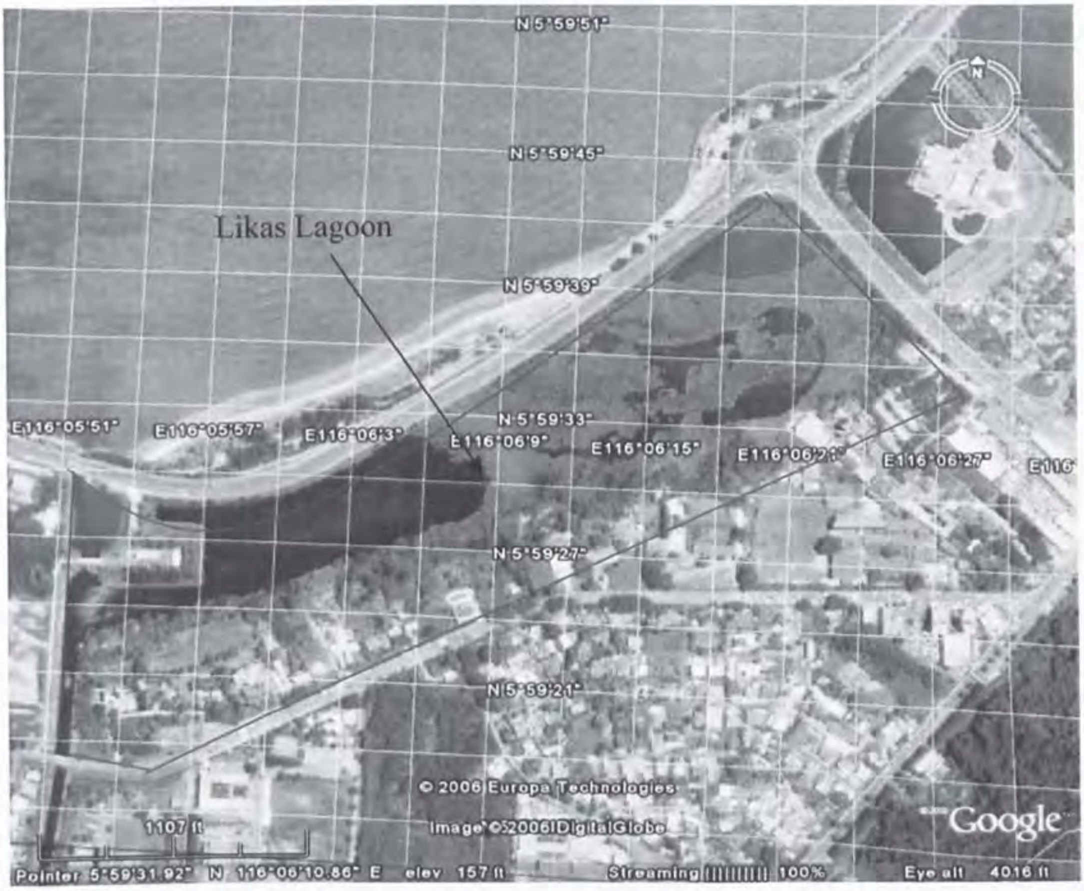
Submerged macrophytes are plants that fully submerge in the water bodies include their leaves and stems. Their root will anchor in the sediment or mud such as *Lamprothamnium* (Williams, 1983). Emerged macrophytes are plants that have leaf and stems emerge from water or leaf the floats on the surface but they are rooted in the sediment or mud such as reeds (Williams, 1983). Free-floating macrophytes are plants that float on the surface of water or suspended in the water column. They are not rooted on any substrate but have suspended roots in water such as hyacinths (Gray, 2005). They have large glossy leaves and a feathery unbranched root system.

1.1.4 Seasonal affects macrophytes' growth rate

The macrophytes have different growth rate according to different season. They need different nutrients and minerals due to different conditions and growth stage. During raining season, macrophytes take in less amount of water. But in dry season which is also the growing season, between 1.5 and 1.8m^3 water is lost by evapotranspiration per square meter of fully developed macrophytes and their water uptake is also very high on the season (Gray, 2005). As a result, higher water uptake by the macrophytes results in higher heavy metals uptake through water by the macrophytes.

