ADVERSE EFFECT OF SHRIMP POND FARMING EFFLUENT TO THE WATER QUALITY OF PEKAN RIVER

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ABSTRACT

Water quality of the Pekan River in Kuantan is influenced by aquaculture activities. This river and its tributaries is important to fisheries and livestock drinking. The characteristics of water quality in Pekan River need to specify because it may affect the water quality of the river. The objectives of this study were to assess the water quality based on National Water Quality Standard (NWQS) and Water Quality Index (WQI) Malaysia and to compare the river water quality before and after the shrimp pond farming effluent being discharged into the river. Water quality of Pekan River is determined based on WQI and NWQS and the samples were collected at three different points and two sampling times. The parameters were divided into two types which were in situ measurement and laboratory measurement. Based on the concentration of pH, Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Dissolved Oxygen (DO), Ammoniacal Nitrogen (NH-3N) and Total Suspended Solid (TSS), the surface water of the Pekan River was found to be slightly polluted. It shows that the mid-stream of the river was discovered to be more polluted contrast with the downstream and upper stream. In conclusion, the Pekan River is slighty polluted and monitoring and preventing control should be conducted to minimize effect of discharged wastewater from the shrimp pond farming to the water quality of the Pekan River.

ABSTRAK

Kualiti air di Sungai Pekan dipengaruhi oleh aktiviti akuakultur di kawasan sekitar tepi sungai. Sungai ini dan kawasan sekitarnya begitu penting untuk kegunaan perikanan dan penternakan. Ciri-ciri air di Sungai Pekan perlu ditentukan kerana ia akan memberi kesan kepada kualiti air. Objektif kajian ini adalah untuk menilai kualiti air Sungai Lembing berdasarkan Piawaian Kebangsaan Kualiti Air (NWQS) dan Index Kualiti Air (WQI) dan juga untuk membuat perbandingan kualiti air sungai sebelum dan selepas air sisa kolam udang disalirkan ke sungai. Kualiti air Sungai Pekan ditentukan berdasarkan NWQS dan WQI dan sampel air diambil pada tiga stesen berlainan dan dua kali persempelan. Semua parameter dibahagikan kepada dua iaitu pengukuran secara langsung atau in-situ dan pengukuran di makmal. Berdasarkan nilai pH, BOD, COD, DO, NH3-N dan TSS, air dipermukaan Sungai Pekan didapati mengalami sedikit pencemaran. Stesen 2 mempunyai nilai pencemaran yang tinggi berbanding dengan Stesen 1 dan 3. Dengan mengalami sedikit pencemaran, langkah pengawalan dan pencegahan harus dilaksanakan untuk mengurangkan kesan pengaliran air sisa kolam udang ke sungai terhadap kualiti air sungai Pekan.

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LIST OF ABBREVIATIONS

WQI	Water Quality Index
INWQS	Interim National Water Quality Standard
DO	Dissolved Oxygen
BOD	Biochemical Oxygen Demand
COD	Chemical Oxygen Demand
TSS	Total Suspended Solid
TDS	Total Dissolved Solid

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Water is a vital source to living things on Earth like human and animals to ensure their survival and health. Water carries important roles in living things like for drinking, agriculture uses, industrial processes, recreation, personal hygiene and hydroelectric power generation (Preena Sharma, 2014) . There are many sources of water that can be found in the Earth. The sources are from rain or hail and springs. The water from the rain or hail normally can be collected at the water catchment area like river or lakes which is the source of community water supplies meanwhile the water from springs normally collected at the bottom of the hills or slope. Water covers more than 70% of Earth’s surface which came from seas and oceans water. The water on earth that came from rivers and lakes cover only around 0.3%. (Amneera, 2013).

There are about 150 rivers in Malaysia which still cannot afford to supply sufficient water for Malaysians since the distribution of the rain in Malaysia is not uniform (Zainudin, 2009). The biggest issue and risk to the river in Malaysia is the pollution. The quality of the river water has being decreased due to the pollution from the industrial and residential sewerage, effluents from the pond farming and livestock farms and also the discharge of heavy metals from the nearest factories or industrial process. According to the Environmental Quality Report 2015, 48% river water of Malaysia was polluted which was higher than previous couple of years.

A standard has been set up in Malaysia regarding the classification of water quality issued by Department of Environment (DOE) focusing to water pollution. The quality of water must be controlled and treated properly, particularly in river basin areas which become the main water supply to the residents, according with the standards that have been set which is National Water Quality Standards for Malaysia (NWQS) and DOE Water Quality Index Classification (WQI). There are three types of water quality parameter namely physical, chemical and biological parameter. Parameters such as dissolve oxygen(DO), biochemical oxygen demand(BOD), chemical oxygen demand(COD), total suspended solid(TSS), total dissolved solid(TDS), Ammoniacal nitrogen(AN), turbidity, salinity, pH, temperature and heavy metals are essential in classifying water quality (Teck-Yee Ling, 2012).

This research is prepared to study on adverse effect of river water pollution due to shrimp pond farming and based on Water Quality Index (WQI) and Interim National Water Quality Standard (INWQS). WQI is a water pollution indicator that used to determine the physic-chemical parameters of surface water.

1.2 Problem Statement

Water quality in Malaysia is something that needs to be taken care of by all sides before it become worse. The polluted water resource will cause troubles to the living creatures that being depended on the clean water resource to undergo their daily life. One of the water resources in Malaysia is river water. The quality of river water depends on several factors such as its climate, geology, topography, land use, biological process and human activities (Amneera, 2013).

The quality of river water and aquatic system in watersheds reduced due to the pollutants that cause by human or anthropogenic that related to land use. The pond farming has being grown up recently for human consumption either fish pond farming or shrimp pond farming. The wastewater from the pond farming is being released into the nearest river in order to change to the clean water. The effluents from the pond farming have polluted the river and contribute to the contamination of the river water.

It is important to study the level of pollution in the river recently and determine effect of pollution to the environment in order to recommend suitable solutions to the problem. This to ensure clean water is being supplied to the surrounding people and to protect the health of the people in the area besides preserving the environment of the ecosystem of the river (Kaijin, 2007) . The need to collect data is to document existing water quality conditions in Sungai Pahang which could be useful for future reference.

1.3 Objectives

1) To characterize the river water quality based on Interim National Water Quality Standard (INWQS).
2) To evaluate the adverse effect from the shrimp pond farming effluent to the river water quality.
3) To compare the river water quality before and after the shrimp pond effluent being discharged into the river.

1.4 Research Question

1) What is the river water quality based on Interim National Water Quality Standard (INWQS)?
2) What is the adverse effect from the shrimp pond farming effluent to the river water quality?
3) Is there any different between to the river water quality before and after the shrimp pond effluent being discharged into the river?

1.5 Scope of Study

The scope of this study is to classify the current status of water quality of the river in Kuantan which near to the shrimp pond farming based on the Water Quality Index (WQI) and Interim National Water Quality Standard for Malaysia (INWQS). The parameters that used are temperature, pH, dissolved oxygen (DO), biochemical oxygen demand (BOD), chemical oxygen demand (COD), total suspended solids (TSS), total dissolved solid (TDS), turbidity, salinity, Ammoniacal Nitrogen (NH_3-N) and heavy metals. River classification was based on INWQS either clean or slightly polluted or polluted. Sample collected from field and testing each at field and laboratory. Then, the environmental effect from the shrimp pond farming wastewater evaluated based on the water quality of the river.

1.6 Significance of Study

The number of shrimp farms and farming areas has increased steadily over the years due to the active participation of farmers, intensive training and courses provided by the government. Locally developed technology and global access to culture and processing techniques, easy access to credit facilities, government incentives and consistent good market price have also contributed to the steady growth.

The study regarding aquaculture industry has discovered by many researchers in the previous research paper but the study of environmental effect from shrimp pond farming wastewater has not being discovered much by the researchers. The concern about the effect towards the environment hopefully will increase with the help of this study. By knowing the water quality level of the nearest river so that can have or develop a proper control measures to prevent the high water quality level and then rising up the chances to get the environmental effects.

The water quality level of the nearest river needs to be identified first to develop the control measure. The correlation of water quality level, effect to the environment and correct control measures will be identified with the help of this study to make aquaculture industries in Malaysia growing safer and healthier. This also will automatically help to increase the aquaculture productivity.

1.7 Conceptual Framework

The river water quality that cause by shrimp pond farming effluent is identified based of Figure 1.1. The water quality parameters need to be tested, analysed and calculated to determine the water quality index (WQI). The parameters are temperature, pH, dissolved oxygen (DO), biochemical oxygen demand (BOD), chemical oxygen demand (COD), total suspended solid (TSS), total dissolved solid (TDS), turbidity, salinity and Ammoniacal Nitrogen (NH_3-N) and heavy metals.

There are two standards that used to determine the water quality status. The standards are water quality index (DOE - WQI) and Interim National Water Quality Standards (INWQS) Malaysia. Then, the WQI data need to be assessed to classify the level of water quality based on INWQS either the river water is clean or slightly polluted or polluted.

There must presence of effect when the water quality has being determined especially if the river is slightly polluted or polluted. This is because when the river is polluted or the water quality decline, it would affect the surrounding ecosystem like to human health, environment and shrimp quality (M. Meybeck, 1996).

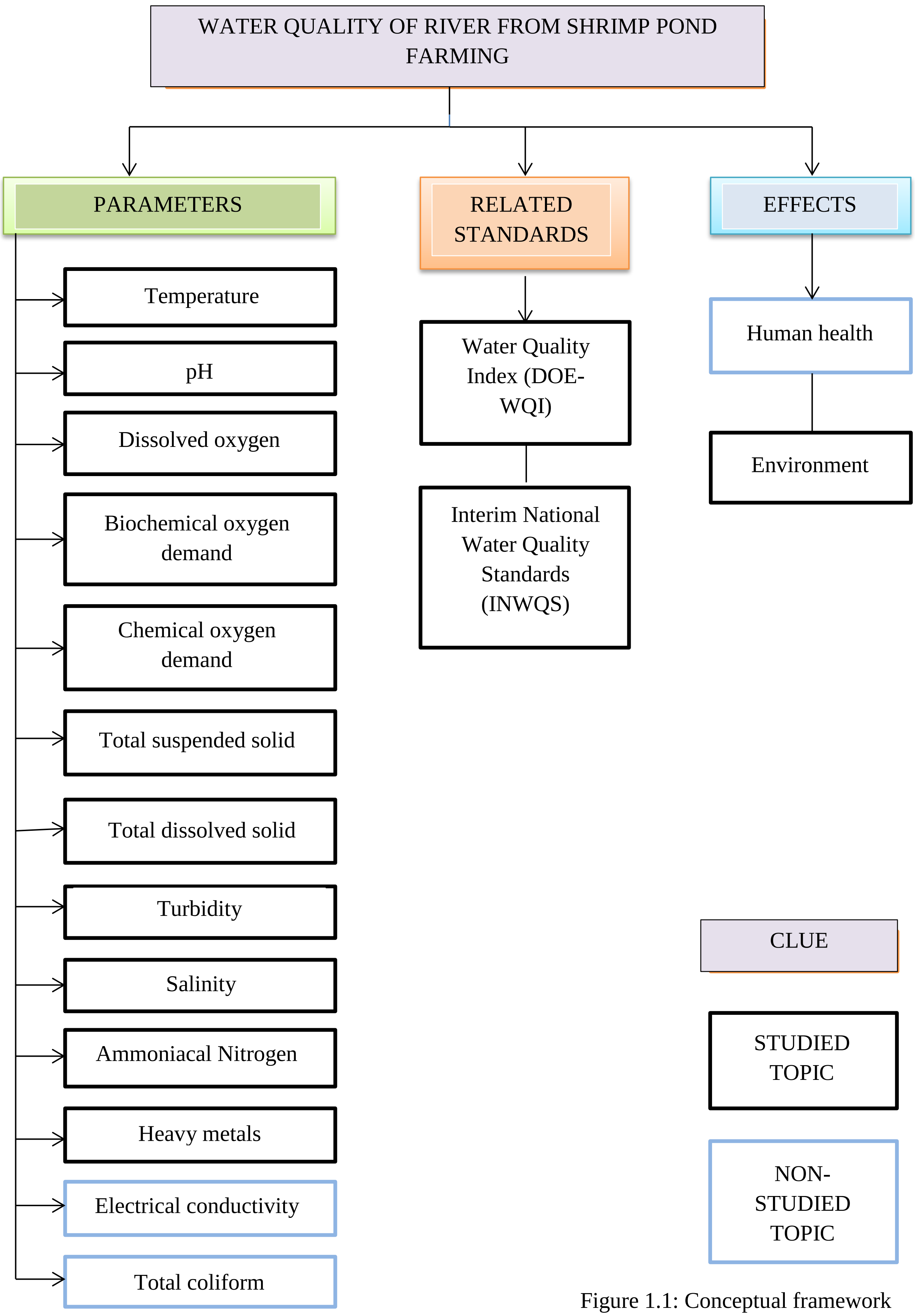


Figure 1.1: Conceptual framework

1.8 Operational Definition

Shrimp pond farming

Shrimp pond farming is an aquaculture business that exists in either marine, freshwater or pond environment which producing shrimps or prawns for human consumption (Kathamuthu, 2005) .

