Faculty of Resource Science and Technology

THE COMMUNITY STRUCTURE OF MACROBENTHOS IN BATANG LUPAR ESTUARY

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DECLARATION

I hereby declare that this Final Year Report 2012 is based on my original work except for quotations and citations, which have been duly declare that it has not been or concurrently submitted for any other degree at UNIMAS or other institutions of higher learning.

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LIST OF ABBREVIATIONS

Abbreviations	Description
%	Percentage
μS	Microsecond
DO	Dissolved Oxygen
g	gram
GPS	Global Positioning System
ind./m^2	Individual per one metre square
K	Kurtosis
m	meter
Md	Median
mg/L	Milligram per litre
N	North
NTU	Nephelometric Turbidity Units
PSU	Practical Salinity Units
QDI	Inclusive Graphic Quartile Deviation
SkI	Inclusive Graphic Skewness
SPSS	Statistical Package for Social Science
TOM	Total Organic Matter

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The Community Structure of Macrobenthos in Batang Lupar estuary

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ABSTRACT

A survey on the macrobenthos was carried out at 6 stations in Batang Lupar estuary, Sarawak. The aims of this study are to determine the community structure of macrobenthos which include species richness, species evenness and species diversity, to investigate the relationship between distributions of macrobenthos and environmental parameter and to establish the baseline data of macrobenthos research in Batang Lupar estuary. Fourteen taxa of macrobenthos were recorded and the five most abundant taxa were Order Eunicida, *Nereis* sp, Order Sternaspida, Oligachaeta, and Amphipoda. The macrobenthos found here are typical of the macrobenthos that can be found on the other part of estuary in Malaysia.

Key: macrobenthos, community structure, environmental parameter, Batang Lupar, estuary

ABSTRAK

Satu kajian terhadap struktur komuniti makrobentos telah dijalankan di 6 stesen di muara Batang Lupar, Sarawak. Objetif kajian ini adalah untuk mengenalpasti struktur komuniti termasuk kekayaan spesies, kepelbagaian spesies dan kesamarataan spesies. Di samping itu, kajian adalah bertujuan untuk melihat hubungan di antara taburan makrobentos dan parameter fiziko-kimia serta menyediakan data asas makrobentos di muara Batang Lupar. Empat belas taxa makrobentos telah direkodkan dan 5 taxa yang tinggi kepadatannya telah dijumpai di kawasan ini iaitu Order Eunicida, Nereis sp., Order Sternaspida, Oligachaeta, dan 0rder Amphipoda. Makrobentos yang dijumpai di sini adalah makrobentos biasa yang juga terdapat di muara-muara sungai lain di Malaysia.

Kata kunci: makrobentos, struktur komuniti, parameter fiziko-kimia, Batang Lupar, muara

1.0 Introduction

Community is a variety of species which living in a particular area. Community structure refers to the number and abundance of species in a habitat. Community structure is dynamic and change over time. It will change over a long time span as they form and maybe suddenly due to the natural and human disturbance.

Macrobenthos is an organism which is live at the bottom of the water column, in or on aquatic substrate. Their sizes are larger than 0.5 millimetre. They include polychaete, worms, gastropods, crustaceans, sponges, and others. Benthic macrobenthos plays an important role in aquatic ecosystems as primary and secondary consumers (Dahanayaka and Aratne, 2006). Macrobenthos have sedentary lifestyles that reflect local sediment conditions, life spans that integrate contaminant impacts over time, they live in sediment and water interface where contaminants accumulate and most importantly they show differential levels of tolerance to contaminants (Yap *et al.*, 2003). The distribution of macrobenthos communities also can explain the relationship between macrobenthos and ecosystems because they are highly correlated with the environmental conditions such as salinity, depth, water current, particles size analysis and organic content of sediment. The response by benthos to natural and anthropogenic perturbations is important because their ability to integrate over time with changes to the water column and sedimentary regime (Dahanayaka and Aratne, 2006).

Estuaries are transitional zones between freshwater and marine environment where species diversity is often driven by physico-chemical variables such as salinity (Rolston and Dittmann, 2009). Estuaries are highly productive area which enhances their suitability as nursery habitats for many juvenile and adult organisms. Estuaries also act as nutrient traps, with nutrients being derived from rivers and sea and rank among the most productive environment on earth (Samkelisiwe, 2002). Instability in these environments comes from natural and human activities such as logging, agriculture, development and others which lead to decrease in abundance and diversity of animals and plants.

