ADVERSE EFFECT OF ANTHROPOGENIC ACTIVITIES ON WATER QUALITY OF KUANTAN RIVER, KUANTAN

MUHAMMAD AMMARHARIZ BIN HAMDAN

B. ENG(HONS.) CIVIL ENGINEERING

UNIVERSITI MALAYSIA PAHANG

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MUHAMMAD AMMARHARIZ BIN HAMDAN

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ABSTRAK

Pada masa kini, keadaan air di Malaysia banyak tercemar dan menjadi lebih serius kerana kualiti air berada dalam keadaan buruk akibat aktiviti antropogenik yang dijalankan. Untuk kajian ini, Sungai Kuantan telah dipilih untuk kualiti air yang terletak pada 03°50.9° latitud dan 103°29.2° dalam negeri Pahang dengan sepanjang 440km. Sungai Kuantan dipilih sebagai tapak kajian kerana dipercayai bahawa sungai ini telah tercemar dengan beberapa jenis pencemaran. Objektif kajian ini adalah untuk menentukan sifat kualiti air berdasarkan Indeks Kualiti Kebangsaan (NWQS) dan Indeks Kualiti Air (WQI) dan untuk mengenal pasti punca dan sumber pencemaran untuk pengurusan kawasan perindustrian Kuantan. Untuk mencapai matlamat ini, tiga kali sampel air diambil setiap bulan dari Mac hingga Mei 2017 pada tiga stesen yang berlainan di sepanjang Sungai Kuantan. Semua stesen adalah kira-kira 5 hingga 6 meter dari longkang yang melepaskan air dari kawasan tercemar yang dijangkakan. Parameter fizikal, kimia dan biologi dianalisis dengan menggunakan kaedah standard. WQI dikira berdasarkan kepekatan pH, jumlah pepejal terampai (TSS), nitrogen ammonia (NH3-N), permintaan oksigen kimia (COD), permintaan oksigen biokimia (BOD) dan oksigen terlarut (DO). Parameter lain yang dianalisis dalam kajian ini ialah kekeruhan, suhu, kekonduksi elektrik (EC) dan logam berat terpilih yang terdiri daripada kadmium (Cd) dan tembaga (Cu). Hasil daripada kajian ini menunjukkan bahawa nilai WQI di setiap stesen berada di rentang 80.53-83.08 yang dalam Kelas II-III. Kepekatan tertinggi tembaga adalah di stesen 3 semasa pensampelan 1. Kepekatan rendah kadmium adalah di stesen 2 semasa pensampelan 2.Nilai skor WQI di Stesen 1, 2 dan 3 masing-masing adalah 82.30, 83.08, dan 80.53. Status sungai ini dalam keadaan tercemar. Di NWQS, Sungai Kuantan diklasifikasikan di bawah Kelas I-III. Faktor utama kegiatan antropogenik yang mempengaruhi kemerosotan kualiti air ialah pembetungan dan saliran di kawasan kediaman, aktiviti pembinaan, pertanian dan hutan yang berhampiran dengan sungai. Cadangan untuk pengurusan mampan untuk mengatasi masalah pencemaran air kerap memeriksa dan penyelenggaraan untuk memastikan tangki septik dan kumbahan betul beroperasi.

ABSTRACT

Nowadays, the condition of water in Malaysia are much polluted and becoming more serious because the water quality is in bad condition due to anthropogenic activity that was carried out. For this study, the Kuantan River has been chosen for water quality which were located at 03°50.9° latitude and 103°29.2° within the capital state of Pahang with length 440km respectively. The Kuantan River was chosen as the sampling site because it is believed that this river has been polluted with several kinds of pollution. The objectives of this study were to determine the characteristic of water quality based on National Quality Standard (NWQS) and Water Quality Index (WQI) and to identify the causes and sources of pollutant for sustainable management of the Kuantan industrial area. To achieve this objective, three times of water samples were collected from March to May 2017 at the three different stations along the Kuantan River. All of the stations were about 5 to 6 meters from drains that discharged water from the expected polluted area. Physical and chemical parameters were analyse using standard methods. The WQI was calculated based on the concentration of pH, total suspended solid (TSS), ammonia nitrogen (NH3-N), chemical oxygen demand (COD), biochemical oxygen demand (BOD) and dissolved oxygen (DO). Other parameters that were analyse in this study were turbidity, temperature, electrical conductivity (EC) and selected heavy metal which are cadmium (Cd) and copper (Cu). Result from this study showed that the values of WQI at each station were in the range 80.53-83.08 that in the Class II-III. The WQI score value at Station 1, 2 and 3 were 82.30, 83.08, and 80.53 respectively. The status of this river was in clean and slightly polluted condition. In NWQS, the Kuantan River is classified under Class I-III. The highest concentration of copper is at station 3 during sampling 1. The lowest concentration of cadmium is at station 2 during sampling 2. The main factors of anthropogenic activities that influence the degradation of water quality were sewerage and drainage in a residential area, construction activities, agricultural and forested that near the river. The suggestion for sustainable management to overcome water pollution problem is regularly inspect and maintenance to ensure the septic tank and sewage is properly operate.

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LIST OF SYMBOLS

H_2O	Water compound
NH_3-N	Ammonia Nitrogen
^oC	Degree Celsius
H+	Hydrogen ions
Cu	Copper
Cd	Cadmium
µS/cm	Microsemens per centimetre
mL	Millilitre
mg/L	Milligram per litre
%	Percentage

LIST OF ABBREVIATIONS

NEST	Northwest Environmental Science and Technology
AAS	Atomic Absorption Spectroscopy
BOD	Biochemical Oxygen Demand
COD	Chemical Oxygen Demand
DO	Dissolved Oxygen
DOE	Department of Environment
EC	Electrical Conductivity
NWQS	National Water Quality Standard
TSS	Total Suspended Solid
WQI	Water Quality Index

CHAPTER 1

INTRODUCTION

1.1 Introduction

The first thing that we must need in our life is water. Water is known as essential element to human, animals, and many living things on earth. Over 70% of the earth's surface were cover with the water and about 70% of human body contains water. Water is a basic molecule that forming a strong bond from the two hydrogen atoms and one oxygen atom combine together by shared electrons. Hence it will produce the chemical formula of H_2O. There is surface water where the water that come from rain or hail that usually collected in the catchment, river or lake that are usually be a community of water supplies and spring are the water that is collected in the bottom of a hills or sloping. As one the earth natural resources, water is important in order to maintain a stable ecosystem on earth as well as to ensure a sustainable development in the process of preservation of our environment.

Nowadays, freshwater resources are really limited which is only about 4.5% while the other remaining source is saline water from the sea. The availability and quality of water always played an important part in determining not only where people can live but also their quality of life. As we all already know, Malaysia our country is emerging with the number of people become higher from year to another year and successful in the sector of industry. Now, Malaysia is striving towards the industrial development such as improvement in oil and chemical based industries. Malaysia are being a developing country but without we noticed this development process have affected our rivers, lakes and seas. Anthropogenic activities are the main causes of the water pollution. The end points of effluent discharged from industries are water bodies (Azhar, 2000). Ever- increasing industries and their effluents are the major threats to the surface water, as the end destination of industrial effluents is the river (Moorthy and Jeyabalan, 2012).

According to Diersing (2009) said that definition of water quality is used to described the biological, chemical and physical characteristics of water and its general composition. Water quality can be as a measure of the suitability of water for a particular use based on selected physical, chemical, and biological characteristics such as drinking, washing, swimming or fishing. Besides, water quality also depends on the local geology and ecosystem, human uses such as sewage dispersion, industrial pollution, use of bodies water as a heat dink and over use which can lower of water. Improper management of wastewater from the industrial area will give more critical problems to the environment especially to the environment.

Besides, the increasing growth of economy and industry in Malaysia are the causes that led to the environmental degradation including river water pollution. At the same time, the rivers are contributing significantly for the industrial development in Malaysia (Moorthy and Jeyabalan, 2012). About 98% of the country's water requirements are fulfilled from river water (Azhar, 2000). Hence, the river water pollution can effect serious health risk as well as environmental threats in the country. The major sources of industrial pollution in Malaysia are food & beverage, chemical & petrochemical, palm oil, textile, paper and rubber processing industries (Iyagba *et* al., 2008). This poor wastewater management practice will affect the quality of water as well as the aquatic life. In urban areas, the careless disposal of industrial effluents and other wastes may contribute to the poor quality of water (Mathuthu, 1997).

In this era of modernization and industrialization, the issues of environment often be a second matters in order to show the rapid growth of development building and environment. Increasing growth in industrial sector will generate more solid or liquid waste which could damage to the environment without having proper treatment plant. Industrialization with an increasing demand for the heavy metals results in a high emission of this pollutant into the atmosphere. Water bodies with heavy metal pollution are a serious threat to the aquatic ecosystem, human health as well as environment (M. A. Hossain *et* al., 2012). In Malaysia, water resources are often taken for granted and as a result, more surface water content become contaminated due to irresponsible action by industrialist and developers. Contaminants that may be in untreated water include microorganisms such as viruses and bacteria, inorganic contaminants such as salts and metal, pesticide and herbicides, organic chemical contaminants from industrial processes.