Wastewater

Wastewater is any type of water that has been affected by human use. Wastewater is used water from any combination of domestic, industrial, agricultural or commercial activities, surface runoff or storm water and any sewer inflow or sewer infiltration (T.Y.Ling, 2010).

Effluent

Effluent is liquid waste flowing out from factory, farm, commercial activities or household into a water body such as river, lake or lagoon or sewer system (Lee Nyanti, 2011).

Water quality

Water quality is a term used here to express the suitability of water to sustain various uses or processes. Any particular use will have certain requirements for the physical, chemical or biological characteristics of water (K.Saffran, 2001).

Water Quality Index (WQI)

Water quality index is a risk communication tool used to describe the status of water by translating a large amount of non-commensurate data into a single value.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Water exists in form of liquid at room temperature but water also has gaseous and solid form of state existence. Water contain of two hydrogen atom attach to single oxygen atom by covalent bond, H_2O. The same water molecules have been transferred time by time again from the oceans and the land surface into the atmosphere by evaporation, precipitated back on land as rain and transferred back to the sea by rivers and groundwater. This endless circulation is known as hydrologic cycle. The cycle keeps fresh water source from completely depleting from human use as shown in Figure 2.1.

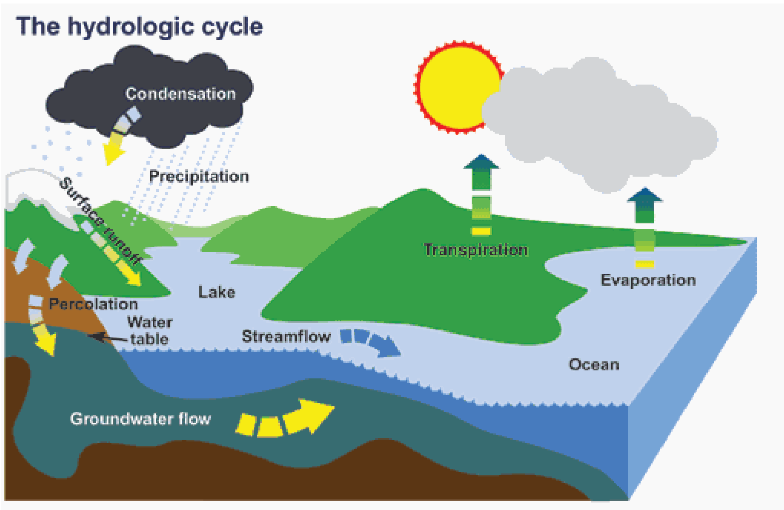


Figure 2.1: Hydrologic cycle

2.2 Aquaculture Activity

Aquaculture is like agriculture where the farmers farm the water instead of land depending on the species. Aquaculture refers to culture of plants and animals in water (Harrell, 2012). Aquaculture defined as cultivation of aquatic organisms in controlled aquatic environment for any commercial, recreational or public purpose. The aquatic organisms may be fish and shellfish like oyster, clams, mussels crab and shrimp (Saremi A., 2012).

2.2.1 Shrimp Pond Farming Activity

Shrimp pond farming is an aquaculture business which raising and producing shrimp in freshwater environment for human consumption.

Pond preparation involves drying the pond until the surface cracks and then scraping the dried organic matter. Flushing of the pond with water jets, although still practiced by some farmers, is not recommended as it causes environmental pollution. The pond bottom and bunds are limed and some water let into the pond. Tea seed cake is applied to get rid of predatory fish and fertilization carried out to encourage a bloom of phyto-and zooplankton that will serve as natural food for the shrimp. The post-larvae are then stocked in the pond, usually in the early hours of the day when the weather is not too hot.

In semi-intensive and intensive culture, the shrimp are fed with pellet feeds, beginning with the starter feed and followed later by the grower feed. There is a whole range of commercial brands of pellet feeds for shrimps available in the market. Feeding frequency varies from 3-5 times a day. The amount of feed given is adjusted periodically according to the growth rate of the shrimp, which is monitored by means of feedings trays.

Zero water exchange or closed system is also being practiced and to some extent, certain farms use probiotics as bioremediators to improve culture system. As a procedure to sterilize, the water is disinfected from pathogenic microbes using chlorine-based compound such as calcium or sodium hypochlorite. Fresh, clean and treated seawater is added whenever necessary to compensate loss through evaporation. In semi-intensive and intensive culture, the shrimp are harvested after 3-5 months (Kathamuthu, 2005).

2.3 Water Quality Parameters

Water quality testing is an important part of environmental monitoring. Not only aquatic life but the surrounding ecosystem will be affected as well when the water quality is poor (Rigos, 2011). Water quality parameters provide significant information regarding health of water body. The parameters used to measure the quality of water whether it is suitable for drinking water, recreation and aquatic life. These sections consist of detailed parameters regarding where it comes and why it is significant to measure that affect the quality of water in the environment.

2.3.1 Temperature

Temperature can be defined as a measurement of average thermal energy of a material. Temperature of water is important for aquatic life. The aquatic organisms are cold blooded, so they cannot control their own body temperature. Temperature is a significant factor to be considered when determining:

(i) Metabolic rates and photosynthesis production
(ii) Dissolved oxygen and other dissolved gas concentrations
(iii) Conductivity and salinity
(iv) Compound toxicity
(v) pH
(vi) Water density

The maximum temperature is the highest temperature of water in which organisms would live for couple hours. The optimum temperature is the temperature at which it will thrive. The surface of water temperature is higher than the wet season.

The speed of chemical and biological reaction happening in water almost double when the water temperature increase by 10°C. The increase in temperatures will cause:

(i) Enhance the Biological Oxygen Demand (BOD)
(ii) Decreasing the amount of Dissolved Oxygen (DO)
(iii) Speed up the nitrification and oxidation process of ammonia to nitrates which will cause oxygen deficiency in water

The availability of dissolved oxygen for aquatic life became limited by the high water temperatures when the solubility of dissolved oxygen decreases with increasing water temperatures. Besides, various biochemical reaction rates that affect water quality being controlled by the water temperature (Ling Cao, 2007). Solar radiation, back radiation, evaporative cooling and heat conduction, thermal discharges, tributary inflows and groundwater discharge are the heat sources and sinks to a water body (Preena Sharma, 2014).

2.3.2 pH

pH of surface water bodies is defined as a measure of the concentration of hydrogen ions. pH indicates water acidity or alkalinity. pH is set for protection of fish life and control chemical reactions that are not desired.

Water molecules (H_2O) consist of hydrogen ions (H^+) and hydroxide ions (OH^-). Other compounds that enter the water body can react with those ions and create the imbalance in the number of hydrogen and hydroxide ions.

The water become basic when more hydrogen ions react and the hydroxide ions left in the solution meanwhile the water become acidic when more hydroxide ions react and the hydrogen ions are left.

The pH can be determined with the help of pH meter. Recommended pH value for public water supply is within 6.5-8.5. The presence of effluents such as iron, aluminium, cadmium and sulphuric acid will make water become acidic which the pH value within 0-7. The presence of effluents like carbonates and bicarbonates of calcium, magnesium and potassium will make the water become alkaline which the pH value within 7-14 (Saremi A., 2012).

High pH value at certain limit may not suitable for the growth of bacteria that maintain high DO level meanwhile slightly low pH level seems suitable and encourage for the growth of bacteria and the DO level also low. The majority aquatic creatures strive in pH value range between 6.5- 9.0. Aquatic life will be disturbed and will impaired their ability to survive and reproduced when the pH level increase or decrease from the pH range. Attributed sewage discharged by the surrounding residences, agriculture and aquaculture fields caused the pH value increase (ERONDU, 2005).

High pH reduces the germicidal potential of chlorine. High pH leads to the formation of trihalomethanes that can cause cancer in humans (Rigos, 2011).

2.3.3 Dissolved Oxygen (DO)

Dissolved oxygen (DO) is the amount of oxygen dissolved in water. Water bodies receive oxygen from the atmosphere and aquatic plants. Running water dissolves more oxygen than the still water of a pond or lake.

DO is needed by all aquatic animals to breathe. Low levels of oxygen or hypoxia and no oxygen levels or anoxia can occur when excess organic materials like large algal blooms being decomposed by microorganisms. During this decomposition process, DO in the water is consumed. Low oxygen levels often occur in the bottom of the water column and affect organisms that live in the sediments (Saeed Shanbehzadeh, 2014).

DO is considered an important measure of water quality as it is a direct indicator of an aquatic resource's ability to support aquatic life. Changes in DO concentrations can be an early indication of changing conditions in the water body (Dosdat, A. 2001). The concentration of DO related to temperature reading. The colder the water, the greater oxygen can be dissolved. Each organism has its own DO tolerance range. Usually DO levels below 3 milligrams per litre (mg/L) are of concern and waters with levels below 1 mg/L are considered hypoxic and usually hard to survive. The aquatic species can be live in the water with DO above 5 mg/L (Madhuri, 2014).

2.3.4 Biochemical Oxygen Demand (BOD)

Biochemical oxygen demand (BOD) is a measurement of the amount of dissolved oxygen (DO) that is used by aerobic microorganisms when decomposing organic matter in water. The term decomposable may be interpreted as meaning that the organic matter can serve as food to the bacteria and energy is generated from its oxidation. BOD commonly expressed in milligrams of oxygen consumed per litre of sample during 5 days (BOD_5) of incubation at 20°C ((APHA), 1999). The higher the BOD, the more oxygen will be demanded from the waste to break down the organics.

BOD directly affects the amount of DO in rivers and streams. The rate of oxygen consumption is affected by a number of variables like temperature, pH, the presence of certain kinds of microorganisms, and the type of organic and inorganic material in the water.

BOD is an important water quality parameter because it provides an index to assess the effect of discharged wastewater to the environment. The greater the BOD, the more rapidly oxygen is depleted in the stream. This means less oxygen is available to higher forms of aquatic life. The consequences of high BOD are the same as those for low DO which aquatic organisms become stressed, suffocate and die. Sources of BOD include topsoil, leaves and woody debris, animal manure, effluents from pulp and paper mills, wastewater treatment plants, feedlots and food-processing plants, failing septic systems and urban storm water runoff (Zainudin, 2009).

BOD is affected by the same factors that affect dissolved oxygen. BOD measurement requires taking two measurements. One is measured immediately for dissolved oxygen considered as initial and the second is incubated in the lab for 5 days and then tested for the amount of dissolved oxygen remaining considered as final. This represents the amount of oxygen consumed by microorganisms to break down the organic matter present in the sample during the incubation period.

BOD is also used extensively for wastewater treatment, as decomposition of organic waste by microorganisms is commonly used for treatment.

2.3.5 Chemical Oxygen Demand (COD)

Chemical oxygen demand (COD) is a measure of capacity of water to consume oxygen during organic matter decomposition and oxidation of inorganic chemicals such as Ammonia and nitrite. COD measurement usually made on a sample of natural water or wastewater contaminated by industry waste or domestic waste.

COD expressed in milligrams per litre (mg/L) which show the oxygen mass consumed per litre of solution. The COD value usually higher than BOD value. If the concentration of COD is higher, the water is considered contaminated or polluted theoretically (Amneera, 2013). The COD value is different for sampling. The increasing and decreasing of COD concentration values for every sampling may contribute by whether condition , distance from discharge sources, runoff factors, accessibility and safety factor during sampling time (Jimoh, 2010).

2.3.6 Total Suspended Solid (TSS)

Total suspended solid (TSS) are particles that are larger than two microns that exist in the water column. Particles which smaller than two microns considered as dissolved solid. Inorganic materials, bacteria and algae are commonly consisted in suspended solid. Anything that floating in the water, from sediment, silts and sand to plankton and algae are considered as suspended solid (S. Caeiro, 2016). TSS concentration also contributed by any organic particles that being decomposed and chemical precipitates. The decomposition process allows small organic particles to break away and enter water column as suspended particles. The more solids present in the water, the less clear the water will be (K.Saffran, 2001).

Suspended solid can settle out into sediment at the bottom of the water over period of time. The heavy particles will settle out when passing or flowing through the area of low or no water flow. The remaining particles that do not settle out are called colloidal or non-settle able solid. The small or light particles will settle down at the bottom. Solids that are settle on the bed of the water body are called bedded sediment or bed load (Kaijin, 2007).

2.3.7 Total Dissolved Solid (TDS)

Total dissolved solid (TDS) combine the sum of all ions particles that are smaller than two microns. TDS measure in mg/L and can be measured using gravimeter or calculated by multiplying a conductivity value by an empirical factor. In clean water, TDS is approximately equal to the salinity (EPA, 2012). In wastewater or polluted areas, TDS can include organic solutes and salt ions. Dissolved solids important for aquatic life by keeping cell density stable. Water with a very high TDS concentration will cause the cell to shrink. This will affect organisms like bacteria and protozoa capability to move in a water column which cause them to float or sink beyond their normal range. TDS can also affect water taste due to the high alkalinity or hardness in the water (Saeed Shanbehzadeh, 2014).

