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STUDY ON WATER QUALITY AT MANJUNG RIVER AND ITS TRIBUTARIES

NUR ATIKA BINTI MOHD ROHANI

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Study on Water Quality at Manjung River and Its Tributaries

By

Nur Atika Binti Mohd Rohani

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Universiti Teknologi PETRONAS
Bandar Seri Iskandar
31750 Tronoh
Perak Darul Ridzuan

CERTIFICATION OF APPROVAL

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A project dissertation submitted to the
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Approved by,

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(Mrs. Husna binti Takaijudin)

UNIVERSITI TEKNOLOGI PETRONAS

TRONOH, PERAK

December 2012

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the reference and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

NUR ATIKA BINTI MOHD ROHANI

ABSTRACT

A study on the water quality has been carried out at selected sites within the river of Manjung and its tributaries. The research is to determine the quality level and classification of 6 sampling station at the Manjung River based on Water Quality Index (WQI), National Water Quality Standards (NWQS) and Environmental Quality Act (EQA). Six (6) point sources were selected for water sampling along the rivers for analysis to identify concentration of pollutant from diffused sources. Water samples taken were subjected to physical, chemical and biological water quality analyses. The physical, chemical and biological water quality analysis had been carried out in accordance to the American Public Health Association (APHA) testing procedures. The study focuses on the analysis of twelve (12) parameters including Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Suspended Solid (TSS), Ammoniacal Nitrogen (NH_3-N), Fecal Coliform, Oil & Grease, Turbidity, Conductivity, Salinity, Temperature and pH. The results shows that the river has low level DO (range 3.20-4.03 mg/L) and high level of COD (range 170.83-420.83 mg/L). Oil and grease shows the concentration in range 2-5 ppm which is in limits Standard B (<10ppm) by following EQA. Feacal coliform presented in class III (<5000MPN) according to NWQS. Based on WQI, water quality at Manjung River fall under class III and indicated as moderate at upstream and downstream. While, classified class IV as slightly polluted at middle of stream. Comparison with previous study by Department of Environment (DOE), in Annual Report 2010 shows that at least 23.9% was decreased water quality at Manjung River. Rapid expansion and increasing important of industrial and aquaculture activities along Manjung River, due attention should be paid to mitigate or remedy the impact of excessive effluent in order to safeguard our future environment.

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TABLE OF CONTENT

LIST OF FIGURE

LIST OF TABLE

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF STUDY

The study area is located in the district of Manjung in the state of Perak on the west coast of Peninsular Malaysia. The region cover an area approximately of 1,074 square kilometers (415 square miles) where located at coordinates 4º11’N 100º39’E. However, the study area is concentrated on the major river and main tributaries of the Manjung River Basin (also known as Dinding). The main tributaries are includes Sg. Air Tawar, Sg. Setiawan, and Sg. Lumut as demarcated in Figure 1.1. Manjung’s land is devoted largely to agriculture, with an agricultural area of 833.75 km^2 or about 71.20% of Manjung District. Forest reserves account for another 168.81 km^2 (14.42%), while residential area is about 29.32 km^2 (2.50%), and swampy area is 68.57 km2. Manjung District has plenty of land for development purposes in the future with small barrier (1/10) due to its large landbank of agricultural land, mining areas and uncultivated lands (Nurhanim, 2011).

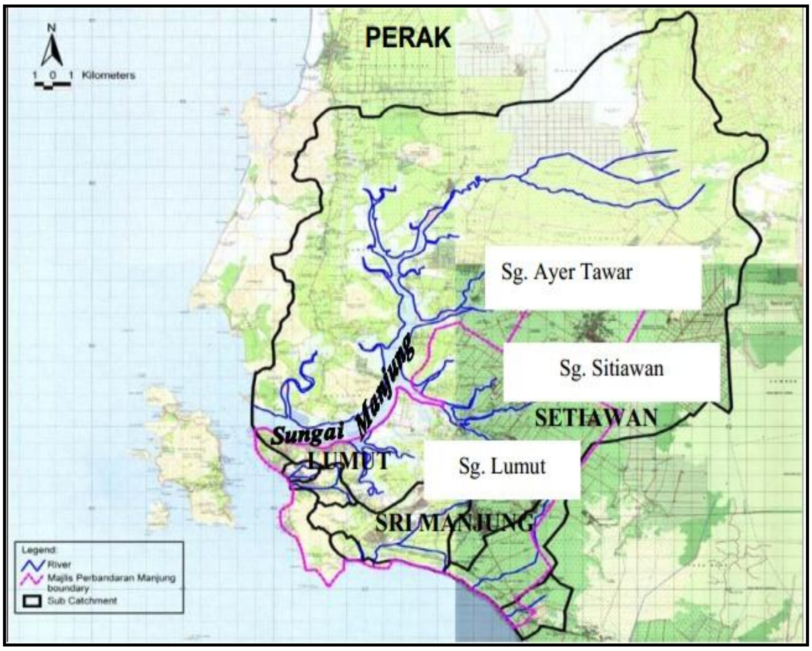

Figure 1.2: Location of Study area-“Study on Water Quality at Manjung River and its Tributaries”

1.2 PROBLEM STATEMENT

1.2.1 Diseases Transmissions And Outbreaks

Disease outbreaks are mainly attributed by poor management practices such as over-stoking and poor water quality in the system which decreases the resistance of the cultured species to the diseases. There is also a great possibility that these diseases will be spread from the cultured organism to the wild organisms stocks in the natural water bodies through effluents discharged or the escaped of live or dead cultured organisms (Mohamad, 2009). For example, in 1994, a major outbreak caused by luminous bacteria occurred almost simultaneously in prawn farms of Kedah and Perak. It has been reported that the diseased shrimps, the river water receiving the pond effluents, shellfishes in the river and even ants feeding on dead shrimps were observed to glow at night.

1.2.2 Mangrove

Mangrove forest was surrounded with loses sediment which receive organic matter from various sources such as bacteria, algae, mangrove litter and human activities. Beside organic matter, human activities such as urbanization and industrialization also contribute to abundance of pollutant in mangrove sediment.

Pollutants released into the environment have been increasing continuously as a result of industrial activities and technological development, posing a significant threat to the environment and public health because of their toxicity, accumulation in the food chain and persistence in nature. The heavy metals lead, mercury, copper, cadmium, zinc, nickel and chromium are among the most common pollutants found in industrial effluents (Bahadir, Bakan, Altas, & Buyukgubgor, 2005).

For swampy area like Manjung River, the mangrove plants require certain substance as essential nutrients; however an excess in these nutrients may potentially have adverse, ecotoxicological consequences for mangrove communities. Each mangrove plant species has specific adaptation systems, which may control their behavior towards pollutant.

1.2.3 Culture Farm Effluent

The relationship between the culture farm effluent and the environment is particularly crucial in culture farms. Wasted water outputs usually consist of dilute farm effluents and in the case of land-based farming operations may also include concentrated farm sediments. They are mainly derived from on-farm feed/nutrient input, either directly in the form of uneaten/leached feeds or animal digestion and excretory products. In addition, some bacteria degrade the organic compounds in fish farms and release dissolved inorganic nutrients to the water (Qian, Madeline Wu, & Ni, 2001).

1.2.4 Commercial

Commercial area is located at the Bandar Seri Manjung which is centre city between Sitiawan and Lumut it would be the contributor to river pollution. Human activities such as restaurants, car and motor services, wet market and clinics may release a lot of pollutant whether like it or not. Market and restaurant contribute much organic substance into the water bodies.

Figure 1.2: Shipping Activities at Lumut Port

Figure 1.2 shows shipping activities handling import and export located to serve nearer trades within South-East Asia, Myanmar, Bangladesh, India, Sri Lanka and Pakistan. As we can see from this figure, Lumut Port is messy as well as busier. Beside oil spillage from ships during ship repairing, loading and unloading goods, workers also tend to dump waste into the estuaries and increased the chances for water quality to be deteriorated.

1.2.5 Industrial

Wood, brick, steel and other building materials manufacturing are identified at Manjung region together with palm oil processing, flour and fertilizer factory and food production. These activities will create abundance of organic substance which are not biodegradable as well as chemical and toxic waste that finally discharged into water column.

1.3 OBJECTIVE

The objectives of present study are:

1. To identify sources of pollution based on main water quality parameters.
2. To determine the water quality level and classification of six (6) sampling station at the Manjung River Basin based on Water Quality Index (WQI), National Water Quality Standards (NWQS) and Environmental Quality Act (EQA).
3. To compare the trend of water quality of Manjung River with the previous study.

1.4 SCOPE OF STUDY

The scope of this study focused on Manjung River, one of major rivers in state of Perak. A few tributaries which are connected to the river were identified as shown in Figure 1.1. The locations of each sampling stations have been proposed and measured by using a point latitude/longitude on Google Maps. Water Quality sampling stations established within the study area is given in Figure 1.3. The Latitude and Longitude of each sampling stations are listed in Table 1.1.

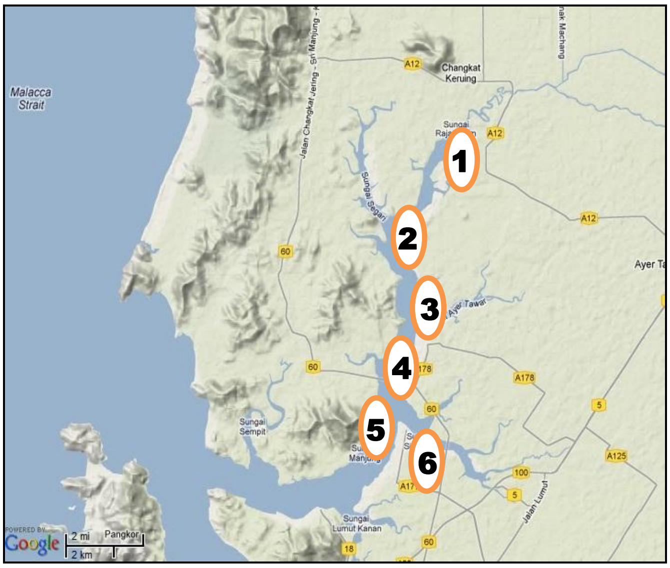

Figure 1.3: Water Quality Location Stations

Table 1.1: Latitude/Longitude of Water Quality Location Stations

Stations	Latitude	Longitude	Descriptions
1	$4^o24'$ N	$100^o41'$ E	Towards palm oil factory at Changkat Kruing
2	$4^o19'$ N	$100^o40'$ E	At shrimp farm outlet
3	$4^o18'$ N	$100^o40'$ E	Near shrimp farm at Sg. Pasir
4	$4^o17'$ N	$100^o40'$ E	At the area of floating fish cages
5	$4^o16'$ N	$100^o40'$ E	Next to Jalan David Sung near with fertilizer factory
6	$4^o16'$ N	$100^o39'$ E	At shipping & port near Lumut Maritime Terminal

In-situ tests were conducted to examine some water quality parameters on site such as dissolved oxygen (DO), conductivity, turbidity, salinity, temperature and pH. While, for biochemical oxygen demand (BOD), chemical oxygen demand (COD), total suspended solid (TSS), ammoniacal nitrogen (NH3-H), fecal coliform and oil and grease were conducted at Environmental Laboratory, Universiti Teknologi Petronas. The sampling of water quality is taken at six (6) stations with five times of frequency for both tides (study period is within July 2012 and November 2006). Each parameter was analysis based on Water Quality Standard and Regulation in Malaysia. Analysis of WQI is obtained by using six (6) parameters as recommended by DOE. As well as comparison between present studies with the previous study was be done.

CHAPTER 2

LITERATURE REVIEW

2.1 WATER RESOURCES

The annual internal renewable water resources are estimated at 630 km³. As surface water is readily available throughout the year, it is abstracted mainly for irrigation and domestic uses. The groundwater potential is limited to some pockets of the coastal region and is generally exploited by rural people to supplement their piped water supply. Figure 2.1 shows the source of water used in Malaysia. Surface water represents 97 percent of the total water use, while groundwater represents 3 percent. About 62 percent was utilized is for domestic and/or municipal purposes, 5 percent for irrigation and 33 percent for industry (Mcginley, 2009).