To determine water quality, there are two types of standard parameters which are Water Quality Index (WQI) and National River Water Quality Standard (NWQS). The quality of water are based on the Water Quality Index consisting of the parameters such as dissolved oxygen (DO), biochemical oxygen demand (BOD), chemical oxygen demand (COD), ammonia nitrogen (NH_3-N), total suspended solids (TSS) and pH (Lim Fui Ling, 2007). This research is prepared to study on water pollution due to industrial activities and Water Quality Index in Kuantan river, Pahang.

1.2 Problem statement

Malaysia is rich with its bounty of water resources. It is contributing to the economic and industrial development of the country (Moorthy R. and Jeyabalan G., 2012). The situation now is also changing day by day with the increasing of population growth, urbanization, and rapid growth of industrialization. The industrial may not properly manage their industrial liquid wastage and drained the wastage into the nearest river. Industries are generating conventional and non- conventional pollutant and discharging into the river flow that causes the deterioration of water quality (M.A. Hossain *et* al., 2012). This causes pollution to the rivers and effect their water quality index.

Kuantan is the main district to Pahang where Kuantan river is a strategic important river where the river links the town with the sea. Rapid growth of population and increasing industrialization at Kuantan producing lots of effluent and they are discharging those effluents in the sea as result polluting the water of the sea. The real situation is the rapid developments including the petrochemical, multifarious industries are generating effluent which contains high concentration of conventional and non-conventional pollutant that deteriorating the water quality of the river. Therefore, the study was conducted to determine water quality characteristic.

1.3 Objective of study

There are two objectives for this study based on the problem statement. The objectives are as below:

1. To determine the characteristic of water quality based on National Quality Standard (NWQS) and Water Quality Index (WQI).
2. To identify the possible cause and source pollutant for sustainable management of the Kuantan industrial area.

1.4 Scope of study

The scope of study area is Kuantan River which is located in the main town of Kuantan, Pahang. Kuantan's river was chosen due to fast development along the river by human kind activities. Kuantan's river has rapidly urban development and there is a lot of sources of river pollution such as surface runoff, industrial activities, municipal solid waste, agriculture and fishing activities. The purpose of this study is to determine the sources of pollution for sustainable management in the Kuantan River. Besides, this study also to classify the water quality based on the Malaysian National Quality Standard and Water Quality Index (WQI). The study of parameter are dissolved oxygen (DO), biochemical oxygen demand (BOD), chemical oxygen demand (COD), ammonia nitrogen (NH_3-N), suspended solids (SS), turbidity, heavy metals, temperature, electrical conductivity and pH value. River classification will follow the DOE-WQI. The samples will be examined at field and laboratory. Six parameters will be tested in-situ which is Dissolved Oxygen (DO), turbidity, temperature, pH value and electrical conductivity and salinity. The other parameters such as BOD, COD, Ammonia Nitrogen, heavy metals and TSS will be tested in the laboratory.

1.5 Significant of study

This study is very important to determine the water quality at Kuantan river according to the standard parameter that have been mentioned. Due to industrial activities and construction activities, the study area is more polluted where they are carrying solid and liquid waste and there are discharging into the Kuantan river which is the one of important river in Pahang. So, this study is important to know the water quality status at Kuantan river before finding a solution of this problem. If the level of water quality in the area is low, the government which is municipal authorities need to take an immediate action to improve the water quality so that the pollution of river will decrease.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Water plays a major basic need in human life. A plentiful of water is one of the important factors in the development of urban societies. Nowadays, the quantity of water is more needed than the quality of water. The availability of water can improve human life. Water is used for domestic, industrial, commercial, agricultural activities and public used. In general, the amount of water supplied to residence is 150-480 L/capita/day.

Surface waters include rivers, lake, oceans and ice or snow. According to Department of Irrigation and Drainage, the number river in Malaysia is around 1800 rivers with a total length of 38,000km. River quality characteristics change from time to time. Rivers is one of the major sources for generating electrical conductivity, transportation and habitat for aquatic life. Rivers also used as a basic need for human being for drinking, agricultural, household activities (cooking and bath) and habitat for aquatic life.

High contaminant in water caused by many sources such as direct storm run-off and effluent released before being treated. The concentration of heavy metal in rivers is increasing because most of the waste water from residential and industrial area are disposed to the river. Aquatic life needs to be preserved from todays because it will generate nation income through tourism and natural sight-seeing for next generation.

2.2 Anthropogenic activities effect

Impact Anthropogenic activity have led to increased river pollution as manmade solid and fluid waste materials of adverse impacts on living and non-living resources in the region. Erosive forces including running water carry chemicals from open farmlands contaminating the rivers in the region which become health insecurity to residents in the region. Most of the residents in the region depend on river water for survival. Contamination of water, air and soil resources affects standards of human life by lowering its quality and normal functioning.

Anthropogenic activity has potential to greatly disrupt aquatic ecosystems. Generally, these ecosystems are adapted to cyclic natural phenomena such as seasonal storms and climatic fluctuations. Organisms are also generally adapted to natural perturbations such as high winds and tides, and pulses of freshwater inflow. In contrast, human disturbances are generally continuous, non-cyclic events (e.g., trawling) for which organisms are not adapted. Some events are episodic, (such as oil and chemical spills) and can be toxic. Anthropogenic activity that impact bay bottom habitats include a variety of activities related to marine transportation, commercial and recreational fishing and tourism. Frequency of these activities and their impact increases with increasing human populations and human use of the ecosystem. (Montagna et.al, 1998).

2.3 River pollution

Since decade ago, water pollution is one of the most critical conflicts that happen in many develop country. Many of the main rivers in developing countries face the degradation of the water quality (Monika et all, 2009). This is due to their urbanization and fast development. Precisely, the water pollution can happen because of urban runoff. Urban runoff may lead to a variety of conflicts, including pollution when receiving water directly, overloading the treatment facilities, improperly management of waste, and various pollutants contained in the runoff itself. In urban area, rainfall runoff is defined as storm water is one of the major pollution because this type of runoff usually polluted with car oil, dust and faeces of animals, while for industrial areas it contained chemicals and toxic.

2.4 Source of water pollution

There are many factors that affect the water pollution which is from natural and anthropogenic activities. There are two type source of water pollution which is point sources and non- point sources.

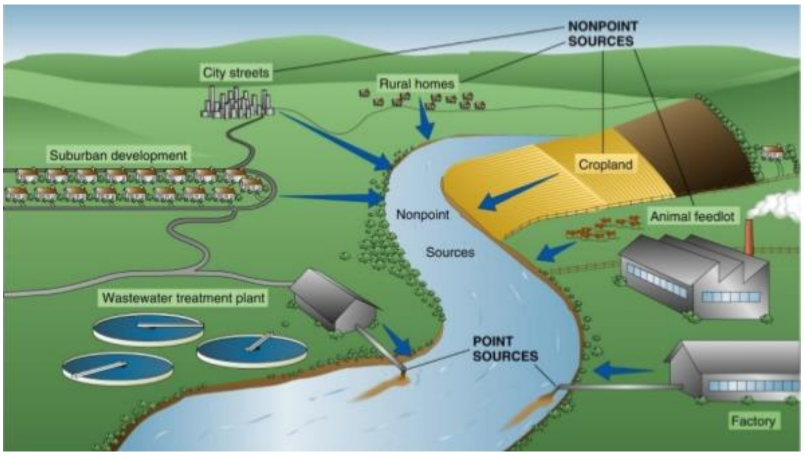

Figure 2.1: Point sources and non-point sources representation

Source: Pearson Prentice Hall, Inc (2005)

2.4.1 Point sources

The U.S. Environmental Protection Agency (EPA) defines point source pollution as "any single identifiable source of pollution from which pollutants are discharged, such as a pipe, ditch, ship or factory smokestack" (Hill, 1997).

Industrial facilities and sewage treatment plants are two basic sorts of point sources. Processing plants, including oil refineries, mash and paper factories, and compound, gadgets and car producers, regularly release at least one contamination in their released waters (called effluents). A few production lines release their effluents specifically into a water body. Others treat it themselves before it is discharged, and still others send their squanders to sewage treatment plants for treatment. Sewage treatment plants treat human squanders and send the treated emanating to a stream or waterway.

2.4.2 Non-point sources

Most non-point source contamination happens as a consequence of overflow. Whenever rain or dissolved snow moves over and through the ground, the water retains and acclimatizes any toxins it comes into contact. Taking after an overwhelming rainstorm, for instance, water will stream over a parking garage and get oil left via autos driving and stopping on the black-top. When you see a rainbow-shaded sheen on water streaming over the surface of a street or parking area, you are really taking a gander at non-point source contamination.

This overflow then keeps running over the edge of the parking area, and in all probability, it in the end purges into a stream. The water streams downstream into a bigger stream, and after that to a lake, waterway, or sea. The contaminations in this overflow can be entirely hurtful, and their sources various. We ordinarily can't indicate one cautious area of non-point source contamination like we can with a release pipe from a processing plant.

2.5 Water quality parameters

Water quality can determine biological, physical and chemical characteristics of the water. The common physical characteristic of water is temperature, turbidity, electrical conductivity and total suspended solids while chemical parameter of water is Dissolved Oxygen, Chemical Oxygen Demand, Biochemical Oxygen Demand, ammoniacal nitrogen and pH.

2.5.1 In-situ Test

2.5.1.1 Temperature

The temperature of water is an important parameter that we should consider because it can influence the rate of chemical and biological reactions. It also creates the maximum capacity of water on dissolved oxygen. The concentration of dissolved oxygen is affected by temperature of the water. Oxygen is more easily consumed in cold water compare to hot water.