Main sources of TDS are agricultural and residential runoff and from industrial or sewage treatment plants. The common chemicals present are calcium, phosphates, nitrates, sodium, potassium and chloride. Pesticides from the agricultural activity are harmful element of TDS (Zainudin, 2009). Freshwater can have 2000 mg/L of total dissolved solids and normally a lower TDS will be found on most freshwater.

2.3.8 Turbidity

Turbidity is the amount of cloudiness in the water. High turbidity is a river full of mud and silt where it would be impossible to see through the water meanwhile low turbidity is a water body which appears to be completely clear. Turbidity can be caused by silt, sand and mud, bacteria and other germs and chemical precipitates. It is very important to measure the turbidity of domestic water supplies, as these supplies often undergo some type of water treatment which can be affected by turbidity. For example during rainy season when mud and silt are washed into rivers and streams, high turbidity can quickly block filters and stop them from working effectively (M. Meybeck, 1996).

Turbidity is commonly measured in Nephelometric Turbidity Units (NTU). The nephelometric method compares how light is scattered in a water sample against the amount of light scattered in a reference solution. An electronic hand-held meter is often used to measure turbidity. Measurements can also be conducted by use of a Secchi disc or similar instrument.

Algae, a primary source of food for certain fish and macroinvertebrates, are affected because turbidity reduces its growth rate due to decreases in light availability for photosynthesis. Turbidity also increases water temperature because suspended particles absorb heat. Many common contaminants that increase turbidity can also change the taste and odors of the water (Jimoh, 2010). Water that has high turbidity may cause staining or even clog pipes over time.

2.3.9 Salinity

Salinity is the measure of all the salts dissolved in water. Salinity is usually measured in parts per thousand (ppt or ‰). The average ocean salinity is 35ppt and the average river water salinity is 0.5ppt or less (S. Caeiro, 2016). Sodium and chloride are the predominant ions in seawater.

Impact on people, industries and pipes depends on the salts level. This is because different salts level will produce different impacts. High levels of dissolved salts can cause corrosion, scale and poor steam quality in industry. The needs for chemicals to be used in water treatment also increase.

Small amounts of dissolved salts in natural waters are vital for the life of aquatic plants and animals. Higher levels of salinity will change the way the water can be used. Besides, high levels of salinity and acidity (if present) are harmful to many plants and animals (Ling Cao, 2007).

2.3.10 Ammoniacal Nitrogen

Ammoniacal Nitrogen (NH_3- N) is a measure of amount of ammonia as an indicator to determine pollution by sewage ((APHA), 1999). Ammoniacal Nitrogen is very soluble in water and react with water to produce ammonium hydroxide. The sources of ammonia present in the river:

i) Uncontrolled landfill leachate and land development
ii) Wastewater discharge from domestic, industrial and aquaculture activity
iii) Municipal sewage treatment plant effluent
iv) Fertilizer for land and agricultural developments
v) Untreated sewage from poultry farms, septic tanks and factories
vi) Surface runoff and washouts from rainfall

High concentration of ammonia in water can be toxic to aquatic life. Nitrogen is a good fertilisers which cause algae and weeds to grow fast. The increase of algae and weeds can reduce oxygen in the water and reduce the dissolved oxygen which this will threat the aquatic life (T.Y.Ling, 2010). River water taste and odour problems are cause by excessive Ammonical Nitrogen in the waterways (Konsortium, 2018).

2.3.11 Heavy Metals

Heavy metal is a metal which has relatively high density or high relative atomic weight. According to Hawkes (1997), heavy metals is a collective term, which applies to the group of metals and metalloids with an atomic density greater than 4 g/ cm3 or 5 times or greater than water. Due to the presence of industrial activities near the Pekan River so there is potential that the water contains heavy metals. Heavy metals such as Cadmium (Cd), Lead (Pb), Zinc (Zn), Nickel (Ni), Copper (Cu) and Chromium (Cr) has been used extensively in industrial, either in mining activities or chemical industries

(Aziz HA, 2007). This parameter has contributed to the increase of contamination of water in Malaysia.

Water pollution is contributed by this important heavy metals like Zn, Cu, Pb, As, Cd, Ni, Cr and Hg. Some of this metals are required as nutrients in some life processes like Cu, Fe, Mg, Cr and Zn but become toxic at high concentration (Madhuri, 2014). The heavy metals may enter the water through natural process like rains. The presence of high concentration of metals will decrease the river water quality.

Table 2.1: Sources of different heavy metals

Metals	Source
Arsenic (As)	Pesticides, fungicides, metal smelters
Cadmium (Cd)	Welding, electroplating, pesticides, fertilisers, batteries, nuclear fission plant
Chromium (Cr)	Mining, electroplating, textile, tannery industries
Copper (Cu)	Electroplating, pesticides, mining
Lead (Pb)	Paint, pesticides, batteries, automobile emission, mining, burning of coal
Manganese (Mn)	Welding, fuel addition, ferromanganese production
Mercury (Hg)	Pesticides, batteries, paper industries
Nickel (Ni)	Electroplating, zinc base casting, battery industries
Zinc (Zn)	Refineries, brass manufacture, metal plating, immersion of painted idols

Source: Paul (2017)

2.4 Water Quality Standard

The water quality index (WQI) pertaining to the group water quality parameters on a scale and combine them into a single number according to the preferred method. WQI intended as a measure of pollution level and actual water quality.

There are two primary methods to classify the river water quality which are Water Quality Index (WQI) and Interim National Water Quality Standards (INWQS). INWQS is a set of standards derived based on beneficial uses of water.

2.4.1 Water Quality Index (WQI)

Water Quality Index (WQI) is a tool for evaluating the quality of river water. WQI ascribes quality value to an aggregate set of measured parameters. It usually consists of sub-index values assigned to each pre-identified parameter by comparing its measurement with a parameter-specific rating curve, optionally weighted, and combined into the final index. The purpose of a WQI is to summarise large amounts of water quality data for a specific river into simple. This makes it easily understandable for communities in the river basin and for river basin management. The WQI primarily used in Malaysia (also referred to as the DOE-WQI) is an opinion-poll formula where a panel of experts is consulted on the choice of parameters and on the weight age to each parameter.

Six parameters were chosen for the WQI which are Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD_5), Chemical Oxygen Demand (COD), Suspended Solids (SS), Ammoniacal Nitrogen (AN) and pH. Calculations are performed not on the parameters themselves but on their sub-indices. The sub-indices are named SIDO, SIBOD, SICOD, SIAN, SISS and SIpH. Once the respective sub indices have been calculated, the WQI can then be calculated. Then, the water quality data is compared with National Water Quality Standards for Malaysia (NWQS) to determine their status.

However WQI has a few limitations which are water quality data cannot met with an index and indexes are less suited to specific area. Next is site specific decision should based on an analysis of the original water quality, but most indexes are based on a pre-identified set of water quality constituents. Then, WQI use only six parameters without consideration for coli form which is relevant to skin contact and also no consideration of heavy metal such as carcinogenic.

2.4.2 Interim National Water Quality Standard (INWQS) Malaysia

The National Water Quality Standards, which is applied to surface waters, ordains standard values of 72 parameters in 6 water use classes. The goal is not to meet the standards of the certain water class in all surface waters, but to improve water quality gradually in order to meet the standards of the better water class than the actual.

INWQS defines its respective beneficial uses. The water quality is considered to be suitable for a specific use as long as it is within the range specified for the designated classes. INWQS specifies the water quality level necessary to sustain macro aquatic life, with varying degree of sensitivity at Class I- III. Fish is used as an indicator due to its economic value. The same is true for potable water supply, where conventional treatment systems should be able to treat Class II designated water source efficiently, whereas, more advanced treatment systems are required for a Class III designated water source. Class IV (and below) can still be used for irrigation, whereas Class V water sources are considered to have minimal beneficial usage.

However, the water quality at a designated point in the same basin may differ from that at another location, depending on whether there are any alterations to ambient levels along that segment, particularly as a result of pollution. Generally that moving down river typically results in worsened water quality conditions, as a result of anthropogenic activity. Therefore, the selection of a monitoring point within a basin must also take into consideration the potential water uses within that vicinity (or lack thereof), prior to benchmarking against the INWQS, only then can a representative assessment be done. Of course, it would better if all stretches along the basin is of pristine quality (between Class I and II), hence also broadening its beneficial use.

Water quality affected also due to seasonal flow variations as a result of precipitation. Water quality during the dry season may remain fairly constant with some variations which there are no serious external disturbances or draught. During the wet season, where precipitation is at its maximum, the water quality has the potential to get better or become worse, depending on input from runoff or non-point source pollution. If pollution from non-point sources, such as agricultural runoff, is significant, then one would expect to observe elevated levels of ammonium, nitrate and phosphate, originating from the organic-fertilisers used. Thus it becomes quite clear; land-use activities have a significant effect on water quality. This makes water quality classification and assessment even more difficult.

Table 2.2: Interim National Water Quality Index Classifications (water classes and uses)

Classes	Index	Uses
Class I	< 92.7	Conservation of natural environment. Water Supply I – Practically no treatment necessary. Fishery I – Very sensitive aquatic species.
Class II- A Class II- B	76.5 – 92.7	Water Supply II – Conventional treatment. Fishery II – Sensitive aquatic species. Recreational use body contact.
Class III	51.9 – 76.5	Water Supply III – Extensive treatment required. Fishery III – Common, of economic value and tolerant Species; livestock drinking.
Class IV	31.0 – 51.9	Irrigation
Class V	< 31.0	None of the above

Table 2.3: DOE Water Quality Classification Based on WQI

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

Source: DOE (2006)

2.5 Effect of Bad River Water Quality

The effect of bad water quality towards the environment is will damage the vegetation surrounding it that use the polluted river water as the main source of water. The shrimp farming that consume water from the river may be affected. This can cause the quality of shrimp decrease since consuming the polluted water. The vegetation near the river also may be polluted as well. This will damage the life of animals that depend of the vegetation to survive. Next is as the streams or river that has bad water quality dumps into larger bodies like sea, then the sea also will be affected and will affect the entire ecosystem (Dabi, 2015).

This excessive growth of nutrients causes algal deposits on the rivers that called as eutrophication or algal bloom. Eutrophication or algal bloom caused by the accumulation of organic nutrients like nitrogen and phosphorus, which promotes a high biomass in the superficial water. The oxygen content in the water reduces due to scarcity of light and causes anaerobic conditions, which is not good for the plant and animal life in the water body since it will increased phytoplankton production, decrease fish stocks, sedimentation, nutrient cycling, and oxygen depletion (Xie Biao, 2004).

Polluted water makes the life of aquatic organism miserable. Water pollution reduces the level of oxygen in it or oxygen deficiency. According to a survey in most of the rivers, the amount of oxygen in a litre of water has decreased to 0.1 cubic centimetre only, while this average in 1940 was around 2.5 cubic centimetres. Fish and other aquatic organisms start dying due to lack of oxygen in the polluted water. Things have become so alarming that many aquatic species are on the brink of extinction (J.G. Cardoso-Mohedano, 2016).

Next is water deterioration and disease breakout cause low productivity. Polluted water also negatively impacts the breeding power of aquatic life. It makes fish and plants deficient in their ability to regenerate and reproduce. Also, animals fall prey to a variety of diseases due to drinking polluted water (Ling Cao, 2007).

CHAPTER 3

METHODOLOGY

3.1 Introduction

Water is important resource for life and river is one of the sources of water in Malaysia. Demand for water is increasing locally and globally but the source of fresh water is limited. There are many factors that contribute to the difficulty of ensuring water quality.

Therefore, the assessment of water quality based on parameters of temperature, pH, DO, BOD, COD, TSS, TDS, Turbidity, Salinity, Ammoniacal Nitrogen and heavy metals was carried out. Then classification of the river water quality was determined based on the calculation of the obtained data and was compared with the standard, INWQS.

This research study was conducted based on the previous reported publications and standard methods. This methodology was significant in implementing this research study accordingly. The method used to achieve the objectives of the study will be discussed more in this chapter.

3.2 Study Area and Sampling Points

The study area of this research focused on aquaculture industry that located around Kuantan. To be more specifically, the study was conducted at nearest river to the shrimp pond farming area where river are exposed to wastewater from the pond farming that was Pekan River. Furthermore, the wastewater flowed into the river every three month during harvesting period and that was the duration for one cycle of shrimp culture. Sampling stations selected based on the before, during and after the wastewater being flowed into the river. Three stations along a main stream are marked as shown in Figure 3.1. The selected locations located at upstream, downstream and intermediate area of the river and marked as Station 1, Station 2 and Station 3.

Figure 3.1: Sampling location

Source: Google maps

3.3 Research Design

The study carried out by using cross sectional study to assess the water quality level of three different stations of the river which near to the aquaculture industry. In this study, it had three different stations with different concept exposure of wastewater from the shrimp pond farming. The data collected based on in-situ and ex-situ monitoring approach to assess the water quality level of the river and to recommend the best solution that can be used to encounter the environmental effects from the polluted river.

