Faculty of Resource Science and Technology

ECOLOGY OF MUDSKIPPERS IN KAMPUNG PASIR PUTIH, SARAWAK

Naquiah binti Abdul Ghani

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NAQUIAH BINTI ABDUL GHANI

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Declaration

I hereby declare that this thesis entitle 'The Ecology of Mudskippers in Kampung Pasir Putih, Sarawak' is based on my original work except for all the sources that has been cited and has been acknowledged in the references section. This thesis also has not been submitted to any other degree at other university or higher education institution.

Naquiah binti Abdul Ghani

Aquatic Resource Science and Management

Department of Aquatic Science

Faculty of Resource Science and Technology

Universiti Malaysia Sarawak

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List of Abbreviations

GPS	Global Positioning System
SL	Standard Length
TL	Total Length
CF	Caudal Fin
DO	Dissolved Oxygen
cm	Centimeter
m	Meter
µm	Micrometer
g	Gram
PSU	Practical Salinity Unit
TOM	Total organic matter
PSA	Particle Size Analysis
DW	Dry weight
SD	Standard Deviation
ANOVA	Analyses of Variance
SPSS	Statistic Package for Social Science

Ecology of Mudskippers in Kampung Pasir Putih, Sarawak

Naquiah binti Abdul Ghani

Aquatic Resource Science and Management
Faculty of Resource Science and Technology
University Malaysia Sarawak

ABSTRACT

The study of ecology of mudskipper was conducted in Kpg. Pasir Putih, Sarawak at intertidal zone of mangrove area. Thirty-five samples of mudskippers were collected by using scoop net and by hands with the aid from local fisherman. The total lengths were ranged from 3.4 to 8.0 cm and there was a very strong correlation between total length and weight of mudskippers (r=0.968). The species of mudskippers were identified as *Periophthalmus chrysospilos.* The distribution of mudskippers in Kpg. Pasir Putih, Sarawak was influenced by dissolved oxygen, pH, salinity, temperature, total organic matter and particle size. Based on particle size analysis, about 80-90% of sediment was silt and clay, whereas 10-20% was sand. There was strong negative correlation (r=-0.763) and (r=-0.625) between TOM with dissolved oxygen and temperature respectively, whereas there was strong positive correlation (r=0.645) between dissolved oxygen and pH value of water parameters. The distribution of juvenile mudskippers was the highest at plot 3 compared to plot 1 and 2 in Kampung Pasir Putih, Sarawak.

Key words: Ecology, distribution, species, sediment, correlation

ABSTRAK

Kajian tentang ekologi ikan belacak telah dijalankan di Kampung Pasir Putih, Sarawak di zon pasang surut kawasan paya bakau. Tiga puluh lima ekor sampel ikan belacak telah ditangkap dengan menggunakan jala pencedok dan tangan dengan bantuan daripada nelayan tempatan. Jumlah panjang ikan tersebut adalah berbagai dari 3.4 ke 8.0 cm dan hubung kait antara jumlah panjang terhadap berat ikan belacak adalah sangat kuat iaitu (r=0.968). Species ikan belacak telah dikenapasti sebagai Periophthalmus chrysospilos*. Taburan ikan belacak di Kampung Pasir Putih Sarawak dipengaruhi oleh oksigen, pH, kemasinan, suhu, jumlah jirim organic dan saiz zarah. 80-90% sedimen adalah kelodak dan tanah liat, manakala 10-20% adalah pasir. Hubung kait negatif adalah sangat kuat iaitu (r=-0.763) dan (r=0.625) di antara jumlah jirim organic terhadap oksigen dan suhu, manakala (r=0.645) di antara oksigen terlarut terhadap nilai pH. Taburan ikan belacak juvenile adalah paling banyak di plot 3 berbanding plot 1 dan 2 di Kampung Pasir Putih, Sarawak.*

Kata kunci: Ekologi, taburan, spesis, sedimen, hubung kait.

1.0 Introduction

Mangrove ecosystems provide habitats for many organisms especially for nursery ground of many species in the commercial and sport-fishing industries (Karleskint et al., 2013). In most of the Old World's mangrove wetlands, mudskippers are outstanding fish in terms of their remarkable behavior patterns and their morphological features (Mastaller, 1997). The distribution pattern of mudskippers has a wide bio-geographical range from the west coast of Africa until the whole Indo-west Pacific region (Ansari et al., 2014).

