UNIVERSITI PUTRA MALAYSIA

CONCENTRATIONS OF HEAVY METALS IN THE SOFT TISSUES OF MUDFLAT SNAILS (*TELESCOPIUM TELESCOPIUM)* FROM THE INTERTIDAL AREAS OF PENINSULAR MALAYSIA

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By

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ABSTRACT

The main aim of this study is to establish mudflat snail *Telescopium telescopium* as a biomonitor of heavy metals for the intertidal area of Peninsular Malaysia. From this study, the concentrations of heavy metals in the different parts of soft tissues and shells were determined in *T. telescopium* collected from 16 geographical sites along the west coast and one site from the east coast (Tumpat, Kelantan) of Peninsular Malaysia. Based on the 17 populations, the mean concentrations of heavy metals in the total soft tissues of *T. telescopium* varied widely from 53.59 – 187.07 µg/g dry weight for Cu, 65.11 – 155.38 µg/g dry weight for Zn, 5.59 – 17.66 µg/g dry weight for Pb, 0.40 – 1.52 µg/g dry weight for Cd, 4.63 – 17.29 µg/g dry weight for Ni and 304.06 – 1062.19 µg/g dry weight for Fe.

The soft tissues of snail *T. telescopium* were dissected, separated and pooled into seven parts namely foot, cephalic tentacle, mantle, muscle, gill, remaining soft tissues and digestive caecum and the concentrations of heavy metals in these tissues were measured. In the study of the relationship between different soft tissues of *T.*

telescopium with its environment represented by sediment samples, the Pearson's correlation coefficients results showed positive significant correlation ($p < 0.05$) were observed between Cd, Cu, Fe, Ni, Pb and Zn in the different soft tissues and geochemical fraction of 6 metals studied in the sediment. The Pearson correlation coefficients suggested that some soft tissues can be good biomonitoring organs (Cu: mantle and remaining soft tissues; Fe: mantle, remaining soft tissues and foot; Ni: gill and remaining soft tissues; Pb: gill, remaining soft tissues and digestive caecum; Zn: gill and remaining soft tissues). It is noted that particular organ may be more effective tool than the total soft tissues to monitor heavy metal contamination in the intertidal zone. The study on the ratio of metals in the shell to the metals in the different soft tissues shows that shell has higher degrees of variability for Cd, Ni and Pb than in the different soft tissues of *T. telescopium*. Therefore, the results indicated lower degrees of variability of Fe, Cu and Zn in the shells of *T. telescopium* than in the different soft tissues of *T. telescopium.*

In conclusion, the metal distributions in the different soft tissues of *T. telescopium* indicated that a particular organ is more useful and accurate to monitor a particular metal contaminations in the intertidal area. The shells and soft tissues of *T. telescopium* are found as potential biomonitor of Cd, Cu, Fe, Ni, Pb and Zn while the usefulness of the shells need further studies.

ABSTRAK

KEPEKATAN LOGAM-LOGAM BERAT DI DALAM BEBERAPA TISU LEMBUT SIPUT MUDFLAT *Telescopium telescopium* (Linnaeus) DARI KAWASAN PASANG SURUT SEMANANJUNG MALAYSIA

Oleh

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Tujuan utama kajian ini adalah untuk mencadangkan dan menggunakan siput lumpur *Telescopium telescopium* sebagai agen penunjuk biologi logam-logam berat bagi kawasan pasang surut Semenanjung Malaysia. Lokasi kajian adalah meliputi 16 lokasi sampel di sepanjang perairan Pantai Barat Semenanjung Malaysia dan satu lokasi sampel dari perairan timur (Tumpat, Kelantan) Semenanjung Malaysia. Kepekatan purata logam-logam berat dalam keseluruhan tisu lembut *T. telescopium* berubah daripada 53.59 – 187.07 µg/g berat kering untuk Cu, 65.11 – 155.38 µg/g berat kering untuk Zn, 5.59 – 17.66 µg/g berat kerng untuk Pb, 0.40 – 1.52 µg/g berat kering untuk Cd, 4.63 – 17.29 µg/g berat kering untuk Ni dan 304.06 – 1062.19 µg/g berat kering untuk Fe.

Siput *T. telescopium* yang telah disampel dari setiap satu lokasi telah dibedah dan diasingkan kepada tujuh bahagian iaitu kaki, tentakel sefalik, mantel, otot, insang, lebihan tisu lembut dan sekum pencerna. Kepekatan logam-logam berat dalam semua tisu ini diukur. Kajian ini juga menjalankan analisis bagi hubungan antara beberapa tisu lembut *T. telescopium* dengan persekitaran (iaitu sedimen), keputusan menunjukkan korelasi positif yang signifikan ($p < 0.05$) antara kadmium, kuprum,