3.4 Sampling and Preservation

The total number of the study sample was three subjects that had selected as samples from the river that near to the aquaculture industry. The samples were river that specifically directly exposed to the wastewater from the aquaculture industry. The exposure of wastewater towards the river was assumed that the river was giving the effect towards the environment.

The water samples were collected about 10 cm below water surface using 1-L polyethylene bottles. The sample needs to be stored in 1-L polyethylene bottles that have been soaked in 10% of nitric acid overnight and rinsed with deionized water and dried (Teck-Yee Ling, 2012).

Preservation of the sample need to be carried out to ensure the samples that want to be tested in the laboratory is in good quality and have the originality that similar to the site for certain period of time. The preserved samples need to be kept in ice for further analysis in the laboratory. The water samples need to be kept in the laboratory refrigerator at a temperature below 4°C to stop all the activities and metabolism of the organisms.

Table 3.1: Preservation techniques

Parameter	Container	Preservation	Max. Holding Time
Biochemical oxygen demand (BOD)	1-L polyethylene bottles	Cool, 4°C	48 hours
Chemical oxygen demand (COD)	1-L polyethylene bottles	Cool, 4°C H_2SO_4 to pH<2	28 days
Ammoniacal Nitrogen	1-L polyethylene bottles	Cool, 4°C	28 days
Heavy metals	1-L polyethylene bottles	HNO_3 to pH<2	28 days

3.5 Data Collection

The first sampling test that used to conduct this study was in-situ test by the river. In-situ test being conducted to test the pH value, temperature and dissolved oxygen (DO) of the river. The data collected using pH and temperature meter HORIBA Laqua Act PH110 as shown in Figure 3.2, DO meter OHAUS Starter 300D as shown I in Figure 3.3 for DO and Turbidity meter LaMotte 2020we as shown in Figure 3.4 for turbidity. The instruments gave the reading directly when the sensor being submerged into the river.

Next sampling test was ex-situ test which conducted in the laboratory to generate the results. Ex-situ test was conducted to test the biochemical oxygen demand (BOD), chemical oxygen demand (COD), total suspended solid (TSS), total dissolved solid (TDS), Ammoniacal Nitrogen and heavy metals.

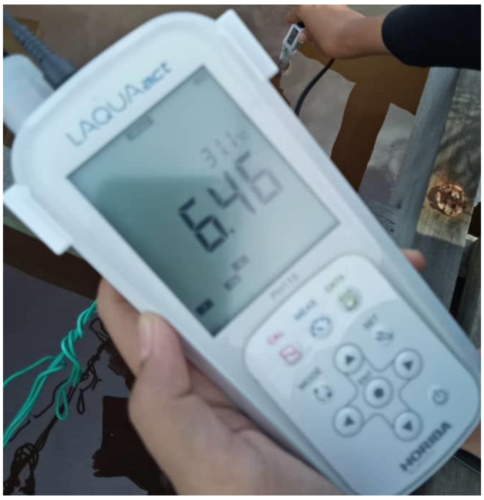


Figure 3.2: Temperature and pH meter

Figure 3.3: DO meter

Figure 3.4: Turbidity meter

3.5.1 Biochemical Oxygen Demand (BOD)

BOD is a chemical procedure for determining how fast biological organisms use up oxygen in a body of water. The BOD test will be carried out according to the procedures in Standard Method APHA 5210-B.The method consisted of filling sample, to overflowing, an airtight 300mL bottle or BOD bottle and incubating it at 20ºC for 5 days. DO was measured initially and after incubation using a DO meter.

Samples for BOD analysis may degrade significantly during storage between collection and analysis, resulting in low BOD values. The reduction of BOD was minimized by analyzing sample as soon as possible or by cooling it to near freezing temperature during storage. Chilled samples was warmed to 20±3ºC before analysis (APHA, 1999).

The calculation for BOD_5 as follows:

BOD_5, mg/L = (D1 – D2) x Dilution factor

Where;

D1 = DO value in initial sample

D2 = DO value in final sample

Dilution factor = Bottle volume (300mL) / Sample volume

3.5.2 Chemical Oxygen Demand (COD)

COD test commonly used to indirectly measure the amount of organic compounds in water (Albulescu et al., 2010). It is expressed in milligrams per liter (mg/L), which indicates the mass of oxygen consumed per liter of solution. According to Theriault et al. (2003), COD can be determined in 3 hours.

The procedure for COD test followed Standard Methods APHA 5220-C.Samples refluxed in strongly acid solution with a known excess of potassium dichromate ($K_2Cr_2O_7$), sulfuric acid (H_2SO_4), mercuric sulfate ($HgSO_4$) and argentums sulfate (Ag_2SO_4) in special vials used for HACH methods or using the sample cells.

2 ml of deionized water was added into one of the sample cell as blank. Then 2 ml of the effluent sample was added to another sample cell as sample. The entire sample cells then were kept in the heater for 2 hours using COD reactor as shown in Figure 3.5 at around 150ºC and left to cool down at room temperature. The sample cells tested with spectrophotometer to obtain the COD value but before being tested the sample cells need to be cleaned with a towel to remove any fingerprints. The HACH equipment gave the COD reading in mg/L.

Figure 3.5: COD Reactor

3.5.3 Total Suspended Solid (TSS)

The procedure described here follows Standard Methods APHA 2540-D and EPA (1983) Method 160.2 (Residue, non-filterable). A well-mixed, measured volume of a water sample was filtered through a pre-weighed glass fiber filter. The filter was heated to constant mass at 104 ± 1º C and then weighed. The mass increase divided by the water volume filtered is equal to the TSS in mg/L.

The calculation of TSS is as follows:

$$TSS = [\ (A - B) \times 1000] / V$$

Where:

A = Weight of filter + residue (mg)

B = Weight of filter (mg)

V = Volume of sample

3.5.4 Total Dissolved Solid (TDS)

The procedure for TDS test followed Standard Methods APHA 2540-C. This standard procedure work based on principle where a well-mixed sample was filtered through a standard glass-fiber filter. For preparation of evaporating dish, clean dish was heated to 180 ± 2°C for 1 h in an oven as shown in Figure 3.6 then store in desiccator until needed and weigh immediately before use.

For sample analysis, the sample was stirred with a magnetic stirrer and pipet a measured volume onto a glass-fiber filter with applied vacuum. Wash with three successive 10-mL volumes of reagent-grade water, allowing complete drainage between washings, and continue suction for about 3 min after filtration is complete. Transfer total filtrate (with washings) to a weighed evaporating dish and evaporate to dryness on a steam bath or in a drying oven. The filtrate was evaporated to dryness in a weighed dish and dried to constant weight at 180°C in an oven. Then cool in a desiccator to balance temperature, and weight. The increase in dish weight represents the total dissolved solids.

Figure 3.6: Oven

3.5.5 Ammoniacal Nitrogen

Ammoniacal Nitrogen test were conducted according to the standard of HACH method 8155 and also known as Salicylate method. The concentration of ammoniacal nitrogen was determined using spectrophotometer as shown in Figure 3.7 with the two reagents Ammonium Salicylate and Ammonium Cyanurate. Green colour turned up when Ammonia nitrogen is present. Samples were diluted before testing since this method only applicable for Ammonia Nitrogen concentration of 0.01-0.50 mg/L.

Figure 3.7: Spectrophotometer

3.5.6 Heavy Metals

Heavy metals test were conducted to know the concentration of metals in the river water. All the samples were prepared in 1% HNO_3 prior to analysis on the Inductively Coupled Plasma (ICPMS) as shown in Figure 3.8. The blank was prepared by deionized water in 1% HNO_3 and the standards are prepared by 1, 4, 5, 10 and 20 mg/L of standard solution in 1% HNO_3. Then, the sample of river water were tested using ICPMS for an hour and the concentration of the heavy metals contained in the sample were detected and displayed in summary report. The heavy metals that can be detected by ICPMS are As, Cd, Cu, Pb, Zn, Cr and Mg.

Figure 3.8: ICPMS

3.5.7 Water Quality Index (WQI)

WQI was calculated using Equation 3.1 and subindex formula that can be found in Table 3.2.

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

Equation 3.1

Where;

SIDO= sub index DO (% saturation)

SIBOD= sub index BOD

SICOD= sub index COD

SIAN= sub index NH_3-N

SISS= sub index SS

SIpH= sub index pH

$0 \leq WQI \leq 100$

Table 3.2: Sub index formulae for WQI calculation

Parameter	Formula	Data Value Range
DO	Sub index for DO (% saturation) SIDO = 0 SIDO = 100 SIDO = $-0.395 + 0.030x^2 - 0.00020x^3$	 for x ≤8 for x ≤92 for 8 < x < 92
BOD	Sub index for BOD SIDOD = 100.4 – 4.23x SIDOD = 108* exp(–0.055x) – 0.1x	 for x ≤ 5 for x > 5
COD	Sub index for COD SICOD = –1.33x + 99.1 SICOD = 103* exp(–0.0157x) – 0.04x	 for x ≤ 20 for x > 20

NH_3-N	Sub index for NH_3-N SIAN = 100.5 – 105x SIAN = 94* exp(–0.573x) – 5* I x – 2 I SIAN = 0	 for $x \leq 0.3$ for $0.3 < x < 4$ for $x \geq 4$
SS	Sub index for SS SISS = 97.5* exp(–0.00676x) + 0.05x SISS = 71* exp(–0.0061x) + 0.015x SISS = 0	 for $x \leq 100$ for $100 < x < 1000$ for $x \geq 1000$
pH	Sub index for pH SlpH = $17.02 - 17.2x + 5.02x^2$ SlpH = $-242 + 95.5x - 6.67x^2$ SlpH = $-181 + 82.4x - 6.05x^2$	 for $x < 5.5$ for $5.5 \leq x < 7$ for $7 \leq x < 8.75$

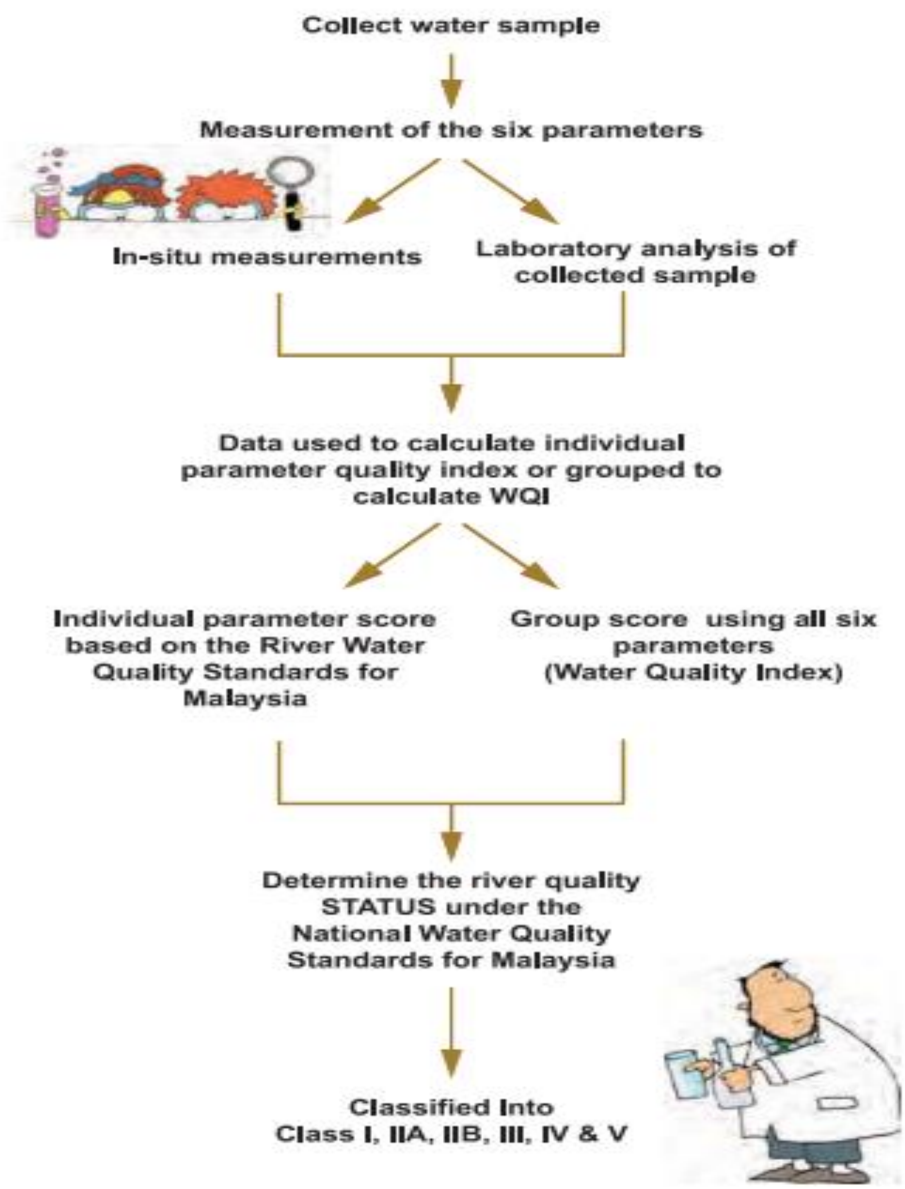


Figure 3.9: Process for calculating WQI

3.6 Analysis of Data

The analysis and interpretation of data represent the application of deductive and inductive logic to the research process. The final result may be a new principle or generalization. Data are examined in terms of comparison between the more homogeneous segments within the group any by comparison with some outside criteria. Analysis of data includes comparison of the outcomes of various treatments upon the several groups and the making of a decision as to the achievement of the goals of research. Data relevant to each hypothesis must be assembled in quantitative form and tested to determine whether or not there is a significant difference in the results obtained from the controlled groups.