In high temperature in water give high rate of reaction due to solubility of chemicals and high reproductive activities, metabolism and growth in aquatic life. Each aquatic life has different temperature that they can withstand to survive. Based on book of Aquaculture Technology and Environment by Ujwala Jadhav, most of tropical fish cannot survive below 100 ^{0}C, Tilapia cannot survive below 80 ^{0}C, Indian major carp can survive a wide range of temperature (200 ^{0}C to 370 ^{0}C) and below 160 ^{0}C and above 400 ^{0}C shows lethal to them.

2.5.1.2 Turbidity

Turbidity is the measure of clarity of water based on the amount of light that scattered by suspended solids. Suspended solid such as industrial waste, sewage, rock fragments, clay or silt are the causes the turbidity in water. Not only those materials, microorganisms and vegetable fibers also contribute to turbidity. Both turbidity and total suspended solid are related but to measure turbidity is not directly from total suspended material in water. It was measure of clarity of the water by indicate changes of total suspended solid concentration in water without an exact measurement of solids.

High turbidity will decrease the aesthetic value and also disturbing aquatic life such as growth and fish feeding. Besides that, in cloudy water a little light can be through into the water this will disturb the plant to undergo photosynthesis and also reduce the visual range of people and animals.

2.5.1.3 Dissolved oxygen (DO)

Dissolved oxygen is the amount of oxygen that is present in the water. This parameter is one of the important parameter to assessing water quality because it is influence the organisms that living within the water. If the dissolved oxygen level either too high or too low can cause harm to aquatic life and affect the water quality.

Usually large river or in a mountain stream has a tendency to contain considerable measure of dissolved oxygen compare to stagnant water which is less dissolved oxygen. Pathogens in water can devour oxygen as organic matter decays. Therefore, surplus of organic material in streams and lakes can promote to eutrophic conditions where an oxygen-deficient circumstance that can cause a water body “to die”. The aquatic life will have difficulties to survive in stagnant water that contain a lot of decaying organic material in it especially during long hot days because the concentration of dissolved oxygen is decreasing when the temperature of water is increasing.

2.5.1.4 Electrical conductivity (EC)

Electrical conductivity is the capability of water to convey electric current. EC is also the value of total dissolved solids in water. EC is caused by the dissolved salts (such as chloride and sodium) presence in water. High value of EC shows high ion content in water. EC will not disturb human and aquatic life literally but it is one of the fast way to find out any changes of water quality. Rivers contain dissolved solid which coming from soil and rock weathering process. The unit use for EC is Siemen per meter

(S/m). EC can be effect by the temperature. Higher temperature will produce high EC in water.

2.5.1.5 pH value

pH indicates the sample's acidity but is actually a measurement of the potential activity of hydrogen ions (H+) in the sample. pH measurements run on a scale from 0 to 14, with 7.0 considered neutral. Solutions with a pH below 7.0 are considered acids. Solutions with a pH above 7.0, up to 14.0 are considered bases. All organisms are subject to the amount of acidity of stream water and function best within a given range.

According to the Pennsylvania Department of conservation and Natural Resources (DCNR), the pH level can be caused by certain chemicals that been dump into water system. Dumping may be done by several individual, communities and industries. The other factor that can affect the pH level in stream or water are due to interactions with surrounding rock and other material. The carbon dioxide will be released during the composition of material where it turns the pH value to low in the water.

On the other hand, during photosynthesis and respiration the carbon dioxide was removed from water. Since plants do photosynthesis when there is sunlight this will increase the pH level in water. At middle of afternoon the pH level of the water will be at highest level due to photosynthesis of the plants.

2.5.2 Ex-situ test

2.5.2.1 Total Suspended Solid (TSS)

Total suspended solid are particles that are larger than 2 microns that can be found in water but if the particles is smaller than 2 microns are known as dissolved solid. Algae and bacteria are organic particles that contribute to total suspended solid concentration. Besides that, inorganic matter such silt, clay and other also contributes to increase total suspended solid in water. The total suspended solid is related to turbidity of water because high total suspended solid cause the water cloudy, murky and affecting the physical look of water.

2.5.2.2 Chemical oxygen demand (COD)

Chemical Oxygen Demand test is usually used to measure the amount of organic compounds in water. In other words, the value of COD indicates the amount of oxygen needed for the organic substances to oxidize in the water. Usually COD used to gain the amount of organic pollutants in surface water. This makes the COD an important element in determination of water quality.

The procedure of COD test based on decomposition of chemical of organic and inorganic contaminants either suspended or dissolved in water. The result of this test indicates the water-dissolved oxygen amount which is expresses as parts per million that consumed by contaminants. The higher the COD shows that higher polluted the water.

2.5.2.3 Biochemical oxygen demand (BOD)

Biochemical oxygen demand is a chemical procedure for determining the amount of dissolved oxygen needed by aerobic biological organisms in water to break down organic material present in a given water sample at certain temperature over a specific time period. Commonly, the standard BOD5 is used to determine the amount of dissolved oxygen can be used by organisms.

The level of BOD should be low in the clean water but high in polluted water. BOD is affected by same factor as dissolved oxygen. Where the higher the BOD, the more rapidly depleted oxygen occur in the stream. The low dissolved oxygen will increase the stress for the aquatic life to survive.

2.5.2.4 Ammonia nitrogen (NH_3-N)

Ammonia nitrogen is a determination of the ammonia amount, which is a toxic pollutant that usually found in the landfill leachate, or in the waste product. NH_3-N also is a measurement of water quality in natural bodies such as lakes, man-made reservoirs, and rivers. This element commonly used in waste water treatment and system of purification. However, this ammonia can be poison to human and change the equilibrium of water system.

While nitrogen is an essential nutrient for all types of life as a building block for proteins of plant and animal. However, if the nutrient is too much, it will be toxic to the living organisms. The excess present of the nitrogen might cause serious distortions to the natural nutrient cycle among the atmosphere, water and soil. Excessive NH_3 can cause the taste and odour problem to the water system.

Ammonia nitrate is soluble in the water, and produce ammonium hydroxide which is a temporary constituent in water because it is part of nitrogen cycle which affected by biological activities.

2.5.2.5 Heavy metals

The term heavy metal refers to any metallic chemical element that has a relatively high density and is toxic or poisonous at low concentrations. Examples of heavy metals include copper (Cu), cadmium (Cd), arsenic (AS), chromium (Cr), thallium (Ti) and lead (Pb). Heavy metals are natural components of the earth' crust. They can't be degraded or destroyed. Heavy metals (HM) are natural trace components of the aquatic environment, but their levels have been increased due to industrial wastes geochemical structure, agricultural and mining activities. (Zeitoun et al., 2014)

Human activities such as industrial production, mining, agriculture and transportation, release high amounts of heavy metals into surface and ground water, soils and ultimately to the biosphere. Accumulation of heavy metals in crop plants is of great concern due to the probability of food contamination through the soil root interface. Though the heavy metal like, Cd, Pb and Ni are not essential for plant growth, they are readily taken up and accumulated by plants in toxic forms. Ingestion of vegetables irrigated with waste water and grown in soils contaminated with heavy metals possess a possible risk to human health and wildlife. Pollution of heavy metals in aquatic environment is a growing problem worldwide and currently it has reached an alarming rate. There are various sources of heavy metals; some originates from anthropogenic activities like draining of sewerage, dumping of Hospital wastes and recreational activities. (Nazir et al, 2015)

The major sources of heavy metal pollution in urban areas of Africa are anthropogenic, while contamination from natural sources predominate in the rural areas. Anthropogenic sources of pollution include those associated with fossil fuel and coal combustion, industrial effluents, solid waste disposal, fertilizers and mining and metal processing. At present, the impact of these pollutants is confined mostly to the urban centres with large populations, high traffic density and consumer-oriented industries. Natural sources of pollution include weathering of mineral deposits, brush burning and windblown dusts. Among the heavy metals, the most serious effect of pollution is presently associated with lead (Pb) emission. (Olade, 1987).

2.5.2.6 National water quality standard (NWQS) and water quality index (WQI)

The development of a composite index of water quality will allow assessment of the overall quality of inland surface water resources as it relates to both human and aquatic ecosystem health. The selection of parameters used to assess the quality of water depends largely on the intended use of the body of water. From a worldwide point of view, it is essential to distinguish a couple of reliable estimations that give understanding into the general nature of surface waters and that can be checked effortlessly, by all, all the time. The parameters utilized here to measure water quality on a nation by nation premise were spoken to various key ecological issues that have worldwide importance, including natural contamination, supplement contamination, acidification, and salinisation, and together permit an appraisal of general water quality.

The Department of Environment (DOE) used Water Quality Index (WQI) to evaluate the status of the river water quality. The WQI serves as the basis for environment assessment of a watercourse in relation to pollution load categorization and designation of classes of beneficial uses as provided for under the National Water Quality Standards for Malaysia (NWQS).

The appendix A shows the water quality based on NWQS and WQI.

CHAPTER 3

METHODOLOGY

3.1 Introduction

We need to do research methodology in order to achieve the objectives of study. Methodology is a planning or rules from which specific methods or procedures may be derived that start from beginning until the end of research to understand or solve different problems within the scope of study. Knowing how the data was collected will help the study in evaluation the validity and reliability of the result.

