BIOACCUMULATION OF SOME OF THE HEAVY METALS IN THE TOTAL SOFT-TISSUE OF *Polymesoda expansa* COLLECTED FROM THE MANGROVE AREA OF KONDONI, KUDAT, SABAH

SOLLYANTIANNA EDWARD

THIS DISSERTATION IS SUBMITTED AS A PART OF THE ASSESSMENT FOR THE DEGREE OF BACHELOR’S OF SCIENCE

ENVIRONMENTAL SCIENCE PROGRAMME
FACULTY OF SCIENCE AND NATURAL RESOURCES
UNIVERSITI MALAYSIA SABAH

2014
VERIFICATION

I hereby declare that this is my own work other than the dissertations and references whereby each of them are being explained of its sources.

________________________
SOLLYANTIANNA EDWARD
(BS11110615)
26 Jun 2014
AUTHENTICATION

VERIFIED BY

Signature,

Rohana Tair
(Supervisor)
ACKNOWLEDGEMENT

With sincere heart I would like to thank God for steering me all the way until I finished this study. Much love and appreciation goes to my parents, Edward J. Masanding and Noorsiah Parasin, for their patience and for providing financial support and also supports in so many ways throughout this study. Thanks are also given to my supervisor, Mdm. Rohana Tair for all the motivations, guidance, help and overseeing the progress throughout the period of this study. Many thanks also goes to the laboratory assistants, Mr. Shaufie Lamjim and Mr. Neldin Geofry, for providing enough tools and apparatus throughout the experiment. My appreciation also goes to Mr. Helldon Kuruput for providing transportation and logistical supports throughout the period of the study. Lastly, a shower of thanks also goes to Shawna Vun Min Fah, Nadeen Serina Bte Marcell Usup and Jennyca Yopong for their guidance and sharing of information regarding this study, specifically regarding the availability of the samples in the sampling sites.
ABSTRACT

The purpose of this study is to investigate the bioaccumulation of the heavy metal (Cu, Fe, Cd, Zn and Pb) in the total soft-tissue of P. expansa and surface sediment. The result of this study is compared with the standard for fish and fishery products in the Food Act 1983 for the P. expansa and the EPA guidelines for the sediment. The total of P. expansa collected were 60 individuals and a total of 16 samples of sediments for the 2 samplings made in January and February 2014 located at the mangrove area near Kondopi village, Kudat. The total soft-tissue is digested using nitric acid and the sediment is digested using aqua regia. The mean concentration in the P. expansa for January’s sampling for the heavy metals Cu, Fe, Cd, Zn and Pb are 12.00 ± 3.98 mg/kg, 92.77 ± 91.49 mg/kg, 4.12 ± 0.76 mg/kg, 99.22 ± 51.92 mg/kg, 7.16 ± 3.89 mg/kg respectively while the mean concentration in the sediment are 42.41 ± 6.07 mg/kg in Cu, 2150.45 ± 1075.76 mg/kg in Fe, 11.27 ± 2.56 mg/kg in Cd, 78.25 ± 50.42 mg/kg in Zn, and 25.36 ± 11.56 mg/kg in Pb. Meanwhile in February, the concentration of Cu, Fe, Cd, Zn and Pb in the P. expansa are 3.36 ± 1.39 mg/kg, 65.20 ± 22.29 mg/kg, 2.01 ± 0.38 mg/kg, 62.01 ± 55.23 mg/kg and 2.87 ± 1.50 mg/kg respectively while the heavy metal concentrations in the sediment are 52.15 ± 5.01 mg/kg for Cu, 1610.23 ± 433.70 mg/kg for Fe, 12.10 ± 1.45 mg/kg for Cd, 169.57 ± 54.72 mg/kg for Fe and 27.64 ± 12.38 for Pb. For P. expansa, the highest mean concentration for January is Zn while Fe is the highest heavy metals mean concentration in February. In the sediment, Fe is the highest heavy metal mean concentration in both months. The bioaccumulation factor shows the highest value for Zn which is 1.80. According to the Pearson’s correlation tested, there are statistically significant correlations among some the heavy metals in the P. expansa and sediment. One-Way ANOVA test showed no statistically significant mean difference in the sediment sampling between January and February. However, for P. expansa, all of the heavy metals studied showed a statistically significant mean difference between the months January and February except for Fe, which has a p>0.05.
BIOAKUMULASI BEBERAPA LOGAM BERAM DI DALAM TISU LEMBUT *Polymesoda expansa* YANG DIAMBIL DARI KAWASAN PAYA BAKAU DI KONDOPI, KUDAT, SABAH