Data from the test were analysed using Microsoft Excel 2010. This study examines statistically the spatial variation of water quality parameters along the river and the best fit WQI to classify the river. Therefore, a conclusion was derived from the measured values and comparison to the standard value based on INWQS was made. Hence, the result data were discussed more in chapter 4. In this research, the collection data were analysed and interpret using Microsoft Excel software and mathematical calculation. The data collected were analysed using Microsoft Excel based on the formula provided.

3.7 Flow Chart of Methodology

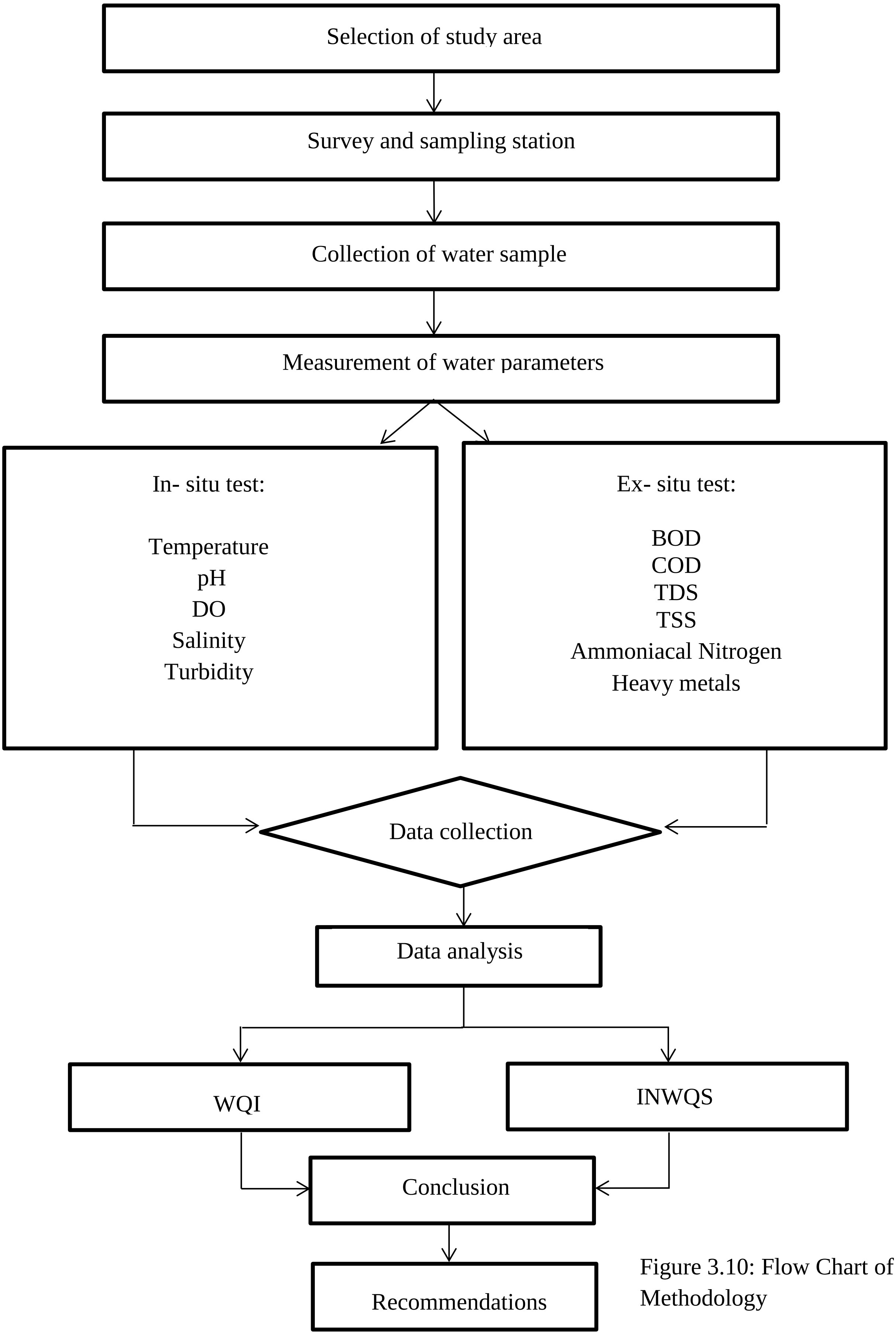


Figure 3.10: Flow Chart of Methodology

Table 3.3: Summary of the method

Parameter	Instrument	Method
pH	-pH meter (HORIBA Laqua Act PH110)	-Standard Method for the Examination of Water and Wastewater -APHA 4500H+B (21^{st} edition)
Temperature	-Temperature meter (HORIBA Laqua Act PH110)	-Standard Method for the Examination of Water and Wastewater -APHA 4500H+B (21^{st} edition)
DO	-DO meter (OHAUS Starter 300D)	-Standard Method for the Examination of Water and Wastewater -APHA 4500H+B (21^{st} edition)
BOD	-DO meter (OHAUS Starter 300D) -Incubator capable of maintaining of 20°C	-APHA 5210-B -Standard Method for the Examination of Water and Wastewater
COD	-DR 5000 Spectrophotometer -COD reactor	-In House Method Based on HACH DR5000 Method 8000 -APHA 5220-C
TSS	-Dessicator -Drying oven for operation 105°C Analytical balance -Vacuum pump	-APHA 2540-D -Standard Method for the Examination of Water and Wastewater

	-Glass weighing dish	
TDS	-Dessicator -Drying oven for operation 105°C Analytical balance -Vacuum pump -Glass weighing dish	-APHA 2540-C -Standard Method for the Examination of Water and Wastewater
Turbidity	-Turbidity meter (LaMotte 2020we)	-Standard Method for the Examination of Water and Wastewater
Ammoniacal Nitrogen	-DR5000 Spectrophotometer	-Standard Method for the Examination of Water and Wastewater -HACH method 8155
Heavy Metals	-ICPMS	

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Introduction

The data collected using in-situ and ex-situ measurement were compared with the Interim National Water Quality Standards (INWQS) Malaysia and Water Quality Index (WQI) to evaluate the water quality of the Pekan River.

There were three stations collected and the distance between the three stations is around 50 meter. The parameters chosen based on INWQS and WQI. There were few parameters that being measured on site which are Temperature, pH and Dissolved Oxygen (DO). The other parameter like Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Suspended Solid (TSS), Total Dissolved Solid (TDS), Ammoniacal Nitrogen, Turbidity and Heavy Metals were tested in the laboratory. The heavy metals measured were lead (Pb), zinc (Zn), chromium (Cr) and copper (Cu). All the data collected were compared with the water quality classes (Class I, II, III and IV).

4.2 Sample Collection

The sampling was done at three stations during the day of the shrimp pond harvest. The data collected before and after the shrimp pond water being released into the river. First sampling referred to before the wastewater released and second sampling referred to after the wastewater released. The water samples were drawn underwater and the bottle cap was closed after the water had full collected in the bottle. The bottles were labelled earlier as shown in Figure 4.1 and 4.2 according to the station which the samples were collected. These samples will be used for the ex- situ tests. After that an in- situ test was performed using the portable instrument which can collect data directly from the river. All the samples were kept in the chiller immediately when arrived at the laboratory and ready to be tested. All the data were recorded and tabulated for further analysis.

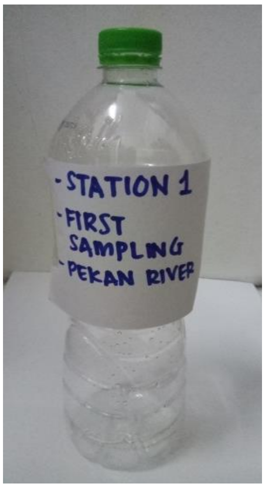


Figure 4.1 and 4.2: Labelled sampling bottle

4.3 Result of the Sample Collection

The results from the tests were tabulated and statistical analysis done in Microsoft Excel where graph for each parameter were obtained. These helps compared the results from the two samplings with the standard. The overall comparison from the sample shows that small or big differences from the results obtained. After all the results were compiled, a general formula was applied to the main parameters to develop the WQI for Pekan River.

4.3.1 Temperature

Based on Figure 4.3, both first and second sampling were higher than the INWQS where the standard temperature is 28°C. The water temperature range of samples collected was between 27°C to 29.1°C. The first sampling still lies between the water temperature range. The temperatures of the samples were slightly higher than the standard might be because of the hot weather when doing the sampling since the time measured was between 8 am to 3 pm.

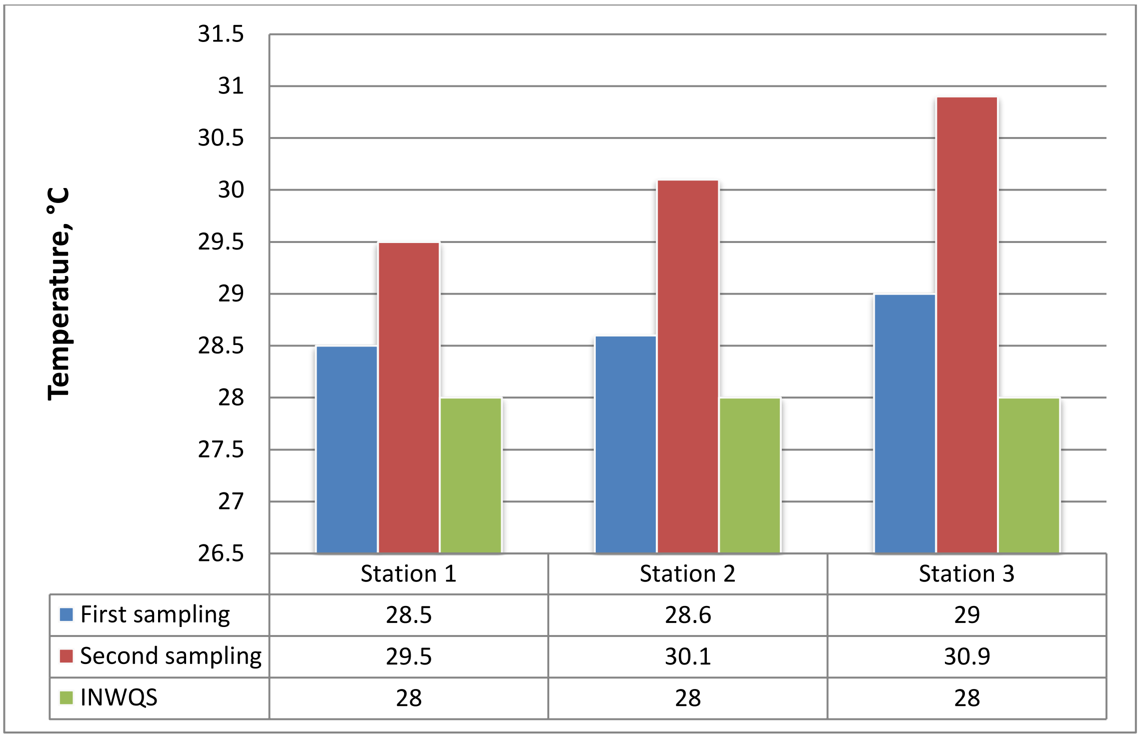


Figure 4.3: Temperature of different stations at Pekan River

4.3.2 pH

The pH reading for first sampling was higher than the second sampling as shown in Figure 4.4. The standard pH value is 7 according to INWQS. The pH value for both sampling shows slightly acidic condition which near to 7. pH is an important indicator for the water quality. The pH of water decides the solubility and natural accessibility which is sum that can be used by sea-going life for example supplements like phosphorus, nitrogen and carbon and heavy metals (lead, copper, cadmium and others).

pH values can be caused by many factors. However the river still suitable to be used as source of water if pH treatment was applied first since all the stations showed an acidic tendency. The river also can be used for recreation purpose since it was not heavily affected by acidity. Most fish can adapt to the pH level of their environment around 6.0 to 9.0 as long as there is no dramatic fluctuations (K.Saffran, 2001). A dramatic fluctuation was considered a shift in pH.

