UNIVERSITI PUTRA MALAYSIA

# AN ASSESSMENT OF EARTHWORM AS BIOINDICATOR FOR HEAVY METAL CONTAMINATION IN PASTURE LAND ADJACENT TO A HIGHWAY

WEE POU LIS NG SHIE LING

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# AN ASSESSMENT OF EARTHWORM AS BIOINDICATOR FOR HEAVY METAL CONTAMINATION IN PASTURE LAND ADJACENT TO A HIGHWAY

**By**

**WEE POU LIS**

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

**January 2008**

## DEDICATION

To my family for their unconditional love, support and encouragement.

Abstract of thesis presented to the Senate of University Putra Malaysia in fulfillment of the requirement for the degree of Master of Science

**AN ASSESSMENT OF EARTHWORM AS BIOINDICATOR FOR HEAVY METAL CONTAMINATION IN PASTURE LAND ADJACENT TO A HIGHWAY**

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**January, 2008**

**Chair : Nor Azwady bin Abd. Aziz, PhD**

**Faculty : Faculty of Science**

The present study showed that *Perionyx excavatus*, *Pontoscolex corethrurus, Amynthas gracilis, Dichogaster bolaui* and *Eudrilus euginiae* could be found in UPM pasture land, with the horizontal burrower, *P. corethrurus* as the most common species. Metal concentrations in soil at different distances were analyzed to determine safe distance and traffic as the main source of roadside heavy metal pollution. Even though most of the traffic pollution studies were based on total heavy metal concentrations in soil, but the present studies on distribution and speciation of heavy metals in soil could provide clearer picture on the degree of heavy metals pollution, their origin, metal bioavailability and actual environmental impact on metal bioavailability. The bioavailable metal in UPM pasture soil was compared to the total metal content and the percentages of bioavailable metal for Zn, Cu, Cd and Pb in the soil were 45.91%, 21.47%, 10.04% and 40.74% respectively. The level of metals in the soil and grass were still below the critical level set

by many other countries. A good biomonitor for heavy metals traffic pollution should have high Bioaccumulation Factor (BAF) value and correlate positively with the traffic volume. BAFs order for the metals in grass, *B. decumbens* was Zn>Cu>Pb>Cd. The rhizome of *B. decumbens* has the highest BAF for Zn, root has the highest BAF for Cu and Pb. For the earthworm, *P. corethrurus*, the BAFs order for metals was Cd>Zn>Cu>Pb. The bioavailable Cd and Pb in the soil were positively correlated with traffic volume. Lead in earthworms, Zn and Cu in *B. decumbens* stems and Zn in the rhizomes also increased with traffic volume. The present study suggested that Pb in earthworm *P. corethrurus* and Zn in the rhizome of *B. decumbens* could be used as an integrated assessment to monitor heavy metal traffic pollution as they have high BAF and correlated positively with traffic volume.

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

**PENILAIAN CACING TANAH SEBAGAI PENUNJUK PENCEMARAN LOGAM BERAT DI KAWASAN PADANG RAGUT BERHAMPIRAN LEBUHRAYA**

Oleh

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Kajian ini menunjukkan cacing tanah yang ditemui di padang ragut UPM adalah dari jenis *Perionyx excavatus, Pontoscolex corethrurus, Amynthas gracilis, Dichogaster bolaui* dan *Eudrilus euginiae* dengan species pengorek tanah secara mendatar, *P. corethrurus*, merupakan spesies yang dominan. Kepekatan logam pada jarak yang berbeza dianalisis untuk menentukan jarak selamat dan jumlah trafik sebagai sumber utama pencemaran logam berat. Walaupun kebanyakan kajian terdahulu mengenai pencemaran logam berat oleh kenderaan adalah berdasarkan jumlah kepekatan keseluruhan (total concentration) logam berat dalam tanah, tetapi kajian berkenaan penyebaran dan pembahagian (speciation) logam berat dalam tanah dapat memberikan gambaran lebih jelas tentang tahap pencemaran logam berat, sumbernya, tahap biotersedia logam dan kesan sebenar persekitaran terhadap biotersedia logam. Perbandingan antara logam biotersedia dengan jumlah keseluruhan logam di padang ragut UPM menunjukkan logam biotersedia untuk Zn, Cu, Cd and Pb terdiri daripada

45.91%, 21.47%, 10.04% and 40.74% dari keseluruhan kepekatan logam tersebut. Secara amnya, paras logam berat dalam tanah dan rumput di lokasi kajian masih lagi jauh di bawah tahap kritikal yang ditetapkan oleh negara-negara lain. Suatu pemantau biologi yang baik untuk pencemaran logam berat oleh kenderaan sepatutnya mempunyai nilai faktor biopengumpulan (FBP) yang tinggi dan mempunyai korelasi positif dengan bilangan kenderaan. Turutan FBP untuk rumput *B. decumbens* adalah Zn>Cu>Pb>Cd dan bahagian rhizom *B. decumbens* mempunyai FBP tertinggi untuk Zn, dan akar pula untuk Cu dan Pb. Untuk cacing tanah *P.corethrurus,* turutan FBP untuk logam-logam ini adalah Cd>Zn>Cu>Pb. Biotersedia Cd dan Pb dalam tanah mempunyai korelasi positif dengan bilangan kenderaan, begitu juga dengan kepekatan Pb dalam cacing tanah, Zn dan Cu dalam batang (stem) *B. debumbens* dan Zn dalam rhizome juga meningkat dengan peningkatan bilangan kenderaan. Kajian ini mencadangkan Pb dalam cacing tanah *P. corethrurus* dan Zn dalam rhizom *B. decumbens* boleh digunakan untuk memantau pencemaran logam berat oleh kenderaan kerana ia mempuyai nilai FBP yang tinggi dan berkorelasi positif dengan bilangan kenderaan.

