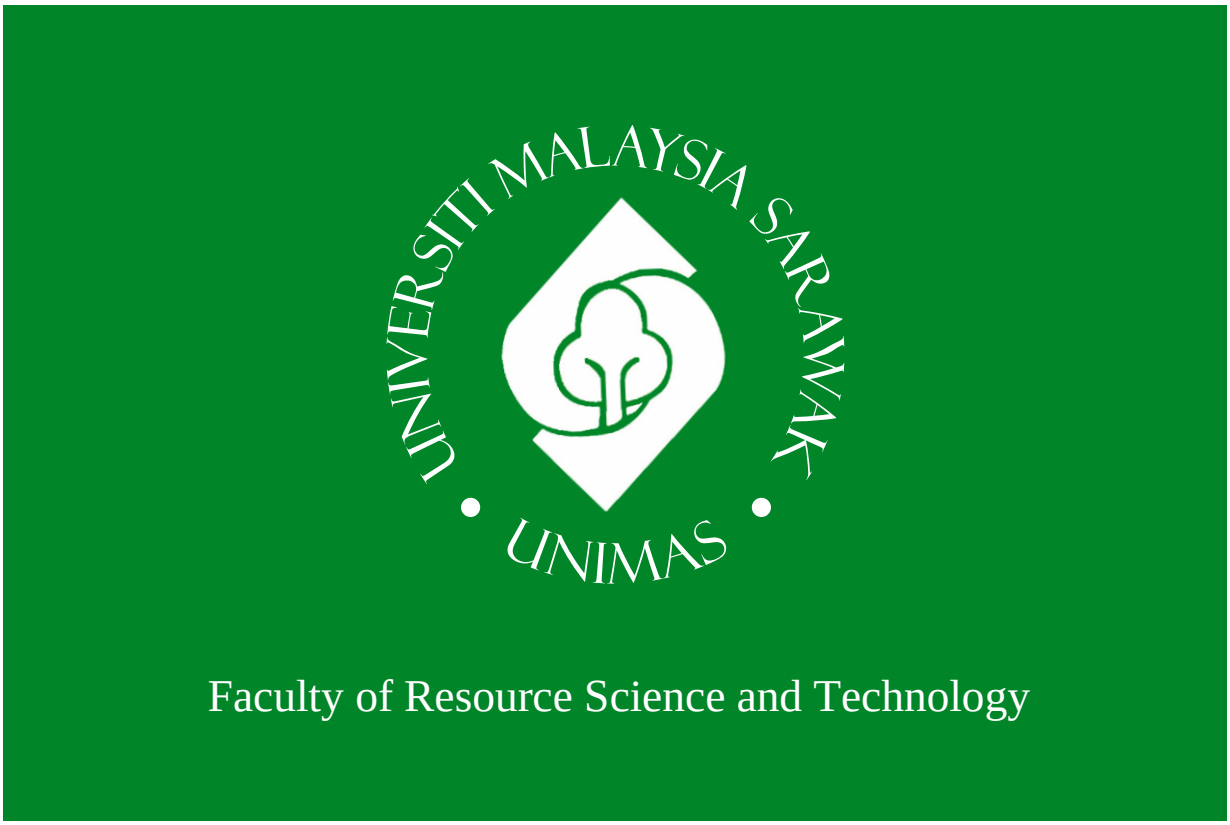

WATER QUALITY STUDY IN RAMBUNGAN MANGROVE AREA

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Bachelor of Science with Honours
(Aquatic Resource Science and Management)
2008

DECLARATION

I hereby declare that no portion of the work referred to in this dissertation has been submitted in support of an application for another degree or qualification to this university or any other institution of higher learning.