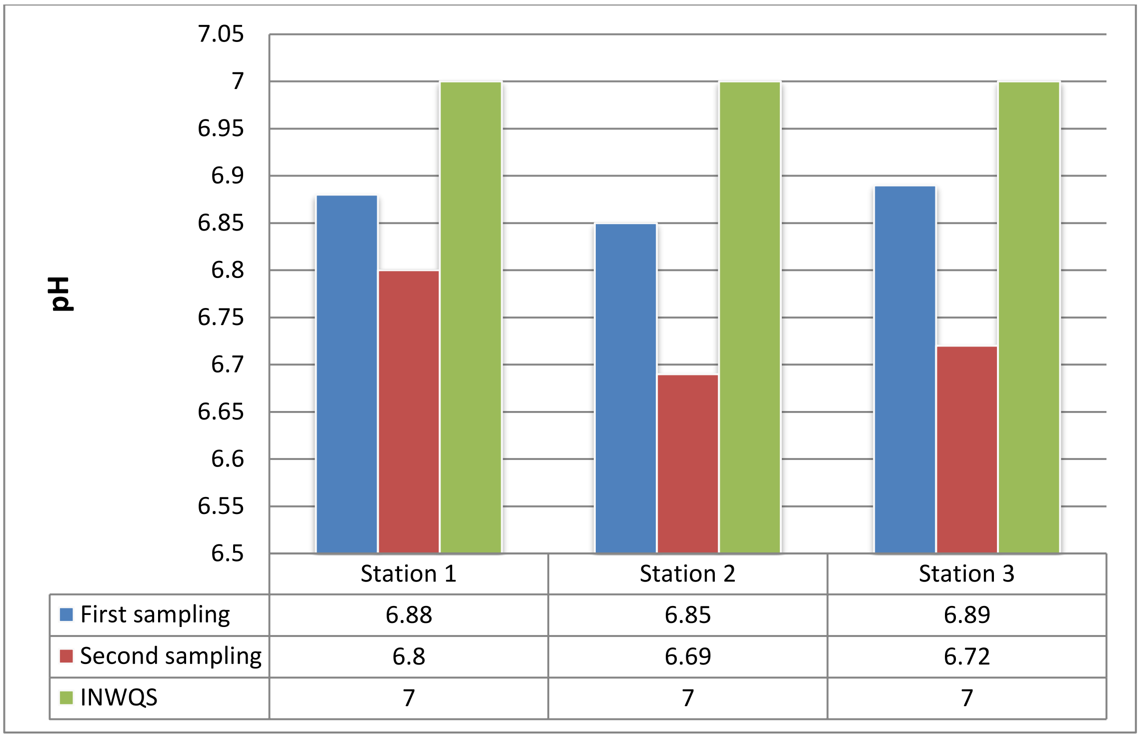


Figure 4.4: pH of each station at Pekan River

4.3.3 Dissolved Oxygen (DO)

The DO level for first sampling was higher than the second sampling as shown in Figure 4.5. The reading for the first sampling is higher than 6 which stated in INWQS. The factors that affect the DO level in the water were temperature, plant growth, salinity, water turbulence and atmospheric pressure. Temperature will affect the DO concentration in the water. When the temperature is low, the DO will increase. Warm water will have lower DO than the cold water since heat provide energy for oxygen to react with other compounds.

Only green plant can split the oxygen through photosynthesis and animal cannot split the oxygen. When the oxygen demand is increase, the green plant also will increase which will cause the DO to be high (T.Y.Ling, 2010). Area with high aquatic plant population will have high DO level as photosynthesis from plants release oxygen to surrounding. The DO level that is too low or too high can affect water quality and also can harm aquatic life. 5-7 mg/L is the ideal DO level for many fish. Most of the fish cannot survive when the DO level is below 3 mg/L. The weather during the sample collection also may be a factor to the DO values recorded.

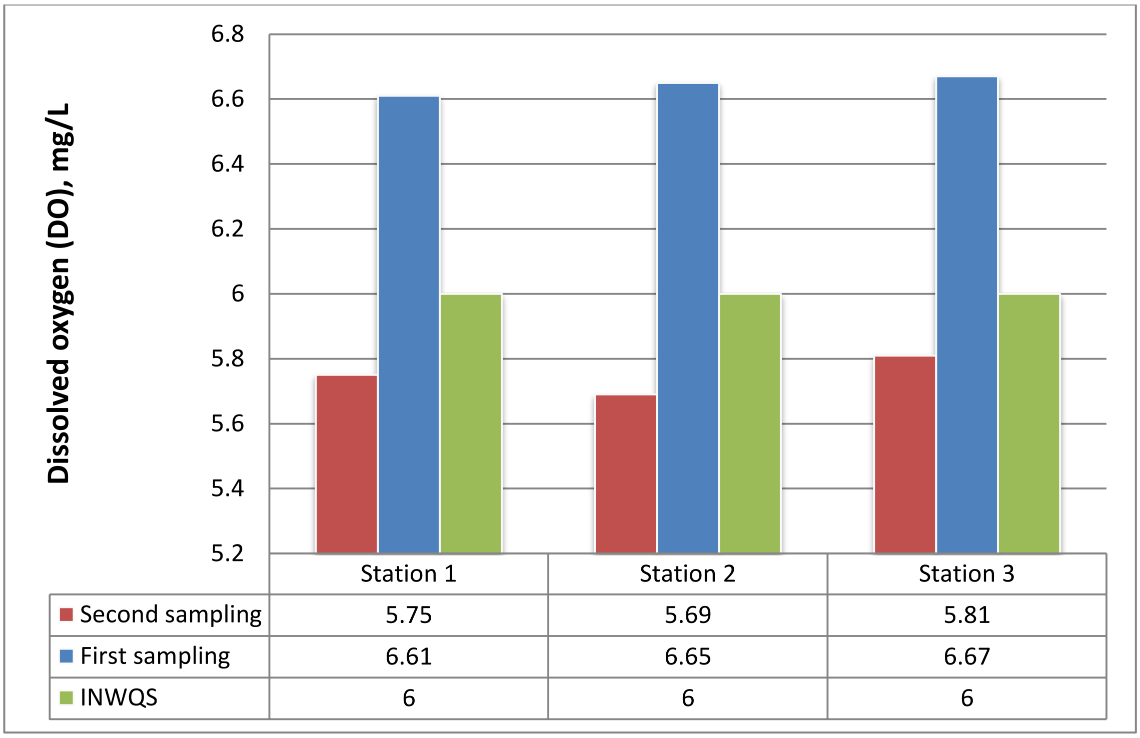


Figure 4.5: DO level for each sampling at Pekan River

4.3.4 Turbidity

Figure 4.6 shows the turbidity reading for first sampling is lower than second sampling but both of the samplings was still below INWQS value which is 50 NTU. However the turbidity value for station 2 second sampling is higher than the others. The turbidity was high may be due to discharged effluents of some source like from effluent of shrimp pond farming.

Turbidity causes water to appear cloudy. Turbid water will seem overcast, cloudy or generally shaded affecting the physical look of the water. Furthermore turbidity also related to suspended solid. The higher the value of suspended solid, the higher the value of turbidity. However, during heavy rain, soil particles from surrounding land were washed down into the river and turned the colour of river water to brown, indicated the water was full of sediment and looked cloudy (Teck-Yee Ling, 2012).

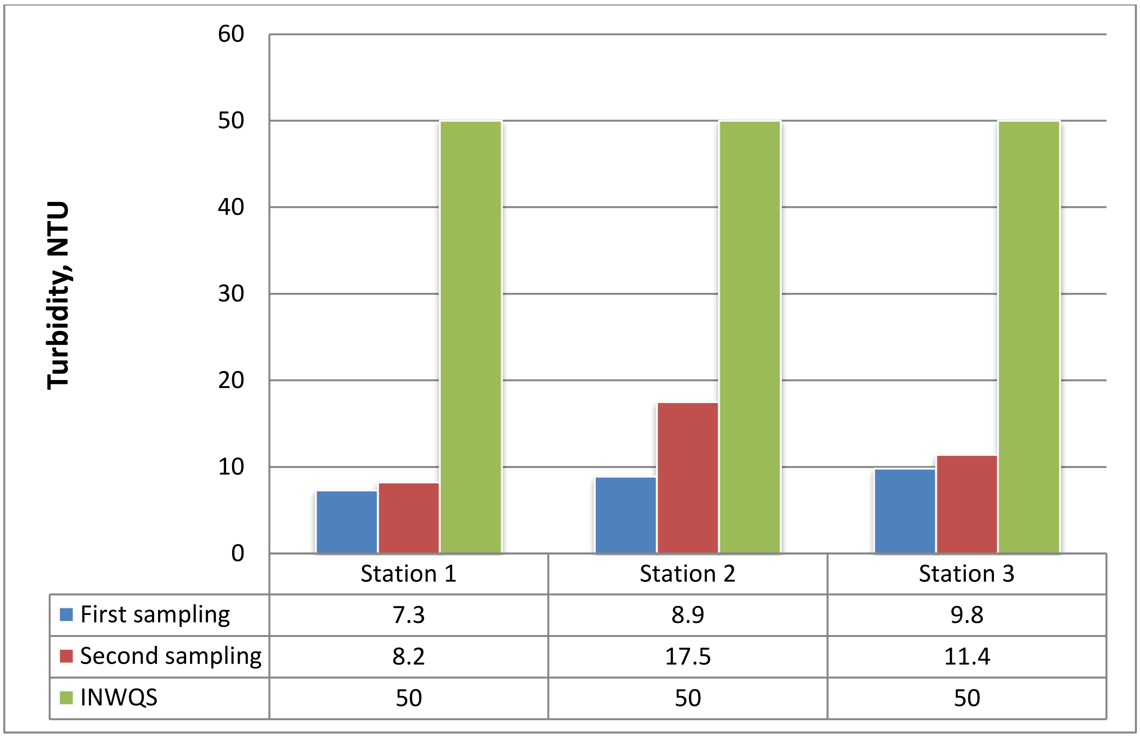


Figure 4.6: Turbidity reading for each station at Pekan River

4.3.5 Biochemical Oxygen Demand (BOD_5)

The graph in Figure 4.7 shows that the value of BOD_5 for second sampling was slightly higher than the first sampling but both sampling was below 6 stated in INWQS. When the BOD value is high, the DO value is low. This happened because demand for oxygen from microbes is high and they are taking that oxygen from the oxygen disintegrated in the water. In the event there was no natural waste present in the water, there would not be the same number of microbes present to break down it and cause the BOD tendency to be lower and the DO level will have tendency to be higher. BOD high meant the water was polluted (Saremi A., 2012).

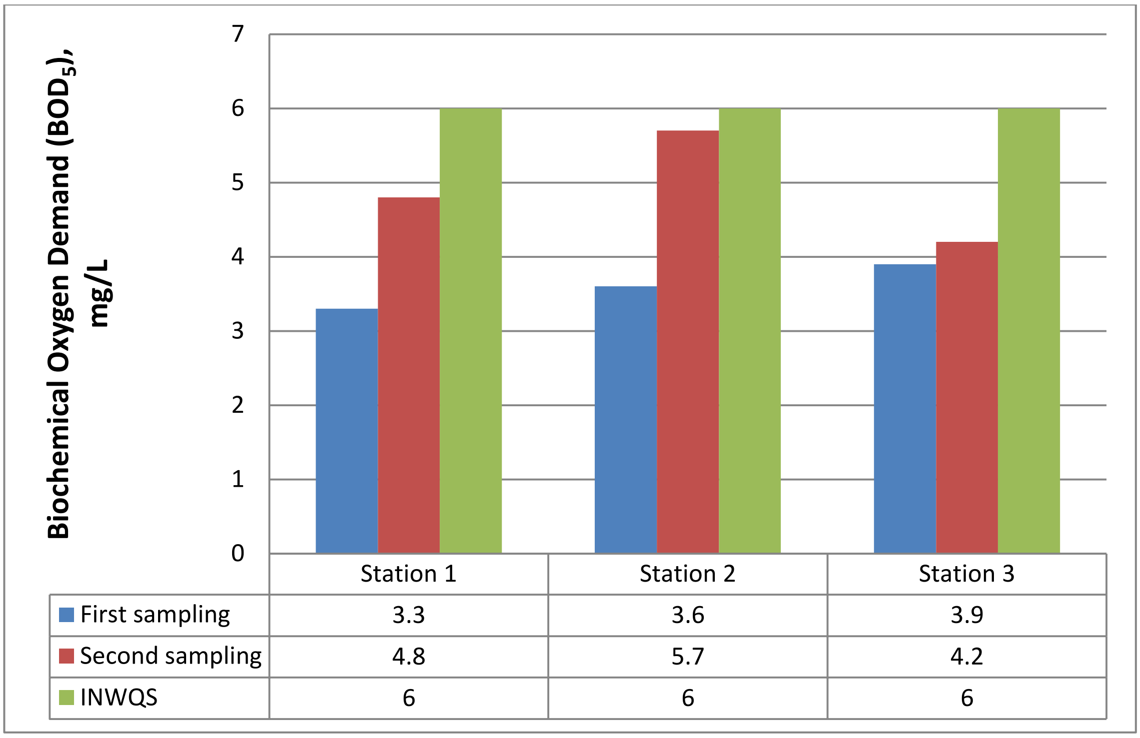


Figure 4.7: BOD_5 value for two sampling at Pekan River

4.3.6 Chemical Oxygen Demand (COD)

Figure 4.8 shows the concentration of COD for first sampling is slightly higher than second sampling but however both sampling is lower than 50 stated in INWQS. High COD level decrease amount of DO available. High COD level means greater amount of oxidized organic material in the sample, which will reduce DO levels. Complete depletion of DO can occurred if excess organics are introduced to the systems. The absence of oxygen will threat the aquatic life and only air-breathing insects and anaerobic bacteria will be available.