In addition, macrobenthos are amongst most sensitive faunal component of estuaries and useful in indicating the status of the aquatic body (Samkelisiwe, 2002). Macrobenthos research in Sarawak is still in infancy stage especially in Batang Lupar estuary. The study of community structure of macrobenthos in Batang Lupar estuary was carried out to determine:

1.1 Objectives

i. To determine the community structure of macrobenthos which include species richness, species evenness and species diversity.
ii. To investigate the relationship between distributions of macrobenthos and environmental parameters.
iii. To establish the baseline data of macrobenthos research in Batang Lupar estuary.

2.0 Literature Review

2.1 Community structure

A community is a group of organisms occurring in a particular environment, presumably interacting with each other and with environment and separable from other groups by means of an ecological survey. Open community structure has relatively rarity of species within a community. Closed community structure has similar geographic range and density peaks. Species in an ecosystem must interact in some significant way to be considered as community members (Hoey *et al*., 2003). Community structure refers to the number and abundance of species in a habitat. Two general patterns of community structure emerged with regard to stability. Some populations or communities maintain constant through time, it means there are persistent.

The other pattern found in benthic species is repeatable cycles either annual or longer term. If the cycle is predictable, the community is considered stable (Samkelisiwe, 2002). Term ‘community’ is used to describe benthos in terms of related species distribution, grouping together organisms that frequently occur together under similar environmental conditions and are part of each other’s biological environment. Community made up of relatively simple food chains is more unstable since stress from pollution may drastically alter the simple, delicately balanced energy pathways by effecting one species (Kenneth, 1970).

2.2 Macrobenthos

Macrobenthos are animals large enough to be retained on a screen with mesh size of 1 or 0.5 mm. Macrobenthos is an organism which is live at the bottom of the water column, in or on aquatic substrate. Worms, shells, shrimps and other crustaceans are the most common animals in the macrobenthos. Macrobenthos are important components of estuarine ecosystems, directly processing a significant portion of system-wide primary production, and providing an important food resource for crustaceans, fish and birds. Estuarine organisms can be described as bioindicators in three ways, as: 1) indicators of a defined set of environmental conditions; 2) indicators of contaminant loads on the system; and 3) indicators of the overall health of the system (Rolston and Dittmann, 2009).

The multiple biotic, abiotic and human-induced factors affect macrobenthos community. Physical influences include water depth, sediment structure, salinity and hydrology, biological factors include predation, competition and recruitment and human-induced factors include organic enrichment, chemical pollution and commercial fishing activity (Currie and Small, 2006 as cited in Rolston and Dittmann, 2009).

The analysis of aquatic macrobenthos is the most used method for the assessment of the environmental quality. Some taxa result very sensitive to pollutants, resulting as good indicators of water quality, while others are extremely resistant (Mancini *et al.*, 2004). In addition, benthic communities are widely used in monitoring the effect of marine pollution as the organism are mostly sessile and integrate the effects of pollutants over time (Gray *et al.*, 1990).

2.3 The Macrobenthos and Environmental Parameter

The composition and abundance of benthic organism are closely related to the water quality of aquatic environments and therefore benthic organisms are considered to be good indicator of the past and present condition of water (Dahanayaka and Wijey Aratne, 2006).

In addition, Australian estuaries are primarily marine-dominated environments, being subjected to major salinity changes only after heavy rains and during flood conditions. The effects of freshwater on estuarine and coastal habitats: heavy mortalities of molluscs and polychaetes have been observed following large volumes of freshwater input after rainfall. Such effects were also observed following the freshwater release across the Ewe Island and Boundary Creek barrages in the Murray Mouth region. Reduced salinities have a negative impact on polychaete larval growth, and that the vertical migration of larvae to facilitate inshore and offshore transport may be influenced by lowered salinities and altered flows following freshwater input. Changes in turbidity, sediment deposition, nutrient load and contaminant load will also affect macrobenthos following increased freshwater input (Rolston and Dittmann, 2009).

Salinity is a major influencing parameter for the abundance and distribution of marine organisms. A constant range of salinity favors the proliferation of macrobenthic organisms. There is recolonisation of benthos with increased salinity value at Konkan West coast of India (Vizakat, 1991 as cited in Debasish *et al.*, 2011). The importance of salinity on estuarine organisms is well documented, and this is likely the single most important factor affecting the distribution of the macrobenthos It is possible that any increase in salinity in this estuary would not adversely affect the benthos other than causing a shift in some of the species distribution on ranges and could result in both introduction of other estuaries fauna and increase in the diversity and productivity of the benthos (Kenneth, 1970).