_____

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Water Quality Study in Rambungan Mangrove Area

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ABSTRACT

This study was conducted to determine the water quality status in Rambungan mangrove area and its associated tributaries. Three field samplings were carried out on 5 October and 10 December 2007 and 11 March 2008 at five different stations along Batang Rambungan. Physical and chemical water quality parameters namely salinity (ranged 11.67 ± 1.53 to 33.00 ± 0.00 ppt) , water temperature (26.90 ± 0.00 to 33.60 ± 1.15 °C), DO (4.00 ± 0.19 to 7.90 ± 0.10 mg/L), BOD_5(0.60 ± 0.00 to 4.53 ± 0.01 mg/L), COD (39.00 to 153.00 mg/L), water transparency (0.37 ± 0.01 to 0.94 ± 0.01 m), pH (7.07 ± 0.06 to 8.12 ± 0.01), turbidity (7.84 ± 1.08 to 41.38 ± 11.39 FTU), TSS (10.33 mg/L to 84.66 mg/L), chlorophyll-*a* (0.47 µg/L to 2.69 µg/L), nitrate (0.04 mg/L to 0.43 mg/L), nitrite (0.009 mg/L to 0.058 mg/L), ammonia-nitrogen (1.56 mg/L to 4.31 mg/L), silicate (0.158 mg/L to 0.593 mg/L) and orthophosphate (0.06 mg/L to 0.42 mg/L) were measured and analyzed to determine the water quality status of Rambungan mangrove area. From the study, conclusion can be made that the water quality at Rambungan mangrove area was slightly polluted in terms of high concentration of nutrients due to the presence of human settlements and aquaculture activity.

Keywords: water quality, Rambungan, mangrove area, nutrient

ABSTRAK

Kajian ini telah dijalankan untuk menentukan status kualiti air di kawasan paya bakau di Rambungan dan sungai-sungai berdekatan. Tiga kerja lapangan telah dijalankan pada 5 Oktober 2007, 10 Disember 2007 dan 11 Mac 2008 di lima lokasi berlainan di sepanjang Batang Rambungan. Parameter fizikal dan kimia untuk analisis kualiti air iaitu kemasinan (dalam lingkungan 11.67 ± 1.53 hingga 33.00 ± 0.00 ppt), suhu air (26.90 ± 0.00 hingga 33.60 ± 1.15 °C), DO (4.00 ± 0.19 hingga 7.90 ± 0.10 mg/L), BOD_5 (0.60 ± 0.00 hingga 4.53 ± 0.01 mg/L), COD (39.00 hingga 153.00 mg/L), kejernihan air (0.37 ± 0.01 hingga 0.94 ± 0.01 m), pH (7.07 ± 0.06 hingga 8.12 ± 0.01), kekeruhan (7.84 ± 1.08 hingga 41.38 ± 11.39 FTU), TSS (10.33 mg/L hingga 84.66 mg/L), klorofil-a (0.47 µg/L hingga 2.69 µg/L), nitrat (0.04 mg/L hingga 0.43 mg/L), nitrit (0.009 mg/L hingga 0.058 mg/L), ammonia-nitrogen (1.56 mg/L hingga 4.31 mg/L), silikat (0.158 mg/L hingga 0.593 mg/L) and ortofosfat (0.06 mg/L to 0.42 mg/L) telah diukur dan dianalisa bagi menentukan status kualiti air di kawasan paya bakau Rambungan. Dari kajian, kesimpulan boleh dibuat bahawa kualiti air di kawasan paya bakau Rambungan adalah sedikit tercemar dari segi kandungan nutrien yang tinggi disebabkan adanya penempatan manusia dan kegiatan akualkultur.

Kata kunci: kualiti air, Rambungan, kawasan paya bakau, nutrien

WATER QUALITY STUDY IN RAMBUNGAN MANGROVE AREA

NOOR'AIN BTE JALIM

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1.0 INTRODUCTION

Throughout history, water has been recognized as an essential requirement for human and ecosystem survival along with development. The presence of water in biota acts as the fulcrum of biochemical metabolism which rests on its unique physical and chemical properties (Wetzel, 1983) and it has been considered as 'the driver of nature' by Leonardo da Vinci. Water covers seven-tenth of the Earth's surface (Horne and Goldman, 1994) and appears in many forms such as polar ice caps, clouds, rivers and seas. Water in these bodies moves through a cycle of evaporation, precipitation and run off to the sea. Clean water is important to mankind for consumption, daily usage, food production electricity generation environmental conservation, industrial developments (Abu-Zeid and O'neil, 2007) and also for the survival of aquatic organisms.