**ABSTRAK**

Tujuan kajian ini dijalankan adalah untuk mengkaji bioakumulasi logam beram (Cu, Fe, Cd, Zn dan Pb) di dalam tisu lembut *P. expansa* dan juga sedimen permukaan. Keputusan kajian ini dibandingkan dengan piawai bagi makanan laut dan hasil laut yang terkandung di dalam Akta Makanan 1983 untuk *P. expansa* dan garis panduan EPA untuk sedimen. Jumlah *P. expansa* yang dipungut adalah 60 biji dan 16 sampel sedimen bagi kedua-dua persampelan pada bulan Januari dan Februari 2014 yang terletak di kawasan paya bakau berdekatan Kampung Kondopi, Kudat. Jumlah tisu lembut *P. expansa* dihadam menggunakan asid nitrik dan sedimen pula dihadam menggunakan *aqua regia*. Min kepekatan di dalam *P. expansa* untuk persampelan Januari bagi logam berat Cu, Fe, Cd, Zn dan Pb adalah 12.00 ± 3.98 mg/kg, 92.77 ± 91.49 mg/kg, 4.12 ± 0.76 mg/kg, 99.22 ± 51.92 mg/kg, 7.16 ± 3.89 mg/kg mengikut urutan, manakala min kepekatan di dalam sedimen adalah 42.41 ± 6.07 mg/kg bagi Cu, 2150.45 ± 1075.76 mg/kg bagi Fe, 11.27 ± 2.56 mg/kg bagi Cd, 78.25 ± 50.42 mg/kg bagi Zn, dan 25.36 ± 11.56 mg/kg bagi Pb. Manakala pada bulan Februari, min kepekatan bagi Cu, Fe, Cd, Zn dan Pb di dalam *P. expansa* adalah 3.36 ± 1.39 mg/kg, 65.20 ± 22.29 mg/kg, 2.01 ± 0.38 mg/kg, 62.01 ± 55.23 mg/kg dan 2.87 ± 1.50 mg/kg meanigik urutan, manakala min kepekatan di dalam sedimen adalah 52.15 ± 5.01 mg/kg bagi Cu, 1610.23 ± 433.70 mg/kg bagi Fe, 12.10 ± 1.45 mg/kg bagi Cd, 169.57 ± 54.72 mg/kg bagi Fe dan 27.64 ± 12.38 bagi Pb. Bagi *P. expansa*, min kepekatan logam beram tertinggi untuk persampelan Januari adalah Fe dan Zn mempunyai min kepekatan loga berat tertinggi pada bulan Februari. Di dalam sedimen, Fe merupakan logam berat yang mempunyai min tertinggi pada kedua-dua bulan persampelan. Faktor bioakumulasi menunjukkan bahawa nilai tertinggi adalah Zn iaitu 1.80. Menurut korelasi *Pearson*, terdapat korelasi statistik yang signifikan dalam kalangan logam berat di dalam *P. expansa* dan sedimen. Ujian ANOVA satu hala menunjukkan tidak terdapat perbezaan min yang signifikan bagi persampelan sedimen pada Januari dan Februari. Walau bagaimanapun, *P. expansa* menunjukkan bahawa terdapat perbezaan min yang signifikan dalam kalangan logam berat yang dikaji pada bulan Januari dan Februari kecuali Fe di mana *p*>0.05.
CONTENTS

VERIFICATION
AUTHENTICATION
ACKNOWLEDGEMENT
ABSTRACT
ABSTRAK
CONTENTS
LIST OF ABBREVIATIONS
LIST OF TABLES
LIST OF FIGURES
LIST OF PHOTOS
LIST OF SYMBOLS