besi, nikel, plumbum and zink dalam beberapa tisu lembut dan fraksi geokimia enam logam berat yang dikaji. Pemalar korelasi yang diperolehi mencadangkan beberapa tisu lembut berpotensi untuk digunakan sebagai organ penunjuk biologi (kuprum: mantel dan lebihan tisu lembut; besi: mantel, lebihan tisu lembut dan kaki; nikel: insang dan lebihan tisu lembut; plumbum: insang, lebihan tisu lembut dan sekum pencerna; zink: insang dan lebihan tisu lembut). Di dapati organ-organ tertentu dalam siput *T. telescopium* lebih berkesan untuk dijadikan agen penunjuk biologi daripada menggunakan keseluruhan tisu lembut untuk mengetahui aras kepekatan logam-logam yang dikaji di kawasan intertidal. Kajian yang dibuat untuk menentukan kadar logam dalam cengkerang kepada logam dalam tisu lembut menunjukkan cengkerang mempunyai darjah berubah-ubah yang tinggi terhadap kadmium, nikel dan plumbum berbanding bahagian tisu lembut *T. telescopium*. Oleh itu keputusan kajian menunjukkan cengkerang *T. telescopium* mempunyai darjah berubah-ubah yang rendah bagi besi, kuprum dan zink berbanding tisu-tisu lembut *T. telescopium*.

Kesimpulannya, taburan logam-logam dalam tisu-tisu lembut *T. telescopium* menunjukkan bahawa organ tertentu lebih berguna dan tepat sebagai penunjuk biologi bagi pencemaran logam-logam tertentu dalam kawasan intertidal. Cengkerang dan tisu lembut *T. telescopium* didapati sebagai agen penunjuk biologi yang berpotensi untuk logam kadmium, kuprum, besi, nikel, plumbum dan zink, manakala penggunaan cengkerang memerlukan kajian yang lebih lanjut.

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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 Universiti Putra Malaysia or at any other institutions.

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CHAPTER 1

INTRODUCTION

It has become a common practice, in many monitoring programmes, to use aquatic organisms as biomonitors because of temporal and spatial variability of the chemical elements in dissolved and particulate phases of aqueous systems (Phillips and Rainbow, 1993). Furthermore, all aquatic invertebrates accumulate trace metals in their tissues, whether or not these metals are essential to metabolism (Rainbow, 2002). Some of the intertidal gastropods that inhabit rocky shores or sediments fulfill most of the requirements of good biomonitors (Phillips and Rainbow, 1994); however, it is important that they accumulate metals in proportion to metal concentrations in the environment because only the bioavailability fraction of metals in sediments can have an impact on metal toxicity and accumulation (Ying *et al.*, 1993) and also metal concentrations in sediments are high and relatively invariant with time (Mastala *et al.*, 1992). In addition to that, gastropods were employed as biomonitors to determine the effect of marine pollution (Bu Olayan *et al.*, 2001; Ismail and Safahieh, 2004; Walsh *et al.*, 1995; Ying *et al.*, 1993). At the same time, gastropod snail, *Telescopium telescopium* is used in this study because their direct contact to the intertidal sediments. Moreover, intertidal sediments can accumulate large amounts of organic matter and can act as an important reservoir of trace metals, particularly in regions of intense shellfish culture activity where natural sedimentation is enhanced by biodeposition (Sokolowski *et al.*, 2005). On the other hand, organisms often exhibit greater spatial variation in metal concentration compared to sediments and are more reliable tool for identifying sources of contamination (Thompson *et al.*, 1983).

According to some authors (Marigomez and Ireland, 1989; Pip, 1992; Tessier *et al.*, 1994), gastropods also have the ability to concentrate the bioavailable heavy metals from their ambient environment. On the other hand, the concentrations of heavy metals in water may vary considerably depending on annual and seasonal fluctuations (SCEP, 1971). Therefore, the measurement in the gastropods can provide an integrated measurement of metal bioavailability of contaminant (Rainbow, 1995). It has already been demonstrated (Langston and Zhou, 1987; Marigomez and Ireland, 1989) that *Littorina littorea* is an excellent indicator species for monitoring environmental with heavy metal contamination particularly cadmium.

It is known that both terrestrial and marine gastropod species accumulate heavy metals; therefore they are suitable for detection of environmental heavy metal pollution as biomonitors organisms (Coughtrey *et al.*, 1977; Leatherland *et al.*, 1973; Navrot *et al.*, 1970; Peden *et al.*, 1973; Stenner and Nickless, 1975). *T. telescopium* was chosen for this study not only because of their abundance but also because the maesurement of metals levels in this organisms might give an idea of the level of metal contamination which might be present in this intertidal area of Peninsular Malaysia. *T. telescopium* is also commonly used as local food. The Telescope-shell creeper is an abundant, gregarious, spiral mollusk that occurs on estuarine mudflats (Nair and Saraswathy, 1971). According to Ismail and Safahieh (2004) *T. telescopium* can be suggested as biomonitoring agent for assessing copper and zinc in the river. Even though *T. telescopium* did not show positive correlation with the levels of metals in surface sediments many other characters such as sessile and sedentary which are representative of the study site, hardy and tolerating high concentrations of pollutants and large ranges in salinity, abundant, easy to identify and enough tissues for analysis contaminants, have made the *T. telescopium* a potential biomonitoring agent (Ismail and Safahieh, 2004) since it fulfils many of the selected criteria of an ideal biomonitor. However, future validation is required to test its usefulness as a good biomonitor of heavy metal pollution. Uniquely, this study used different soft parts of *T. telescopium* in order to gain some information on the ecological distribution of *T. telescopium* along the west ccoast of Peninsular Malaysia and redistribution of heavy metals in snail tissues. On the other hand, accumulation of metals varies from organ to organ in invertebrates depending upon the balance between uptake and elimination of metals (Soto *et al.*, 1997). So far, metal distribution in the different soft tissues of *T. telescopium* are not found in the literature.

