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WATER FLUXES AND SUSPENDED SOLIDS DISTRIBUTION IN THE WATER COLUMN OF MENGGATAL ESTUARY, KOTA KINBALU

DAYANG SITI MARYAM BINTI MOHD HANAN

THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE DEGREE OF BACHELOR OF SCIENCE

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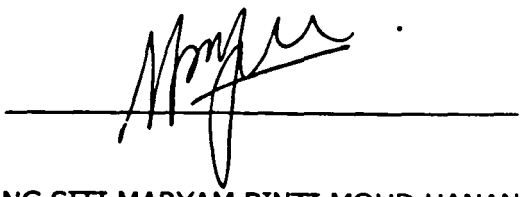
APRIL 2010

DECLARATION

The materials in this thesis are original except for quotations, summaries and references, which have been duly acknowledged.



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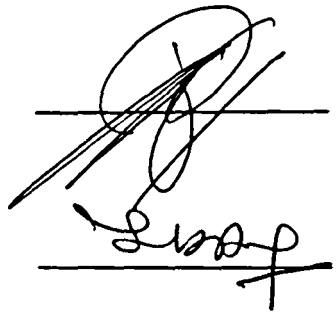

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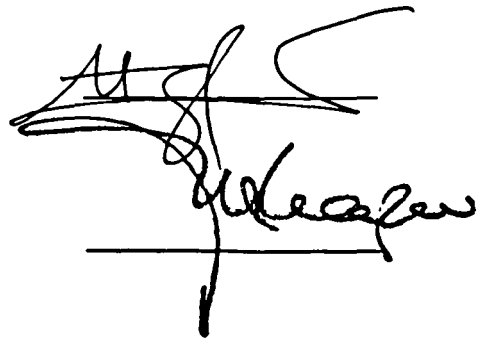

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ABSTRACT

Study on water fluxes and suspended solids distribution in the water column of Menggatal estuary, Kota Kinabalu had been conducted on 15th and 16th October 2009 (Sampling 1) and 18th and 19th February 2010 (Sampling 2). This study was conducted to identify total suspended solids, total suspended solids fluxes and water fluxes during high tide and low tide during spring tides. This study was also conducted to measure water parameters such as pH, salinity (psu), dissolved oxygen (mg/l) and temperature (°C) in the study area. Sampling stations were divided into three area across the width of the estuary. Water samples were collected using water sampler, current velocity and direction data were collected using current meter (Model AEM 213-D) and data for water parameters were collected using Hanna Multiparameter (Model HI 9828). Total suspended solids and suspended solids fluxes was higher during flood tide, as well as total water fluxes. Water parameters are also affected by tides. For Sampling 1, the highest level of total suspended solids, suspended solids flux and water fluxes was 0.0431 g/l, 0.233 kg/m²/s and 213.36 m³/s respectively. The highest level of pH, salinity, dissolved oxygen and temperature recorded at the study area were 8.41, 31.11 psu, 5.46 mg/l and 31.58°C respectively. For Sampling 2, the highest level of total suspended solids, suspended solids fluxes and water fluxes was 0.443 g/l, 0.222 kg/m²/s and 173.11 m³/s respectively. The highest level of pH, salinity, dissolved oxygen and temperature recorded was 8.41, 28.80 psu, 6.38 mg/l and 30.86 °C respectively.

ABSTRAK

Kajian mengenai fluks air dan sedimen terampai di dalam turus air muara Sungai Menggatal, Kota Kinabalu telah dijalankan pada 15 dan 16 Oktober 2009 (Penyampelan 1) dan 18 dan 19 Februari 2010 (Penyampelan 2). Kajian ini dilakukan untuk mengetahui jumlah sedimen terampai, fluks sedimen terampai dan fluks air semasa air pasang dan air surut pasang perbani. Kajian ini juga dijalankan untuk mengetahui ciri-ciri air seperti pH, saliniti (psu), oksigen terlarut (mg/l) dan suhu (°C) di kawasan kajian. Stesen penyampelan telah dibahagikan kepada tiga bahagian pada satu keratan rentas muara sungai tersebut. Sampel air diambil menggunakan alat penyampelan air. Data untuk halaju dan arah arus diambil dengan menggunakan meter arus (Model AEM 213-D) dan data untuk ciri-ciri air diambil dengan menggunakan Hanna Multiparameter (Model HI 9828). Keputusan menunjukkan jumlah sedimen terampai , fluks sedimen terampai dan fluks air adalah lebih tinggi ketika air pasang. Ciri-ciri air juga dipengaruhi oleh pasang surut air. Untuk Penyampelan 1, nilai tertinggi bagi jumlah sedimen terampai, fluks sedimen terampai dan fluks air adalah 0.0431 g/l, 0.233 kg/m²/s dan 213.36 m³/s masing-masing. Nilai pH, saliniti, oksigen terlarut dan suhu tertinggi yang direkodkan adalah 8.41, 31.11 psu, 5.46 mg/l dan 31.58°C masing-masing. Untuk Penyampelan 2, nilai tertinggi bagi jumlah sedimen terampai, fluks sedimen terampai dan fluks air adalah 0.443 g/l, 0.222 kg/m²/s dan 173.11 m³/s masing-masing. Nilai pH, saliniti, oksigen terlarut dan suhu tertinggi yang direkodkan pula adalah 8.41, 28.80 psu, 6.38 mg/l dan 30.86 °C masing-masing.