1.1.5 Study Site Background

Likas Lagoon is situated from E 116° 05′ 51′′ to E 116° 06′ 27′′ and N 5° 59′ 21′′ to N 5° 59′ 45′′ (Photo 1.1). It is a 26 hectare wide man made lagoon due to the construction of the new highway. It is a fresh water lagoon that the water came from the river and loading from the community of Likas citizen. Saline water subsequently flows into the lagoon from the sea during high tide. However, there is a tide gate to control the amount of saline water that flows into the Likas Lagoon. It is being managed by the Sabah Drainage and Irrigation Department and served as a flooding retention pond to direct the water to come in when flooding happens. Likas Lagoon will be filled with water during wet season but the lagoon will become dryer during dry season. In addition, the organisms in Likas Lagoon have to suit itself to the environment. Likas lagoon is a tropical lagoon that supports many organisms including a variety of macrophytes, mammals, birds and fishes. It serves as a refuge for the migrating birds such as black herons during migrating seasons to rest and find food. With the collaboration from Kota Kinabalu Wetland Centre and WWF Malaysia, Likas Lagoon is under protected and conserved through a series of education programs about the importance of wetlands like Likas Lagoon.



Scale: 1cm: 337.5 meters

Photo 1.1 Aerial view of Likas Lagoon

1.2 Justification

Chemical waste especially heavy metals and sewage management are always a problem to the environment. There are no official places that are suitable to dispose chemical waste. As a result, wetlands and water bodies are targeted as a place to dispose chemical waste and sewage is ducted there. Likas lagoon is a recreational spot for avian lovers because there are many migrating birds rest during the migrating season and it is also an important habitat for the organisms living there. Likas Lagoon has an economical value to attract tourist and improve the tourism industry as many foreigners come to visit Likas Lagoon during migrating season. In addition, we have the responsibility to protect Likas Lagoon from being polluted by any pollutants including heavy metals. Many people have abuse Likas Lagoon to dump their garbage and sewage is also ducted to it. The water in the drain that channeled to Likas Lagoon may also contain heavy metals. As a result, the heavy metal concentration is very high in the water at Likas Lagoon due to many unknown sources. The heavy metals in the water are harmful to Likas Lagoon and the organisms living there. Macrophytes can be used to absorb heavy metals in the water. There are abundant of macrophytes growing in Likas Lagoon. The macrophytes can act as hyperaccumulator to absorb heavy metals by using different parts of the plants. The different local season can affect the absorption rate of the macrophytes. During the dry season, which coincides the growing season, macrophytes have the highest absorption rate of heavy metals. The macrophytes play an important role as a habitat and provide food to organisms. A study of heavy metals absorption by macrophytes is important as they can become agents of phytoremediation.

1.3 Objective of Study

1. To determine the concentration of Nickel and Cadmium in *Typha* sp. and *Eichornia crassipes*.
2. To determine the parts of the macrophytes which concentrate the highest level of Nickel and Cadmium.

1.4 Hypothesis of Study

1. *Typha* sp. and *Eichornia crassipes* accumulate Cadmium and Nickel differently.

2. The root of macrophytes accumulate higher levels of Nickel and Cadmium

CHAPTER 2

LITERATURE REVIEW

2.1 *Typha* sp. in phytoremediation

Typha sp. is from the cattail family which is also Typhaceae (Fassett, 2000). The flowers are borne in close cylindrical spikes, which consist of two portions, the portion below the pistillate, or the female and the portion above is the staminate, or the male (Fassett, 2000). Cattails may appear in almost any wet place and are often the first invaders in a newly excavated pool. The underground stems spread extensively, so that a stand of Cattails an acre in extent may actually consist of but a few plants (Fassett, 2000). Therefore, an assumption of assume that each stand of Cattails is an individual plants must be made (Fassett, 2000). This assumption can be made because each stands of Cattails is absorbing nutrients, water and making food by themselves and most of the nutrients will not transfer to other stands (Fassett, 2000). Based on ecological value, cattails are very important to most of the animals like fish, birds and mammals. The stalks and stems are important food for muskrats and beaver. It is also important to attract marsh birds, wildfowl and song birds to serve them as habitats (Fassett, 2000). It is also the spawning ground for sunfish and the shelter for young fish.