CHAPTER 1 INTRODUCTION
1.1 Introduction
1.2 Scope of Study
1.3 Objectives
1.4 Importance of Study

CHAPTER 2 LITERATURE REVIEW
2.1 Mollusca
2.1.1 Polymesoda expansa
2.2 Factors Affecting the Bioaccumulation of Heavy Metals Inside the Mollusks
2.2.1 Shell Size
2.2.2 Species-specific
2.2.3 Seasonality
2.2.4 Location
2.2.5 Salinity
2.2.6 Sex/Gender
2.3 Heavy Metal
2.3.1 Copper (Cu)
2.3.2 Cadmium (Cd)
2.3.3 Iron (Fe)
2.3.4 Zinc (Zn)
2.3.5 Lead (Pb)
2.4 The Role of Metallothionein on the Bioaccumulation of Heavy Metals in the Soft-Tissue of Marine Organisms

CHAPTER 3 METHODOLOGY
3.1 Description of Study Area
3.2 Sampling
3.2.1 Sampling Technique
3.2.2 Quality Control
3.2.3 Preservation and Storage

Page
1
1
4
4
4
1
6
6
13
14
14
15
16
18
19
20
21
22
23
23
24
24
25
27
27
28
29
29
29

vi
<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.3 Heavy Metal Analysis</td>
<td>29</td>
</tr>
<tr>
<td>3.3.1 Standard Solution Dilution Series Preparation</td>
<td>29</td>
</tr>
<tr>
<td>3.3.2 Sample Analysis of the <em>P. expansa</em>'s Soft-Tissue</td>
<td>30</td>
</tr>
<tr>
<td>3.3.3 Sample Analysis of the Sediment</td>
<td>31</td>
</tr>
<tr>
<td>3.3.4 Bioaccumulation Factor</td>
<td>32</td>
</tr>
<tr>
<td>3.4 Unit Conversion</td>
<td>32</td>
</tr>
<tr>
<td>3.5 Standard Reference Control</td>
<td>33</td>
</tr>
<tr>
<td>3.6 Statistical Analysis</td>
<td>34</td>
</tr>
<tr>
<td>CHAPTER 4 RESULTS &amp; DISCUSSION</td>
<td>35</td>
</tr>
<tr>
<td>4.1 Statistical Analysis and Discussion of the Heavy Metal Concentration of the <em>P. expansa</em> and the Sediment</td>
<td>37</td>
</tr>
<tr>
<td>4.1.1 Copper (Cu)</td>
<td>37</td>
</tr>
<tr>
<td>4.1.2 Iron (Fe)</td>
<td>42</td>
</tr>
<tr>
<td>4.1.3 Cadmium (Cd)</td>
<td>46</td>
</tr>
<tr>
<td>4.1.4 Zinc (Zn)</td>
<td>51</td>
</tr>
<tr>
<td>4.1.5 Lead (Pb)</td>
<td>55</td>
</tr>
<tr>
<td>4.1.6 Overall Comparison of Heavy Metals in <em>P. expansa</em> for January and February 2014</td>
<td>59</td>
</tr>
<tr>
<td>4.1.7 Overall Comparison of Heavy Metals in the Sediment for January and February 2014</td>
<td>61</td>
</tr>
<tr>
<td>4.2 Comparison of Bioaccumulation Factor of This Study with a Previous Study</td>
<td>63</td>
</tr>
<tr>
<td>CHAPTER 5 CONCLUSIONS</td>
<td>64</td>
</tr>
<tr>
<td>REFERENCES</td>
<td>65</td>
</tr>
<tr>
<td>APPENDICES</td>
<td>70</td>
</tr>
</tbody>
</table>
## LIST OF TABLES