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LIST OF SYMBOLS

No. of Symbols

N	North
E	East
cm	centimeter
m	meter
km	kilometer
s	seconds
mg	milligram
g	gram
kg	kilogram
ml	milliliter
l	liter
µm	micrometer
psu	practical salinity unit
°C	degree Celcius
Σ	sum

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CHAPTER 1

INTRODUCTION

1.1 Introduction

The study of estuaries has been of high interest for researchers for many decades ago. And yet, it is still one of the most studied habitats and coastal lagoons today. Estuaries can be defined as a body of water that are partially surrounded by land, and where freshwater mixes with seawater (Garrison, 2005). Mixing of seawater and freshwater that occur in the estuaries will cause changes in both water characteristics and also the composition and abundance of marine organisms in the area. Part of the fascination and interest of estuaries is due to their dynamic nature. This is because most of estuaries variables really does have significant variations. For example, the salinity in estuarine areas varies according to the strength or volume of freshwater flow and the tidal regimes in that area also produces strong currents and turbid water (Little, 2000). Estuaries are also areas where sediments are accumulated and trapped. Patterns of sedimentation vary with overall estuarine shape and with distribution of salinity.

However, greatest contrast in sedimentation pattern is found between the wave-dominated and tide-dominated estuaries (Little, 2000). Therefore, the understanding of the sedimentation in estuarine environment is important due to several reasons. First, estuaries does not only provide habitat for many organisms, but are also important in the fisheries sectors. Estuaries are also important for human development and activities, for many of modern development projects are done in the nearby areas.

The rate of sediment transport in forested stream or river can be affected by activities such as cutting the hill areas for housing development and road building. Other pollutants also adhere to sediment particles, making suspended sediment a great indicator of water quality (Thomas, 1988). Understanding sediment dynamics is also important in the need to assess the possible environmental impacts of the present and future development projects (Kitheka *et al.*, 2004).

Menggatal estuary is located in an area semi-enclosed by bays and mangroves forest. Near the estuary area, islands such as the Sepanggar Island and also Gaya Island can be found. Since it is located near to the ocean, the water movement in the area are mainly affected by tides. During certain times of the month, especially spring tides, the tidal range are considerably large.

Other than tide, rainfall is another factor that plays an important role in carrying sediment from the surrounding catchment area of Menggatal estuary. When rain falls, the sediment or runoff will be carried into the river, moves into the estuary area and finally carried out to the sea.

Studies on water fluxes and sediment distribution and tidal effect in Menggatal estuary have been conducted by University Malaysia Sabah (UMS) since the past 6 years. For example, Suhaili (2003) studied about the effect of tides on total sediment distribution. Study of tidal effect on temperature and salinity was also done by Amirullah (2003) in the same study area. Four years later, Yusup (2007) studied about suspended sediment and water fluxes in Menggatal estuary. Since the last study conducted by Yusup (2007), the area surrounding Menggatal estuary had undergone many developments and constructions. This includes the completion of the 1Borneo Hypermall, which open its door to customer in 2008, as well as the development of new housing

areas such as the Kingfisher-Sulaman housing, 1Sulaman Hypermall and Alamesra residential areas.

Development and construction works also includes new buildings in University Malaysia Sabah, some of which is still under construction. Observations and study on sedimentation during flood and ebb tide, total suspended solids, water and suspended solid fluxes in the estuary was conducted in this study. Study on water parameters such as pH, salinity (psu), dissolved oxygen (mg/l) and temperature (°C) was also conducted in the study area.