A research can lead to new contributions to the existing knowledge. Only through research is it possible to make progress in a field with the help of study, experiment, observation, analysis, comparison and reasoning. Researches need to understand the assumptions underlying various techniques and criteria instead of develop certain techniques or methods that to be apply. The research methodology consists of the methods use, procedure for data collection and data analysis.

3.2 Flow chart

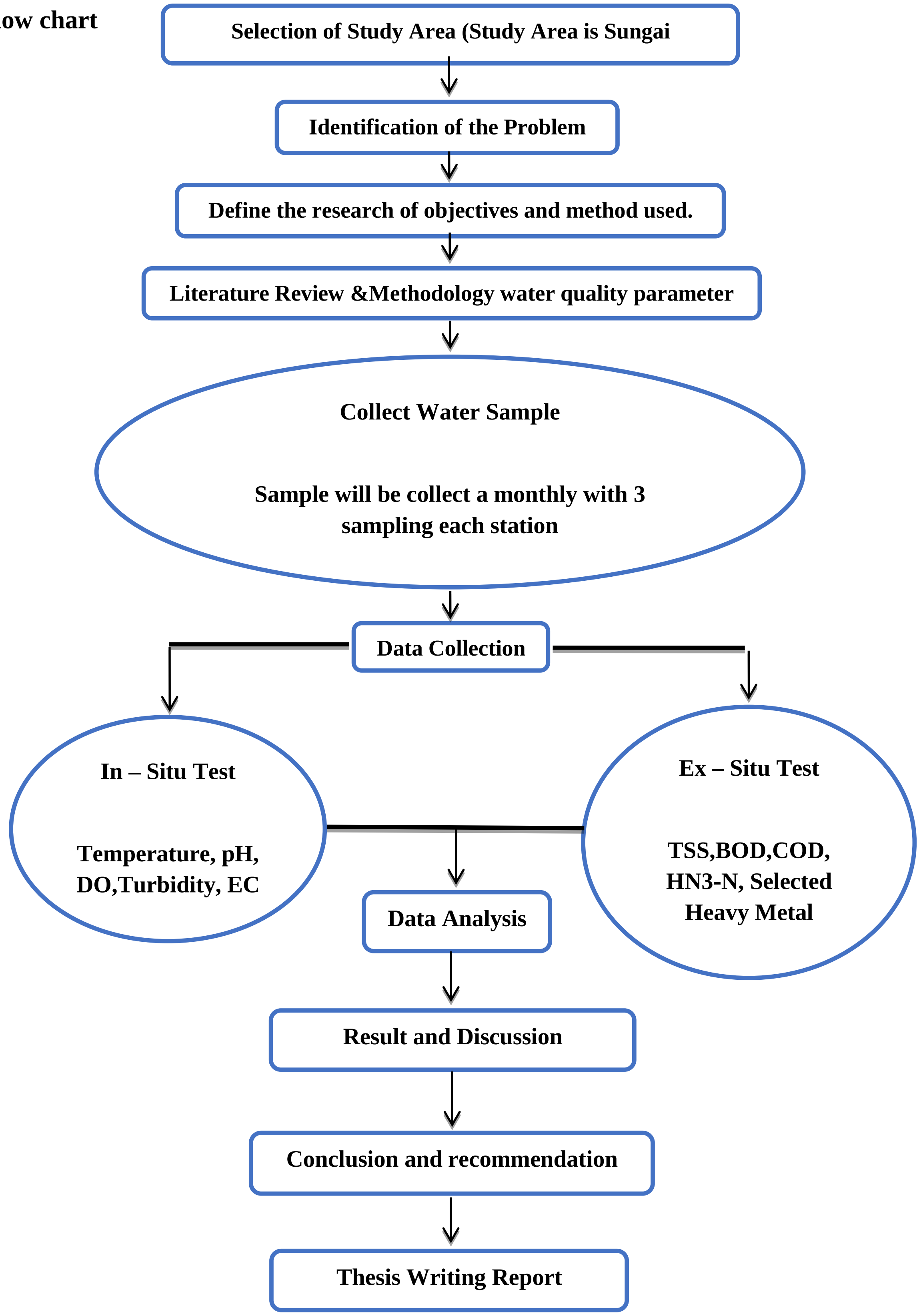

Figure 3.1: Research outline

3.3 Study area

Kuantan River located at 03◦50.9◦N latitude and 103◦29.2◦ E longitude, within the capital state of Pahang. Kuantan River was chosen as the sampling site because it is believed that this river has been polluted with several kinds of pollution. In addition, the location was near the fishing villages and there is rapid development in this area.

3.4 Location of sampling

Three different stations along the Kuantan River were chosen (Figure 3.2). The first station is located near to the fish landing jetty and industrial area. The second station is located in front of Hospital Tengku Ampuan Afzan (HTAA) Kuantan. The last station is near to Kampung Tanjung Api. All of the stations were about 5 to 6 meters from drains that discharged water from the expected polluted area. The samples were taken from the surface level. So, each station will take 3 sample each so that we can compare the difference in results.

Figure 3.2: Location of stations

3.5 Sampling collection

This study involves two types of study which are in situ test and analysis at laboratory for sampling and data collection. The three samples will be taken on Mac until May 2017 at three point source of area. The sampling locations are influenced by the location of human activities that surrounding the river. The information obtained from studies is used at this stage to help determine the points.

The samples were collected from three different of locations hence the samples bottle need to be prepared by labelled each of the bottles based on the sampling locations. However, the sample bottles need to rinse with distilled water. Make sure that the sample water does not contain other object which may affect the result when the time water sample taken.

Then, I repeated the same steps for every station until all water samples from different station was collected. The objective is to prevent the changes of the samples qualities. In additional, some extra specific preservation to the specimens for ex-situ parameters test had been provided.

3.6 Preservation method

Water sample collected at 10cm below the surface water using polyethylene bottles of acid wash. The water samples had been taken to the laboratory for further testing on the same day after a proper handled the sample in cool box with ice with low temperature (4°C or less). Maintain pH water samples in the acidity by adding dilute acid. The sample should be analysed within 24 hours for the best result. The water sample preservation based on the test will be conducted.

3.7 Testing method

3.7.1 In-situ test

This test is usually simple and easy to perform. The parameters involved for in situ tests are temperature, turbidity, dissolved oxygen (DO), pH and Electrical Conductivity (EC). I used the Kit-Probe instrument for in-situ test. Although it is simple to perform, it is very important to make sure the apparatus is calibrated before used in order to get valid and precise results. I can directly take the reading although the water is in flow mode. In order to obtain an average answer, I had repeated the steps for 3 times at every station along my monitoring period. Every time I repeat the steps, I will wash the sensor in order to prevent the environment effect to manipulate my reading.

3.7.2 Ex-situ test

Laboratory test is conducted in Laboratory at UMP. Based on standard procedure provided and helps form lab technician, all this test will be successfully done.

3.7.2.1 Biochemical oxygen demand (BOD)

The biochemical oxygen demand determination is a chemical procedure for determining the amount of dissolved oxygen needed by aerobic organisms in a water body to break the organic materials present in the given water sample at certain temperature over a specific period of time.

BOD of water or polluted water is the amount of oxygen required for the biological decomposition of dissolved organic matter to occur under standard condition at a standardized time and temperature. Usually, time is taken as 5 days and the temperature is 200 ^{0}C.

The test measures the molecule oxygen utilized during a specified incubation period for the biochemical degradation material such as sulfides and ferrous ion. It also may measure the amount of oxygen used to oxidize reduced forms of nitrogen (nitrogenous demand).

$$BOD_t = \frac{DO_i - DO_t}{P} \quad (3.1)$$

$$P = \frac{\forall_s}{\forall_s + \forall_D} \quad (3.2)$$

Where:

BOD_t	Biochemical oxygen demand, mg/L
DO_i	Initial DO of the diluted waste water sample about 1 minutes after preparation, mg/L
DO_t	Final DO of the diluted waste water sample after incubation for t days, mg/L
P	Dilution factor
$\forall_S$	Volume of sample
$\forall_D$	Volume of dilution water

3.7.2.2 Chemical oxygen demand (COD)

The chemical oxygen demand (COD) test is commonly used to indirectly measure the amount of organic compounds in water. Most applications of COD determine the amount of organic 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.

COD is measurement of the amount of oxygen in water consumed for chemical oxidation of pollutant. COD determines the quantity of oxygen required to oxidize the organic matter in water or waste water sample, under specific conditions of oxidizing agent, temperature and time.

This method covers the determination of COD in ground and surface waters, domestic and industrial wastewaters. The applicable range is 3-900 mg/L.

3.7.2.3 Total suspended solid (TSS)

A well-mixed sample is filtered through standard glass-fiber filter and the retained residue on the filter is dried to a constant weight at 103 to 105ºC. The increase in weight of the filter indicates the total suspended solids. If the total suspended solids material and substances clogs the filter and prolong filtration process, it may be necessary to increase the diameter of the filter or reduce the volume of the sample. To obtain the amount of the total suspended solid (TSS), the difference between total dissolved solid and total solid is calculated.

If there are large floating particles or submerged agglomerates of nonhomogeneous materials from the samples, they are excluded because it is determined that their illusion is not representative. This is because; the excessive residue on the filter may form a water-entrapping crust that limits the sample size to yielding not more than 200 mg residue. To ensure the removal of dissolved materials, the sample that has high dissolved solids thoroughly washes the filter. Prolonged the filtration times resulting from the filter clogging may produce high results to increased colloidal materials trapped on the clogged filter.