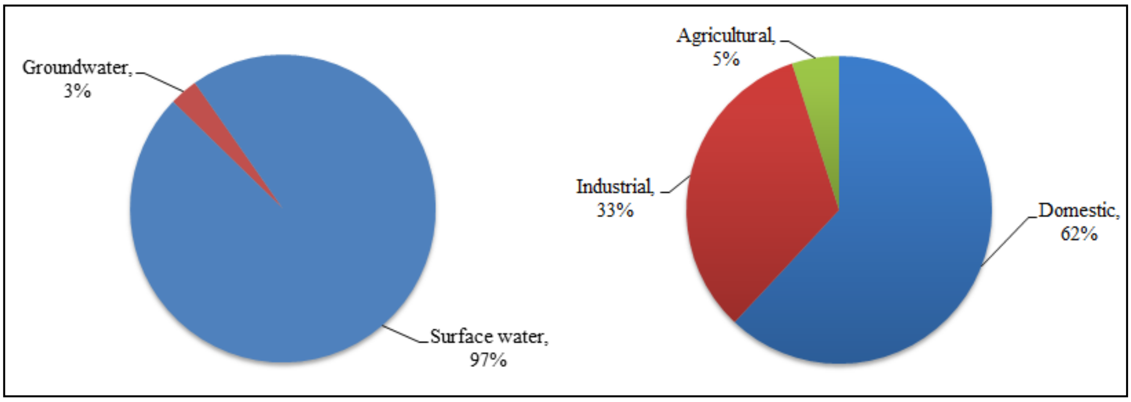

Figure 2.1: Source of Water Used in Malaysia

Surface water is the most important water resources in Malaysia. River is one of the sources of surface water. It has many purposes such as for the domestic and industry use, agriculture, transportation, hydroelectric power plant and recreation. However the quantity of surface water has decreased due to the degradation of water quality caused by pollution.

The National Water Resources Council (NWRC) was set up in 1998 to pursue a more effective water management, including the implementation of inter-state water transfers. To ensure sustainable water resources and efficient water supply services, the Federal Government is moving towards greater involvement in the management of water resources and water supply services, and the implementation of integrated water resources management (Zainal Abidin, 2008).

2.2 DEFINING WATER QUALITY

Water quality refers to the physical, chemical and biological characteristics of water. It is a measure of the condition of water relative to the requirements of one or more biotic species and or to any human need or purpose. It is most frequently used by reference to a set of standards against which compliance can be assessed. The most common standards used to assess water quality relate to health of ecosystems, safety of human contact and drinking water.

A practical evaluation of water quality depends on how the water is used, as well as its chemical makeup. The quality of water in a stream might be considered good if the water is used for irrigation but poor if it is used as a drinking water supply (Zainal Abidin, 2008).

2.3 RIVER WATER QUALITY ISSUES

A study has been done by Department of Environment (DOE) on 116 rivers nationwide. Some 10 percent of these rivers are heavily polluted or dead, 63 percent are polluted only 27 percent are healthy. The study also showed that 70 percent of the pollution is caused by human activities such as wanton dumping and logging.

In year 2010, DOE was conducted river water quality monitoring at seven (7) of river basin in Perak State. Manjung river was indicated as higher pollution compared to the others. It can be seen in Figure 2.2. The pollution mainly comes from NH_3-N, which is caused by human and animals waste. Furthermore, arising of new development land use for agriculture and sand extractions was detected in Manjung river. Comparison of water quality index between DOE study and the present study has been done, and the detailed will shows in Chapter 4.

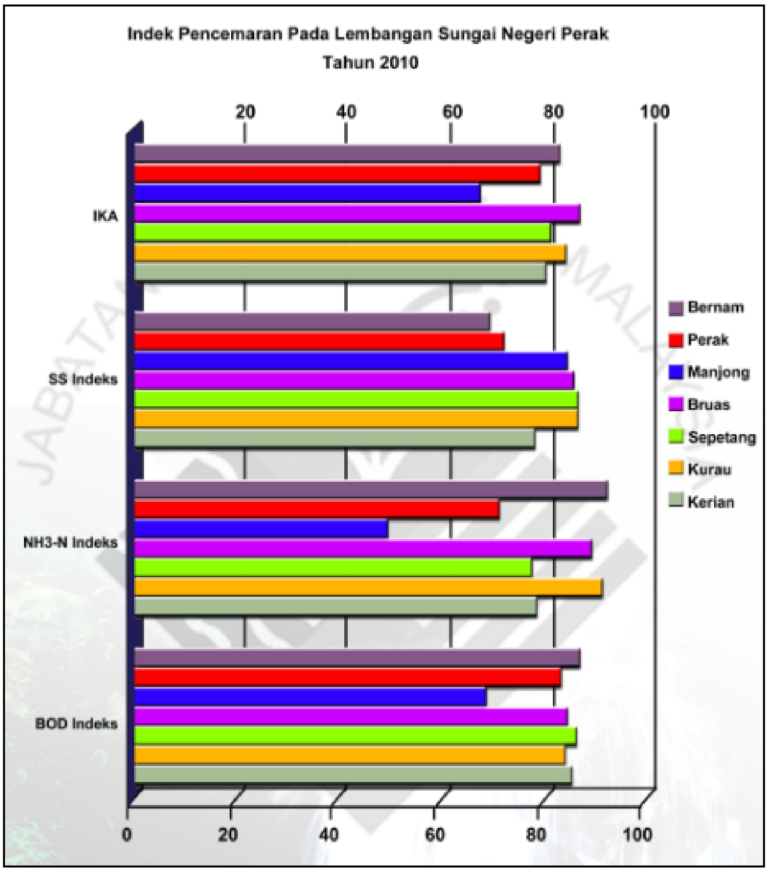

Figure 2.2: Pollution Index of River Basin in Perak State (DOE, 2010).

2.4 SOURCES OF RIVER WATER POLLUTION

River water pollution may occur from non-integrated and non-systematic of existing management system. There are two main sources in contributing of river water pollution, which are point sources and non-point sources. The point sources consist of detectable sources pollution component such as domestic waste water discharge and industrial waste water discharge. While non-point sources is undetectable pollution sources such as surface run off, agriculture and so on. River pollution depending on natural factor and human factor as discuss as follows;

2.4.1 Natural Factor

Natural factor is hard to identify and it depending on geological factor climate changes local soil erosion, storm and flood conditions. There are two major factors was identified as natural pollution contribution to degradation of water quality which were agriculture runoff and urban runoff (Dalman, Demirak, & Balcy, 2006). These factors may cause flooding because of river incapable to support large quantity and immediate surface runoff during heavy rain or continuous rain or both conditions. The characteristic of catchment area may effect to the rate and quality of flow rate. Sloppy earth surface may increase the speed of surface runoff as it decreases water retention time. Hence, soil absorption ability will be decreased because normally vegetation in this area is less thickening and the soil easy to erosive. For that reason, the effect of surface runoff became more serious by affecting public health and economy for particular country (Noor, Ismail, Salleh, & Ibrahim, 2009).

2.4.2 Human Factor

Human factor or known as anthropogenic sources were the major contributor to river water and sediment pollution. During the course of the 20th century anthropogenic influence in river systems has become an increasing limiting factor of river discharge. The trace element that was identifies as most impacted elements by human activities is Cd, Cu, Hg and Zn (Davide, Pardos, Diserens, & Ugazio, 2002).

However, according to Marchand, Lallier, Baltzer, & Cossa (2005), the variations in heavy metal content with depth or between mangrove areas result largely from digenetic processes rather than changes in metal input resulting from local human activities. In some country, the main function of river is as transportation and shipping activities. Heavy ship traffic may cause a lot of pollution to river water quality.

Beside, dredging activities, thermal power plant, intensive aquaculture, inadequate water use management, intensive deforestation and also mining activities such as gold mining, uranium and tin mining, mining of chromites and decorative stones and copper mining, are the major factor in releasing pollutant to river. Many study shows that non-biodegradable substance measured in surficial bottom sediment near industrial area, all show higher levels of inorganic matter compared to non-industrial area. Meaning that, industrial activities discharge a lot of inorganic matter. Inorganic matter especially chemical and toxic wastes are discharged from various industries, such as smelters, electroplating, metal refineries, textile, mining, ceramic and glass (Bahadir, Bakan, Altas, & Buyukgubgor, 2005). For non-industrial area, the main sources of inorganic substances in surface water are likely to have been traffic emissions, city wastewater and bio solids that used as fertilizer (Zhang, Sun , Niu, & Chen, 2006). Municipal waste water, also known as point sources becomes worldwide concern because the effluent discharge is hard to comply with country standard. In suburban areas, the use of industrial or municipal wastewater is common practice in many parts of the world (Sharma, 2010). Ammonia concentration is normally high at downstream of waste water treatment plant and nearby the pond with large water habitat population such as duck and swan which discharge abundant of unwanted waste.

2.5 WATER QUALITY STANDARDS IN MALAYSIA

2.5.1 National Water Quality Standards of Malaysia (NWQS)

In Malaysia, the Department of Environment (DOE) has chosen the NWQS to classify the river for the use of water resources. The data for water quality monitoring should be compared with the water criteria and standard since this data is vital for the water management (DNASB, 2011).

River in Malaysia have been classified into 5 main classes namely Class I, IIA, IIB, III, IV and V based on NWQS as shown in Appendix A.

2.5.2 Water Quality Index (WQI)

There are so many methods used to determine the water quality. One of the usual methods is via WQI. A Water Quality Index, in common with many other indices system, relates a group of water quality parameters to common scales and combines them into a single number in accordance with a chosen method or model of computation. The main objective of the WQI system is to use it as a preliminary means of assessment of water body for compliance with the standards adopted for five designated classes of beneficial uses (DOE, 2008). The desired used of WQI to an assessment of water quality trends is for management purposes even though it is not specially as an absolute measure of the degree of pollution or the actual water quality.

The first calculation of WQI was made by Deplhi in 1970, which comprised 9 parameters of water quality. However, based on the WQI given by the DOE there are only 6 parameters such as BOD, COD, NH_3-N, DO, TSS and pH, usually measured for water quality assessment as shown in Appendix B.

2.5.3 Environment Quality Act 1974 (EQA)

“Environmental Quality (Sewage and Industrial Effluents) Regulations 1979" was replaced by new three laws in 2009, which are "Environmental Quality (Sewage) Regulations", "Environmental Quality (Industrial Effluent) Regulations", and "Environmental Quality (Control of Pollution from Solid Waste Transfer Stations and Landfills) Regulations". In addition, other discharge standards is established for the prescribed premises (raw natural rubber and crude palm-oil) ("Environmental Quality (Prescribed Premises) (Raw Natural Rubber) Regulations 1978" and "Environmental Quality (Prescribed Premises) (Crude Palm-Oil) Regulations 1977").

Section 25, EQA 1974 ordains restrictions on pollution of inland waters where no person shall, unless licensed, emit, discharge or deposit any environmentally hazardous substances, pollutants or wastes into any inland waters in contravention of the acceptable conditions specified under Section 21. This provision allows its enforcement whereby surprise inspections are carried out at all premises by DOE officials in ensuring compliance with all provisions in the act. Non-compliance will result in prosecution and punishment (W.P William, 1997). The standards are used in this study as shown in Appendix C.

2.6 WATER QUALITY PARAMETERS

Having good water quality is important for a healthy river and ecosystem. Several basic conditions must be met for aquatic life to thrive in the water. When these conditions are not optimal, species populations become stressed. When conditions are poor, organisms may die. Thus, various water quality parameters need to be measured in order to determine the health of the river water so that it is safe to use for any purpose. In order to develop a water quality or river index, there are several parameters that need to be considered (JPS, 2009). For this study, quality parameters chosen include DO, Turbidity, Conductivity, Salinity, Temperature, pH, BOD, COD, NH_3-N, TSS, Fecal Coliform and Oil & Grease.

Those chosen parameters are enough to determine the preliminary water quality even though there are other parameters which can be used to determine the water quality. They were chosen based on the availability of facilities in Environmental Engineering Laboratory at UTP. These parameters can be divided into three groups, which are physical, chemical and biological.

2.6.1 Physical Parameter

2.6.1.1 Temperature

The rates of biological and chemical processes depend on temperature. Temperature affects the oxygen content of water (oxygen levels become lower as temperature increase). Water temperature is an important parameter to study in streams. And it is probably the number one reason why many streams and rivers may exceed water quality standards. Most aquatic organisms need a constant water temperature in order to survive. When the water temperature changes rapidly, many organism become stressed, which often leads to increased disease or makes them more susceptible to predation.

2.6.1.2 Turbidity

Turbidity is a measure of the cloudiness of water. Cloudiness is caused by suspended solids (mainly soil particles) and plankton (microscopic plants and animals) that are suspended in the water column. Moderately low levels of turbidity may indicate a healthy, well-functioning ecosystem, with moderate amounts of plankton present to fuel the fuel the food chain. However, higher levels of turbidity pose several problems for stream systems. Turbidity blocks out the light needed by submerged aquatic vegetation. It also can raise surface water temperatures above normal because suspended particles near the surface facilitate the absorption of heat from sunlight (EIA, 1997).