There was a clear evidence of increasing rate of population density at deeper regions than the shallow depth. Because in shallow depth regions, high turbidity, often fluctuation of environmental parameters and more fishing pressure disturbs habitat condition, while in deeper region favoring condition is existed due to stable environmental parameters (Debasish *et al*., 2011). The effect of depth, sediment grain size, salinity and predation, density are factors in controlling the population density of macrobenthos and the most important factors are sediment size and predator density (Montira, 1996).

Dissolved oxygen levels can also exert tremendous effect on the distribution and occurrence of benthic organisms, especially in those marine environments where stratification of the water column results in anoxic conditions in the water overlying the bottom. The present salinity in most of the Pamlico River is quite low and is one of the factors responsible for the low diversity and density of the benthic community (Kenneth, 1970).

Some of the benthic organisms are non-mobile due to their burrowing nature and cannot move away from highly turbid area, a factor that could be important to them. Filter feeding species like bivalves are mostly affected by high turbidities since their gills become clogged when excessive fine suspended matter is present. Increased turbidity can be favourable to aquatic ecosystem by reducing algal blooms and increasing protection from predators (Samkelisiwe, 2002).

However, the amphipods and polychaetes are important constituents of macrobenthic community of inner areas of estuaries which are associated with finer sediments. The sampling sites at the canal segments are rich with sand and associated with coarser sediments than other sampling sites. From the research in Negombo estuary, the Spearman rank correlation coefficients indicates that environmental variables that significantly influence the community structure of macrobenthos are the depth, salinity, organic matter content, percentage sand and clay content in the sediments and the abundance of mangroves (Dahanayaka and Wijey Aratne, 2006).

Estuaries in southwestern Louisiana maybe characterized as vertically well mixed, with large annual salinity fluctuation, weak tidal flushing, fine sediment (often approaching 100% silt/clay content) and widespread low oxygen of bottom waters during warm months (Gaston *et al*., 2001). Macrofaunal density of the region is typically modest by comparison with United State East coast estuaries and larger estuaries of the Gulf of Mexico.

Sediment is a major controlling factor in the ecology of estuaries. It is not only forms a habitat for benthic organisms but also influences life processes of organisms. The morphology, feeding and dominance patterns of macrobenthic species are a function of the substratum type. In addition, ecological relationships among macrobenthos are related to the characteristics of estuarine sediments (Samkelisiwe, 2002).

The change in macrobenthos composition could be due to change in sediment type from sand to clayey-silt. Change in benthic composition is important as variation in fauna composition; densities and biomass of organisms are used in biotype mapping to zone habitats in estuaries like the Bonny River in Niger Delta. It may be said that a suitable bottom environment for a cockle habitat has a particle composition with a high proportion of very fine sand to silt-clay and without a coarse sand fraction such as the distribution area of the *Anadara* type community (Nakao *et al*., 1989).

2.4 Batang Lupar estuary

Batang Lupar estuary is famous with the crocodile attack and tidal bore or 'benak'. Most of species in the Batang Lupar estuary were well adapted to the ever-changing estuarine environment; clearing of the ecosystem they depend on for life sustenance will bring about inherent physical, chemical and biological limits beyond which significant effects will occur. Sebuyau River as a tributary to Batang Lupar also provides the fresh water inflows to the estuarine waters of Batang Lupar. Land clearing will expose the land and drainage alterations will increase erosion and sediment run-off into nearby streams during heavy downfalls. The freshwater stream would be affected of its benefial use, by the increase in turbidity, colour and sediment load deposition. The complex physical and chemical properties of suspended and resuspended sediments and substratum changes associated with deposition can have both direct and indirect effects on estuarine organism (Hadil and Albert, 2000).

Research on macrobenthos study is limited in Sarawak especially in Batang Lupar estuary. Therefore, focus on this study is on community structure of macrobenthos and its relationship with environmental parameter which included physico-chemical parameter of water. The species diversity, species evenness and species richness of macrobenthos in Batang Lupar area will be analysed in this research.

3.0 Material and Methods

3.1 Study area and sampling site

This study was carried out in Batang Lupar estuary which is located at Sri Aman, Sarawak. Sampling was carried out on 17 December 2011. Benthic samples were obtained from 6 selected sites which parallel to the river bank of the estuary; approximate distance between station were 2 kilometre.