<table>
<thead>
<tr>
<th>Table</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1</td>
<td>Shell size distribution of the mollusks species collected in Kg. Air Sembulan</td>
<td>14</td>
</tr>
<tr>
<td>2.2</td>
<td>The mean concentration ($\mu g \cdot g^{-1}$, wet wt.) of heavy metals in one of the sampling site (Weihai) of three bivalves species in the research of Liang <em>et al.</em> (2003)</td>
<td>15</td>
</tr>
<tr>
<td>2.3</td>
<td>The month of when the heavy metals were found in the highest concentration in the wedge clam</td>
<td>17</td>
</tr>
<tr>
<td>2.4</td>
<td>The result of the Zn and Cd concentrations ($\mu g \cdot g^{-1} \cdot day^{-1}$) under different salinity and temperature</td>
<td>20</td>
</tr>
<tr>
<td>3.1</td>
<td>The guidelines for the fish and fishery products in the Food Act 1983</td>
<td>33</td>
</tr>
<tr>
<td>3.2</td>
<td>EPA guidelines for heavy metals in sediments (mg/kg dry weights)</td>
<td>33</td>
</tr>
<tr>
<td>4.1</td>
<td>The number of percentage of <em>P. expansa</em> that is below and exceeds the mean number and Food Act 1983 of Cu in January and February</td>
<td>37</td>
</tr>
<tr>
<td>4.2</td>
<td>The number of percentage of sediment that is below and exceeds the mean number and EPA guideline of Cu in January and February</td>
<td>39</td>
</tr>
<tr>
<td>4.3</td>
<td>The number of percentage of <em>P. expansa</em> that is below and exceeds the mean number and Food Act 1983 of Fe in January and February</td>
<td>42</td>
</tr>
<tr>
<td>4.4</td>
<td>The number of percentage of sediment that is below and exceeds the mean number and EPA guideline of Fe in January and February</td>
<td>44</td>
</tr>
<tr>
<td>4.5</td>
<td>The number of percentage of <em>P. expansa</em> that is below and exceeds the mean number and Food Act 1983 of Cd in January and February</td>
<td>46</td>
</tr>
</tbody>
</table>
4.6 The number of percentage of sediment that is below and exceeds the mean number and EPA guideline of Cd in January and February

4.7 The number of percentage of *P. expansa* that is below and exceeds the mean number and Food Act 1983 of Zn in January and February

4.8 The number of percentage of sediment that is below and exceeds the mean number and EPA guideline of Zn in January and February

4.9 The number of percentage of *P. expansa* that is below and exceeds the mean number and Food Act 1983 of Pb in January and February

4.10 The number of percentage of sediment that is below and exceeds the mean number and EPA guideline of Pb in January and February

7.1 Some uses of molluscs shells

7.2 The initial volume required to prepare a solution with final concentrations of 0.1 mg/L, 0.2 mg/L, 0.5 mg/L, 1.0 mg/L and 2.0 mg/L

7.3 Absorption range for each heavy metal in order to obtain more accurate ICP-OES reading values according to the American Public Health Publication