Mudskippers are consist of 25 air-breathing species that can be classified into four genera namely *Periophthalmodon, Periophthalmus, Boleophthalmus* and *Scartelaos,* derived from subfamily Oxudercinae, family Gobiidae (Murdy, 1989). Presently, the group includes 34 species in seven genera *Periophthalmodon, Periophthalmus, Boleophthalmus*, *Scartelaos*, *Pseudapocryptes, Zappa* and *Apocryptes* (Ansari et al., 2014). According to Atack (2006), there are three main species that inhabit Sarawak River which are *Boleophthalmus boddarti*, *Periohthalmodon schlosseri* and *Parapocryptes serperaster*. The differences between each species can be identified by observing on the features and characteristics of body parts of the mudskipper such as upper jaw, dorsal fin, pelvic fin, pectoral fin and others for species identification.

Distribution pattern of mudskippers are not uniformly distributed because the habitat preferences of mudskippers are still not clear. The size of sediment play important role to create well oxygenated microenvironment for egg development and nursery. Sedimentation is considered as an important factor in mangrove ecology (Hutching & Saenger, 1987; Clarke, 1995; Ellison, 1998) as mangroves usually grow at low-lying continental coastlines, where

sedimentation is certainly paramount importance to coastal forests. The sediment grain size can determine the drainage of the beach which greatly affected by interstitial oxygen content (Ellingsen, 2002).

In order to understand the distribution species of mudskippers in the coastal wetlands of Kpg. Pasir Putih, an observation point is necessary before conducting the survey on ecology and lifestyles of mudskippers. With high sensitivity towards environmental changes, mudskippers are considered as bio-indicator organisms of wetland environmental changes. In addition, they are economically important as a food source in certain country and used in traditional medicine. Unfortunately, there were little studies about mudskippers of marine pollution in Kpg. Pasir Putih. However, the mudskipper's environmental tolerance is not strong as expected due to vulnerability to environmental changes such as embankments, fish farms, roads and other public buildings that bring cement and affect their habitat (Chih, 2013).

Therefore, the objectives of this study were (1) to assess the ecology and the distribution of mudskippers in Kpg. Pasir Putih, Sarawak, (2) to determine the relationship between selected physico-chemical parameters towards mudskippers' distribution in Kpg. Pasir Putih, Sarawak and (3) to identify the species of mudskippers available in Kpg. Pasir Putih, Sarawak.

2.0 Literature Review

2.1 Ecology of Mangrove Areas

Ecology is the study of interrelationships between organisms and their natural environments, either living or non-living (Oxford, 2008). Mangrove represents the dominant soft bottom plant communities of the marine terrestrial transition that display remarkable adaptations. These allow them to survive under harsh environmental conditions such as high salinity, low oxygen and nutrient abundance in the soil, wind and wave action and substrate instability (Pernetta, 1993).

According to Atack (2006), mangrove forest is the collective name given for the types of tree vegetation found in brackish water environment. Nipah palms, small trees and shrubs of *Avicennia* spp. and *Rhizophora* are examples of trees that have adapted to the high levels of salt and the fluctuating water levels. All the plants have their own way of adaptations in order to survive and grow in mangrove area.

Besides that, mangrove is important as nursing grounds for many species of juvenile fish as it provides relatively safe haven, food-rich environment that is ideal for nursery and spawning requirements (Atack, 2006). Mangrove's diverse and numerous root systems combined with detritus and nutrient abundance provide excellent shelter, feeding and spawning ground for many aquatic organisms. In addition, mangrove is considered as an important role in coastline protection and as a buffer against storm-tide surges (Hashim et al., 2013)

2.2 Physico-chemical Parameters

According to Barnes (1974), the main parameters that give effects on mangrove organisms are salinity, temperature, oxygen level, the nature of the substratum and the nutrients availability. Based on mudskippers' high sensitivity to environmental changes, mudskippers are considered as indicator organisms of wetland ecosystems (Chih, 2013). However, their environmental tolerances are not strong as expected which may cause mudskippers to disappear due to their susceptibility to environmental changes. Better understanding of physico-chemical can describe mudskipper distribution pattern where physico-chemical parameters covered variability effects on physical, biology, and ecology of mudskippers. Besides that, physico-chemical parameters are the most effective tools to detect the alteration of mudskippers because they have high sensitivity toward the changes of some physicochemical parameters.