2.6.1.3 Total Suspended Solid (TSS)

TSS is usually referred to the particles in water which is usually larger than 0.45 μm. Many pollutants (e.g. toxic heavy metals) can be attached to TSS, which is not good for the aquatic habitat and lives. High suspended solids also prevent sunlight to penetrate into water. Total dissolved solid (TDS) consists of dissolved minerals and indicates the presence of dissolved materials that cannot be removed by conventional filtration. The presence of synthetic organic chemicals (fuels, detergents, paints, solvents etc) imparts objectionable and offensive tastes, odors and colors to fish and aquatic plants even when they are present in low concentrations (DID, 2009).

2.6.1.5 Conductivity

Conductivity is the measurement of a solution's ability to conduct an electrical current. Absolutely pure water is actually a poor electrical conductor. It is the substances (or salt) dissolved in the water, which determine how conductive the solution will be.

Conductivity is the reciprocal of the resistance in ohms between the opposite faces of a 1cm cube of an aqueous solution at a specified temperature (usually 25^oC). It is temperature dependent. When the temperature is high, the conductivity will increase.

Conductivity in water is affected by the presence of inorganic dissolved solids such as chloride, nitrate, sulfate and phosphorus anions (ions that carry a negative charge) or sodium, magnesium, calcium, iron and aluminium cautions (ions that carry a positive charge). Dissolved gasses such as carbon dioxide and ammonia also affect the conductivity of water.

2.6.2 Chemical Parameter

2.6.2.1 pH

pH is the percentage of hydrogen ion (H^+) in a solution. A solution is more acidic when it contains more hydrogen ions. The level of acidity of water is important to the plant and animal life in the water. The pH influences the uses of water by humans. A pH of 7 is considered to be neutral. When the pH is less than 7, it is acidic; a pH greater than 7 is basic. Water with excessively low or high pH will be very corrosive. A range between 6.5 and 8.5 is generally suitable. The mathematical definition of pH is given as equation 2.1:

$$pH = -\log10\,[H^+] \tag{2.1}$$

2.6.2.2 Dissolved Oxygen (DO)

Oxygen is as important to life in water as it is life on land. The amount of oxygen found in water is called the dissolved oxygen concentration. DO is a very important measure of health of stream. The presence of oxygen in water is a positive sign wilst the absence of oxygen in water is often a sign that the stream is polluted. Normally the oxygen can dissolve easily in the water but the content of oxygen dissolved in water is not constant. It depends on the water temperature, atmospheric pressure and salinity.

Most aquatic plants and animals require oxygen affects their growth and development. The contamination in the water may reduce the dissolved oxygen, thus affect the aquatic life which can lead so the bad water odor.

2.6.2.3 Biological Oxygen Demand (BOD)

The BOD has a wide application in water pollution. When organic matter decomposes, microorganisms (such as bacteria and fungi) feed upon this decaying material and eventually it becomes oxidized. BOD measures the amout fo oxygen consumed by microorganism in process of decomposing organic matter in stream water.

BOD directly affects the amount of dissolved oxygen in rivers and streams. The more rapidly oxygen is depleted in the stream, the greater the BOD. This means less oxygen available. The detriment of high BOD is the same as low dissolved oxygen, aquatic organisms become stressed, suffocate and die.

2.6.2.4 Chemical Oxygen Demand (COD)

COD test is commonly used to measure the amount of organic and inorganic oxydizable compounds in water. Most applications of COD determine the amount of total oxidizable pollutants found in surface water, making COD a useful measure of water quality. It is expressed in milligrams per liter (mg/L), which indicates the mass of oxygen consumed per liter of solution (DID, 2009).

2.6.2.5 Oil & Grease

Oil in water can be present in four basic forms which are free oil, mechanically emulsified oil, chemically emulsified oil, and dissolved oil. Free oil will rise to the surface of the water in which it is contained. Mechanically emulsified oil is caused by agitating a free oil and water mixture to the point where it breaks the oil up into very small droplets (10-20 microns). High water temperatures and use of liquid vegetable oils promote mechanically emulsified oil. Oil and grease may also become chemically emulsified, primarily through the use of detergents and other alkalis. Chemically emulsified oil particles are very small (<1 micron) and do not rise to the surface of the water regardless of how much time is allowed. Oil may also be present as dissolved oil in which case it is no longer present as discrete particles. Oil generally becomes dissolved in water through the use of degreasing compounds which are soluble in both oil and water.

2.6.2.6 Ammonical Nitrogen (NH_3-N)

Ammonia levels in excess of the recommended limits may harm aquatic life. Although the ammonia molecule is nutrient required for life, excess ammonia may accumulate in the organism and cause alteration of metabolism or increases in body pH. It is an indicator of pollution from the excessive usage of ammonia rich fertilizers.

According DOE reported in 2010, NH_3-N is major pollutants detected in Manjung River. The main sources of NH_3-N were livestock farming and domestic sewage, whilst the sources for SS were earthworks and clearing activities.

2.6.1.7 Salinity

Salinity is the concentration of dissolved salts in the water. Aquatic animals are adapted to living within certain salinity ranges. Salinity is measured as a ratio of salts to water and is expressed in parts per thousand (ppt), which means the number of units (parts) of salts per thousand units of water. These are three main categories of salinity; fresh water (0-0.5 ppt), brackish water (partly salty, or 0.5-30 ppt), and salt water (full seawater, greater than 30 ppt).

2.6.3 Biological Parameter

2.6.3.1 Fecal Coliform

Fecal coliform is a form of bacteria found in human and animal waste. Fecal coliform are bacteria whose presence indicates that the water may have been contaminated with human or animal fecal material. If fecal coliform counts are high in a site, it is very likely that pathogenic organisms are also present, and this site is not recommended for swimming and other contact recreation.

A few micro–organisms are an important cause of the corrosion of steel pipes. Water for the purpose of drinking that contained micro–organisms can cause sensory defects in odor, color and taste. Various healths related problems due to contaminated waters are diarrhea, abdominal cramps and vomiting due to salmonella, cholera is due to vibro cholera, infection of lungs due to mycobacterium (DID, 2009).

CHAPTER 3

METHODOLOGY/PROJECT WORK

3.1 PROJECT FLOW

This chapter explains on the few phases used from the beginning to the final stage in order to achieve the objectives of this study. The overall schedule plan during this study will showing in Gantt chart (see Appendix D). Before fieldwork is carried out, there are a few scopes and methodology inflows that need to follow to ensure the information is well gain in order to make study easier in term of data assemblages and editing as showed in Figure 3.1.

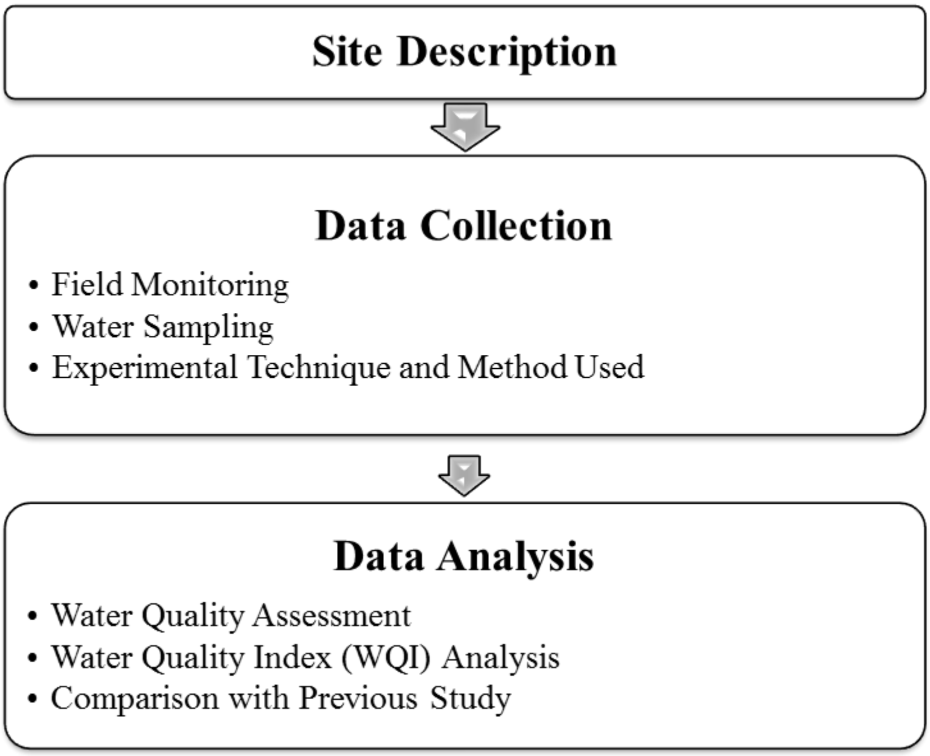

Figure 3.1: Flow of Work

3.2 SITE DESCRIPTION

The area chosen is reported to be one of major location where sea fishing and fish/prawn farming is commercially in our country. Linear arrangement of earthen ponds can be found on both sides of these rivers; especially in reclaimed mangrove areas (see Figure 3.2). The Manjung mangroves to the south have been highly degraded by agricultural, aquaculture industrial and port activities. Since these forests are not forest reserves, existing mangroves are therefore probably much less in area (EIA, 1997).

The sampling stations covered an overall area of latitude (4^{o}16' N - 4^{o}24' N) and longitude (100^{o}39' E - 100^{o}41' E). Manjung River flows through Lumut and Sitiawan before entering the Straits of Melaka. This area has been promoted as a tourist destination, with Lumut being the ferry point to the popular tourist island namely Pangkor Island. Manjung River is large and deep with a large tidal prissm, navigable by large boats and catamarans to as Kg. Baharu (see Figure 3.3). The main river is mostly mangrove-lined particularly at the upper half but mostly thin fringe, thicker pockets largely on its tributaries. The renovation of the water river is controlled by the semi-diurinal tidal range, with the mean high water springs (MHWS), mean high water neaps (MHWN), mean low water neaps (MLWN) and mean low water springs (MLWS) as reported by Tide Table Malaysia (Malaysian Meteorological Department Offical Website). The freshwater input is relative high and controlled by seasons.

Shrimp culture is one of the fastest growing brackishwater aquaculture sectors in Malaysia. In the district of Manjung, the main species cultured is Penaueus monodon (black tiger shrimp). There is more than 300 shrimp ponds operating now where by most of them are situated along the Manjung River (LKIM, 2012).

There are four major industrial estates in te district of Manjung; Kampung Acheh Industrial Estate (also known as Lumut Port Industrial Park), Batu Undan Industrial Estate, Seri Manjung Estate and Lumut Naval Dockyard. Agricultural land use is the highest in Majung, representing 60% of total land use, with oil palm, fruits, rubber and coconut being the main crops. The industries are mainly marine based and heavy industries.

Figure 3.2: Mangrove Towards Upstream along Manjung River

Figure 3.3: Boats and Catamarans at Kg. Baharu

Table 3.1: Tide Schedule and Computed Tidal Amplitudes during Sampling Expeditions

Date	Time	Tides	Tidal Height (m)	Tidal Amplitude (m)
Preliminary Sampling 1 July 2012 (3 days before full moon)	02:25 07:35 13:35 20:30	High Low High Low	2.0 1.3 2.3 0.2	 0.7 1.0 2.1
1st Sampling 14 Oct 2012 (14 days after full moon)	03:05 09:05 15:25 21:30	High Low High Low	2.4 0.7 2.6 0.8	 1.7 1.9 1.8
2nd Sampling 4 Nov 2012 (4 days after full moon)	00:05 06:25 13:00 19:30	Low High Low High	1.3 2.5 0.5 2.2	 1.2 2.0 1.7
3rd Sampling 18 Nov 2012 (4 days after full moon)	00:40 06:25 13:25 20:00	Low High Low High	1.4 2.8 0.2 2.4	 1.4 2.6 2.2
4th Sampling 25 Nov 2012 (10 days before full moon)	01:50 08:20 14:55 20:35	High Low High Low	2.3 0.8 2.2 1.3	 1.5 1.4 0.9

(Sources: Based on station Lumut, Tide Tables Malaysia, 2012)

3.3 DATA COLLECTION

3.3.1 Field Monitoring

The project began with a preliminary visit on July 2012 at 4 sampling stations in the study area. Two more sampling points were added and carried out later during October and November 2012. Water samples for in-situ collection time was started at 6am, 10am, 2pm, 6pm and 10pm. While water samples for laboratory test, the waters taken at 2pm (during the last day of monitoring). Station 2, 3 and 4 are considered located in the area where most of the fishes/shrimp farm can be found. Station 5 and 6 were consider as industrial area, where location of factory and marine industries. Station 1 is located away from the culture area and the waters were taken from jetty Kg. Changkat Kruing.

3.3.2 Water Sampling

In-situ parameter such as pH, DO, Temperature, Salinity, Conductivity, Turbidity were determine by using Multi-Parameter Water Quality Sonde Model 6600 V2 (see Figure 3.4). The rest parameter will be analysis at laboratory by taken water sample for each point into 5000ml High Density Polyethylene (HDPE) bottle using river water sampler (see Figure 3.5). Figure 3.6 to Figure 3.12 showed the equipment used during laboratory experiment which was clean according to Standard Method APHA. The water sample then being preserved by stored at 4°C cold room. Table 3.2 will show the preservation techniques and holding times.