Since, metals accumulated in the total soft tissues could be affected by many biotic and abiotic factors apart from pollution, therefore the selection of a particular suitable tissue/organ therefore would increase the accuracy of the determination of metal bioavailability and contamination (Yap *et al.*, 2006). Furthermore, knowledge on the distribution of metals in isolated organs/tissues of marine organisms is useful in the identification of specific organs that may tend to accumulate higher levels of heavy metals (Szefer and Szefer, 1990). This particular information has not been reported yet in the literature for *T. telescopium*.

The west coast of Peninsular Malaysia was focused upon because there is no detailed study of metals in this snail around this region. At the same time, comparisons of contaminant levels in a biomonitoring agent collected from different geographical sites will provide on the status of the pollutant contamination of coastal areas of Peninsular Malaysia.

In a number of previous investigations on the metal pollution of coastal sites and estuaries, various number of the indigenous biota have been engaged to evaluate the bioavailability levels of metals in the marine environment (Cubadda *et al.*, 2001). The use of bivalve or gastropod molluscs looks attractive as these organisms accumulate metals from all environmental compartments (i.e. from the aqueous medium and through ingestion – from food and inorganic particulate material) and heavily concentrate them (Phillips, 1978). In addition to that, sediment samples cannot provide enough information on bioavailability, and then analysis of the snail would give a better answer on the bioavailability of metal which is concerns.

The objectives of this study are:

a) To determine the heavy metal distribution in different parts of soft tissues and shells of snail, *T. telescopium*
b) To study the relationship of metal concentrations between the snail and their environmental surface sediment.

CHAPTER 2

LITERATURE REVIEW

2.1 Biology of *Telescopium telescopium*

2.1.1 Taxonomy

Telescopium telescopium is classified into the Family Potamididae (Houbrick, 1991).

Below is the classification of *T. telescopium*.

Kingdom : Animalia
Phyllum : Mollusca (Linnaeus, 1758)
Class : Gastropoda (Courier, 1797)
Subclass : Prosobranchia
Order : Mesogastropoda
Superfamily : Cerithiacea
Family : Potamididae
Subfamily : Potamidinae
Genus : *Telescopium* (Montfort, 1810)
Species : *Telescopium telescopium* (Linnaeus, 1758)

2.1.2 Species description

The Telescope-shell Creeper has a very distinctive, large, telescope-shaped shell. It grows up to 65-110 mm in length. Its shell is large and conical in shape, with a broad and flat base. The shell sides are straight (Plate 1a and Plate 1b). The shell sculpture consists of numerous flat-sided whorls and spiral grooves. The shell base has concentric cords, and a deep channel around a short, twisted, columellar pillar. The shell is beautifully patterned under the thick layer of mud that usually covers it. The shell is also sometimes covered with barnacles and other encrusting animals (Plate 2) and can remain out of water for long periods (7 days) (Tan and Chou, 2000).

Plate 1a and 1b : The shell description of *T. telescopium*

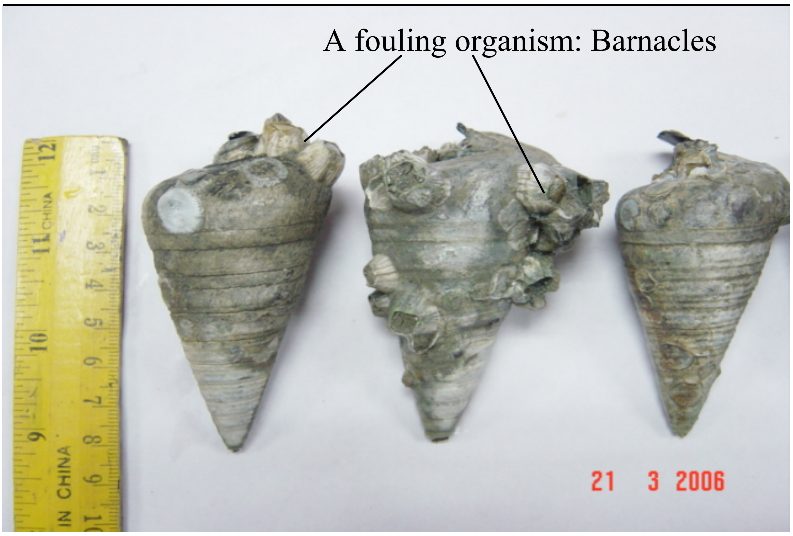

Plate 2. The shell covered with barnacles

Plate 3 : Multispiral oprculum