The selected physico-chemical parameters in this study are pH, temperature (°C), dissolved oxygen (mg/L), salinity (PSU) and sedimentation (total organic matter and particle size analysis). Salinity values of mangrove area can be varied due to the influence of freshwater and sea water input. Besides that, dissolved oxygen are also varies as it is influenced by biological activity, tides and temperature.

2.3 Sediment

2.3.1 Total Organic Matter

According to Nardi et al. (2002), soil organic matter was defined as total organic component in soil exclusive of undecayed plant and animal tissues, their 'partial decomposition' products (the organic residue) and the soil biomass (living microbial tissue). It also helps to improve soil structures, enhances water penetration, increase water-holding capacity, and stores nutrients for growth of microorganisms in plants and soil (Nardi et al., 2002). The organic carbon content can be a sensitive indicator of the nature source area and the extent of deposition in the environment.

However, the organic matter content can be influenced by climate condition such as temperature, rainfall, soil aeration, pH value and microbial population of the soil. The accumulation of organic matter might be greater when the temperatures are cooler, while decomposition of organic matter was greater in warmer conditions. Sampling during monsoon months of October to December particularly might increase organic contents due to high accumulation of sedimentary matter (Zaleha et al., 2012).

2.3.2 Particle Size Analysis

Particle size analysis is important to identify the structures and productivity of mangrove area. The species composition and growth of mangroves are influenced by the physical composition of mangrove soils. The grain size and proportions of clay, silt and sand indicate the permeability of the soil to water which will affects soil salinity and water content.

2.4 Mudskippers

2.4.1 Morphological characteristics

Basically, the common mudskippers are brown in colour with irregular spots and markings on their bodies. Their heads are round-shaped with a pair of protruding eyes above which allow them to locate the potential predators. In addition, their periscope-like eyes can receive a well-focused picture of their surroundings in both above and below the water surface (Mastaller, 1997). They also have strong pectoral fins and tails which enable them to skip on the mud surface and to walk on land (Graham et al., 1985). Besides that, the pelvic fins are evolved into sucking disc which allows them to grip on mangrove trunks and roots. Some of the species have marked with orange spots, whitish-blue spots, white spots, black spots and many more on opercles and flanks to differentiate between the species.