Table 3.2: Samples Preservation Techniques and Holding Times (UTP, 2012).

Parameter	**Preservative**	**Maximum Holding Time**
BOD	Cool, 4ºC	48 hours
NH_3-N	Cool, 4ºC	28 days
COD	Cool, 4ºC H_2SO_4 to pH < 2	28 days
TSS	Cool, 4ºC	7 days
Oil and Grease	Cool, 4ºC H^2SO^4 to pH < 2	28 days
Fecal Coliform	Cool, 4ºC 0.008% $Na_2S_2O_3$	6 hours

Figure 3.1: Multi-Parameter Water Quality Sonde Model 6600 V2

Figure 3.5: River Water Sampler

Figure 3.6: BOD Incubator

Figure 3.7: BOD Bottle 300mL

Figure 3.8: Spectrophotometer

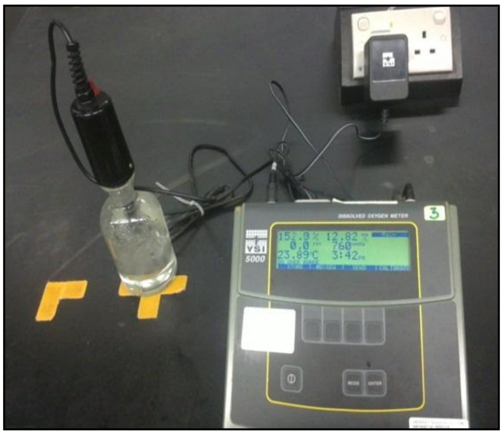

Figure 3.9: DO Meter

Figure 3.10: COD Reactor

Figure 3.11: Quanti-Tray Sealer

Figure 3.12: TSS Equipment

3.3.3 Experimental Technique and Method Used

All water samples will be analyzed based on in-situ measurement and laboratory analyses accordance with APHA Standards. Laboratory analyses will be conduct by the Environmental Engineering Laboratory at UTP. Table 3.3 shows the water quality parameters and method use that are required to determine Manjung River and its tributaries water quality.

Table 3.3: Water Quality Parameters and Method Use

Parameters	Unit	Method Use
pH	-	In- situ
DO	mg/l	In- situ
Temperature	^{o}C	In- situ
Salinity	%	In- situ
Conductivity	µS/cm	In- situ
Turbidity	NTU	In- situ
BOD	mg/l	APHA 5210 B, 1995
COD	mg/l	APHA 5220 B, 1995
TSS	mg/l	APHA 2540 D, 1995
NH_3-N	mg/l	APHA 4500-NH_3 E 1992
Oil and Grease	mg/l	APHA 5520 B, 1992
Fecal Coliform	mg/l	Most Probable Number (MPN) method

3.4 DATA ANALYSIS

3.4.1 Water Quality Assessments

This analysis was carried out using concentrations of water quality parameters based on in-situ test and laboratory experiments. In this study, the water quality was analyzed between low tide and high tide with each sampling station along the Manjung River. The result of each parameter is an average value of sampling frequency. Then, determination of classification has been made based on NWQS and EQA standard in Malaysia.

3.4.2 Water Quality Index Analysis

In Malaysia, there are six (6) main water quality parameter that strongly recommended by DOE in order to classifying the status of particular water bodies. The parameters are BOD, COD, NH_3-N, DO, TSS and pH. In this study, the water quality was analyzed based on Water Quality Index (WQI) calculation.

The formula used in calculation of the DOE's WQI as in equation 3.1:

$$\begin{aligned} WQI = {} & (0.22*SIDO)+(0.19*SIBOD)+(0.16*SICOD)+(0.15*SIAN) \\ & +(0.16*SISS)+(0.12*SIpH) \end{aligned} \tag{3.1}$$

Where;

SI - Sub index of parameter
DO - Dissolve Oxygen
BOD - Biological Oxygen Demand
COD - Chemical Oxygen Demand
AN - Ammonical Nitrogen
SS - Suspended Solid
pH - Acidity/Alkalinity

(DOE, 2008)

3.4.3 Comparison with Previous Study

Measurement of water quality in Manjung River had been done before during year 2010 under the Department of Environment, Malaysia (DOE) collaborative project with Alam Sekitar Malaysia Sdn. Bhd. (DOE, 2010). Based on the river water quality graph in their annual report (see Figure 2.2), it shows the comparison value of water quality index (WQI), suspended solid index (SSI), ammoniacal nitrogen index (NH_3-NI) and biochemical oxygen demand index (BODI) with other catchment river basin in Perak State. However, only Manjung River will be carry out to compare with the present study.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 IN-SITU TEST

Water quality were sampling five (5) times within July to November 2012. On July 2012 sampling trip, it was preliminary sampling data which is only conducted the in-situ measurement. Table 4.1 shows each in-situ parameter result during high tide while Table 4.2 shows low tide's in-situ water quality parameter result.

Table 4.1: In-Situ Water Quality Parameter Result during High Tide

Sampling Station	In-situ Water Quality Parameter					
	DO (mg/l)	Salinity (ppt)	Conductivity (µS/cm)	Temperature (^oC)	Turbidity (NTU)	pH
1	3.55	28.87	45.10	31.17	15.61	7.44
2	3.57	41.80	68.63	31.00	32.47	7.61
3	3.28	48.81	70.99	30.86	15.02	7.70
4	3.50	43.90	64.52	30.87	14.26	7.73
5	4.54	42.08	66.96	30.36	29.66	7.87
6	4.69	45.94	67.15	31.03	31.46	7.80

Table 4.2: In-Situ Water Quality Parameter Result during Low Tide

Sampling Station	In-situ Water Quality Parameter					
	DO (mg/l)	Salinity (ppt)	Conductivity (µS/cm)	Temperature (^oC)	Turbidity (NTU)	pH
1	3.62	30.59	34.95	31.06	16.35	7.64
2	2.62	44.88	66.59	31.30	28.20	7.43
3	3.20	47.27	68.73	30.98	15.39	7.47
4	3.79	41.75	64.22	30.86	53.86	7.75
5	3.85	43.18	65.29	30.75	81.69	7.66
6	4.03	45.60	66.34	30.90	20.40	7.80

4.1.1 Dissolved Oxygen

The level of DO exhibited an obvious trend in the illustrated graph below (Figure 4.1). At upstream, DO concentration during low tide was slightly higher 1.93% as compared during high tide. The lowest DO recorded was found at stations 2 during low tide which is dropped about 27.62% from station 1. Both tides recorded the highest DO concentration at station 6 (4.69 mg/L and 4.03 mg/L respectively). It is probably because of abundance of DO at coastal water which has wide-range of area with cooler water and high velocity. According to Kassan (2006), cooler water has a higher saturation point for DO than warmer water and water that is flowing at higher velocities can hold more DO than slower water. Markedly decrease of DO level at these particular stations is believed causing by the discharge of shrimp farm effluent since the collection points are in proximity to these farms.

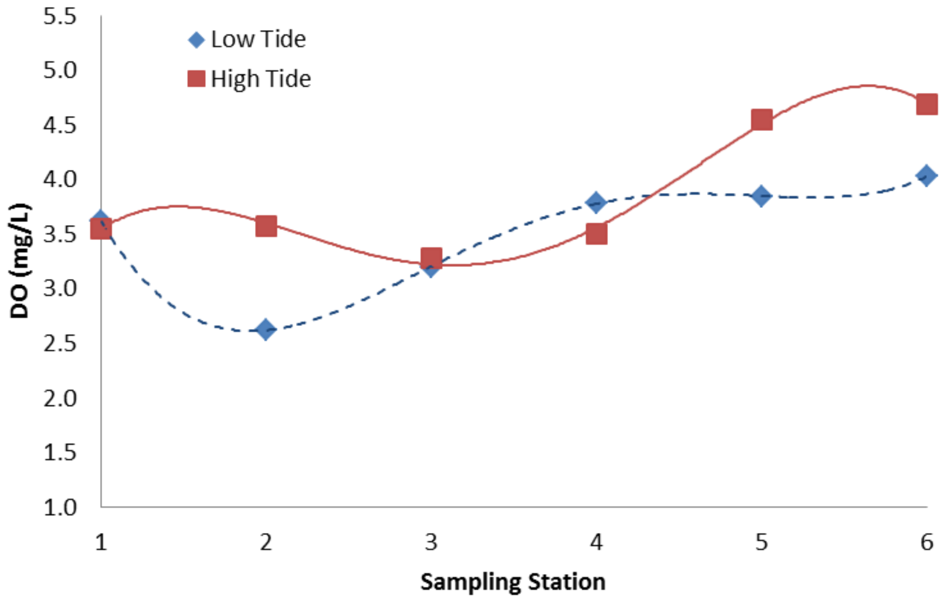

Figure 4.1: DO Concentrations during High Tide and Low Tide

4.1.2 Salinity

The variation of salinity is shown in Figure 4.2. The recorded salinity was quite consistent between each sampling points during both tide with variations between ±2 ppt. However the value recorded at upstream were lower 31.84% during high tide and 30.93% during low tide. This highlighted the freshwater influence or larger dilution from river runoff by raining season. In fact, from the data collection during sampling trip, there were some raining days in Manjung and Sitiawan during November. The highest value obtained was always shows at station 3 for both tides (48.81 ppt during high tide and 47.27 ppt during low tide).

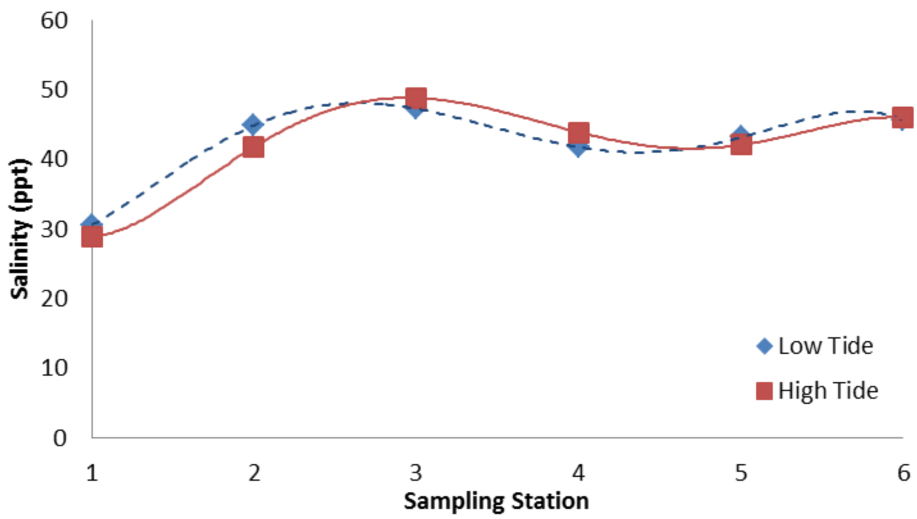

Figure 4.2: Salinity Concentrations during High Tide and Low Tide

4.1.3 Conductivity

The conductivity values measured indicate the capacity of the river water to carry an electrical current, which in turn is related to the concentration of ionized substances in the river water. Most dissolved inorganic substances in river water are in the ionized form and so contribute to the conductivity. From Figure 4.3 during high tide, in-situ conductivity values range from 34.95µS/cm to maximum concentration 68.73µS/cm.

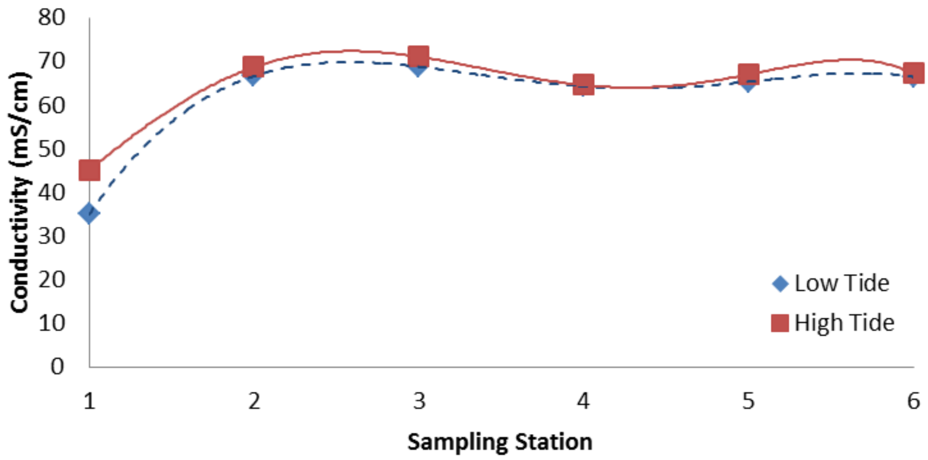

Figure 4.3: Conductivity Concentrations during High Tide and Low Tide

4.1.4 Temperature

Temperature is one the significant parameter in the evaluation of water quality. It probably because of influences the chemical, biological rate and regulates the dissolve oxygen concentration of water. It is due to govern the types of aquatic life. The temperature in the warm water stream should not exceed 32^{o}C. High temperature will reduce available oxygen in the water and cause fish dead (Rauf, 2010).