Figure 1: Map of Batang Lupar estuary, Sarawak

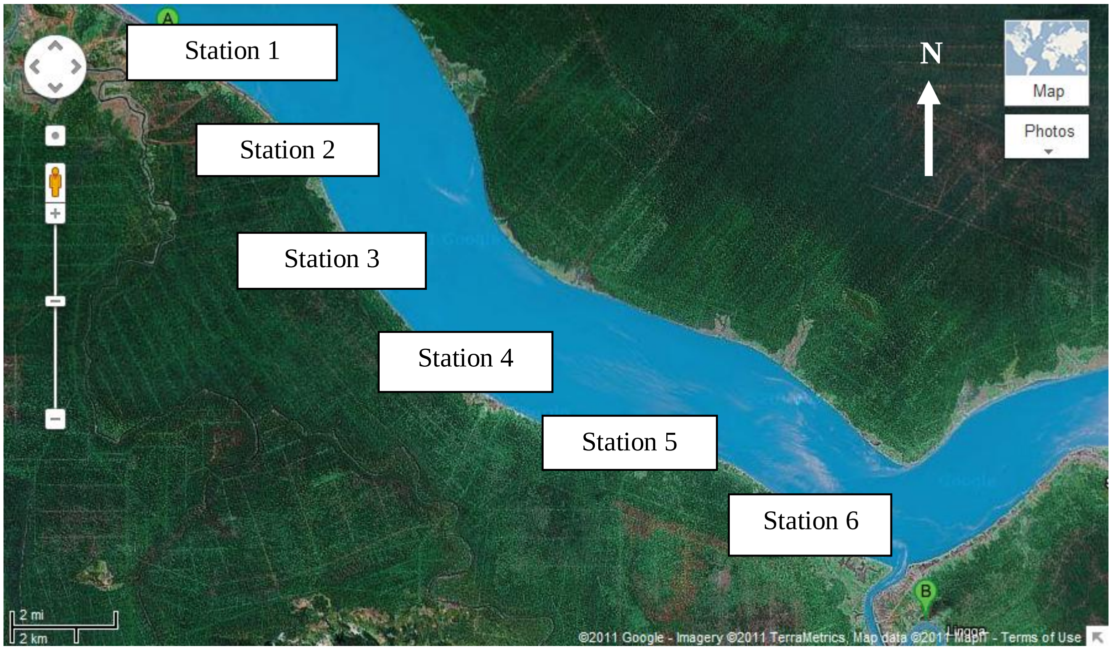

Figure 2: Sampling station

Table 1: The location of sampling station

Station	Coordinates
Station 1	N 01^{o}31.472' E 111^{o}00.349'
Station 2	N 01^{o} 30.727' E 111^{o}01.958'
Station 3	N 01^{o} 29.217' E 111^{o} 02.954'
Station 4	N 01^{o}27.400' E 111^{o}03.467'
Station 5	N 01^{o}26.423' E 111^{o}04.368'
Station 6	N 01^{o}25.993 E 111^{o}05.532'

3.2 Physico-chemical parameter

The coordinates of the sampling station were determined by using Global Positioning System (GPS Map 60CSX). Temperature, dissolved oxygen, turbidity, pH, conductivity and salinity were measured *in situ* by multiprobes meter (Eutech Instrument PCD 650). The depth was recorded by depth finder. At each selected sites, three readings of each physico-chemical parameter of water were determined.

Sediment samples were collected at all stations for particle size analysis and total organic matter. The sediment samples were taken by using simple flow-through corer. The sample was placed into labeled plastic bag and brought back to laboratory for analysis.

Particle size analysis was determined in the laboratory by sieving and pipette analysis methods proposed by Buchannan (1984). It was included the process of silt-clay fraction, dry sieving and pipette methods.

3.3 Total Organic Matter (TOM)

The method used following Greiser and Faubel (1988). The organic matter was occupied drying at 60^{o}C for 24 hours. After the water completely removed, the sediments were weight as initial weight. Then, combustion of the organic matter at high temperatures in furnace for 8 hours to 12 hours with temperature was about 450^{o}C to 500^{o}C. Next, the sediments were weight as final weight to determine weight loss. Therefore, the loss of weight indicates the amount of total organic matter in the samples.

3.4 Macrobenthos

Van Veen grab sampler was used to collect the macrobenthos. Three replicate of sediment were sampled at each selected sites. The sediment was sieved on boat by using 500µm sieve. Organisms which retain on the sieve were collected and washed into the labelled plastic bags. Macrobenthos sample in labelled plastic bag were preserved with 10% formalin and stained with Rose Bengal. Sample was brought back to the laboratory for further analysis.