Considerable information may be gained on a wastewater sample by determining all its solids content. The types of the suspended and dissolved solids in the wastewater can be determined gravimetrically.

$$TSS = \frac{(A - B) \times 1000}{C} \qquad 3.3$$

Where:

A	Weight of filter and disc + residue in mg
B	Weight of filter and dish in mg
C	Volume of sample filtered in ml

3.7.2.4 Ammonia Nitrogen (NH_3-N)

Ammonia nitrogen test conducted according to the standard method which are Method 8155 or Salicylate Method. The concentration of NH_3-N is determined using Spectrophotometer DR5000 with Ammonium Salicyte and Ammonium Cyanurate as reagents. Green colour shows positive presence of NH_3-N. Samples are diluted before testing since this method is only applicable for Ammonia Nitrogen concentration of 0.01 – 0.50 mg/L.

3.7.2.5 Heavy Metal

In this study, heavy metals consist of Copper (Cu) and Cadmium (Cd). A set of standard solution of this type of metals need to be prepared. The sample prepared by filtering each sample through a 0.45-micron micro-pore membrane filter, if necessary to avoid clogging of the burner capillary. The concentration of the element of interest read directly proportional to standards.

Atomic Absorption Spectrophotometric method was used in estimate the concentration of heavy metal (mg/L) in the water. Calibration Standard that I prepared in my research included 05N,1.0N, 1.5N and 2.0N by 125µL, 250µL, 375µL and 500 µL standard solution of each types of parameter that I selected into 250 mL volumetric flask and made up to the volume with distilled water. By using flame atomic absorption spectrophotometers method, the sample water was aspirated into the flame to be atomized. A beam of light was focussed through the flame to measure the quantity of light that have been absorbed by the atomized element inside the flame. Since every metal has its own feature to absorb the wavelength directed from a source lamp, the analysis for particular metal within the sample was made. The heavy metal was recorded directly from the digital display.

3.8 WQI calculation

Water Quality Index is a form of average derived by relating a group of variables to a common scale and combining them into a single number. A WQI summarizes information by combining several sub-indices of constituents (quality variables) into a univariate expression. The group should contain the most significant parameters of the data set, so that the index can describe the overall position and reflect change in a representative manner.

The Water Quality Index uses a scale from 0 to 100 to rate the quality of the water, with 100 being the highest possible score. Once the overall WQI score is known, it can be compared against the following scale to determine how healthy the water is on a given day. Formula shown below have been use to determine the value of Water Quality.

$$WQI = (0.22 \times SIDO) + (0.19 \times SIBOD) + (0.15 \times SIAN) + (0.16 \times SISS) + (0.12 \times SIpH) + (0.16 \times SICOD) \qquad 3.4$$

Where:

SIDO	Sub-Index Dissolved Oxygen (%)
SIBOD	Sub-Index Biochemical Oxygen Demand
SIAN	Sub-Index Ammonia Nitrogen
SISS	Sub-Index Total Suspended Solids
SIpH	Sub-Index pH value
SICOD	Sub-Index Chemical Oxygen Demand

3.9 Conclusion

As the conclusion, all the selected parameters including the physical and chemical parameters were tested to achieve the objective of the study which is to evaluate the characteristics of current water quality in the study area based on NWQS and WQI. It is according to Department of Environment (DOE) guideline standard uses for river water quality.

In-situ and ex-situ test were conducted by using specific methods and instruments for achieve the second objective of study which is to identify the possible factors or sources that influences the water quality of the river system. After test analysis, I will get the result of each selected parameters so that based on the result, I will make a conclusion and can identify the possible factors or sources based on value of the parameter tested and also make an appropriate strategy for effective management of the water resources.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Introduction

All the data obtained on in situ measurement and lab analysis referred to NWQS and WQI, Malaysia in order to classify the classes of water. The sampling points located at Kuantan River, Kuantan. Three samples were taken to be analyses based on their different station. The sampling conducted three times from Mac to May 2017.

Water Quality Parameters are classified into physical and chemical. Parameters that have been test for each sample are turbidity, temperature and TSS for physical water quality. pH, DO, EC, BOD, COD, NH_3-N, and selected heavy metal such as cadmium (Cd) and copper(Cu) for chemical water quality.

Based on the earlier chapter that already explained about the methodology of the study, results from the in-situ tests and ex-situ tests had been plotted into graphical form for each sampling station data in certain period of time. This is due to show precise explanation about the result and makes more understanding concerning the topics of water quality in Kuantan River.

4.2 Result and discussion

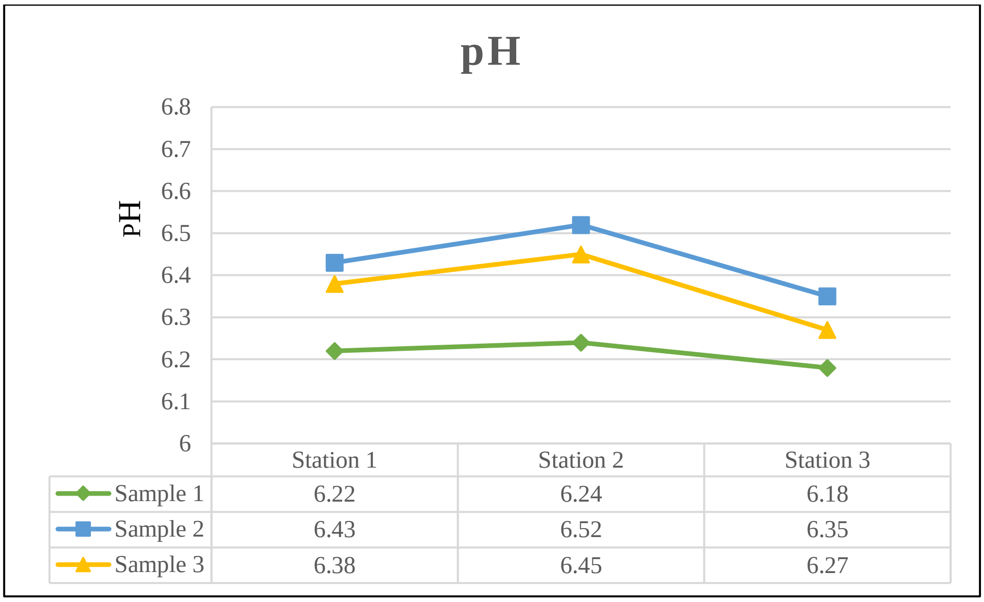

Figure 4.1: The pH value at different station.

Based on Figure 4.1, the pH values for the collected water samples is in range 6.18 and 6.52. The average pH values for sampling 1,2 and 3 is 6.21,6.43 and 6.37 respectively. The average pH values for station 1,2 and 3 is 6.34, 6.40 and 6.27. Based on both average samples and average station, Kuantan river's pH values indicated in Class II in NWQS. The lowest pH value is during sampling1 at station 3 which is 6.18 and the highest pH value is during sampling 2 at station 2 which is 6.52.

Based on result above, there need some treatment before it can distribute for domestic uses. The pH concentration is increase due to the photosynthetic algae activities that consumes carbon dioxide in watershed of river (Utah State University, 2013). Therefore, it is very important to maintain the pH value within the range because the lowest and highest pH value can harm the aquatic life and human being. Aquatic species are not the only ones affected by pH. While humans have a higher tolerance for pH levels (drinkable levels range from 4-11 with minimal gastrointestinal irritation), there are still concerns. pH values greater than 11 can cause skin and eye irritations, as does a pH below 4. A pH value below 2.5 will cause irreversible damage to skin and organ linings (Fondriest Environmental, 2013).

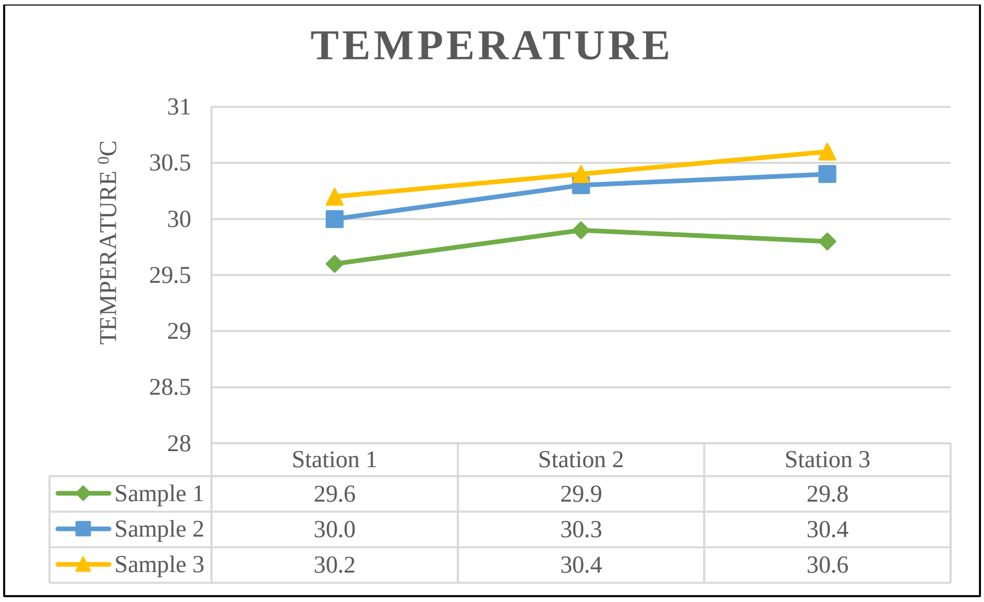

Figure 4.2: The value of temperature at different station

Based on Figure 4.2, the temperature for the collected water samples is in range 29.60 ^{0}C and 30.60 ^{0}C. The average temperature for sampling 1,2 and 3 is 29.90 ^{0}C, 30.20 ^{0}C and 30.30 ^{0}C respectively. The average temperature for station 1,2 and 3 is 29.80 ^{0}C, 30.20 ^{0}C and 30.40 ^{0}C. From result above, Kuantan river's temperature indicated in Class II in NWQS.