From Figure 4.4, it shows that during low tide is slightly higher rather than high tide. The fluctuation of temperature level within the 30.75^{o}C - 31.30^{o}C during low tide and 30.36^{o}C - 31.17^{o}C during high tide. The temperature values did not exceed 32^{o}C. Therefore, it will not be a great concern to the developer and authority.

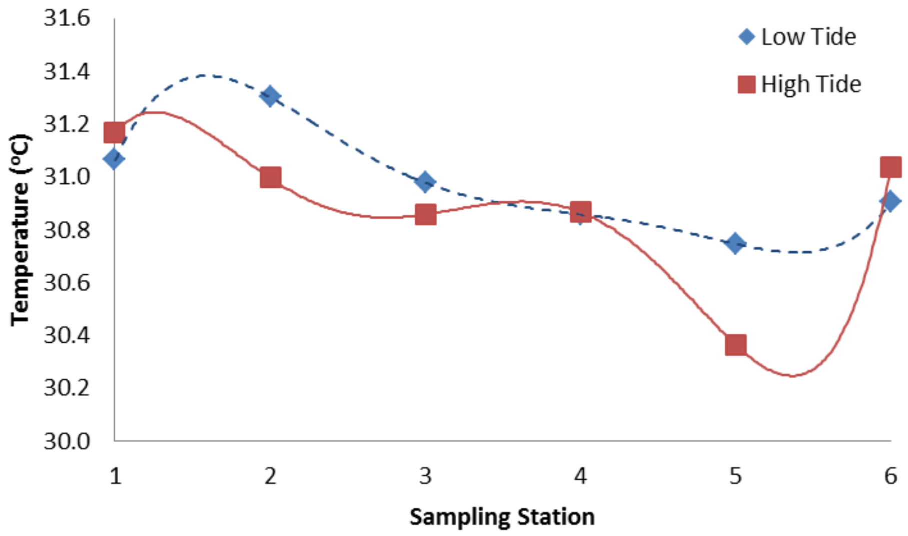

Figure 4.4: Temperature Concentrations during High Tide and Low Tide

4.1.5 Turbidity

Turbidity is caused by a wide variety of suspended materials, which range in size from colloidal to coarse dispersions, depending upon the degree of turbulence. From Figure 4.5 it shows both tide were quite consistent at upstream towards middle stream. At station 5 turbidity concentration increased 89% during high tide and 34.1% during low tide. It probably because of effluent from fertilizer factory were produce essentially toxic components such as free ammonia, numerous ammonium compounds, phosphate compounds, urea, heavy metals from chemicals used in stabilizing production processes, oil, grease and fuel from machinery (Obire, Ogan, & Okigbo, 2008)

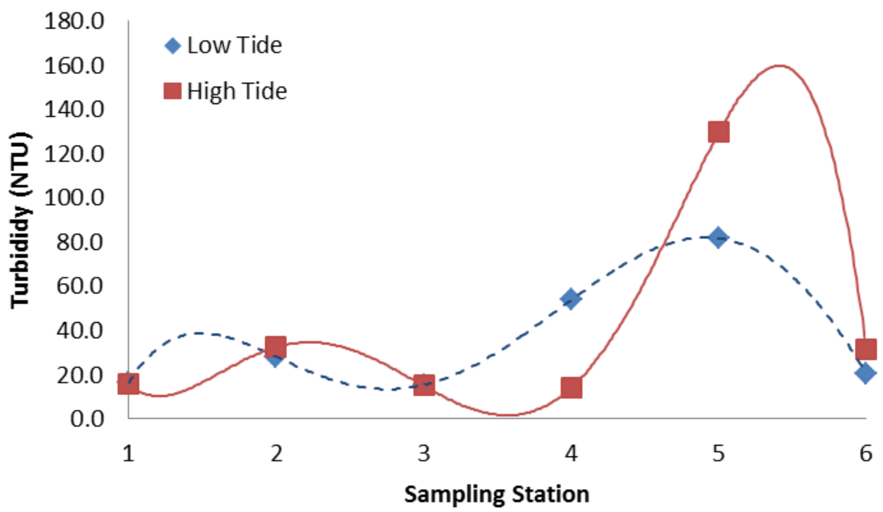

Figure 4.5: Turbidity Concentrations during High Tide and Low Tide

4.1.6 pH

Based on the National Water Quality Standard (NWQS) for Malaysia, the normal pH range for water body which is fit for used as water supply and as habitat for sensitive aquatic species in 6.5-9.5. The data obtained are shown in Figure 4.6. The pH values measured during the study range 7.44 to 7.87 during high tide and 7.43 to 7.80 during low tide. The maximum value recorded at station 5 (high tide) and the minimum value was recorded at station 2 (low tide). According to Xie (2004), he found that decrease of pH value in water close to shrimp farm zone could be due to the high concentration of ammonium in the effluent and to the acidic character of the faeces and shrimp food. However, the pH values indicate that the river water sampling station is neutral from upstream to downstream for both tides.

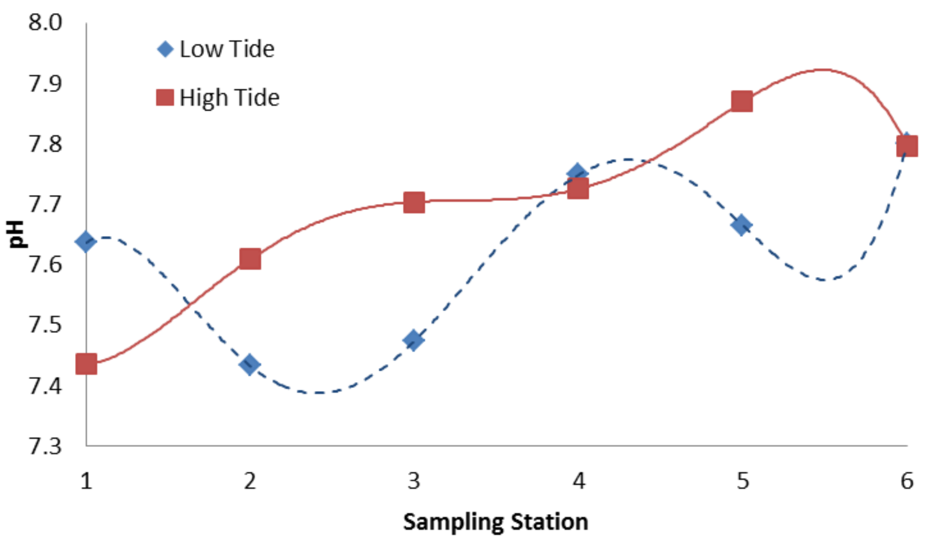

Figure 4.6: pH Levels during High Tide and Low Tide

4.2 LABORATORY EXPERIMENTS

Laboratory experiments were conducted at Environmental Laboratory of Universiti Teknologi Petronas. The method used was discussed in Chapter 3. Water sampling was taken at the final session of the trip. Table 4.3 shows each laboratory parameter result during high tide while Table 4.4 shows average of low tide's laboratory water quality parameter result.

Table 4.3: Laboratory Water Quality Parameter Result during High Tide

Sampling Stations	Water Quality Index Parameter					
	BOD_5 (mg/l)	COD (mg/l)	NH3-N (mg/l)	TSS (mg/l)	Fecal Coliform (MPN)	Oil and Grease (ppm)
1	15.5	170.83	2.2	12.89	204.6	3
2	11.52	216.67	1.42	19.11	298.7	4
3	15.23	420.83	1.02	48.22	>2419.6	3
4	18.89	407.86	1.54	37.33	66.3	2
5	17.4	325.94	0.64	30.22	45	3
6	17.06	349.07	0.72	30.22	41.4	4

Table 4.4: Laboratory Water Quality Parameter Result during Low Tide

Sampling Stations	Water Quality Index Parameter					
	BOD_5 (mg/l)	COD (mg/l)	NH3-N (mg/l)	TSS (mg/l)	Fecal Coliform (MPN)	Oil and Grease (ppm)
1	17.29	194.46	2.88	50.89	172.5	5
2	9.51	154.17	0.97	56.67	>2419.6	4
3	15.05	235.86	1.15	61.33	60.9	4
4	18.04	341.9	0.87	50.67	161.6	3
5	13.08	289.04	0.8	66.44	66.3	4
6	11.85	267.97	0.92	50.22	45	5

4.2.1 Biochemical Oxygen Demand

BOD is one of essential parameter in order to determine organic pollutant level as consequence of domestic wastes, agricultural waste and anthropogenic inputs. Figure 4.7 shows the profile of BOD concentration towards the adjacent coastal water. At upstream, BOD concentration during low tide is higher 1.04 % from concentration during high tide. The lowest BOD concentration was always seen at station 2 for both tide which is dropped about 25.65 % during high tide and 45% during low tide from station 1.

At middle stream which has busy human activities, BOD was increasing at station 4 for both tide because according to Lung (2001), squatters activities that release untreated sewage and food wastes directly into water bodies will finally increase the BOD concentration. However, towards downstream which is at shipping activities, industrial area, and onwards, BOD was decreasing due to wide range area and organic matters were well distributed because of mixing water and strong current by coastal water.

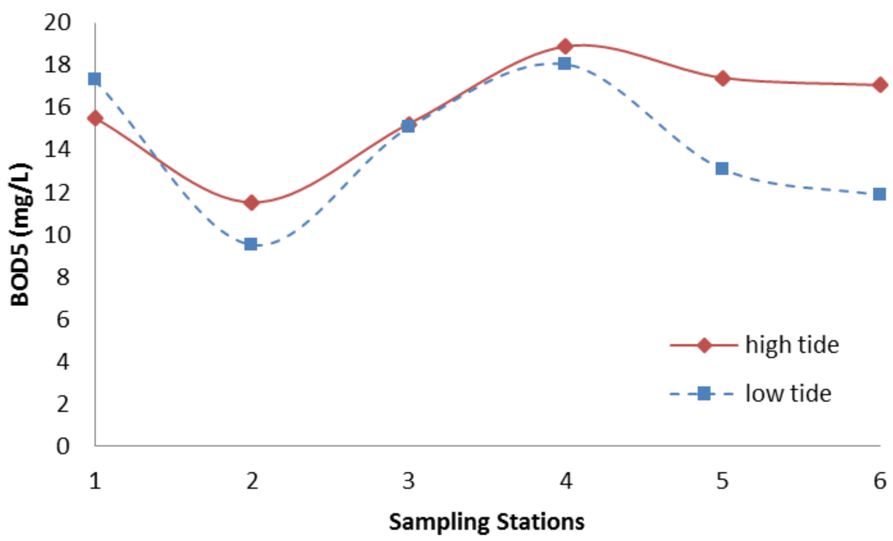

Figure 4.7: BOD Concentrations during High Tide and Low Tide

4.2.2 Chemical Oxygen Demand

Generally, COD values are greater than BOD values and may be much greater when significant amounts of biologically resistant organic matter is present. From Figure 4.8, it shows that the COD concentration at upstream during high tide was 170.83 mg/L and it was higher concentration towards middle stream about 420.83 mg/L. It came back decreased about 17.1 % towards downstream to seaward. While during low tide is decreased at station 2 from the upstream is about 20.7 %. At middle stream the concentration increased with 341.9 mg/L at station 4. The rapidly higher at station 3 and station 4 for both tides it probably because a lot of human activities such as aquaculture farm, commercial area and settlement area at the middle stream, the COD concentration were increased rapidly due to non-biodegradable discharged.