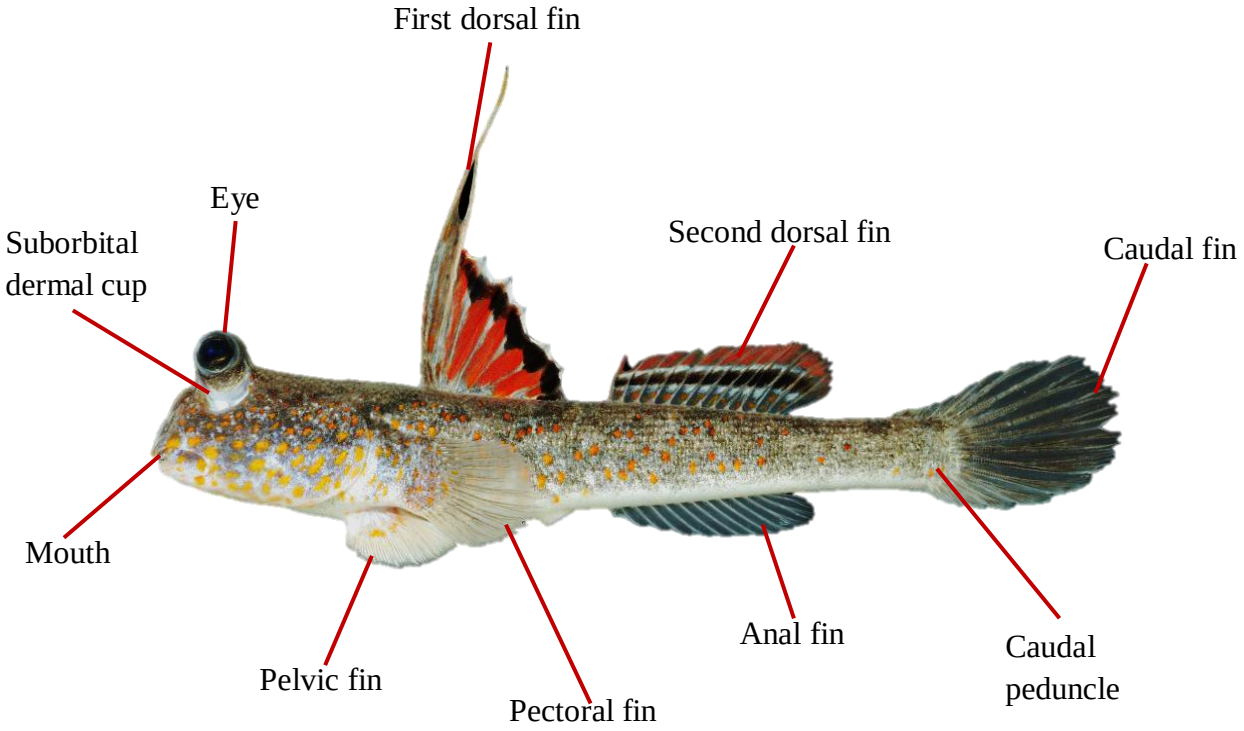

Figure 1: Body parts of mudskipper in lateral view (Google source).

2.4.2 Behavioral and Physiological

Mudskippers are well-known true resident of fish where the whole life cycles are occurred in mangrove area. Compared to other fish, mudskippers have unique behavioral and physiological to ensure they are well-adapted to amphibious lifestyle (Graham, 1977). These allow them to breathe effectively either in land or water. These fishes have a range of strange behavioral and physiological adaptations to an amphibious lifestyle including anatomical and behavioral adaptations that allow them to move effectively on land as well as in the water (Al-Behbehani & Ebrahim, 2010). In addition, Graham (1977) also stated that mudskippers breathe through their skin and the mucosa (the lining of their mouth) and throat (the pharynx). Usually, mudskippers digging of deep burrows in soft sediments sediments during low tides to allow them to thermo regulate, avoid marine predators during high tide, breeding and laying their eggs and raise their young (Al-Behbehani & Ebrahim, 2010). Even when their burrow is submerged, mudskippers maintain an air pocket inside it, which allows them to breathe in conditions of very low oxygen concentration (Sasekumar et al., 1984). In addition, mudskippers reproduced by spawning their eggs in the burrow and this afford protection for the eggs. In addition, when they are out of water, they are actively feeding and interacting with one another. However, this is only possible when the mudskipper is wet, which limiting mudskippers to moist habitats and requiring them to keep themselves moist.

3.0 Materials and Methods

3.1 Field Work

3.1.1 Study Area

The study was carried out in Kpg. Pasir Putih, Sarawak (Figure 2) which is indeed well known for new replantation mangrove forest. It is located between Senari Port and Bako National Park and will take about 40 minutes if drive from Kuching. The coordinates of sampling site was recorded on 20th April 2014 by using Global Positioning System (GARMIN GPS map 62s) as shown in Table 1 below. The reading of *in-situ* parameters were recorded three times at intertidal area during low tides and sunny weather.

Table 1: The coordinates of three sampling plots

Plots	Global Positioning System
1	N 01°39'48.3" E110°28'30.1"
2	N 01°39'46.7" E110°28'31.6"
3	N 01°39'47.4" E110°28'33.5"