Water quality indicates the cleanliness of water bodies and consists of the physical, chemical and biological characteristics of water. Water quality is a term used to express the sustainability of the water to remain for various usages and is determined by measuring characteristics such as salinity and dissolved mineral content. A standard list of physico-chemical parameters is being used so that all waters are subjected to undergo similar testing. Thus, water quality has become quantitative and can be measured accurately without ambiguity. Aquatic organisms vary in habitats due to the ability to survive in certain condition. For example, few species of aquatic organisms can tolerate high salinity and harsh environment. Water quality of an aquatic ecosystem also changes naturally with the seasons and geographic areas variation, without the presence of any pollutant.

However, there are many factors that affect water quality level apart from the natural causes. In the present condition, anthropogenic disturbances due to human activities such as industrial disturbances, urban infrastructure, agriculture and aquaculture are potentially contributing to pollution in the water systems. According to Kalff (2002), high water resources withdrawal for primarily agricultural purposes is able to increase probability of water pollution from fertilizers and biocides. Conversely, a primarily industrial withdrawal except the usage for hydroelectric generation suggests the probability of industrial pollution.

Brackish waters, which are one type of aquatic ecosystems, were formed as results from the mixing of seawater with freshwater, which are best described as fluctuating environments. Brackish waters contain diluted sea water which enters through tidal rivers or by percolation through permeable deposits that lie between the basin and sea coast (Moss, 1994). Salinity in brackish water depends on the tidal regime, the amount of freshwater that enters from rivers or as rain and also the rate of evaporation.

Estuary is defined by Pritchard (1967) as a semi-enclosed coastal body of water which has free connection with the open sea and within which sea water is measurably diluted with fresh water (Davies-Colley *et al.*, 1993) derived from land drainage. In common words, estuaries are the point where a river meets the sea. Most estuaries originate from drowned river valleys which create fjords, but some are produced by tectonic events (Horne and Goldman, 1994). Laws *et al*. (1991) stated that estuaries can be efficient sediment and nutrient traps, but their trapping efficiency is a function of

many factors, including loading rate, estuarine morphology and water residence time. Tidal and salinity fluctuation make the structure of estuaries more complex than other aquatic ecosystems. However, estuaries support commercially valuable fish and shellfish. Moss (1994) suggested that estuaries consist of a mixed community composition but the diversity is low when compared with lakes that have steady and regular brackishness.

In hot climates, low trees collectively called mangroves dominate the lowland tropics. Mangrove forests are among the most productive (Lo, 2005) and valuable ecosystems in the world with total area of 6410 km^2 in Malaysia (Kathiresan and Rajendran, 2005); 17% in Peninsular Malaysia, 26% in Sarawak and 57% in Sabah. Mackey and Smail (1996) stated that mangroves are open systems and are important in providing energy and matter to estuarine and coastal systems via leaves litter fall and decomposition. These leaves litters contribute greatly to local fisheries in terms of nutrition. Most of the mangroves forests are dominant at the mouth of most rivers similar to Rambungan mangrove area. They act as feeding, nursery and breeding areas for many marine fishes and invertebrates (Chong and Sasekumar, 2002). Economically, mangroves play important roles in the increasing aquaculture activities. These forests also act as important buffer zones between land and sea, and are natural barriers against tsunami and hurricane damages.