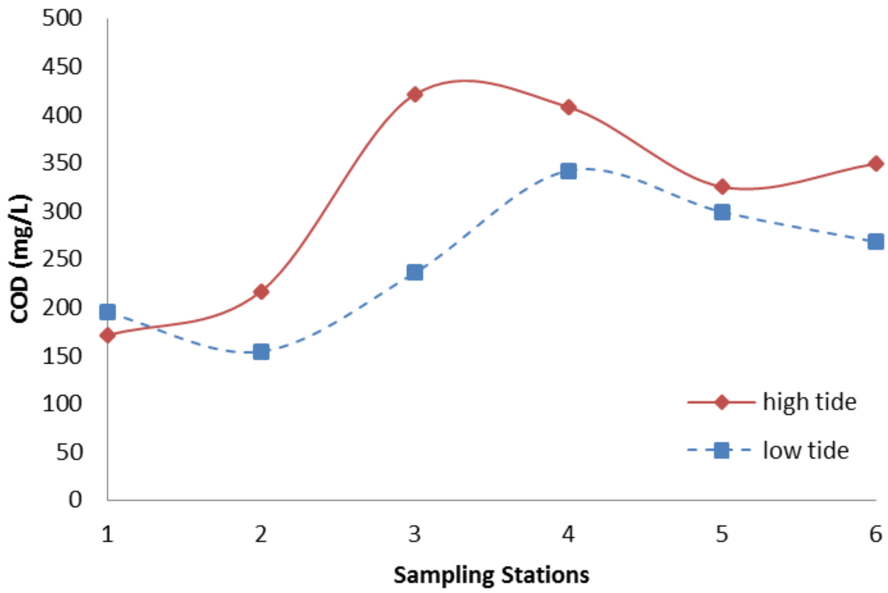

Figure 4.8: COD Concentrations during High Tide and Low Tide

4.2.3 Ammoniacal Nitrogen

Figure 4.9 shows the NH_3-N concentration at upstream during low tide is higher 23.61% during high tide. Trend of NH_3-N concentration during high tide and low tide most significant where the concentration it was drop at middle stream and continuous decreasing towards downstream. The decreasing concentration of NH_3-N on seawards probably because of increasing DO concentration. During day, aquatic plant add DO to the water when photosynthesis is occurring and oxygen is consumed during night time respiration.

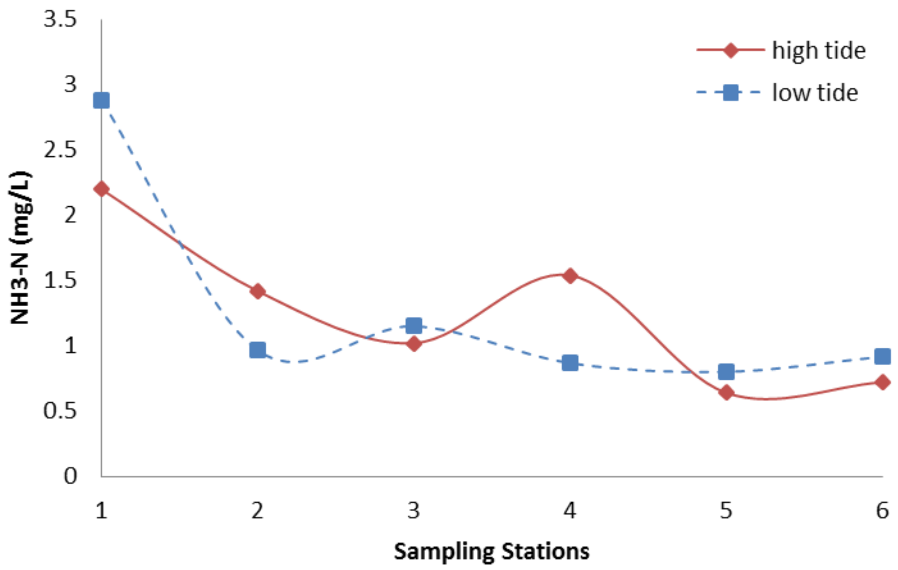

Figure 4.9: NH_3-N Concentrations during High Tide and Low Tide

4.2.4 Suspended Solids

During high tide, the suspended solid was increased at upstream as shown in Figure 4.10 with concentration of 12.89 mg/L. But at middle stream, the suspended solid concentration was rapidly increased to 48.22 mg/L probably associated to sediment that has abundance of suspended solids imported from shrimp farm effluent. However, it was decreased at downstream towards the coastal area.

During low tide, the suspended solid was slightly increased from upstream and middle stream with concentration 50.9 mg/L and 56.7 mg/L respectively. Station 5 contributed high concentration, which is 66.44 mg/L. It probably because increasing of fertilizer factory effluent.

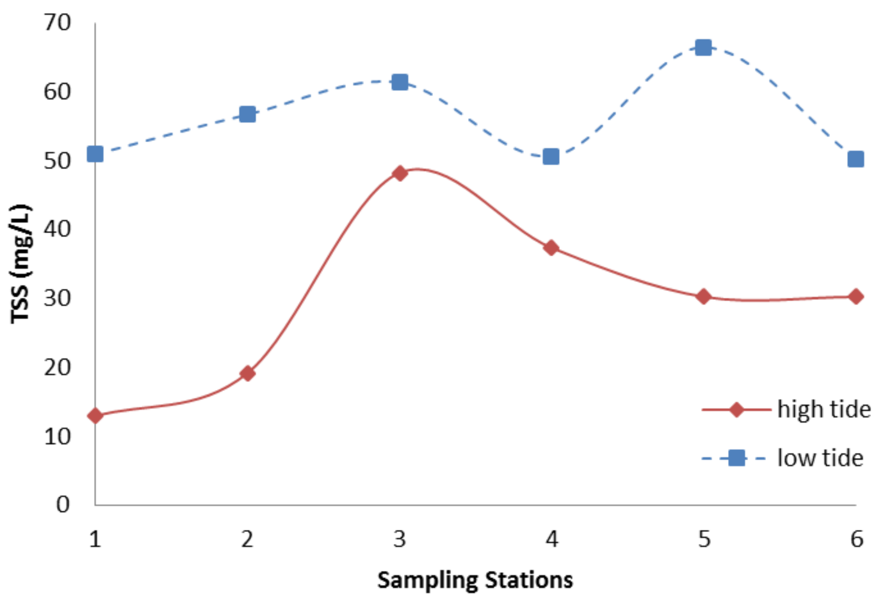

Figure 4.10: TSS Concentrations during High Tide and Low Tide

4.2.5 Faecal Coliform

The analysis of microbiological parameter of Faecal coliform was been showed in Figure 4.11. Faecal coliform was observed that station 2 (low tide) and Station 3 (high tide) presented a high rate most probable numbers (MPN) (>2419.6 MPN.100mL^{-1}). Increased level of coliform may indicated the water has been contaminated with the fecal material of humans and animals. Large amounts of fecal coliform bacteria may indicate higher risk of pathogens being present in water that able to contribute such of diseases, for example ear infections, typhoid fever and hepatitis A (Nur Hidayah, 2010). According to NWQS, standard limits for faecal coliform was not exceed than 5000 MPN.100mL^{-1}. The analysis was in a limit where in class III.

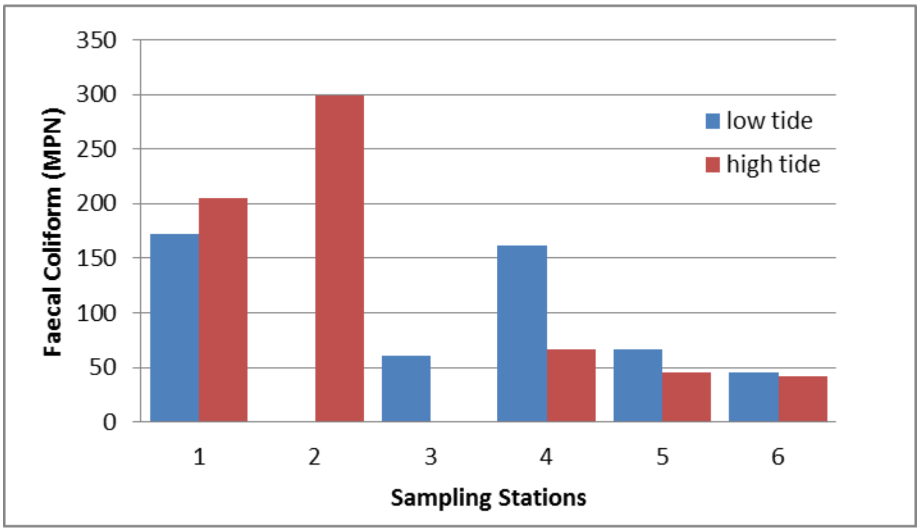

Figure 4.11: Faecal Coliform Levels during High Tide and Low Tide

4.2.6 Oil and Grease

Figure 4.12 shows that fluctuated concentrations of oil and grease were inconsistent patterns from upstream to downstream. High rate were presented at station 6 during both tide. It probably because of station 6 is located near to Lumut Marine Terminal and lot of shipping activities and boat repairing are involved. However, based on Environmental Quality Act (EQA) for industrial effluent standard in Malaysia, this concentration were meet a limit in Standard B which is not exceed than 10 ppm.

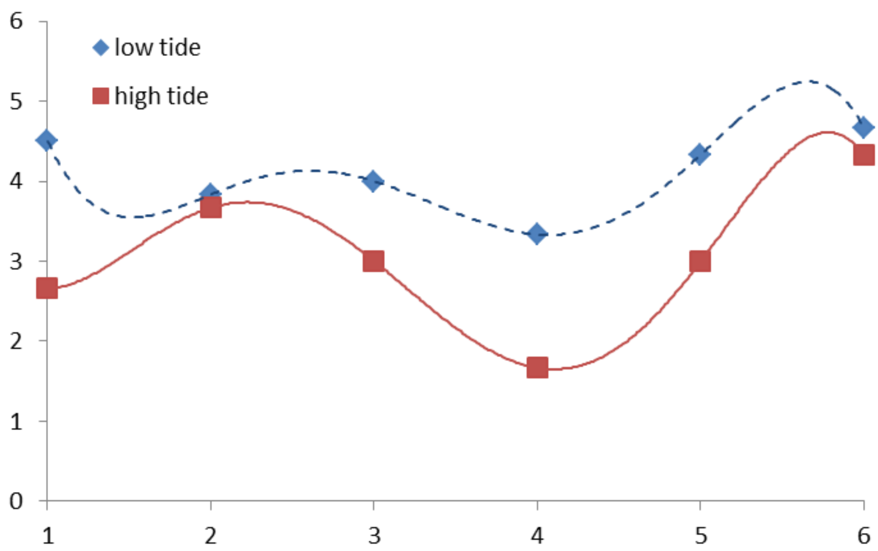

Figure 4.12: Oil and Grease Concentrations during High Tide and Low Tide

4.3 WATER QUALITY INDEX ANALYSIS

After the concentration of each parameter was catered**,** equation 3.1 was shown in Chapter 2 previously was used in determining the subindex of each parameter and finally the water quality index and its class were determined. Table 4.3 shows the result of subindex during high tide while during low tide as shown in Table 4.4.

Table 4.3: Water Quality Subindex Parameter Result during High Tide

Sampling Station	Water Quality subindex						WQI	CLASS
	SIDO	SIBOD	SICOD	SIAN	SISS	SIpH		
1	73.89	44.51	0.21	25.65	90.01	97.17	54.65	III
2	71.26	56.16	-5.23	38.76	86.64	95.70	56.67	III
3	64.65	45.22	-16.69	47.50	72.79	94.78	50.29	IV
4	63.18	36.34	-14.90	36.60	77.62	94.45	47.66	IV
5	72.08	39.74	-12.37	58.34	81.00	92.77	54.27	III
6	82.63	40.57	-10.84	55.82	81.00	93.64	56.72	III

Table 4.4: Water Quality Subindex Parameter Result during Low Tide

Sampling Station	Water Quality subindex						WQI	CLASS
	SIDO	SIBOD	SICOD	SIAN	SISS	SIpH		
1	55.81	40.01	15.91	13.60	71.66	95.40	47.38	IV
2	41.94	63.06	2.99	48.86	69.31	97.24	51.77	III
3	43.54	45.69	-21.14	44.39	67.47	96.93	43.96	IV
4	58.54	38.24	-19.45	51.54	71.76	94.22	47.55	IV
5	59.57	51.29	-8.83	53.44	65.54	95.20	51.36	IV
6	72.76	55.10	-12.99	50.18	71.94	93.64	54.67	III

Water quality Index (WQI) shows classification with class IV and class III and at upstream, back to class IV at middle stream and consistent classification with class III towards downstream as shown in Figure 4.13. Class III represent that the river is still can support and protecting common and tolerant aquatic species while class IV defines that the water is suitable for only major agricultural irrigation activities. The fluctuation of class within study area was consequence of human activities along the river.