The lowest temperature was recorded during sampling 1 and the highest temperature was recorded during sampling 3. The different of temperature between sampling is because sampling 1 was taken during cloudy weather but sampling 2 and 3 during hot weather. According to Rainforest cruises (2013), during the flooded season the average temperature is 86 degrees Fahrenheit, 12 degrees cooler than in the dry season at Amazon. This is shows that weather can influence the temperature at river.

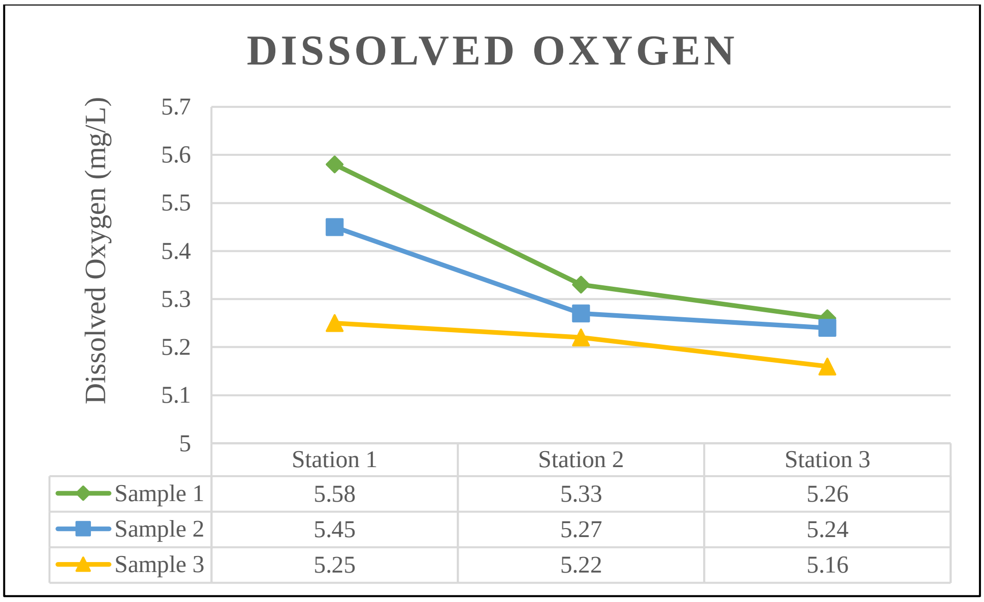

Figure 4.3: The concentration of DO at different station.

Based on Figure 4.3, the dissolved oxygen for the collected water samples is in range 5.16 mg/L and 5.58 mg/L. The average dissolved oxygen for sampling 1,2 and 3 is 5.39 mg/L, 5.32 mg/L and 5.21 mg/L respectively. The average dissolved oxygen for station 1,2 and 3 is 5.43 mg/L, 5.27 mg/L and 5.22 mg/L. From result above, Kuantan river's dissolved oxygen indicated in Class II in NWQS.

The highest dissolved oxygen refers to station 1 during sampling 1 because that point was near to forested area that produced the amount of oxygen. Besides that, the temperature was low during that time also effected the amount of dissolved oxygen in water. However, the lowest dissolved oxygen was during sampling 3 at station 3 due to temperature and aquatic life that use oxygen for respiration. There is also probability caused by motor boat that used on Kuantan River. A certain amount of the fuel that enters into a motor is discharged unburned and ends up in the water. Two stroke motors can emit 25-30% of their unburned gas and oil mixture into the water. In contrast, four-stroke motors emit 97% less air and water pollution than old two-stroke motors (RMBEL, 2013).

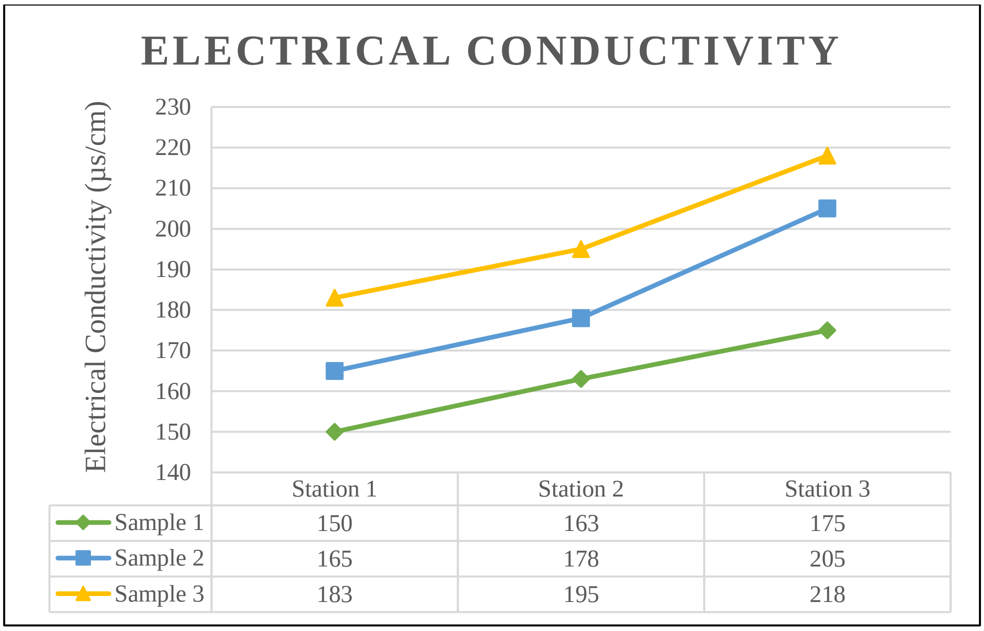

Figure 4.4: The value of EC at different station

Based on Figure 4.3, the electrical conductivity for the collected water samples is in range 150µS/cm and 218µS/cm. The average electrical conductivity for sampling 1,2 and 3 is 163µS/cm, 183µS/cm and 199µS/cm respectively. The average electrical conductivity for station 1,2 and 3 is 166µS/cm, 179µS/cm and 199µS/cm. From result above, Kuantan river's electrical conductivity indicated in Class I in NWQS.

The lowest reading was taken during sampling 1 at station 1 which is 150µS/cm. the highest reading was taken during sampling 3 at station 3 which is 218µS/cm. The electrical conductivity was affected by temperature whereas the temperature is increases, the electrical conductivity also increases. Besides that, the activities inside the watershed also can push up the value of conductivity of surface waters include residential sewage and septic.

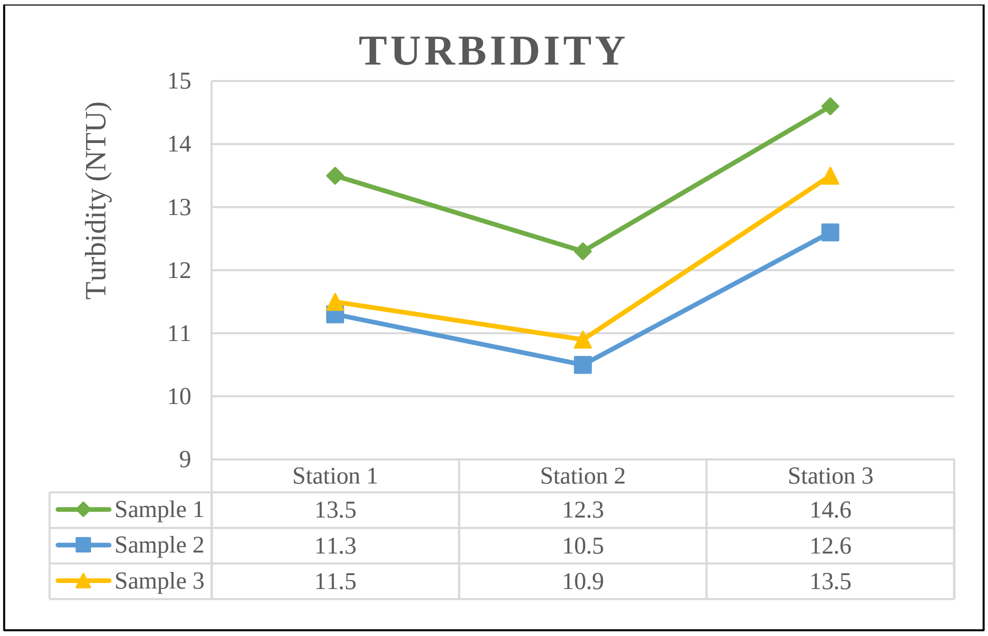

Figure 4.5: The value of turbidity at different station.

Based on Figure 4.5, the turbidity for the collected water samples is in range 10.5 NTU and 14.6 NTU. The average turbidity for sampling 1,2 and 3 is 13.5 NTU, 11.5 NTU and 12.0 NTU respectively. The average turbidity for station 1,2 and 3 is 12.1 NTU, 11.2 NTU and 13.6 NTU. From result above, Kuantan river's turbidity indicated in Class II in NWQS.