Comprehensive water quality baseline data is important in order to identify the sources of pollutant in an aquatic ecosystem. The loss of mangrove areas, reported from 1980-1990 assessments in Peninsular Malaysia is of much concern given the ecological

and socioeconomic values of mangroves (Chong and Sasekumar, 2002). Studies on water quality in the mangrove ecosystems are important. However, no research has been made in the Rambungan mangrove area or any of its associated tributaries. The sources of pollutant to this area will be identified and the data can be used as future reference to reduce the negative impacts to the mangrove area. The water quality in Rambungan tributaries can affect the nearby settlements either through point or non-point sources. Therefore, this study is important to determine the water quality status of Rambungan mangrove area and its associated tributaries and also to record the impacts of any anthropogenic activities that are affecting water quality. The objectives of this study were (i) to document the present water quality parameters in Rambungan mangrove area and (ii) to determine the impacts of present anthropogenic activities to the water quality.

2.0 LITERATURE REVIEW

Studies on water quality are important to monitor the impacts of human activities and natural causes to the aquatic environment. Water quality also serves as a key determinant of ecosystem health. Tripathy *et al.* (2005) stated that there are wide variations in environmental parameters which depend on their topography. Water quality studies on mangroves are important as these communities function as habitat for commercially valuable species of aquatic organisms. In addition, mangrove roots are particularly suitable for juvenile habitat, foraging and breeding of the non-residential organisms of mangrove areas.

2.1 Water Quality Parameters

Water quality level can influence the distribution of aquatic organisms. Environmental parameters that are usually being used in water quality studies are salinity, temperature, dissolved oxygen, water transparency, pH, turbidity, conductivity, total suspended solids (TSS), chlorophyll-*a* and nutrients. Other core parameters such as date, time, weather condition and surface current speed are also essentially needed.

2.1.1 Salinity

Total suspended matters are dominated by sodium chloride, by which the full-strength seawater (Horne and Goldman, 1994) has salinity about 35 ppt. Variable salinity is the most characteristic feature of estuaries whereby salinity falls gradually from the sea to the upstream limit of the estuary. Horne and Goldman (1994) stated that low salinity was recorded at the head of the estuary. A research on September 2001 conducted by Tripathy *et al.* (2005) supports the statement by reporting that high salinity was observed nearer to the coastal environment, whereas lower salinity was recorded in the mangrove area. The values of salinity vary among sampling stations due to the mixing of freshwater and seawater. Salinity distributions in estuary are usually stratified; however, during higher river flow conditions followed by well mixing occurrences, salinities are recorded to be the lowest. According to Padmavathi and Satyanarayana (1999), increasing trend of salinity can be observe from riverine to the estuarine and coastal regions due to combined effects of high insulation, cessation of river water influx and intense precipitation. Prabha Devi *et al.* (1996) stated that surface salinity was observed to be lower than the bottom part of the water as stratification mainly being controlled by the rate of freshwater inflow through link canals and seawater intrusion through the bar mouth. Other than that, high salinity in backwater was related to the reducing of freshwater inflow rate and increasing evaporation. Aquatic species that are commonly found in the estuary are classified as euryhaline species, able to withstand wide range of salinity changes.

2.1.2 Water temperature

Temperature is defined as a measurement of the intensity of heat, not the quantity. It is also an important physical variable in water quality studies because it influences the chemical and biological processes. Chemical reaction rates are generally increases at higher temperature, which will affects the biological activity. For example, temperature gives effects to the oxygen level. Warm water hold less oxygen than cool water, so the water may be saturated with oxygen but is still not enough for the survival of aquatic life. Some compounds are also more toxic to aquatic life when the temperature increases. Temperature showed an inverse relationship with salinity (Padmavathi and Satyanarayana, 1999). It shows decreasing values from the riverine to estuarine and the coastal region. Mazlin *et al.* (1994) reported that temperatures of the surface and bottom water samples in Inanam River, Sabah estuary were within the range of 29 - 31°C. According to Rajagopal *et al.* (2005), higher temperature may induce mortality and significant changes in physiological activities rates that influence the ability of organisms to tolerate unfavourable conditions. Physiological activities such as oxygen consumption will be significantly decreased over the increased of temperature. Likens and Wetzel (1991) stated that direct absorption of solar irradiance plays as the vital source of heat in water. Heat transfer from the air and sediments also occur but usually in small input compared to direct absorption of solar radiance by water, dissolved organic compounds and suspended particulate matter.