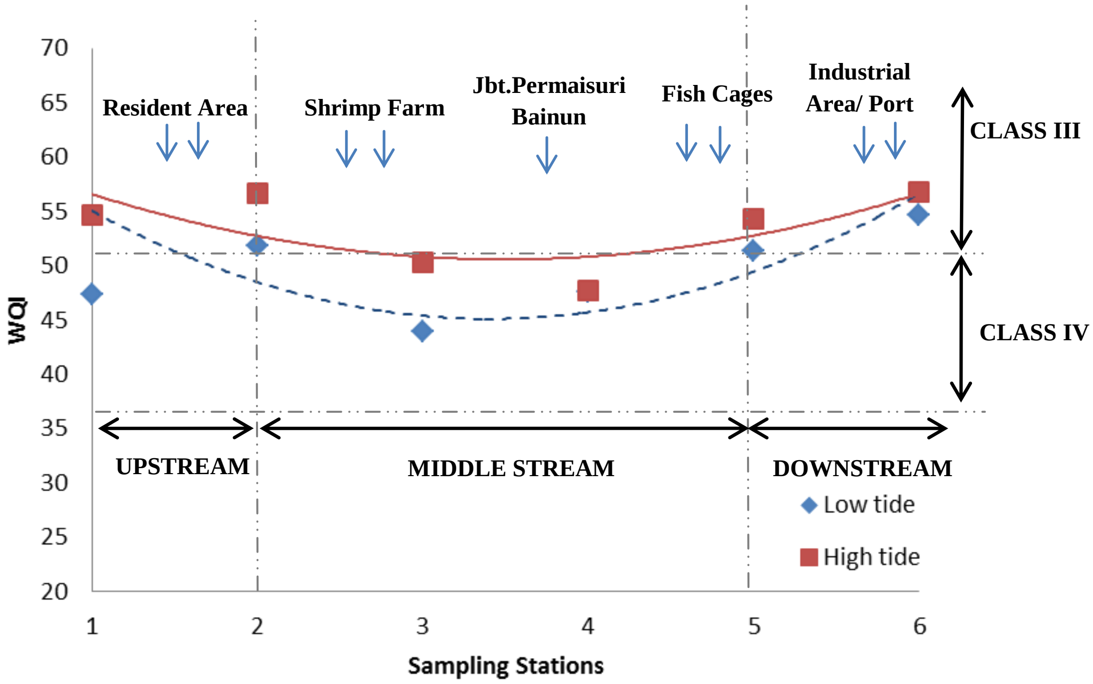

Figure 4.13: Trend of Water Quality from Upstream to Downstream

At upstream of study area shows slightly polluted with average value of water quality index (WQI) is 47.38 during low tide. It was due to agriculture runoff and road runoff. The upstream of the study area is located at the tributaries towards oil palm factory area that situated at Kg. Changkat Kruing. Thus, the water quality still hampered by local communities' activities such as agricultural and new development area which mostly found at the upstream of Manjung River.

However, the situation was differing for Manjung River. This was caused by human refuse which common at almost all mangrove estuaries of similar size and type in Malaysia (DOE, 2008). The source of water quality deteriorating towards middle stream is because of discharging from shrimp ponds, on- farm feeding, fishing activities, and settlement activities at adjacent river.

The major reason of depleting water quality at middle stream is it located at urban area (non-industrial area) that discharges effluent via drainage and tributaries. From observation, Sg. Pasir was potential tributaries that contribute to decreasing of water quality at station 3 and station 4 where during high tide average value of WQI is 50.29 and 47.66 respectively. It is same situation during low tide WQI value, which is 43.96 and 47.55 respectively. Due to this, aquaculture farm effluent will affect the water quality and sediment in the area nearby. Cultures fish are mostly fed with trash fish in tropical and sub-tropical regions (example; China, Malaysia and Thailand) compare to temperate regions (example; Canada and Norway) (Orachunwong, 2005). It is found that the food wastage, organic and nutrient loading were several times higher when trash fish was used compared to pellet moist or dry feed. Qian, (2001) also reported that the nutrient release coefficients from trash fish especially minced trash fish (commonly used in rearing fry or juvenile fishes).

At downstream of study area, the WQI for both tides shows class III which is classified as moderate. Downstream of Manjung River is at adjacent coastal water that has wide open to Straits of Melaka. According to Yap, Ismail, & Tan (2006), downstream being usually characterized by greater width, lower flow rate, and softer bottom. As refer back to Figure 4.13, WQI at downstream has similar classification due to dilution of estuarine water. This is regards to water level that increased during high river flows that trap suspension from coastal water at inundation of mangrove swamps and forest. Rainy season and tidal pumping effects became the major factors influencing the water quality within the estuaries.

During rainy season, suspended sediment from estuaries will supply to both mangrove forest and shelf and stocked it there temporarily. When the river discharge decrease and low tide occur, the suspended sediment is re-injected into the estuaries (Ahsen, Erdogan, Yilmaz, & Tas, 2006).

From physical observation, during both high tide and low tide, there were still having rubbish and lubricant oil floating at surface water were produce at shrimp farm outlet as shown in Figure 4.14. The direction of those floating matter are dependent on tide which high tide, its goes upstream and during low tide it goes seaward. The other reason for this because of effluent discharging from human activities at riverbank is not depending on tide. Floating oil will remain stranded on aerial roots, stems and leaves after the tide ebbs, leading to oxygen deficiency and suffocation (Zhang, Sun , Niu, & Chen, 2006).

Figure 4.14: Effluents from Shrimp Farm Outlet at Station 2 and Station 3

4.4 COMPARISON PRESENT WATER QUALITY STUDY WITH PREVIOUS STUDY

The summarization of the result in determining the index values of water quality between previous study and present study was listed and showed in graph (see Figure 4.15).

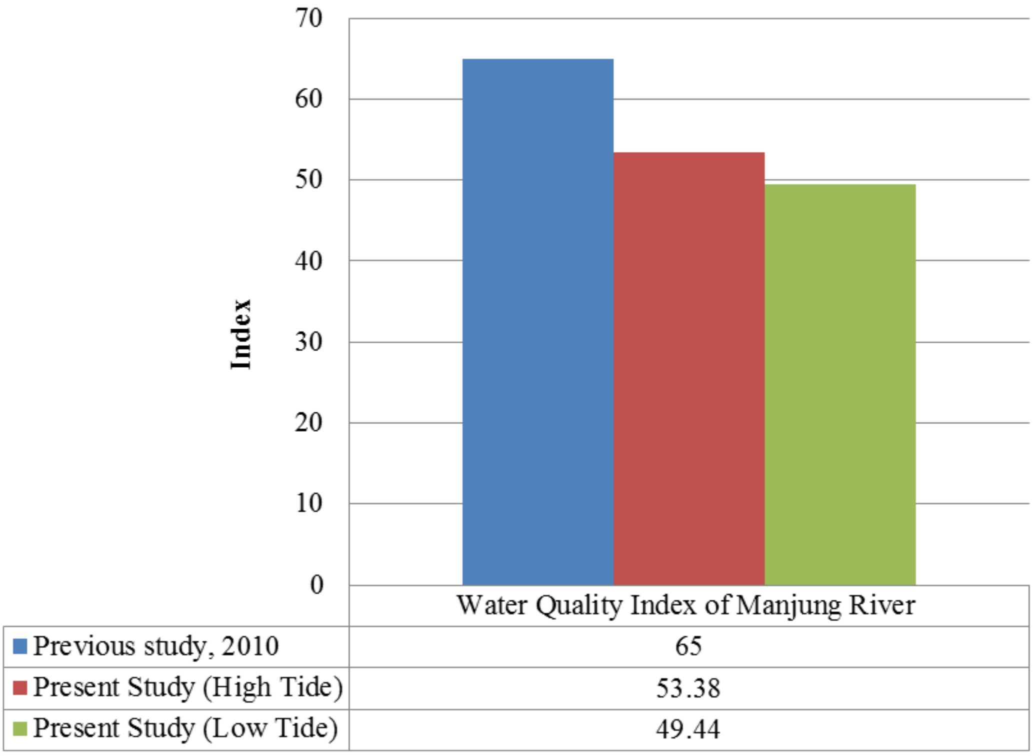

Figure 4.15: Comparison Values Index of Water Quality of Manjung River between Present Studies with Previous Study

In general, water quality along Manjung River during previous study can be classified in Class III, which is in range 51.9-76.5 based on WQI. Class III represent that the river is still can support and protecting common and tolerant aquatic species. The present data was analyzed based on an average of each station during both tides. From the Figure 4.15, comparison between the previous study (2010) and the present study (2012) can be seen during high tide the WQI were decreased about 17.88%. Furthermore, it was still in Class III. While during low tide it was more decreased about 23.9% from the previous study and categorized in Class IV. Class IV defines that the water is suitable for only major agricultural irrigation activities. Due to this, it would be described Manjung River potentially polluted and getting worst if still not properly in management sources of pollution and aquatic habitat may have bad impact causes by this deteriorating of water quality.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

The study of water quality at Manjung River has achieved its objectives. Water quality was analyzed by using DOE-WQI and was found that, water quality at Manjung River was inconsistent from upstream towards downstream with class III during high tide and class IV during low tide at upstream. It shows consistent during both tide in class IV at middle stream and eventually increases to class III at downstream. The fluctuating of water quality at Manjung River is strongly related to human activities especially by industrial effluents, agriculture and aquaculture, settlement and shipping activities.

While, since we go through to each parameter analysis, the most influence parameter that causes the deteriorating of water quality to class IV at middle stream for high tide and low tide are organic and inorganic matter which can be seen at BOD and COD analysis. During high tide, water quality is much better rather than during low tide due to mixing of coastal water and freshwater that resulting dilution. During low tide, water quality much worst because of polluted water injected to estuaries from tributaries. Together with rapid expansion and increasing important of industrial and aquaculture activities, due attention should be paid to mitigate or remedy the impact of excessive effluent in order to safeguard our future environment.

5.2 RECOMMENDATION

There are a few measures which can be taken in order to improve the water quality at Manjung River such as:

a) Involves the proper selection of culture system; good shrimp pond preparation in terms of feed management and use of pond liner;
b) Increasing the treatment management and controlled excessive industrial effluents before discharging;
c) Relocated the squatters along the riverbank to another proper place to stay;
d) Governments should issue and enforce legislation to control industrial activities in the coastal zone. Such legislation would profitably be accompanied by monitoring and should be enforced by authorized government agencies.

In order to improve the accuracy as well as the effectiveness of this study there are a few recommendation that should been follow such as;

a) The critical impact of aquaculture and industrial wastes is the organic matter and nutrients especially ammonium. This study should be added more water quality parameter analyses such as heavy metals and phosphate;
b) Detail study should be made on mangrove activities in order to achieved actual nutrient contributor to biota growth.
c) Added more sampling station and sampling event should be made longer period.
d) Storage of sample should be improved to avoid or minimize loss of the desired compounds in the water samples.

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APPENDIX A:

“National Water Quality Standard (NWQS)”

Presented to the

Study on Water Quality at Manjung River and Its Tributaries

Project Dissertation

December 2012

National Water Quality Standards For Malaysia

PARAMETER	UNIT	CLASS				
		I	IIA/IIB	III#	IV	V
Al	mg/l		-	(0.06)	0.5	
As	mg/l		0.05	0.4 (0.05)	0.1	
Ba	mg/l		1	-	-	
Cd	mg/l		0.01	0.01* (0.001)	0.01	
Cr (IV)	mg/l		0.05	1.4 (0.05)	0.1	
Cr (III)	mg/l		-	2.5	-	
Cu	mg/l		0.02	-	0.2	
Hardness	mg/l		250	-	-	
Ca	mg/l		-	-	-	
Mg	mg/l		-	-	-	
Na	mg/l		-	-	3 SAR	
K	mg/l		-	-	-	
Fe	mg/l		1	1	1 (Leaf) 5 (Others)	
Pb	mg/l		0.05	0.02* (0.01)	5	L
Mn	mg/l		0.1	0.1	0.2	E
Hg	mg/l	N	0.001	0.004 (0.0001)	0.002	V
Ni	mg/l	A	0.05	0.9*	0.2	E
Se	mg/l	T	0.01	0.25 (0.04)	0.02	L
Ag	mg/l	U	0.05	0.0002	-	S
Sn	mg/l	R	-	0.004	-	
U	mg/l	A	-	-	-	A
Zn	mg/l	L	5	0.4*	2	B
B	mg/l		1	(3.4)	0.8	O
Cl	mg/l	L	200	-	80	V
Cl_2	mg/l	E	-	(0.02)	-	E
CN	mg/l	V	0.02	0.06 (0.02)	-	
F	mg/l	E	1.5	10	1	IV
NO_2	mg/l	L	0.4	0.4 (0.03)	-	
NO_3	mg/l	S	7	-	5	
P	mg/l		0.2	0.1	-	
Silica	mg/l	O	50	-	-	
SO_4	mg/l	R	250	-	-	
S	mg/l		0.05	(0.001)	-	
CO_2	mg/l	A	-	-	-	
Gross-_	Bq/l	B	0.1	-	-	
Gross-_	Bq/l	S	1	-	-	
Ra-226	Bq/l	E	< 0.1	-	-	
Sr-90	Bq/l	N	< 1	-	-	
CCE	µq/l	T	500	-	-	-
MBAS/BAS	µq/l		500	5000 (200)	-	-
O & G (Mineral)	µq/l		40; N	N	-	-
O & G (Emulsified Edible)	µq/l		7000; N	N	-	-
PCB	µq/l		0.1	6 (0.05)	-	-
Phenol	µq/l		10	-	-	-
Aldrin/Dieldrin	µq/l		0.02	0.2 (0.01)	-	-
BHC	µq/l		2	9 (0.1)	-	-
Chlordane	µq/l		0.08	2 (0.02)	-	-
t-DDT	µq/l		0.1	(1)	-	-
Endosulfan	µq/l		10	-	-	-
Heptachlor/Epoxide	µq/l		0.05	0.9 (0.06)	-	-
Lindane	µq/l		2	3 (0.4)	-	-
2,4-D	µq/l		70	450	-	-
2,4,5-T	µq/l		10	160	-	-
2,4,5-TP	µq/l		4	850	-	-
Paraquat	µq/l		10	1800	-	-