7.4 ICP-OES reading of the January sampling of the *P. expansa*

7.5 ICP-OES reading of the February sampling of the *P. expansa*

7.6 ICP-OES Heavy Metal Reading in Sediments for January 2014

7.7 ICP-OES Heavy Metal Reading in Sediments in February 2014

7.8 Correlation matrix between heavy metals in sediment and *P. expansa* from the mangrove area near Kondopi, Kudat

7.9 ANOVA test result on the heavy metal concentration in the *P. expansa*
### LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figures</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1 Example of an internal anatomy of a bivalve mollusk species Sphaeriidae (<em>Musculium securis</em>)</td>
<td>9</td>
</tr>
<tr>
<td>2.2 The life cycle of a clam</td>
<td>12</td>
</tr>
<tr>
<td>2.3 Schematic representation of the intracellular detoxification mechanism involving ZnMT</td>
<td>22</td>
</tr>
<tr>
<td>3.1 The map of the sampling site</td>
<td>28</td>
</tr>
<tr>
<td>3.2 Flowchart of the sample analysis of <em>P. expansa</em></td>
<td>31</td>
</tr>
<tr>
<td>3.3 Flowchart of the sample analysis of the sediment</td>
<td>32</td>
</tr>
<tr>
<td>4.3 Cu in <em>P. expansa</em> in January</td>
<td>38</td>
</tr>
<tr>
<td>4.4 Cu in <em>P. expansa</em> in February</td>
<td>38</td>
</tr>
<tr>
<td>4.5 Fe in <em>P. expansa</em> in January</td>
<td>43</td>
</tr>
<tr>
<td>4.6 Fe in <em>P. expansa</em> in February</td>
<td>43</td>
</tr>
<tr>
<td>4.7 Cd in <em>P. expansa</em> in January</td>
<td>47</td>
</tr>
<tr>
<td>4.8 Cd in <em>P. expansa</em> in February</td>
<td>47</td>
</tr>
<tr>
<td>4.9 Zn in <em>P. expansa</em> in January</td>
<td>52</td>
</tr>
<tr>
<td>4.10 Zn in <em>P. expansa</em> in February</td>
<td>52</td>
</tr>
<tr>
<td>4.11 Pb in <em>P. expansa</em> in January</td>
<td>56</td>
</tr>
<tr>
<td>4.12 Pb in <em>P. expansa</em> in February</td>
<td>56</td>
</tr>
<tr>
<td>4.13 The concentration of Cu, Cd and Pb in <em>P. expansa</em></td>
<td>60</td>
</tr>
<tr>
<td>4.14 The concentration of Fe and Zn in the <em>P. expansa</em></td>
<td>60</td>
</tr>
<tr>
<td>4.15 Concentration for Cu, Cd, Zn and Pb in the sediment for January and February 2014</td>
<td>62</td>
</tr>
<tr>
<td>4.16 The concentration of Zn in the sediment for January and February 2014</td>
<td>62</td>
</tr>
</tbody>
</table>
7.1 Trends of distribution of heavy metal (Cu, Pb, Cr and Ni) concentrations (µg/g dry weight) in the wedge clams at the study site in the study of Singh et al. (2012)

7.2 Trends of distribution of heavy metal (Cu, Pb, Fe, Cr and Ni) concentrations (µg/g dry weight) in the wedge clams at the study site in the study of Singh et al. (2013)
7.10 ANOVA test result on the heavy metal concentration in the sediment

7.11 Bioaccumulation Factor (BAF) of the *P. expansa* and sediment
LIST OF SYMBOLS

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>L</td>
<td>Liter</td>
</tr>
<tr>
<td>µg</td>
<td>microgram</td>
</tr>
<tr>
<td>C°</td>
<td>Celcius</td>
</tr>
<tr>
<td>Figure</td>
<td>Description</td>
</tr>
<tr>
<td>--------</td>
<td>-------------</td>
</tr>
<tr>
<td>4.1</td>
<td><em>P. expansa</em></td>
</tr>
<tr>
<td>4.2</td>
<td>The total soft-tissue of <em>P. expansa</em></td>
</tr>
<tr>
<td>7.3</td>
<td>The roots of the mangrove trees on the way to the sampling site</td>
</tr>
<tr>
<td>7.4</td>
<td>The mangrove trees near the sampling area, in which this is the nearest mangrove area with the sea</td>
</tr>
<tr>
<td>7.5</td>
<td>The mangrove area in the study site</td>
</tr>
<tr>
<td>7.6</td>
<td>One of the <em>P. expansa</em> found in the sediment</td>
</tr>
<tr>
<td>7.7</td>
<td>An undisturbed <em>P. expansa</em> in the sediment</td>
</tr>
<tr>
<td>7.8</td>
<td>The internal view of the <em>P. expansa</em></td>
</tr>
</tbody>
</table>
CHAPTER 1

INTRODUCTION

1.1 Introduction

Prior to understanding the meaning of aquatic ecosystem, the definition of ecosystem must first be understood. Ecosystem contains biotic and abiotic components which are interacting with each other (Fisher & Sponseller, 2010). Therefore, the scope of the aquatic ecosystem lies inside the water body only. Mangrove, as defined by Robertson & Alongi (1992), basically describes the physical characteristics possessed by tree, shrub palm or ground fern which exceeds the height of one half metres and grows in estuarine margins or coastal environments above the sea mean level. However, when referring to a habitat or a certain area specifically called as mangrove forest (or sometimes called as ‘tidal forest’), the term ‘mangroves’ is used.