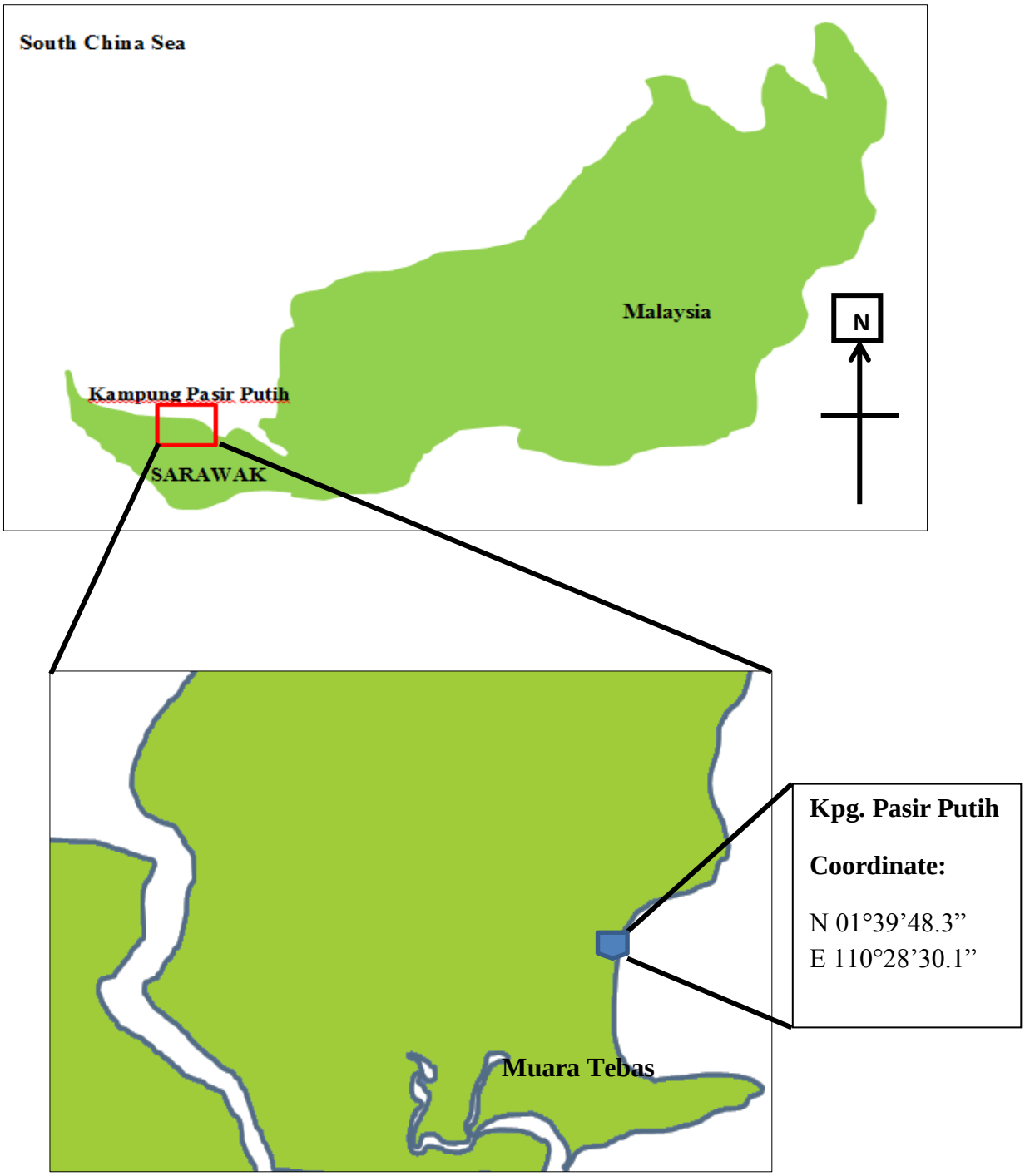

Figure 2: Study sites of mangrove area in Kpg. Pasir Putih, Sarawak.

3.1.2 Sampling Design

Plot method was used in this study by setting up three plots with similar length and width (approximately 50 m X 50 m) perpendicular to the sea at intertidal zone (Figure 3). Each coordinates of plot were recorded by using GPS (Garmin, GPS map 62s). Then, four quadrats (0.5 m X 0.5 m) were selected in each plot to record the species distribution of mudskippers and selected physico-chemical parameters.