Figure 2.1 : *Typha* sp.

Typha sp. is widely use for research especially in phytoremediation. This is because *Typha* itself is a very strong bioaccumulator that can tolerates with many kinds of heavy metals. Seedlings from metal-contaminated populations accumulated considerably more metals (up to nearly twice as much Zn and Pb and three times as much Cd) in roots than the uncontaminated population in a pot trial (Ye *et al*, 1997). In general, however, different populations of *T. latifolia* showed similar growth responses (the longest leaf elongation, the longest root elongation, shoot and root dry weight), metal uptake and indices of metal tolerance when seedlings were grown in the same metal treatment solutions or in the same metal-contaminated media under laboratory conditions (Ye *et al*, 1997). The data do not support the hypothesis that populations from metal-contaminated sites have evolved tolerance to Zn, Pb and Cd, but rather that *T. latifolia* shows constitutional tolerance (Ye *et al*, 1997).

Typha sp. tissues have high ability to accumulate different heavy metals (Staelens *et al.*, 1998). Both leaves and roots are main target storage for heavy metals for *Typha* sp. However, over storage will due to some negative symptoms such as reduced root growth, reduced leaf expansion followed by chlorosis. In Staelens *et al.* (1998), the highest level concentration for Cadmium and Nickel in roots are 0.58 mg/kg dry wt. and 10.6 mg/kg dry wt respectively. In leaves, the highest concentration for Cadmium and Nickel are 0.23 mg/kg dry wt. and 1.82 mg/kg dry wt respectively. In Staelens *et al.*, the number of macrophytes did not decline. This shows that *Typha* sp. is able to tolerate with Cadmium and Nickel.

Blake (1994) developed methods to analyze zinc in various segments of *Typha latifolia* grown in outdoor microcosms. The obtained evidence shows that the accumulation of the metal preferentially occurred in the roots and in the oldest leaves (Figure 2.2). This demonstrated both the necessity to consider the heterogeneous distribution of metals in plant tissues and the potential difficulty in obtaining a representative measurement of average metals concentration by analysis of tissues isolated from a particular part of the plant (Blake, 1994).

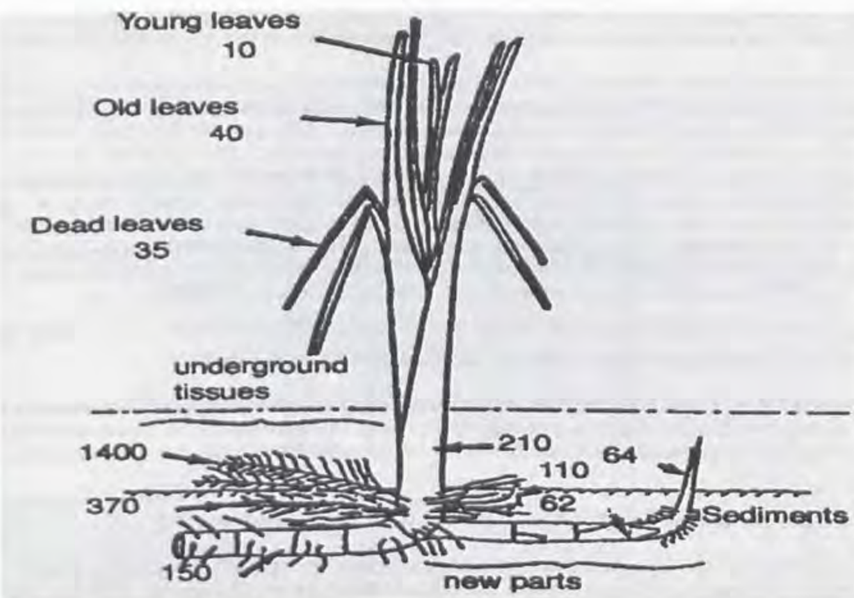


Figure 2.2 : Distribution of zinc (mg/kg dry matter in *Typha sp.*) (Blake, 1994)

REFERENCES

American Public Health Association (APHA)., 1985. *Standard methods of water and wastewater analysis.* 16th Edition. APHA, Washington DC.