COD and BOD were two main indexes used to assess the organic pollution in aqueous systems and assess the effect of discharged wastewater on the receiving environment. High COD means the water is contaminated and not suitable for aquatic life. The pollution of the water resources can have serious and wide-scale effects on human health, agriculture, fisheries and industry and economic cost. The immediate effects of water pollution can be seen in water bodies, animals and plant life that inhabits them (Rigos, 2011).

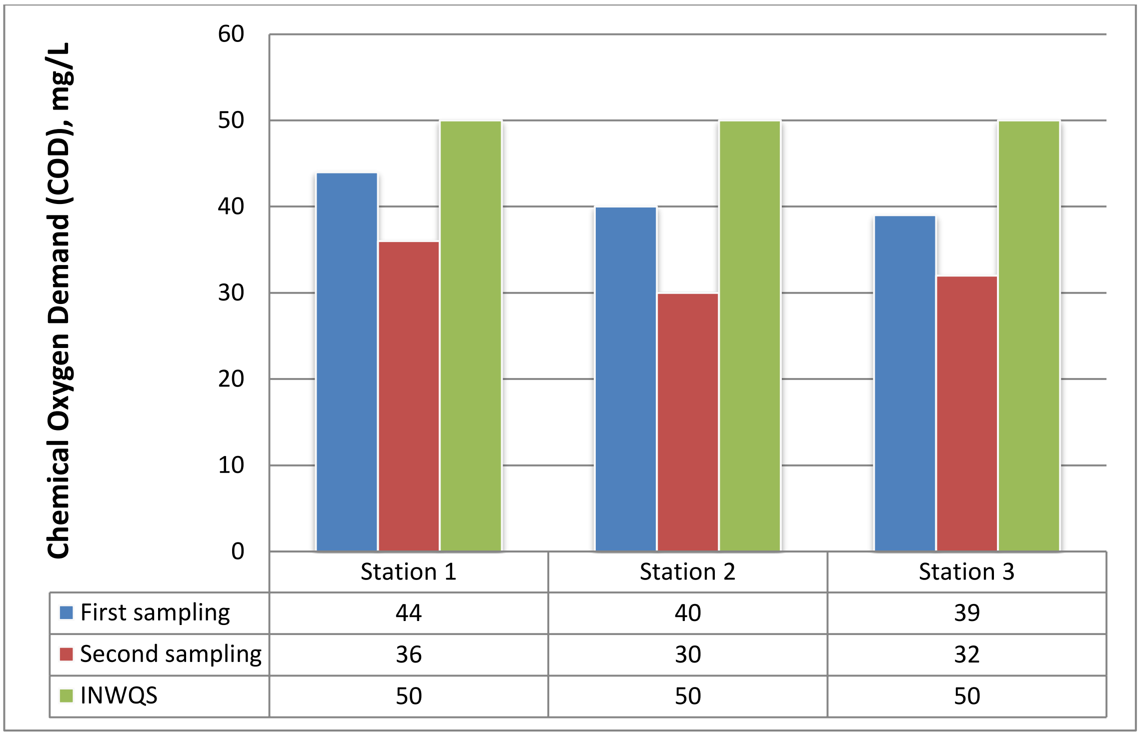


Figure 4.8: COD concentration at different station of Pekan River

4.3.7 Total Suspended Solid (TSS)

The graph in Figure 4.9 shows that the value of TSS for both sampling compared to INWQS. For first and second sampling, the TSS value was low compared to the standard which is 50 mg/L. The low value of TSS might be because of turbidity value also low. High concentration of TSS can cause issues for stream health and amphibian life. In terms of water quality, high amounts if TSS will cause water temperature to be increased and decrease the DO level. This is since suspended solid ingest more warmth from sun based on radiation than water atoms will. Hot water cannot hold as highly broke down oxygen as cold water, so DO level will decrease. The increasing of water surface temperature will cause stratification or layering of a waterway. When the water stratifies, the upper and lower layers will not blend. This can turn out to be excessively hypoxic or low broke down oxygen levels for organic things to survive because deterioration and respiration regularly happened in the lower layer. Normally soil erosion from the surrounding area can also be the source of suspended solid or soil transported by rain runoff water (S. Caeiro, 2016).

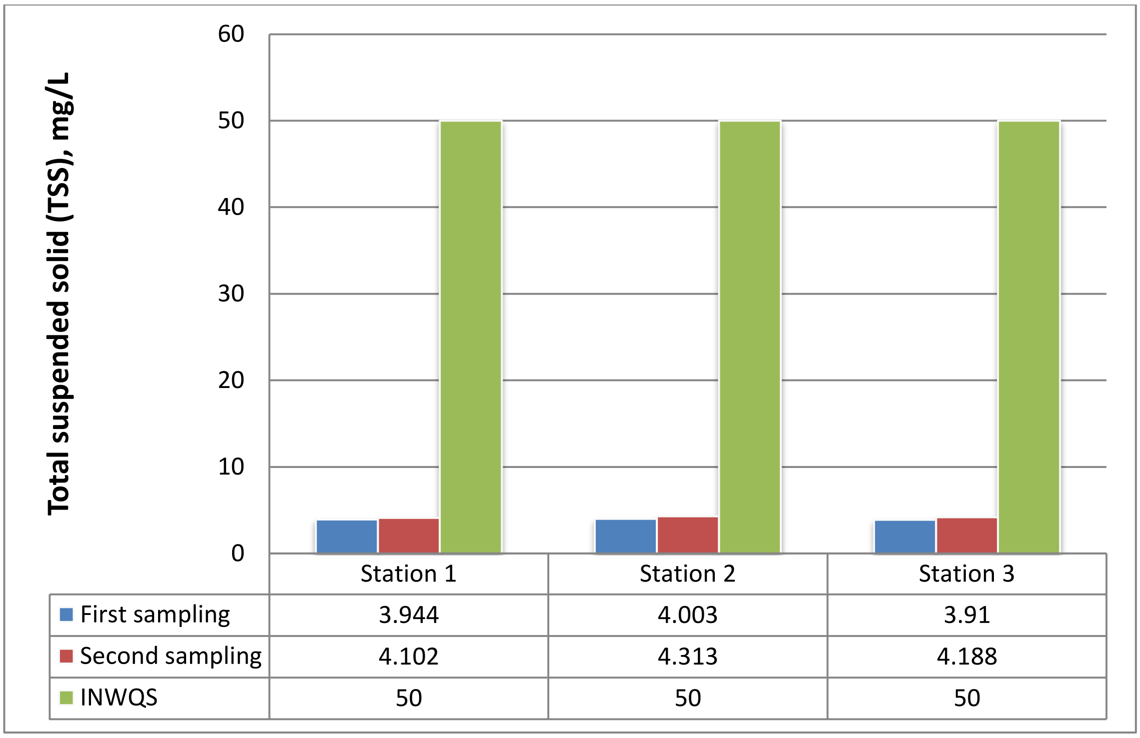
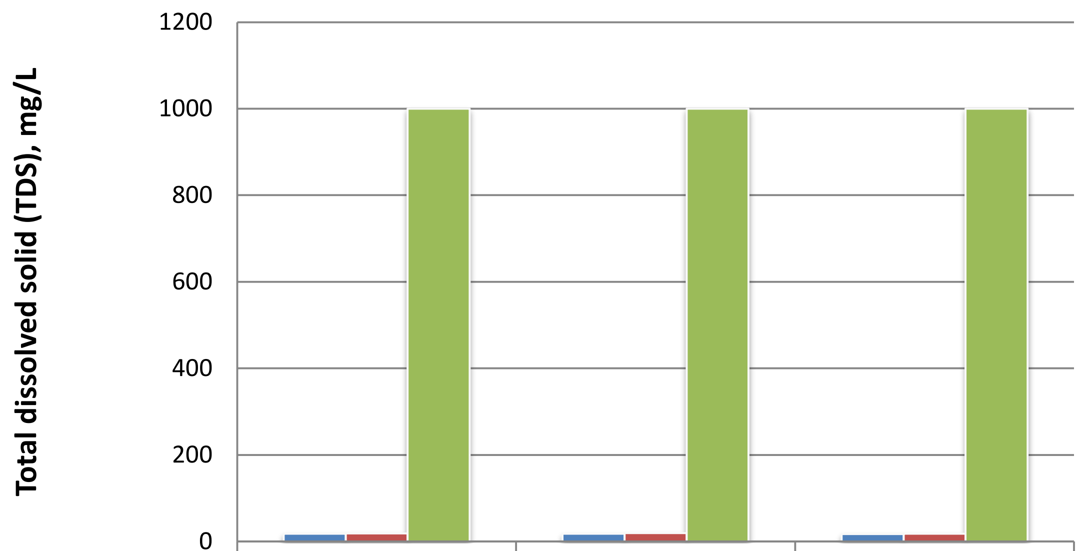


Figure 4.9: TSS value for each sampling at Pekan River

4.3.8 Total Dissolved Solid (TDS)

Figure 4.10 shows that second sampling was higher than first sampling but still below the standard which 1000 mg/L. The most common source of dissolved solids in water was from the weathering of sedimentary rocks and the erosion of the earth's surface. Since many minerals are water soluble, high concentrations accumulate over time through the constantly reoccurring process of precipitation and evaporation. Usually groundwater has higher levels of TDS than surface water, since it has a longer contact time with the underlying rocks and sediments. In addition to the main inorganic components of total dissolved solids, TDS can come from organic sources such as decaying organisms like plants and animals, urban and agricultural runoff and municipal and industrial effluent discharges (Amneera, 2013).

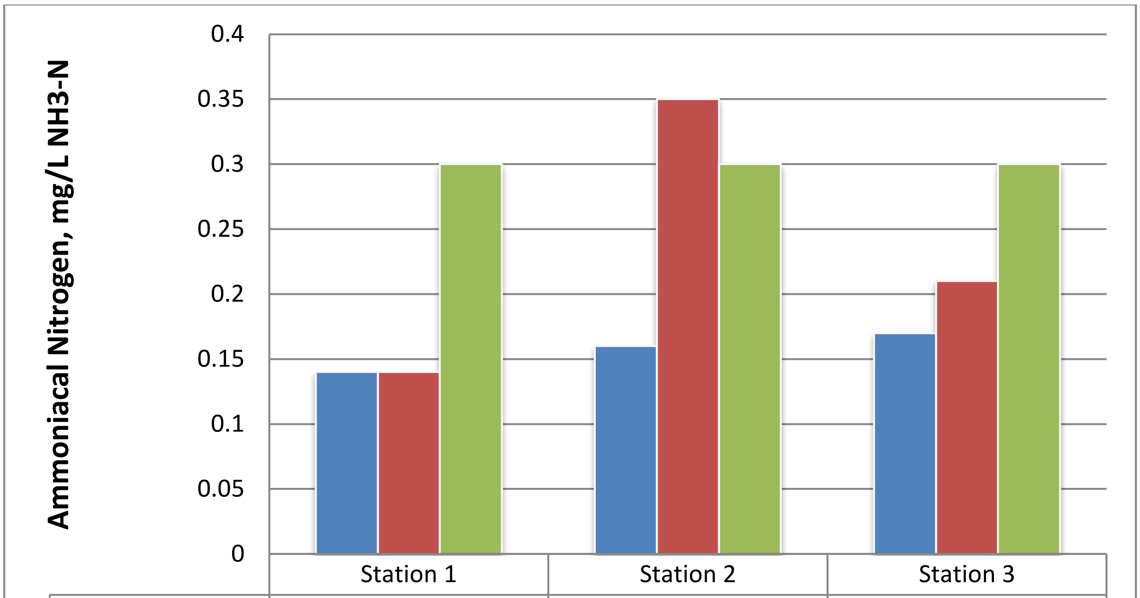


	Station 1	Station 2	Station 3
First sampling	17.788	18.069	17.471
Second sampling	18.877	19.184	18.047
INWQS	1000	1000	1000

Figure 4.10: The value of TDS at different station of Pekan River

4.3.9 Ammoniacal Nitrogen

Figure 4.11 shows that second sampling was higher than first sampling. The values of Ammoniacal Nitrogen were low than the standard which 0.3 mg/L NH_3-N except for station 2 of second sampling which is higher than the standard. If the value is higher than 2.7 mg/L NH_3-N, the water is consider dangerous because it may harm aquatic life. More NH_3 will present if pH value is high. Many types of fish can bear distinctive level of ammonia but however less of ammonia is better. Ammonia toxicity may be the main reason of unexplained misfortunes in fish hatcheries. The fish response to toxic level could be loss of appetite, laying on the bottom of pond or water body with clamped fins or gasping at the surface of the water if the gills being affected. Those response similar with the response to poor water quality, parasite infestations and other disease (Irena Noubi, 2015).