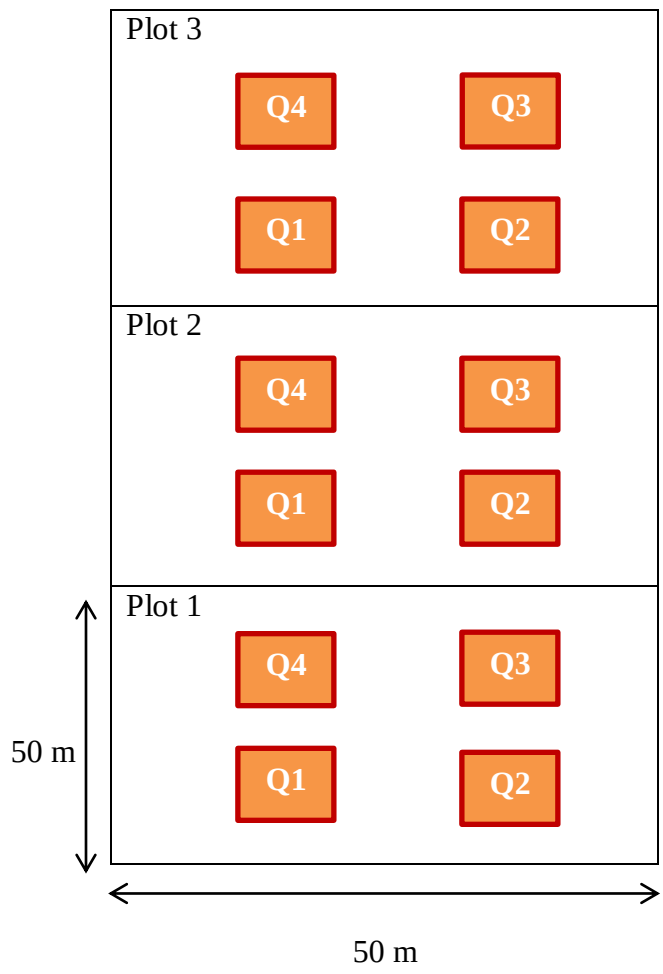

Figure 3: Plot method at intertidal area

3.1.3 Selected Physico-chemical Parameters

Selected physico-chemical parameters such as pH, dissolved oxygen, temperature and salinity were measured *in-situ* by digging a hole and let the pour water filled through the hole next to each quadrat of every plot as shown (Figure 3). Then, the reading of dissolved oxygen (mg/L) and temperature (°C) were recorded by using DO meter (EUTECH, CyberScan DO 110), pH value and salinity (PSU) were recorded by using pH meter (HANNA, HI 8424), and hand refractometer (Atago, Master-S/miilα) respectively within each quadrat. The data were recorded triplicate to get an average and to increase accuracy.

The sample of sediment was collected with three replicates within each quadrat for further sediment analysis by using core sampler (15 cm), and was placed into labelled plastic.

3.1.4 Vegetation Observation

For species identification, the samples of leaf and root were taken during the sampling and the photos of the whole trees in that particular area were taken by using camera. Besides that, the density of the trees at intertidal area of Kpg. Pasir Putih was observed and recorded.

3.1.5 Sampling of Mudskippers

A total of 5 mudskippers were collected on 20th October 2014 and 30 mudskippers were collected on 22nd November 2014 with the aid from local fishermen. The samples of mudskipper were collected by using scoop nets and bare hand. Then, the caught specimens were placed in small plastic containers in cooler box for future studies in laboratory analysis.

3.2 Laboratory Work

3.2.1 Total Organic Matter (TOM)

The method of total organic matter analysis was used to determine the percentage of organic matter in the sediment which has been adopted by Greiser & Faubel (1988). First, about 50 g of sediment was weighed by using digital balance, was placed in the crucible and was dried at 60ºC for 24 hours in the oven. After that, the sediment was cooled down and the initial weight was recorded. Then, the sediment was combusted in furnace for 4 hours in temperature of 475ºC. After the sediment was cooled down for about 3 hours, the final weight was measured to determine the loss of weight in sediment. The mass (%) was obtained by using the formula TOM as shown below:

Formula for TOM (Mass, %):

$$\left(\frac{Dw60 - Dw475}{Dw\ 60}\right) x\ 100$$

Dw60 = Wight of sediment after taking out from oven

Dw475= Weight of sediment after taking out from furnace

3.2.2 Particle Size Analysis

Particle size analysis was determined through the procedure of wet sieve analysis, dry sieving of the sand fraction and pipette method for silt-clay fraction as recommended by Buchanan (1984). Then, the sample of sediment was degraded and the type of sediment was classified and sorted by using Udden-Wenworth (1992) grade scale to describe grain size: very coarse sand (>1.0 mm), coarse sand (>0.5 mm) medium sand (>0.25 mm), fine sand (>0.125 mm), very fine sand (>0.0625 mm) and silt (<0.0625 mm).

3.2.2.1 Wet Sieve Analysis

About 30 g of sediment samples were dried overnight at 60°C. Then, the sample was transferred into one litre beaker containing 100 mL of 6% hydrogen peroxide and was stand overnight to break any clumps in the materials. The sample was dispersed in sodium hexametaphosphate to separate the fine/clay particles. Next, 250 mL of tap water and 10 mL of 6.2 g/L sodium hexametaphosphate solution of was added to the sample into one beaker. The solution was stirred for 15 minutes and was soaked overnight.

The soaked sediment was transferred to 63 µm mesh sieve with a plastic basin below the sieve to collect the silt/clay fraction that was pass through. The remained sand on the surface of sieve was dried in oven at 70-100°C for overnight, and the silt/clay fraction in the basin was used in Pipette Method. The dried sand was transferred into petri dish and the weight was recorded and was used in Dry Sieve Analysis. The silt content was obtained by using the formula below:

$$\text{Silt content (\%)} = \frac{(\text{Total weight of sample} - \text{Weight of sand}) \times 100}{\text{Total weight of sample}}$$