Sorting, counting and identifying of macrobenthos to the lowest practical taxon were done by using stereo and compound microscope in the laboratory. Identification followed the various keys in the available literature such as Bird (1991), Daeur (1993), Peckarsky *et al*. (1993), Fauchald (1977), Brusca (2002), Thorp and Covich (1991), Thorp and Rogers (2011), and Shabdin and Rosniza (2010).

3.5 Data Analysis

3.5.1 Particle Size Analysis

The sand fraction is analyzed by passing through a geometric series of test sieves. For assessment of characteristics sediment indices, the sediment weight fractions were transformed into cumulative frequency series and plotted as cumulative frequency curve. The phi value is the negative logarithm to the base 2 of the particle diameter. By using cumulative frequency curve graph, the phi values of phi at 5% (ø5), 16% (ø160, 25% (ø25), 50% (ø50), 75% (ø75), 84% (ø84), and 95% (ø95) were determined (Table 16).

Median (Md), Inclusive Graphic Quartile Deviation (QDI), Inclusive Graphic Skewness (SkI) and Kurtosis (K) were calculated. The formulas involved were as follows,

Median (Md),

= (ø16 + ø50 + ø84) / 3

Inclusive Graphic Quartile Deviation (QDI),

= (ø84 – ø16 / 4) + (ø95 – ø5 / 6.6)

Inclusive Graphic Skewness (SkI),

= [ø16 + ø84 – 2 ø50 / 2 (ø84 – ø16)] + [ø 5 + ø95 – 2 ø50 / 2 (ø95 – ø5)]

Kurtosis (K),

= ø95 – ø5/ 2.44 (ø75 – ø25)

3.5.2 Community Structure of Macrobenthos

Shannon-Wiener Index (H'), Pielou's Evenness Index (J') and Margalef Index (D), were used to determine the species diversity, species evenness and species richness. The equations involved were as follows:

Shannon-Wiener Index (H'):

$$-\sum (P_i) \log_2 (P_i)$$

Note:

$P_i = n_i / N$

n_i = the total number of individual for species i

N = total number of individuals in the sample

Pielou's Evenness Index (J'):

$$H' / \log_2 S$$

Note:

H’ = species diversity (from Shannon-Wiener Index)

S = total number of species in the sample

Margalef Index (D):

$$(S - 1) / \ln N$$

Note:

S = total number of species in the sample

N = total number of individual in the sample

3.5.3 Correlation

The data of species diversity, species richness and species evenness were keyed into the SPSS Version 20 (Pearson correlation coefficient) in order to calculate the r-value. The r-value (α = 0.05) were compared with physico-chemical parameters, percentage sand, percentage silt clay and total organic matter in order to determine whether the value have strong or weaker correlation. The strength of correlations was identified and analyzed as in Table 2.

Table 2: Strength of correlation (Bartz, 1988)

Correlation (r) range	**Degree of indication**
0.800-1.00	Very strong correlation
0.60-0.79	Strong correlation
0.40-0.59	Moderate correlation
0.20-0.39	Weak correlation
0.00-0.19	Very weak correlation

4.0 Results

4.1 Physico-chemical parameter

There were seven *in situ* parameters of water recorded in this study namely temperature, dissolved oxygen (DO), turbidity, depth, pH, conductivity and salinity (Table 3). Triplicate of reading were analysed for each station in order to reduce the errors.

4.1.1 Temperature

The value of water temperature of Batang Lupar estuary ranged from 29.8 to 31.4 ^{o}C (Figure 3). The water temperature reflects the typical water in tropical countries. Station 1 recorded the temperature value with 29.8 ^{o}C, the lowest value of temperature recorded in this study. While for Station 2, Station 3, Station 4, Station 5 and Station 6 the temperature were 31.4 ^{o}C, 30.8 ^{o}C, 31.4 ^{o}C, 30.8 ^{o}C and 31.3 ^{o}C respectively. At Station 2 and Station 4, the value for temperature recorded were the highest between other stations.

4.1.2 Dissolved Oxygen

The dissolved oxygen varied in the six stations with the value ranged between 6.91 to 7.77 mg/L (Figure 4). The highest value for dissolved oxygen recorded at Station 3 with 7.77 mg/L while the lowest was at Station 4 with 6.91 mg/L. The value for Station 1, Station 2, Station 5 and Station 6 were 7.56 mg/L, 6.94 mg/L, 7.21 mg/L and 7.14 mg/L respectively. The value of dissolved oxygen was high in all stations.