Notes :
** = At hardness 50 mg/l CaCO3*
 # = Maximum (unbracketed) and 24-hour average (bracketed) concentrations
N = Free from visible film sheen, discolouration and deposits

National Water Quality Standards For Malaysia

PARAMETER	UNIT	CLASS					
		I	IIA	IIB	III	IV	V
Ammoniacal Nitrogen	mg/l	0.1	0.3	0.3	0.9	2.7	> 2.7
Biochemical Oxygen Demand	mg/l	1	3	3	6	12	> 12
Chemical Oxygen Demand	mg/l	10	25	25	50	100	> 100
Dissolved Oxygen	mg/l	7	5 - 7	5 - 7	3 - 5	< 3	< 1
pH	-	6.5 - 8.5	6 - 9	6 - 9	5 - 9	5 - 9	-
Colour	TCU	15	150	150	-	-	-
Electrical Conductivity*	mS/cm	1000	1000	-	-	6000	-
Floatables	-	N	N	N	-	-	-
Odour	-	N	N	N	-	-	-
Salinity	%	0.5	1	-	-	2	-
Taste	-	N	N	N	-	-	-
Total Dissolved Solid	mg/l	500	1000	-	-	4000	-
Total Suspended Solid	mg/l	25	50	50	150	300	300
Temperature	°C	-	Normal + 2 °C	-	Normal + 2 °C	-	-
Turbidity	NTU	5	50	50	-	-	-
Faecal Coliform**	count/100 ml	10	100	400	5000 (20000)a	5000 (20000)a	-
Total Coliform	count/100 ml	100	5000	5000	50000	50000	> 50000

Notes :

N : No visible floatable materials or debris, no objectional odour or no objectional taste

** : Related parameters, only one recommended for use*

*** : Geometric mean*

a : Maximum not to be exceeded

Water Classes And Uses

CLASS	USES
Class I	Conservation of natural environment. Water Supply I – Practically no treatment necessary. Fishery I – Very sensitive aquatic species.
Class IIA	Water Supply II – Conventional treatment required. Fishery II – Sensitive aquatic species.
Class IIB	Recreational use with body contact.
Class III	Water Supply III – Extensive treatment required. Fishery III – Common, of economic value and tolerant species; livestock drinking.
Class IV	Irrigation
Class V	None of the above.

APPENDIX B:

"Water Quality Index (WQI)"

Presented to the

Study on Water Quality at Manjung River and Its Tributaries

Project Dissertation

December 2012

DOE Water Quality Classification Based On Water Quality Index

SUB INDEX & WATER QUALITY INDEX	INDEX RANGE		
	CLEAN	SLIGHTLY POLLUTED	POLLUTED
Biochemical Oxygen Demand (BOD)	91 - 100	80 - 90	0 - 79
Ammoniacal Nitrogen (NH_3-N)	92 - 100	71 - 91	0 - 70
Suspended Solids (SS)	76 - 100	70 - 75	0 - 69
Water Quality Index (WQI)	81 - 100	60 - 80	0 - 59

DOE Water Quality Index Classification

PARAMETER	UNIT	CLASS				
		I	II	III	IV	V
Ammoniacal Nitrogen	mg/l	< 0.1	0.1 – 0.3	0.3 – 0.9	0.9 – 2.7	> 2.7
Biochemical Oxygen Demand	mg/l	< 1	1 – 3	3 – 6	6 – 12	> 12
Chemical Oxygen Demand	mg/l	< 10	10 – 25	25 – 50	50 – 100	> 100
Dissolved Oxygen	mg/l	> 7	5 – 7	3 – 5	1 – 3	< 1
pH	-	> 7.0	6.0 – 7.0	5.0 – 6.0	< 5.0	> 5.0
Total Suspended Solid	mg/l	< 25	25 – 50	50 – 150	150 – 300	> 300
Water Quality Index (WQI)		< 92.7	76.5 – 92.7	51.9 – 76.5	31.0 – 51.9	< 31.0

WQI FORMULA AND CALCULATION

FORMULA

WQI = (0.22 * SIDO) + (0.19 * SIBOD) + (0.16 * SICOD) + (0.15 * SIAN) + (0.16 * SISS) + (0.12 * SIpH)

where;

SIDO = Subindex DO (% saturation)
SIBOD = Subindex BOD
SICOD = Subindex COD
SIAN = Subindex NH_3-N
SISS = Subindex SS
SIpH = Subindex pH
$0 \leq WQI \leq 100$

BEST FIT EQUATIONS FOR THE ESTIMATION OF VARIOUS SUBINDEX VALUES

Subindex for DO (in % saturation)

SIDO = 0 for $x \leq 8$
SIDO = 100 for $x \geq 92$
SIDO = $-0.395 + 0.030x^2 - 0.00020x^3$ for $8 < x < 92$

Subindex for BOD

SIBOD = $100.4 - 4.23x$ for $x \leq 5$
SIBOD = $108 * \exp(-0.055x) - 0.1x$ for $x > 5$

Subindex for COD

SICOD = $-1.33x + 99.1$ for $x \leq 20$
SICOD = $103 * \exp(-0.0157x) - 0.04x$ for $x > 20$

Subindex for NH_3-N

SIAN = $100.5 - 105x$ for $x \leq 0.3$
SIAN = $94 * \exp(-0.573x) - 5 * | x - 2 |$ for $0.3 < x < 4$
SIAN = 0 for $x \geq 4$

Subindex for SS

SISS = $97.5 * \exp(-0.00676x) + 0.05x$ for $x \leq 100$
SISS = $71 * \exp(-0.0061x) - 0.015x$ for $100 < x < 1000$
SISS = 0 for $x \geq 1000$

Subindex for pH

SIpH = $17.2 - 17.2x + 5.02x^2$ for $x < 5.5$
SIpH = $-242 + 95.5x - 6.67x^2$ for $5.5 \leq x < 7$
SIpH = $-181 + 82.4x - 6.05x^2$ for $7 \leq x < 8.75$
SIpH = $536 - 77.0x + 2.76x^2$ for $x \geq 8.75$

Note: means multiply with*

APPENDIX C:

"Environmental Quality Act (EQA) 1979"

Presented to the

Study on Water Quality at Manjung River and Its Tributaries

Project Dissertation

December 2012

ENVIROMENTAL QUALITY (SEWERAGE AND INDUSTRIAL

EFFLUENTS) REGULATIONS 1979

THIRD SCHEDULE
[Regulation 8(1), 8(2), 8(3)]

PARAMETER LIMITS OF EFFLUENT OF STANDARDS A AND B

	Parameter	Unit	Standard	
			A	B
(i)	Temperature	°C	40	40
(ii)	pH Value	-	6.0 - 9.0	5.5 - 9.0
(iii)	BOD_5 at 20 °C	mg/l	20	50
(iv)	COD	mg/l	50	100
(v)	Suspended Solids	mg/l	50	100
(vi)	Mercury	mg/l	0.005	0.05
(vii)	Cadmium	mg/l	0.01	0.02
(viii)	Schromium, Hexavalent	mg/l	0.05	0.05
(ix)	Arsenic	mg/l	0.05	0.10
(x)	Cyanide	mg/l	0.05	0.10
(xi)	Lead	mg/l	0.10	0.5
(xii)	Chromium, Trivalent	mg/l	0.20	1.0
(xiii)	Copper	mg/l	0.20	1.0
(xiv)	Manganese	mg/l	0.20	1.0
(xv)	Nickel	mg/l	0.20	1.0
(xvi)	Tin	mg/l	0.20	1.0
(xvii)	Zinc	mg/l	2.00	2.0
(xviii)	Boron	mg/l	1.00	4.0
(xix)	Iron	mg/l	1.00	5.0
(xx)	Phenol	mg/l	0.001	1.0
(xxi)	Free Chlorine	mg/l	1.0	2.0
(xxii)	Sulphide	mg/l	0.50	0.5
(xxiii)	Oil and Grease	mg/l	not detectable	10.0

APPENDIX D:

"Gantt Chart"

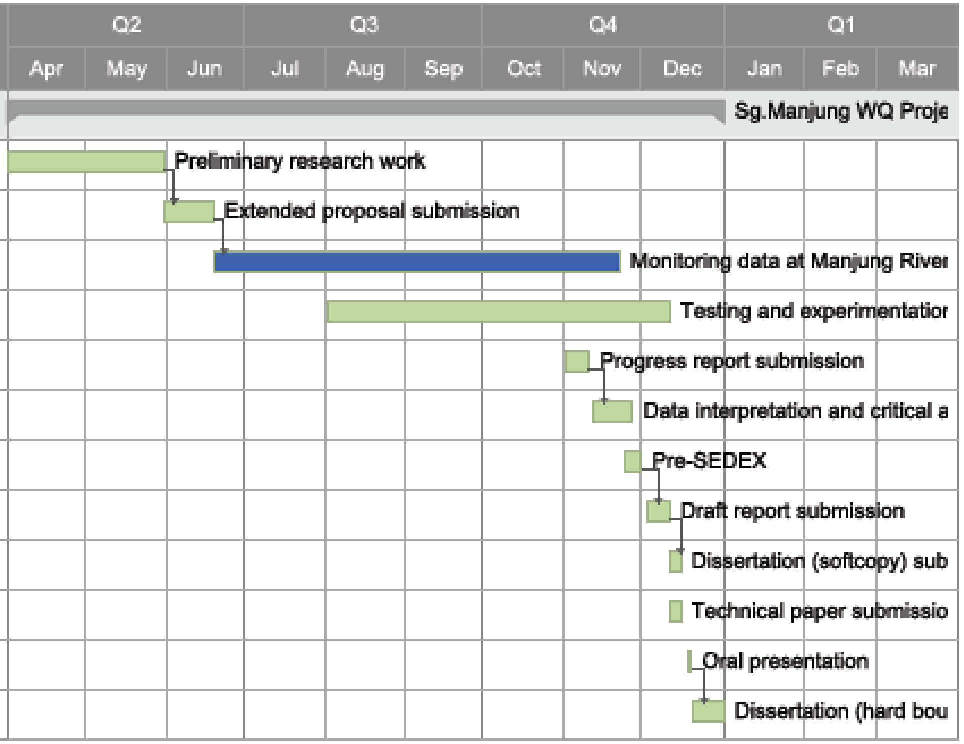
Presented to the

Study on Water Quality at Manjung River and Its Tributaries

Project Dissertation

December 2012

Task Name	Start Date	End Date
Sg.Manjung WQ Project	04/01/12	12/31/12
Preliminary research work	04/01/12	05/30/12
Extended proposal submission	05/31/12	06/18/12
Monitoring data at Manjung River	06/19/12	11/21/12
Testing and experimentation phase	08/02/12	12/10/12
Progress report submission	11/01/12	11/09/12
Data interpretation and critical analysis	11/12/12	11/26/12
Pre-SEDEX	11/24/12	11/30/12
Draft report submission	12/03/12	12/10/12
Dissertation (softcopy) submission	12/11/12	12/14/12
Technical paper submission	12/11/12	12/14/12
Oral presentation	12/19/12	12/19/12
Dissertation (hard bound) submission	12/20/12	12/31/12



APPENDIX E:

"Results of In-Situ Experiments"

Presented to the

Study on Water Quality at Manjung River and Its Tributaries

Project Dissertation

December 2012

WATER QUALITY DATA AT MANJUNG RIVER

(29TH JUNE – 1ST JULY 2012)

WATER QUALITY DATA AT MANJUNG RIVER

(12^{TH} OCT– 14^{TH} OCT 2012)

WATER QUALITY DATA AT MANJUNG RIVER

(2^{ND} NOV– 4^{TH} NOV 2012)

WATER QUALITY DATA AT MANJUNG RIVER

(16^{TH} NOV– 18^{TH} NOV 2012)

WATER QUALITY DATA AT MANJUNG RIVER

(23RD NOV– 25TH NOV 2012)