2.1.3 Dissolved Oxygen

Dissolved oxygen is a seasonal fluctuation parameter in the environment and is associated with the amount of rainfall and freshwater discharge into the backwater (Prabha Devi *et al.*, 1996). It was continuously consumed by both aquatic plants and animals through respiration process but is produced by plant photosynthesis only when adequate light and nutrients are available (Horne and Goldman, 1994). Wetzel (1983) stated that the distribution of DO is important for activities of aquatic organisms and it affects the availability of nutrients and productivity of an aquatic ecosystem. Organic matter from natural sources and from the domestic or industrial wastes can result in dissolved oxygen depletion. Low DO level may affects the distribution and growth of fish and invertebrates. Moreover, the depletion of DO also have major impacts on solubility of phosphorus and other inorganic nutrients (Kalff, 2002). Few aquatic organisms can tolerate this fluctuation but others may die. Similar to temperature, DO shows decreasing trend from riverine to estuarine and coastal regions. Lin *et al*. (2006) reported that lower values of DO in estuaries are due to strong river flow and estuarine gravitational circulation. Previous studies conducted at Mandovi-Zuari estuary in Goa, uniform DO concentrations were observed from the surface to the bottom layers during monsoon period (Padmavati and Gosmawi, 1996).

2.1.4 Biochemical Oxygen Demand

Phytoplankton consumed much of the dissolved oxygen in the water and gradually reduces the amount of oxygen available for other aquatic organisms (Feldman, 1995). BOD measures the oxygen consumption from degradation of organic material. According to Waite (1984), a BOD analysis is run for 5 days as the period is long enough to determine the first-stage BOD. BOD plays as indicative parameter that shows the presence of organic pollution of water. High BOD values may indicate the influence of domestic and agricultural wastes carried through the canal links. Low DO level accompanied by high BOD may be due to the contamination, either by the inflow of wastes from terrestrial runoff or from any anthropogenic activities present in the surrounding areas.

2.1.5 Chemical Oxygen Demand

Chemical oxygen demand (COD) determine the amount of organic pollutants that are found in the surface water such as lakes, rivers and estuaries, which makes COD a useful water quality parameter. COD also is used as a measure of oxygen requirement in water bodies that are susceptible to oxidation by strong chemical oxidant such as potassium dichromate and concentrated sulfuric acid. Based on Trivedi and Raj (1992), COD values are not affected by the presence of toxins and other unfavourable conditions for microorganisms' growth. Waite (1984) stated that the value for COD is higher than the BOD value for the same sample. An advantage of COD analysis is that COD analysis can be run rapidly in 2 hours time, while a BOD analysis take five days to complete (Waite, 1984).

2.1.6 Water Transparency

Water clarity refers to the sighting distance through water and penetration of diffuse irradiance from the sun into the water bodies (Davies-Colley *et al.*, 1993). High concentration of dissolve organic matter will decrease transparency in a nonlinear way (Wetzel and Likens, 1991). Determination of water transparency is usually done using Secchi disc; a disc painted in black and white quadrants. The depth of a Secchi disc to disappear into the water bodies was measured and the transparency of water is used to measure the penetration of light in water. Davies-Colley *et al.* (1993) also stated that euphotic depths in 25 estuaries in New Zealand range from less than 1m to 20-30 m. As the waters in estuaries are naturally turbid, minor changes in constituent composition are unnoticeable.

2.1.7 pH

pH is the measurement of acidity and alkalinity of water bodies with accordance to the concentration of hydrogen ions that are present in the water. pH values lower than 7 is indicated as acidic while values higher than 7 is alkaline. pH also have influence on the toxicity level of several nutrients such as ammonia concentration, which will turn toxic to aquatic organisms in low pH. pH values were observed changing from slightly alkaline to alkaline condition in the surface and bottom layers in the mangroves areas. Prabha Devi *et al.* (1996) described that the pH of the backwater was slightly alkaline and the pH of the bottom layer was higher than that of the surface in accordance with salinity variation. Nutrient loadings from human induced activities and the decompositions of dead aquatic organisms will produce ammonia, which induced alkaline condition.