1.2 Objectives of Study

The specific objectives of this study are:

i) To amount total suspended solids during flood tide and ebb tide
ii) To estimate total water fluxes and total suspended solid fluxes during high tide and low tide
iii) To measure water parameters such as pH, salinity (psu), dissolved oxygen (mg/l) and temperature (°C) in the study area

1.3 Hypotheses

The predicted outcomes and results of this study are:

i) Total suspended solids and total suspended solid fluxes will be higher during flood tide
ii) Water fluxes will also be higher during high tide
iii) The readings for water parameters, pH (pH unit), salinity (psu), dissolved oxygen (mg/l) and temperature (°C) will be different for each depth.

1.4 Significance of study

i) To relate the possibility of human activities impacting the Menggatal estuary area
ii) As an indicator for the safe level of suspended sediment concentration for organisms
iii) As a reference for proper management plan in Menggatal estuary area

CHAPTER 2

LITERATURE REVIEW

2.1 Estuaries

Estuaries can be defined as an area where freshwater mixes with seawater (Garrison, 2005). Estuaries are therefore zones of transition, with strong gradients and discontinuities. Another definition for estuary is a semi- enclosed coastal body of water, which has a free connection with the open sea. Estuaries are also areas within which sea water is measurably diluted with fresh water derived from land drainage (Kramer *et al.*, 1994).

Estuaries are the most significant and important route through which terriginious or land material enters the ocean (Simpson *et al.*, 2000). Estuaries are zones of sedimentation. River water flows downstream into the estuary area. The bigger sediment particles will be deposited along the river bed. At the same time, the smaller particles will continue to be carried out and finally deposited in the estuary.

Therefore, estuaries are typically dominated by soft sediment substrates, particularly fine muds (Dobson and Frid, 1998).

Coastal and estuarine areas can be said to be a strategic area for human settlement. This is due to the significant number of natural resources available in the area. This can be proven as more than 60% of the world's population lives within 60 km of the coast (Post and Lundin, 1996). Therefore, the estuarine area are also affected by a high level of human activity such as fishing activities, developments and so on. The increasing urban and industrial development within estuarine areas leads to significant habitat losses (Coleman *et al.*, 2008). Furthermore, estuaries are the discharge point for all particle stemming from anthropogenic activities carried out within the drainage basin, including urban and industrial development as well as intensive agriculture (Courrat *et al.*, 2008). Many estuaries are affected by activities such as nutrient loading from agricultural runoff, domestic sewage and atmospheric deposition (Goolsby *et al.*, 1999; Boyer *et al.*, 2002).

2.2 Types of estuaries

According to Garrison (2005), estuaries are classified into four types depending on their origin: drowned river mouth, fjords, bar-built and tectonic. The most common type of estuaries that can be found in Malaysia are drowned river mouth and bar-built estuaries.

Drowned river mouths are the most common type of estuaries that can be found, especially in Europe and British Isles (Dobson and Frid, 1998). These estuaries occurs when sea level rise, thus resulting in the incursion of seawater into river mouths (Garrison, 2005). Drowned river mouths are often V-shaped in section but are also normally relatively shallow and wide. At low water, extensive mudflats are revealed, and these estuaries have low sedimentation rates and low river flow (Dobson and Frid, 1998).

Based on Dobson and Frid (1998), bar-built estuaries are predominantly tropical in their distribution. Basically, bar built estuaries are drowned river valleys that have high

sedimentation rates. The sediment that have been deposited across the estuary mouth will form a partial barrier. The barrier, or bar, is formed of sediments which are not necessarily of river origin. However, river sediments will be deposited behind it, forming extensive mudflats. Fjords are steep, glacially eroded, U-shaped troughs. Often, fjords are 300 to 400 meters deep, and terminate in a shallow lip, or sill of glacial deposits. Fjords are common in Norway, Greenland and New Zealand (Garrison, 2005). According to Garrison (2005), estuaries that are produced due to tectonic processes are called tectonic estuaries. Usually, faulting or local subsidence will form coastal indentations. Here, fresh water and seawater will flow into the depression, forming an estuary.

Another way to classify estuaries are based on their circulation patterns (Figure 2.1). These includes salt wedge estuaries, well mixed estuaries, partially mixed estuaries and also fjords. Based on Garrison (2005) and Kramer *et al.* (1994), highly stratified salt wedge estuaries' mixing process are dominated by rapid river flow. They have low or moderate tidal range, and have very sharp halocline. The existing freshwater will hold back a wedge of intruding seawater, thus the name. Due to density differences, freshwater will flow on top of seawater. These seawater wedge will flow back to sea during low tide, and returns to shore during high tide.