	Station 1	Station 2	Station 3
First sampling	0.14	0.16	0.17
Second sampling	0.14	0.35	0.21
INWQS	0.3	0.3	0.3

Figure 4.11: The concentration of Ammoniacal Nitrogen at Pekan River

4.3.10 Heavy Metals

The heavy metals that have been measured were lead (Pb), Zinc (Zn), Chromium (Cr) and Copper (Cu). Water pollutants mainly consist of heavy metals, microorganisms, fertilizer and plenty of toxic compounds. The heavy metals measured according to the stations for every sampling.

Heavy metals can be found easily in water environments because of natural sources and those due to anthropogenic causes. Heavy metals were the most important pollutants which affect water, soil and air quality. The presence of heavy metals creates permanent effects to living organisms that participate in the food chain which can cause many diseases include cancer. A large part of heavy metals got into the water and went deep because of the molecular weight which can resulted pollution in river. Many creatures that inhabit the rivers were suffered by these metals, as a part of the absorption of these organisms in food chain (EPA, 1980).

Table 4.1: Heavy metals contain in Pekan River

Heavy Metals	Station	First Sampling (mg/L)	Second Sampling (mg/L)
Pb	1	0.014	0.019
	2	0.022	0.031
	3	0.017	0.025
Zn	1	1.361	1.519
	2	1.623	2.484
	3	1.429	2.178
Cr	1	0.481	0.492
	2	0.490	0.532
	3	0.488	0.499
Cu	1	0.396	0.401
	2	0.411	0.452
	3	0.399	0.412

Lead (Pb)

The concentration of lead for the first station was decreased during the second sampling as shown in table 4.1. This may be due to the water was hot and the area was dried. The amount of lead for the second and third station were slightly increased and may be cause by the discharge of effluent from the shrimp pond farming. However the amount of lead from all the station and both sampling were below than 0.05 mg/L which stated in the standard limit of lead from the Ministry of Health under untreated raw water category. Lead in nature emerges from both natural and anthropogenic sources. Exposure can happen through sustenance air, soil and dust from old paint containing lead. Lead pollution in water systems had seriously influenced the quality of life, especially in developing country (Ling Cao, 2007).

Zinc (Zn)

Table 4.1 shows the amount of zinc for the all stations were increased during the second sampling but still within the standard limit of zinc 3 mg/L stated in the Ministry of Health untreated raw water standard. Zinc normally present in water. Zinc was not credited as a danger class water and not view as a hazard to the user. This however just concern on basic zinc because some mixed zinc like zinc arsenate and zinc cyanide may be greatly dangerous. Zinc was a dietary mineral for human being and other living things but still overdose of zinc might adversely impact the user and more than a certain limit consumed, zinc may even be dangerous. The other factor that contributes of zinc in river might be from natural sources. the largest input of zinc to water results from erosion of soil particles containing natural traces of zinc (45400 metric tons/ year) (EPA, 1980).

Chromium (Cr)

The concentration of chromium was increased for the second sampling of all stations as shown in table 4.1. However the value still below 0.05 mg/L which the standard made by Ministry of Health under untreated raw water category. The chromium in water might came from natural sources such as leaching from topsoil and rocks. Chromium was unstable in an oxygenated environment and, when exposed to air, immediately produces an oxide layer which is impermeable to further oxygen contamination. The most common forms of chromium were chromium-3 and chromium-6. Chromium-3 is an essential human dietary element. It is found in many vegetables, fruits, meats, grains, and yeast. Chromium-6 occurs naturally in the environment from the erosion of natural chromium deposits. It can also be produced by industrial processes (Preena Sharma, 2014).

Copper (Cu)

Table 4.1 shows the amount of copper was increased in the second sampling but still below the standard of 1.0 mg/L. When copper ends up in soil, it strongly attaches to organic matter and minerals. As a result it did not travel very far after release and it hardly ever enters groundwater. In surface water, copper can travel great distance either suspended on sludge particles or as free ions (MERC, 2010).

4.4 Water Quality Classification

Based on the result from the test, all the data and value had been used to calculate the Water Quality Index (WQI) classification for each station. The data for parameter DO, BOD, COD, TSS, pH and Ammoniacal Nitrogen had been used to calculate the WQI. After calculation, the result of water quality classification for each station either the river clean, slightly polluted or polluted was showed in table 4.2.

Table 4.2: The result of WQI

Station	DO	BOD	COD	NH_3-N	TSS	pH	WQI	Class	Status
1 (Before)	0	86.44	49.86	85.8	95.13	99.32	64.61	Class III	Slightly polluted
2 (Before)	0	85.17	53.37	83.7	95.10	99.20	64.40	Class III	Slightly polluted
3 (Before)	0	83.90	54.27	82.65	95.15	99.36	64.26	Class III	Slightly polluted
1 (After)	0	80.10	57.09	85.8	95.04	98.98	64.31	Class III	Slightly polluted
2 (After)	0	78.37	63.11	69	94.91	98.37	62.33	Class III	Slightly polluted
3 (After)	0	82.63	61.04	78.45	94.99	98.55	64.17	Class III	Slightly polluted

WQI results for the three stations were calculated based on six weighted parameters. Based on the three sampling station, WQI ranged were from 60 to 80 which were classified into class III and their status was slightly polluted. As compared to the Malaysian’s WQI guideline by Department of Environment (DOE), the WQI index for class III represented common use for fishery, economic value and tolerant and also can be used for livestock drinking but however require extensive treatment if for water supply usage.

CHAPTER 5

CONCLUSION

5.1 Conclusion

Water quality of Pekan River has been known through the test that were conducted for each parameter. The entire test such as temperature, pH, DO, turbidity, BOD, COD, TSS, TDS, Ammoniacal Nitrogen and heavy metals has been successfully conducted to be able to calculate the WQI classification. Besides, all the result has been compared to INWQS to show the class of water and their status.

As conclusion, the water of Pekan River is under class III which is slightly polluted. It shows that the river water is not suitable to be used as water supply and need further treatment if want to do so. The calculation of sub-indexes for individual water quality parameter was helpful in identifying the problematic parameter of the river cause by the effluent of shrimp pond farming. Monitoring and preventing control should be conducted to minimize effect of discharged wastewater from the shrimp pond farming to the water quality of the Pekan River.

5.2 Recommendation

A series of water quality test on the water sample was successfully done. The recommendation proposed to improve the quality of water at Pekan River is societies should aware about the quality of river nowadays. It is because the responsibilities in protecting and maintaining the quality of the river are not depends on government only. This is a shared responsibilities and cooperation by all societies in protecting the water quality of Pekan River especially the aquaculture industry that being conducted along the riverside. The awareness campaign could be practice to produce the healthy and quality life.

5.3 Study Limitation

There are some factors that can give affect towards the quality and accuracy of this study. The results of this study may be differs from the other research paper that have been done by the other researcher because of these factors.

Firstly, it is regarding the limited number of samples. This is because the location of some point of samples is quite dangerous to be taken like at estuary so only the point that near to the pond farming can be taken.

Then, there is limited time to take the samples. The samples need to be taken once the pond farming is being harvested and the pond water being discharged into the river that is every three month.

Next is regarding the salinity parameter cannot be tested in this study. This is because the equipment to check the level of salinity is not functioning well and the reading is not accurate. Furthermore the laboratory has only one equipment or salinity meter so there is no back up equipment to test this parameter.

REFERENCES

(APHA), A. P. (1999). *Standard methods for the examination of water and wastewater.* Retrieved from American Public Health Association, American Water Works Association and Water Pollution Control Federation 20th edition.

Amneera, W. R. (2013). Water Quality Index of Perlis River, Malaysia. *International Journal of Civil & Environmental Engineering IJCEE-IJENS Vol:13 No:02*.

Aziz HA, A. M. (2007). Heavy metals (Cd, Pb, Zn, Ni, Cu and Cr(III)) removal from water in Malaysia: post treatment by high quality limestone. *Bioresource technology*, 1578-1583.

Dabi, M. (2015). The Impact of Aquaculture on the Environment: A Ghanaian Perspective. *The International Journal Of Science & Technoledge*, 106-113.

EPA. (1980). *Exposure and Risk Assessment for Zinc*. Retrieved 20 November, 2018, from EPA: https://nepis.epa.gov

ERONDU, E. a. (2005). Potential hazards and risks associated with the aquaculture industry. *African Journal of Biotechnology Vol. 4(13)*, 1622-1627.

Harrell, R. M. (2012). *What is Aquaculture?* Retrieved 22 April, 2018, from Maryland Institute for Agriculture and Natural Resources: http://www.mdsg.umd.edu/sites/default/files/files/What_is_Aquaculture.pdf

Irena Noubi, N. H. (2015). Effectiveness of Water Quality Index for Monitoring Malaysian River Water Quality. 231-239.

J.G. Cardoso-Mohedano, F. P.-O.-M.-F.-R.-C. (2016). Combined environmental stress fromshrimp farmand dredging releases in a subtropical coastal lagoon (SE Gulf of California). *Marine Pollution Bulletin*, 83-91.

Jimoh, J. Y. (2010). Analytical Studies on Water Quality Index of River Landzu . *American Journal of Applied Sciences 7 (4)*, 453-458.

K.Saffran, K. K. (2001). CCME Water Quality Guidelines for the Protection of Aquatic Life. *Canadian Environmental Quality Guidelines, Canadian Council of Ministers of the Environment*.

Kaijin, X. B. (2007). Shrimp farming in China: Operating characteristics, environmental impact and perspectives. *Ocean & Coastal Management*, 538-550.

Kathamuthu, M. H. (2005). Shrimp farming in Malaysia. *Shrimp farming in Malaysia. In: Regional Technical Consultation on the Aquaculture of P. vannamei and Other Exotic Shrimps in Southeast Asia, Manila, Philippines,* 50-56.

Konsortium, I. W. (2018). *Ammonia.* Retrieved 23 April, 2018, from Indah Water: https://www.iwk.com.my/do-you-know/ammonia

Lee Nyanti, G. B. (2011). Shrimp Pond Effluent Quality during Harvesting and Pollutant Loading Estimation using Simpson's Rule. *International Journal of Applied Science and Technology*, 208-213.

Ling Cao, W. W. (2007). Environmental Impact of Aquaculture and Countermeasures to Aquaculture Pollution in China. *Aquaculture Pollution in China*, 452-462.

M. Meybeck, E. K. (1996). Chapter 2 - WATER QUALITY. *Water Quality Monitoring - A Practical Guide to the Design and Implementation of Freshwater Quality Studies and Monitoring Programmes*, 1-22.

Madhuri, G. P. (2014). Heavy Metals Causing Toxicity in Animals and Fishes. *Research Journal of Animal, Veterinary and Fishery Sciences*, 17-23.

MERC. (2010). Study on Pollution Prevention and Water Quality Improvement of Sungai Kuantan Basin, Pahang. *RMK 9 Special Study: Department of Environment (DOE) Malaysian Environmental Resources Center*.

Preena Sharma, P. M. (2014). Sustainability of water quality and ecology. 67-76.

Rigos, K. G. (2011). Aquaculture effects on environmental and public welfare – The case of Mediterranean mariculture. *Chemosphere*, 899-919.

S. Caeiro, P. V.-F.-D. (2016). Environmental risk assessment in a contaminated estuary: An integrated weight of evidence approach as a decision support tool. *Ocean & Coastal Management*, 1-12.

Saeed Shanbehzadeh, M. V. (2014). Heavy Metals in Water and Sediment: A Case Study of Tembi River. *Journal of Environmental and Public Health*, 1-5.

Saremi A., S. K. (2012). The effect of aquaculture effluents on water quality parameters of Haraz River. *Iranian Journal of Fisheries Sciences*, 445-453.

T.Y.Ling, D. L. (2010). Water Quality and Loading of Pollutants from Shrimp Ponds during Harvesting. *Journal of Environmental Science and Engineering*, 13-18.

Teck-Yee Ling, N. J. (2012). Water and Sediment Quality Near Shrimp Aquaculture Farm in Selang Sibu River, Telaga Air, Sarawak, Malaysia. *World Applied Sciences Journal*, 855-860.

Xie Biao, D. Z. (2004). Impact of the intensive shrimp farming on the water quality of the adjacent coastal creeks from Eastern China. *Marine Pollution Bulletin 48*, 543-553.

Zainudin, A. B. (2009). "Keynote Paper: Moving Towards Integrated River Basin Management (IRBM) in Malaysia". *The Institution of Engineers, Malaysia (IEM), Proceedings 11th Annual IEM Water Resources Colloqium*.

APPENDIX A
SAMPLE COLLECTION

Figure A1: Sampling station1

Figure A2: Sampling station 2

Figure A3: Sampling station 3