Trace metal is a term concerning the identification of a large group of metallic elements in nature or living organisms that exists in a limited amount (Moloukhia & Sleem, 2011). Heavy metals such as iron (Fe), manganese (Mn), copper (Cu), and zinc (Zn) are essential for most living organism for processes such as growth. However, they are only needed in small amounts. Excessive amount may lead give harmful effects. On the other hand, there are metals which are termed as non-essential heavy metal for metabolic activities such as cadmium (Cd), lead (Pb) and chromium (Cr), which are toxic even though they exist at relatively low concentration (Nur Atiqah Mohamad Yusoff & Shabdin Mohd Long,
Both non-point and point source pollution are contributing widely to this issue, especially of anthropogenic activities such as agricultural, industrial, surface runoff and precipitation and urban effluents that enters the aquatic ecosystems (Gupta & Singh, 2011). According to Zhou et al. (2007), heavy metals may exist naturally due to the slow leaching from soil or rocks to water. However, this is usually at low levels which cause no serious effects on human health. Gupta & Singh (2011) added that volcanic eruption may also introduce heavy metal to the aquatic system naturally.

Generally, the accumulation of heavy metals throughout the trophic chain is caused by their inability to degrade. The concentration of heavy metals in a living organism may be higher compared to concentration of the surrounding area of the living organism. However, the relationship between the concentration of metal in an aqueous phase and in an organism does not work in a straight forward way. This relationship depends on some factors such as environmental origin and biological factors, such as age, sex and maturity, to reach a certain ratio of accumulation (Gupta & Singh, 2011). When the concentration of heavy metal increases, this increases the damage effect towards the human body of the living organism being accumulated. As a result of a long term exposure, the effects include chronic poisoning, abnormal development of fetus, immunodeficiency and procreation failure (Moloukhia and Sleem, 2011; Zhou et al., 2008).

Due to its wide occurrence, there has been an increasing attention gained by the issue of heavy metal pollution in the aquatic ecosystem (Zhou et al., 2008). Heavy metal contamination determination in water is often done by determining the heavy metal contents in sediments. However, according to Liang et al. (2004), the hazards caused by heavy metals to human health and their pollution in waters are better reflected by investigating the heavy metal contamination in organism rather than investigating the sediments. This is due to the fact that organisms can absorb the heavy metals that possess a high bioavailability. Hence, there is a chance that elements that are not contained in the water might be contained in the organism that is inhabiting the water. Different heavy metals have different levels of easiness to move from the water body to organisms. Hence, this is the major concern in
terms of the toxicity of heavy metals to human and living organism. According to Lovejoy (1999), the pollutants entering an environment, depending on their state of stability, undergo variety of interactions which lead either to their activation or detoxification. The more toxic forms are formed by the less stable compounds. Stable compounds are not so toxic in term of acute toxicity, they are less likely to bind to biological molecules within organisms thus, they are less likely to cause damage compared to the less stable compounds.

Terminologies employed in this study are closely related to bioaccumulation and biomonitoring. Many of the times, environmental terminologies are being synonymized hence contributes to an improper use of the key terms. The study paper by Zuykov et al. (2013) clearly stated that bioaccumulation is an addition to the tools used to study contamination (water quality analysis, toxicity testing and ecological survey). This is because it provides a direct measure of the bioavailability of contaminants and also some of the toxicity level of the environment studied. The study by Zhou et al. (2008) explained that the bioaccumulation process occurs when the loss rate of toxic substance fail to exceed the absorbance rate in an organism. According to Gupta & Singh (2011), biomonitoring is an important approach in the assessment of risk from environmental and occupational exposures. By biomonitoring a target site, an estimation of the total dose absorbed and the concentration of the risk faced is accessed indirectly and being determined. Being short-formed from the words ‘biological’ and ‘monitoring’, it is also used to assess the state of environmental changes shown by the particular water quality. In addition, this term should be limited to only complex observations of living organisms which is suspected or undergoing an evaluation of changes in their environmental quality (Zuykov et al., 2013).