2.1.8 Turbidity

Water bodies may turn turbid due to the presence of suspended inorganic and organic particles (Wetzel and Likens, 1991) such as carbonate particles, silt, clay, plankton and small organisms. These particles may differ in sizes ranging from the smallest that cannot be seen without magnification, and the others may be large and heavy enough to settle in the bottom layer. The presence of these particles will reduce the intensity of light that enters the water bodies as they scatter and absorb light (Trivedi and Raj, 1992). High turbidity will completely covers the upper surface of water body. Turbidity is usually measured based on the concentrations of suspended matters in a water body. High turbidity in the estuarine waters is due to the inflow of freshwater (Davies-Colley *et al.,* 1993).

2.1.9 Total Suspended Solids (TSS)

TSS contents in water are one of the most common measurements of all water quality analyses. Suspended solids that are present in a water body can affect the turbidity and the transparency of water as well. The suspended solids have to remain suspended in the water body for a period of time, have low specific gravity and are small in size. Suspended solids are usually transported into the estuarine ecosystems from the sea and the inflowing waters.

2.1.10 Chlorophyll-*a*

Chlorophyll-*a* is a green pigment found in plants that is important for photosynthesis process. Chlorophyll-*a* concentration are determined as an indicator of phytoplankton abundance and biomass in a water body. The concentrations of chlorophyll-*a* are usually included as a water quality parameter. High concentration of chlorophyll-*a* indicate low water quality level and low concentration indicates good water quality level. Lopes *et al.* (2005) reported that higher chlorophyll-*a* concentration is caused by the phytoplankton growth induced by both nutrients and light. This situation can results in an increase of photosynthetic activity and an increase in value of DO. Chlorophyll-*a* concentration is usually higher after a rainfall, due to the flushing of nutrients into the water.

2.1.11 Nutrients

Clymo (1995) stated that nutrients are limiting factors but not vice versa. In spite of that, according to Andersen (1994), the nutrient concentration is relatively high in the estuary ecosystem and these nutrients are not presently limited for phytoplankton production. The nutrient concentration will only become a limiting factor until a substantial reduction occurs.

Nitrate

Nitrate is less abundant but usually become of more biological interest as it is the most highly oxidized form of nitrogen species. Aquatic organisms are indirectly dependent on nitrate concentration as nitrates are important for major growth events of

phytoplankton (Horne and Goldman, 1994). Nitrate is usually non-toxic at lower concentration to the aquatic organisms such as fish. However, according to Waite (1984), nitrate is generally the most common form of aqueous nitrogen. This is followed by ammonia being the second and nitrite being the third. Waite (1984) also emphasized that the abundance order of nitrogen species are represented on a natural water system. One of the other forms of nitrogen may become dominant due to disturbance into the natural system.

Nitrite

Apart from nitrates, other form of nitrogen that usually exists in water bodies is nitrites. It is generally present only in trace quantities in water. Nitrites level can be associated with the presence of calcium content and pH level of water bodies. Lower pH can be used to indicate the increasing toxicity of nitrite.

Ammonia-nitrogen

Ammonia is generated by heterotrophic bacteria as their end product for the decomposition of organic matter (Wetzel, 1983). The removal of ammonia-nitrogen is high due to the uptake by phytoplankton during their primary production. Nutrients such as ammonia-nitrogen show a decreasing trend from riverine to estuarine and coastal region and thus, indicate that they are particularly dominant in the river (Padmavathi and Satyarayana, 1999). Horne and Goldman (1994) stated that ammonia differs from nitrate due to its toxicity. Ammonia is considered high in toxicity if present in more than 0.1 mg/l in a water body. According to Wu *et al.* (1994), ammonia is toxic to fish and marine