The lowest value was 10.2 NTU at station 2 during sampling 2. The highest value was taken at station 3 during sampling 1 which is 14.6 NTU. The turbidity in Kuantan River was influenced by rains and human activities near that area. According to American Public Health Association found that turbidity emanate from runoffs from building construction works, the existence of an un-bitumen road near river and residential areas that carry silt, clay and organic matter into the water. Raining during the wet season had diluted the soil into the river and increased the concentration of TSS and turbidity.

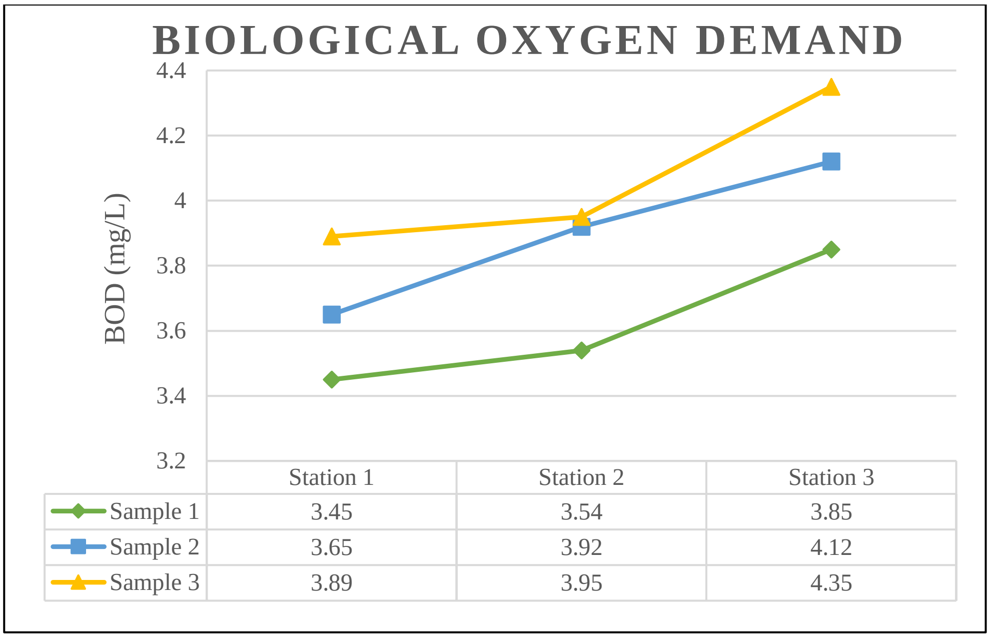

Figure 4.6: The concentration of BOD at different station.

Based on Figure 4.6, the concentration BOD for the collected water samples is in range 3.45 mg/L and 4.35 mg/L. The average concentration BOD for sampling 1,2 and 3 is 3.61 mg/L, 3.90 mg/L and 4.06 mg/L respectively. The average concentration BOD for station 1,2 and 3 is 3.66 mg/L, 3.80 mg/L and 4.11 mg/L. From result above, Kuantan river's concentration BOD indicated in Class III in NWQS.

The lowest concentration of BOD was at station 1 during sampling 1 which is 3.45 mg/L. The highest concentration of BOD was at station 3 during sampling 3 which is 4.35 mg/L. The high concentration of BOD indicated high organic matter in water caused by wastage contains chemical that capable of suppressing microbiological growth. The high concentration of BOD due to domestic sewage, and septic tank leakage.

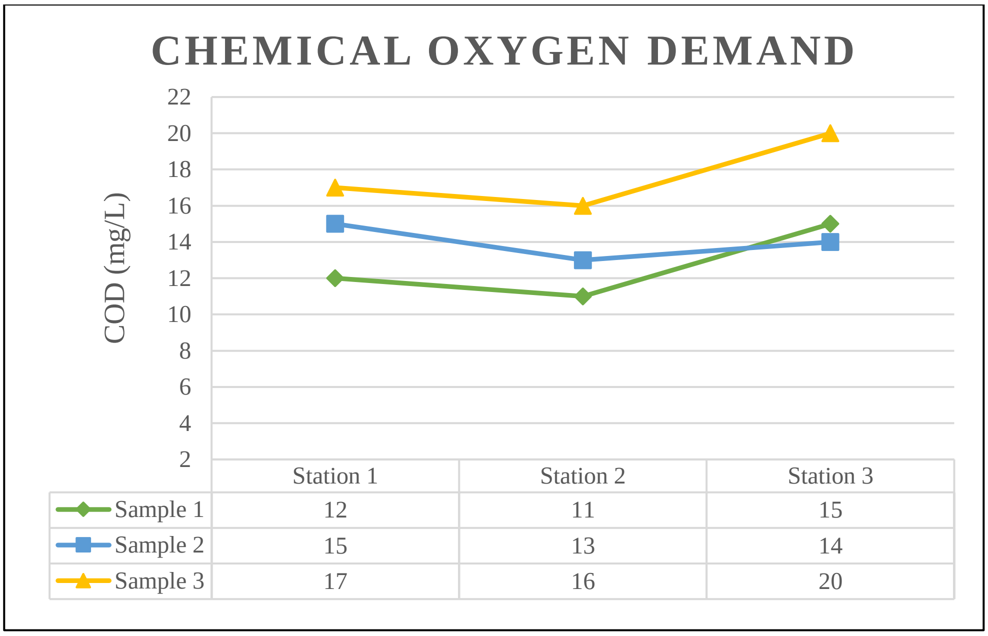

Figure 4.7: The concentration of COD at different station.

Based on Figure 4.7, the concentration COD for the collected water samples is in range 11 mg/L and 20 mg/L. The average concentration COD for sampling 1,2 and 3 is 13 mg/L, 14 mg/L and 17 mg/L respectively. The average concentration COD for station 1,2 and 3 is 15 mg/L, 13 mg/L and 16 mg/L. From result above, Kuantan river's concentration COD indicated in Class II in NWQS.

From result above, the highest concentration COD was at station 3 during sampling 3 which is 20 mg/L. Even though it is high but based on NWQS the concentration of COD is acceptable to be used for recreational activities. This river also can distribute for domestic uses after treated by conventional treatment. The highest COD was found on water contaminated with sewage, water from food processing plants, textile factories or water contain organic chemicals based on Real Tech Inc.

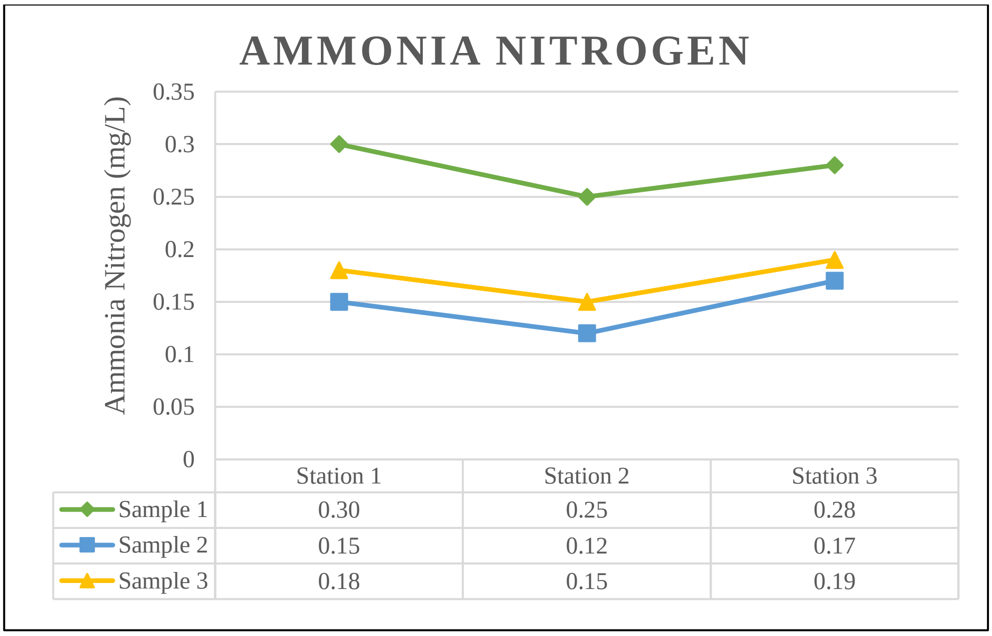

Figure 4.8: The concentration of ammonia nitrogen at different station.

Based on Figure 4.8, the concentration of ammonia nitrogen for the collected water samples is in range 0.12 mg/L and 0.3 mg/L. The average concentration of ammonia nitrogen for sampling 1,2 and 3 is 0.28 mg/L, 0.15 mg/L and 0.18 mg/L respectively. The average concentration of ammonia nitrogen for station 1,2 and 3 is 0.21 mg/L, 0.17 mg/L and 0.21 mg/L. From result above, Kuantan river's concentration of ammonia nitrogen indicated in Class II in NWQS.

The highest concentration of ammonia nitrogen was at station 1 during 1 sample which is 0.3 mg/L. Based on NQWS, the ammonia nitrogen is not too high so the water still can be used for domestic. The higher concentration of ammonia nitrogen can be toxic to fish, but in small concentrations, it could serve as nutrients for excessive growth of algae (Fawaz Al-Badaii, Mohammad Shuhaimi-Othman, and Muhd Barzani Gasim, 2013) .