Well mixed estuaries occur when the river flow is more slow, and the tidal range in from moderate to high. This will allow different mixture of seawater and freshwater throughout their length. Partially mixed estuaries are a combination of both salt wedge estuaries and well mixed estuaries. Therefore, it have the properties of both. These type of estuary occur when deeper estuaries are exposed to similar tidal condition, but with a greater river flow compared to the prior two (Dobson and Frid, 1998).

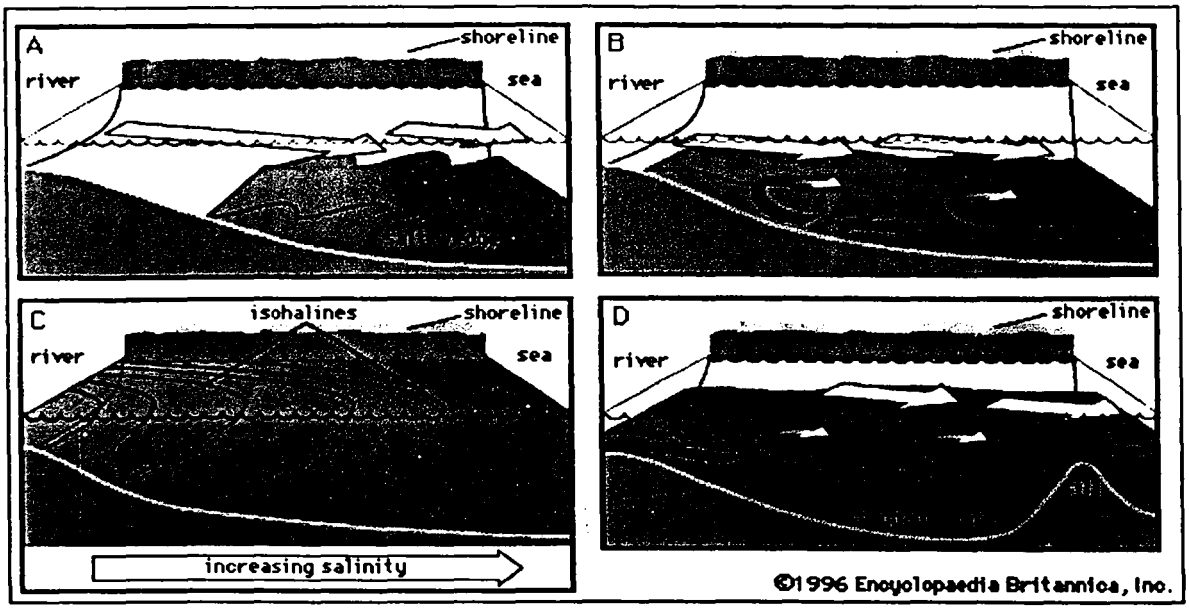

Figure 2.1 Estuaries classified based on circulation patterns. (A) Salt wedge estuary. (B) Partially mixed estuary. (C) Well-mixed estuary. (D) Fjords. (Source: www.britannica.com)

2.3 Tides

Tides are periodic, short-term changes in the height of the ocean surface at a particular place, caused by a combination of the gravitational force of the moon, sun and the motion of Earth (Garrison, 2005). Tides originates in the oceans and progress toward the coastlines where they appear as the regular rise and fall of the sea surface.

When the highest part or crest of the wave reaches a particular location, high tide occurs. Low tide corresponds to the lowest part of the wave, or its trough. The difference in height between the high tide and low tide is called the tidal range (Gordon and Lohrmann, 2001).

Tidal dynamics is affected mainly by the tidal range. When the tidal range is small, erosion rate is greater. More sediment will be transported out from the estuary. This is because, all the energy will be concentrated in a smaller area. On the other hand, when the tidal range is bigger, less sediment will be transported out of the estuary. The rise or fall in sea level as a tide crest approaches and passes will cause a tidal current of water to flow into or out of bays and harbors. Water rushing into an enclosed area because of the rise in sea level as a tide crest approaches is called a flood current. Water rushing out because the fall in sea level as the tide trough approaches is called the ebb current.

Tidal currents reach maximum velocity midway between high tide and low tide. The weakest currents occur between the flood and ebb currents and are called slack tides, and it occurs when the current changes direction (Garrison, 2005).

Tides are also characterized as diurnal, semidiurnal and a mix between the two (Eisma, 1998). Diurnal tides occur only once per day. They have only one high tide and one low tide within 24 hours. The height of the tides differs daily, according to the location of the sun and moon. Semidiurnal tides have two high tides and two low tides in a day. It have a relatively small inequality or differences in the tidal range. A mixed tides shows a sequence of a low low tide, a low high tide, a high low tide and a high high tide.

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