Another element to be investigated in this study is the sediment of the sampling site. Sediment as defined by Owens (2008) is solids, which are deposited or suspended, made of minerals or organic material that is susceptible to being transported by water. Depending on the location of the sediment, the mechanisms of sediments’ transportation may vary. For example, in a river catchment, a flowing water, wind, gravity-driven processess and animals may also be a relevant influence
of sediment transportation. Depending on the location, anthropogenic factor and seasonal changes may cause changes in sediment fluxes. Sediment is important for global biogeochemical cycling, as a transport for the nutrients and contaminants from a place to another (e.g. from terrestrial to freshwater to marine and coastal systems), and also as a habitat for aquatic biota and creating a landform. The momentum of impact being driven by the society is somehow manipulating sediments in response of the manipulation of the landscape of agriculture, industry, transportation and recreational use.

1.2 Scope of study

This study analyses the bioaccumulation of five heavy metals which are copper (Cu), iron (Fe), cadmium (Cd), zinc (Zn) and lead (Pb) in the total soft-tissue of *P. expansa* collected in the mangrove area of Kondopi, Kudat. This study also studies the same heavy metals as in the *P. expansa* in the sediments taken in the same study site.

1.3 Objectives

1.3.1 To investigate the heavy metal bioaccumulation in the *P. expansa* and sediment collected from the sampling site

1.3.2 To compare the heavy metal concentration in the *P. expansa* with the Malaysian standard, Food Act 1983

1.4 Importance of Study

This study aims to provide the basic information regarding the current status of heavy metal contamination of the sampling site, specifically the heavy metals of interest which are Cu, Fe, Cd, Zn and Pb. This is possible because according to the formula of the bioaccumulation factor (Nur Atiqah Mohamad Yusoff & Shabdin Mohd Long, 2011), not only the tissue of the mollusk is tested in the laboratory but the metal concentration of the sediment is also taken into consideration. This study is important to know whether the *P. expansa* in the sampling site is safe to be eaten or not based on the heavy metal concentration inside the organism. Therefore, the aims of this study will show results on whether or not the amount of heavy metal
contained in the mollusks is on track with the standard set by the Food Act 1983. In addition, there has been no study yet done on this study site. Hence, this might be a good start for studies to be carried on in the mangrove areas in Kudat in times to come.
CHAPTER 2

LITERATURE REVIEW

2.1 Mollusca (Bivalvia)

Mollusca, being the second largest phylum after the Arthropods (Rawat, 2010), is split into seven classes: Aplacophora (solenogastres); Scaphopoda (tusk shells); Polyplacophora (chitons); Polecypoda (Bivalvia or Lamellibranchiata); Monoplacophora; Cephalopoda (squids); and Gastropoda (snails) (Saxena, 2005). There are three classes of mollusca that are more dominant than the others, they are namely bivalves, gastropods and cephalopods (Taylor & Lewis, 2005). The meaning of the word mollusk is ‘soft-bodied’ which comes from the Latin word, mollis. There are more than 50,000 living species of mollusks around today, with about 30,000 of the species are found and living in the sea (Vermeij, 1993; Gosling, 2003), although it is thought that 60,000 of mollusks fossil species have been described. There are 1211 species of mollusk bivalves in Southeast Asia, which is the highest diversity of bivalves compared with other regions throughout the world (Taylor & Lewis, 2005).

A total of 21 characteristics of mollusks were listed by Saxena (2005) seen in Appendix A. It is a group that is very distinct and having no similarities with other living groups where it is known to have the softest, most flexible bodies amongst the animal kingdom. Therefore, mollusks are said to be a successful group due to their existence in the oceans, freshwaters and on land taking various kinds of
forms (Rawat, 2010). Meanwhile, Rawat (2010) also included 20 essential physiologies of mollusks (Appendix B), which is almost similar with Saxena (2005).

One of the most famous characteristic features of mollusk is having shells which are made of calcium carbonate (hard calcareous shell). The shells are used as a protection from predators. According to Vermeij (1993), the shells also often function to provide the sense organs a good protection system. Shells may make it difficult for predators to detect the mollusks due to the visual blending of the mollusks with the surrounding. In addition, some of the mollusk species are popular with shell collectors due to the uses of the mollusks’ shells (Kay, 1995) as seen in Appendix C.