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This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfillment of the requirement for the degree of Master of Science. The members of the Supervisory Committee were as follows:

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Date: 10 July 2008

## DECLARATION

I declare that the thesis is my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously, and is not concurrently, submitted for any other degree at UPM or at any other institutions.

_____

**WEE POU LIS**

Date: 26 June 2008

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## LIST OF ABREAVIATIONS

| | |
|---|---|
| $NH_4CH_3COO$ | Ammonium acetate |
| $NH_4OH.HCl_2$ | Hydroxyl amine chloride |
| $HClO_4$ | Perchloric acid |
| $HNO_3$ | Nitric acid |
| $H_2O_2$ | Hydrogen peroxide |
| BAF | Bioaccumulation Factor |
| PI | Pollution Index |
| IPI | Integrated Pollution Index |
| Zn | Zinc |
| Cu | Copper |
| Cd | Cadmium |
| Pb | Lead |
| n.a. | Not available |
| u.d. | Undetectable |
| N | Number of sample |
| mg/kg | Milligram per kilogram |
| DW | Dry weight |

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# CHAPTER 1

## INTRODUCTION

Since late 19th century, people have traveled and good have been moved using cycles and motor vehicles such as cars, buses and lorries (O'Flaherty, 2002). Everybody travels, whether to work, play, shop, do business, or simply visit people. All foodstuff and raw materials must be carried from their place of origin to that of their consumptions, and manufactured goods must be transported to the market place and the consumer

The number of human is increasing day by day. In order to carry out their daily activities; they need to move around. Therefore, more traffic vehicles been used on the roads, whether in the highway, trunk roads or outline areas. For the vehicles to move around, fuels are needed to run the engines and to move the wheels. Due to combustions in the engine, exhausts containing Pb is emitted by traffic vehicles in the form of minute particles into the air. In 2005 alone, there were 1,020,103 vehicles registered in Malaysia, there were 422,255 motorcycles, 537,900 motorcars, 1,568 buses, 8,413 taxis and hire cars, 33,532 goods vehicles and 16,440 other vehicles (Department of Statistics, Malaysia, 2006).

The heavy metal fallout in the atmosphere will land on all over the soil, water, plants, and animals nearby. The fallout ingested by animals and human may become hazardous to the body system. A more deadly effect is the poisoning of plants and animals by toxic

chemicals leached off the farmlands. The biological effects of such chemical are commonly magnified many times as they move up a food chain/web (Bortman *et al.*, 2003). The concentration of heavy metal higher than certain level is considered toxic to our body. Therefore, it is utmost important to find the means to monitor the level of heavy metal concentration around the sources of pollution.

Generally compound of mineral substances such as lead (Pb), cadmium (Cd), copper (Cu) and zinc (Zn) dissolve best in the water (Environmental Encyclopedia, 2003). Once a toxic substance is released into the environment, plants may absorb it along with water and nutrients through their roots or through pores or tissues in their leaves and stems. Animal including humans, take up environment toxic substances by eating, drinking, or breathing, absorbing them through the skin, or by direct transmission from mother to egg or fetus (see Figure 1.1). Although heavy metals may change their chemical form in the environment, they tend to persist in one form or another, and some constitute significant environmental hazards.

Shaw and Chadwick (1998) had shown that the grazing food chain involves a flow of energy from primary producers via primary consumers to the predatory carnivores. Typical example is in the pasture land ecosystem where energy input is from sunlight, this is assimilated by grass to make nutrients which are consumed by grazing herbivores (cattle), and carnivores (man) lie in wait to eat the herbivores. The authors also mentioned that as a toxic chemical is introduced at the bottom of the biomass pyramid, there is likely to be a significant concentration effect as one moves up the trophic levels.

It is therefore inevitable that the tertiary consumers will succumb to the toxic effects of the chemical (see Figure 1.1).

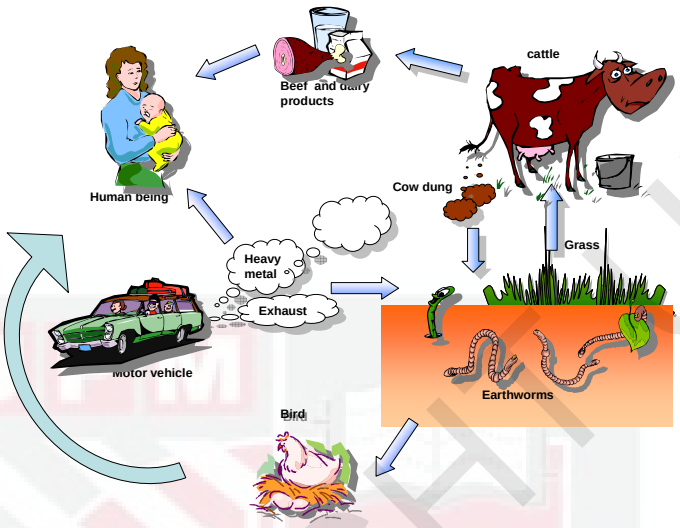


**Figure 1.1: The cycle of heavy metals in the terrestrial ecosystem**

In 1982, Rodriguez and Rodriguez had studied Pb and Cd pollution in roads in Puerto Rico. They found that the levels of these metals in soil and vegetation are much higher that typical background concentrations. They also discovered that the integration of the concentration vs. distance curves along transects perpendicular to the roads yield areas proportional to the heavy metal burden of the roadside soil and vegetation.

These areas exhibit a significant correlation with the vehicular traffic density. They found that wind direction affects the distribution of Pb along a transect, Pb and Cd concentration in soil, Pb concentration in vegetation fall of rapidly with increasing distance from the roads and the accumulation of Pb and Cd above background levels