Blake, G., 1994. Are aquatic macrophytes useful in field test? *Fresh water field test for hazardous assessment of chemicals*. pp. 183-189

Bowner, K.H., 1982. Aggregates of particulate matter and autwuchs on Elodea *canadensis* in irrigation water, and inactivation of diquat. *Australian Journal of Marine and Freshwater Research.* **33**, pp. 443-448.

Fassett, N.C., 2000. *A Manual Of Aquatic Plants.* Agrobios, India.

Gonzaga, M.I.S., Santos, J.A.G., Ma, L.Q.., 2006. Arsenic phytoextraction and hyperaccumulation by fern species. *Scientia Agricola*. **63** (1) , pp. 90-101.

Gray, N.F., 2005. *Water Technology : An Introduction For Environmental Scientist and Engineers*. 2nd Edition. Elsevier Butterworth-Heinemann, Oxford, Amsterdam, Boston, London, New York, Paris, San Diego, San Francisco, Singapore, Sydney and Tokyo.

Keskinkan, O., Goksu, M.Z.L., Yuceer, A., Basibuyuk, M., Forster, C.F., 2003. Heavy metals absorption characteristics pf a submerged aquatic plants(*Myriophyllum spicatum*). *Process Biochemistry* **39** (2), pp.179-183.

Knudsen, J.W., 1966. *Biological Techniques*. Harper & Row, New York.

Lu, X.M., Kruatrachue, M., Pokethitiyook, P., Homyok, K., 2004. Removal of Cadmium and Zinc by Water Hyacinth, *Eichhornia crassipes. ScienceAsia* **30,** pp. 93-103.

Miretzky, P., Saralegui, A., Cirelli, A.F., 2004. Aquatic macrophytes potential for the simultaneous removal of heavy metals (Buenos Aires, Argentina). *Chemosphere* **57,** pp. 997-1005.

Osmolovskaya, N., Kurilenko, V., 2005. Macrophytes in phytoremediation of heavy metals contaminated water and sediments in urban inland ponds. *Geophysical Research Abstracts.* **7,** pp. 101-107.

Rai, U.N., Sinha, S., Tripathi, R.D., Chandra, P., 1995. Wastewater treatability potential of some aquatic macrophytes: Removal of heavy metals. *Ecological Engineering* **5,** pp. 5-12.

Sami E., Fayed, Hussein, I., Abd-El-Shafy., 1985. Accumulation of Cu, Zn,Cd and Pb by aquatic macrophytes. *Environmental International* **11** (1), pp. 77-87

Sinha, S., Chandra, P., 1990. Removal of Cu and Cd from water by *Bacopa monnieri L. Water, Air and Soil Pollution* **51** (3-4), pp. 271-276.

Shutes, R.B.E., 2001. Artificial wetlands and water quality improvement. *Environmental International* **26,** pp. 441-447.

Staelens, N., Polprasert, C., Koottatep, T., Parkpian, P., 1998. Fate of metals and heavy metals in constructed wetlands for septage dewatering. *Asian Institute of Technology Bangkok, Thailand – Urban Environment Engineering & Management Program Associated with Water and Sanitation in Developing Country (EAWAG/SANDEC).*

Williams, W.D., 1983. Life In Inland Waters. Blackwell Scientific Publications, Melbourne, Oxford, London, Edinburgh and Boston.

Wong, M.H., 2004. *Wetlands Ecosystems In Asia: Function And Management.* Elsevier, Amsterdam, Boston, Heidelberg, London, New York, Oxford, Paris, San Diego, San Francisco, Singapore, Sydney and Tokyo.

Ye, Z.H., Baker, A.J.M., Wong, M.H., Willis, A.J., 1997. Zinc, lead and cadmium tolerance, uptake and accumulation by *Typha latifolia. The New Phytologist* **136** (3), pp. 469.