Apart from shells, another special feature of mollusks is the body wall that surrounds the body cavity. In the foot of mollusks, the muscle tissue is very thick. The internal organs are located and are contained in the body cavity. Each species of mollusks have a distinctive shape of their body wall. The body wall is folded in most species of the mollusks. The folded part is to form the mantle that has a connection with the top of the body (Kubesh et al., 2007).

Mollusks are highly adaptive and have various form, structure, habits and habitats. Therefore, they occupy all possible aquatic and terrestrial habitats, except aerial. Most of the species are marine, living in shallow waters or among coral reefs. However, there are some that are adapted to great depths up to 12,000 meters. While various snail and bivalves are mostly living in brackish waters, in freshwater lakes, rivers, and ponds. Surprisingly, one species of snail is found in the desert at Death Valley, California. One of the she survival skills of the snail in the desert is that it keeps its shell opening sealed with mucus. It only feeds ranging from only two or three weeks in a year during the short periods of its moist environmental surrounding (Rawat, 2010).
Each species in the class of mollusca has evolved and have a distinctive form and size (Rawat, 2010). The major body system of a mollusk are the digestive system, respiratory system, circulatory system and also the nervous system (Kubesh et al., 2007). Generally for mollusks, the digestive system works with the help of the salivary glands and digestive glands (figure 2.1). The salivary glands secrete carbohydrate enzyme and mucus, in which mucus acts as a lubricant for the food particles. There are two types of respiratory system of a mollusk, which are aquatic respiration and aerial respiration. A single ctenidium (a comb-like gill) is used in the aquatic respiration while aerial respiration is carried out by the pulmonary sac or lung. Mollusks have an open type of circulatory system (Puranik & Bhate, 2007).

According to Taggart & Starr (2009), ‘radula’ is the organ of which most mollusks feed with. It is a an organ that looks like a tougue but at the same time, it is hardened with an exoskeleton called as chitin. To further understand the information about radula, Puranik & Bhate (2007) in the book of has a more detailed explanation stating that radula has several transverse rows of minutes recurved horny teeth. According to Kubesh et al. (2007), the feeding mechanisms of clams start when water enters the clam through one siphon. Secondly, the water will flow to the clams gills and the gills will capture oxygen and food from the water that entered. This is done by cilia, tiny hairs of the gills, that traps the particles of food and bring the food particles into the mouth. Lastly, the leftover water will flow out through the other cilia.
Figure 2.1 Example of an internal anatomy of a bivalve mollusk species Sphaeriidae (*Musculium securis*) (Source: Mackie & Claudi, 2010)

Mollusks live in both salty and fresh water such as lakes, rivers, ponds and oceans (Kubesh *et al*., 2007). They need water to be active. However, as it is seen in most temperate countries and in the tropics, there is an existence of slugs and snails in land. The habitat needs to be damp and the species of mollusks are almost completely absent in dry habitats like deserts. In addition, it is observed that where there is less plants, the number of land slugs and snails are also less. This is because they are vegetarian creatures (Gilpin, 2006). To prevent them from losing too much water inside their body, they tend to be found in mostly buried or covered by mus areas (Feinberg, 1980).

It is a typical method to have bioindicators such as algae, macrophyte, zooplankton, insect, bivalve mollusks, gastropod, fish and amphibian. Each species has its own advantage. For example, heavy metal exposure or pollution may be expressed through algae’s species and amount because it reflects the water quality in an aquatic ecosystem. Due to its high bioaccumulation abilities, one of its roles other than as a tool for biomonitoring is as a useful phytoremediation technology to restore water quality. Despite all the good qualities naturally possessed by algae, one of its limitations to be used as a universal bioindicator of heavy metal pollution in the
REFERENCES


Nur Atiqah Mohamad Yusoff & Shabdin Mohd Long. 2011. Comparative bioaccumulation of heavy metals (Fe, Zn, Cu, Cd, Cr, Pb) in different edible mollusks collected from the estuary area of Sarawak River. *Universiti Malaysia Terengganu Annual Symposium*, (pp. 806-811). Kuala Terengganu.