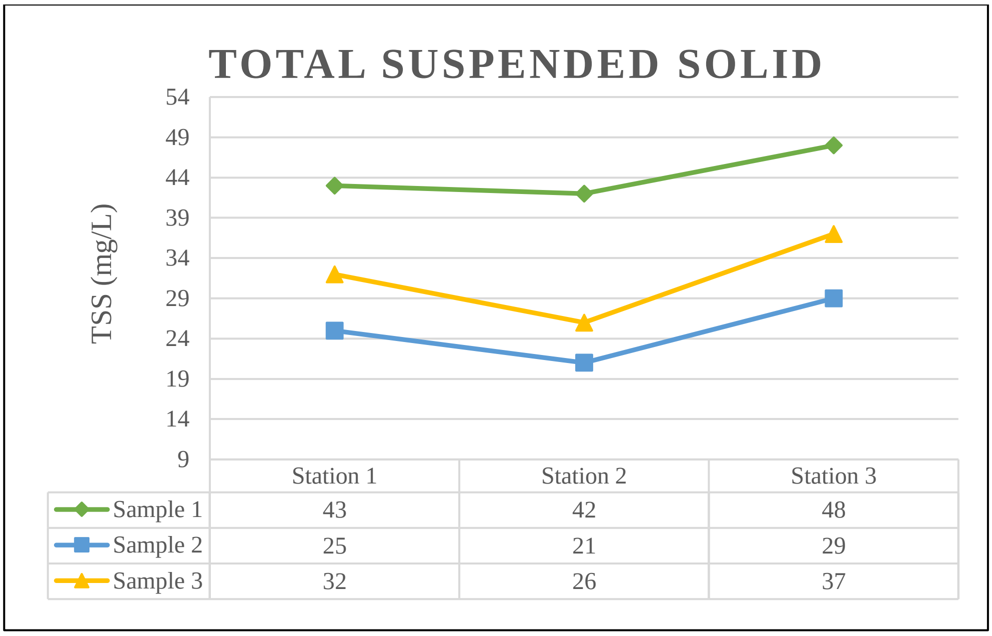

Figure 4.9: The concentration of total suspended solid at different station.

Based on Figure 4.9, the concentration of suspended solid for the collected water samples is in range 21 mg/L and 43 mg/L. The average concentration of total suspended solid for sampling 1,2 and 3 is 44 mg/L, 25 mg/L and 32 mg/L respectively. The average concentration of total suspended solid for station 1,2 and 3 is 33 mg/L, 30 mg/L and 38 mg/L. From result above, Kuantan river's concentration of total suspended solid indicated in Class II in NWQS.

The highest concentration was at station 3 during sampling 1 because of the day before take the reading was raining. The increasing of the suspended solid inside the river also due to anthropogenic activities such as residential activities where the waste discharged into the river. According to Chapman, (1996), high TSS value in the river were tidal influence, forested area and homestead activities in those area.

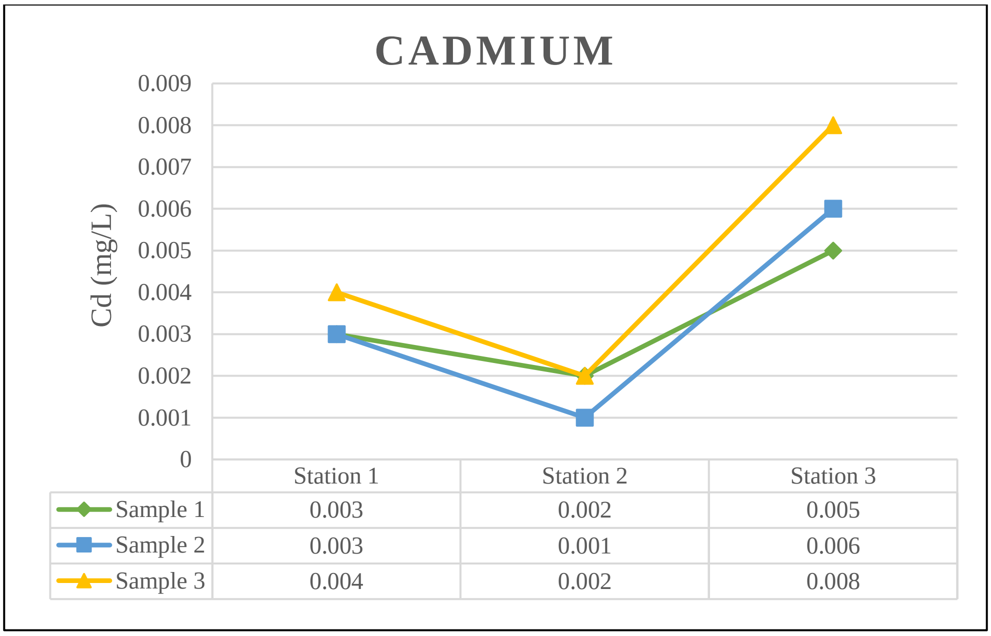

Figure 4.10: The concentration of cadmium at different station.

Based on Figure 4.10, the concentration of cadmium for the collected water samples is in range 0.001 mg/L and 0.008 mg/L. The average concentration of cadmium for sampling 1,2 and 3 is 0.003 mg/L, 0.003 mg/L and 0.005 mg/L respectively. The average concentration of cadmium for station 1,2 and 3 is 0.003 mg/L, 0.002 mg/L and 0.006 mg/L. From result above, Kuantan river's concentration of cadmium indicated in Class II in NWQS.

The highest concentration of cadmium was at station 3 during sample 3 which is 0.008 mg/L. This was due to motor boat that using Kuantan River as transport. Besides that, there is also probability that paint on boat fall to the river that increase the concentration of cadmium. Other sources of cadmium include emissions from industrial activities, including mining, smelting, and manufacturing of batteries, pigments, stabilizers, and alloys (Tchounwou, P. B., Yedjou, C. G., Patlolla, A. K., & Sutton, D. J. , 2012)

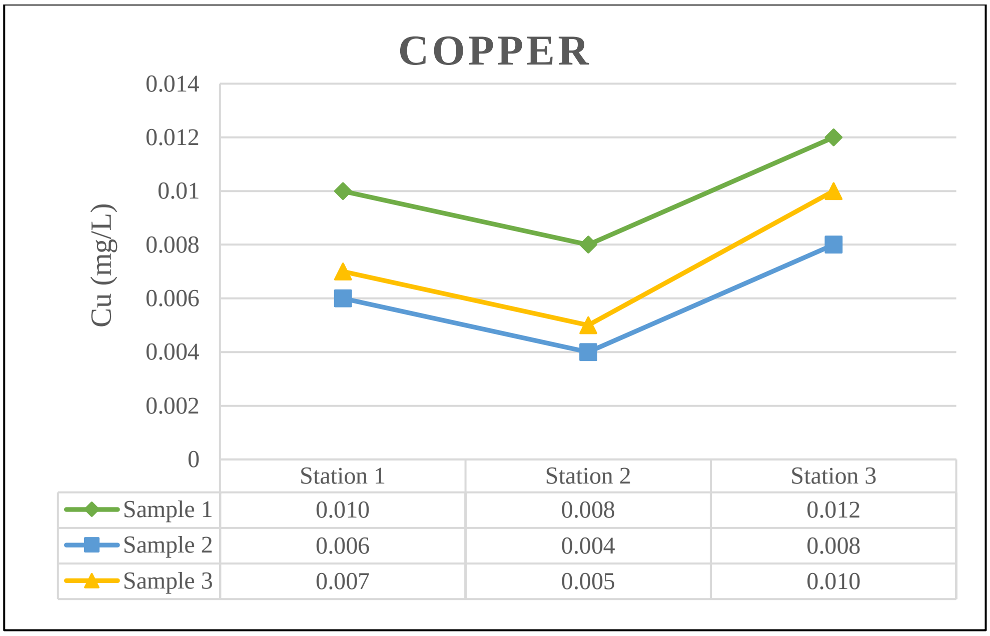

Figure 4.11: The concentration of copper at different station.

Based on Figure 4.11, the concentration of copper for the collected water samples is in range 0.004 mg/L and 0.012 mg/L. The average concentration of copper for sampling 1,2 and 3 is 0.010 mg/L, 0.006 mg/L and 0.007 mg/L respectively. The average concentration of copper for station 1,2 and 3 is 0.008 mg/L, 0.007 mg/L and 0.010 mg/L. From result above, Kuantan river's concentration of cadmium indicated in Class II in NWQS.

The highest concentration was occurred at station 3 during sample 1 due to raining a day before taking the sample. The rain from land flows into Kuantan River had increase the concentration of cooper because all metal on earth went into river by rains. Discharged from residential septic contribute to small amount of Copper into Kuantan River. This was stated from study by Perwak et al. (1980) which showed discharges of copper into sewer systems from residential areas to be significant.

Table 4.1 Sub-Index of WQI for Kuantan River at different station

	Station 1	**Station 2**	**Station 3**
SIDO	79.74	77.33	76.48
SIBOD	84.92	84.33	83.01
SICOD	79.15	81.81	77.82
SIAN	78.45	82.65	78.45
SISS	79.65	81.10	77.31
SIpH	95.37	96.49	94.57
WQI	82.30	83.08	80.53
CLASS	II	II	II
CONDITION	CLEAN	CLEAN	SLIGHTLY POLLUTED

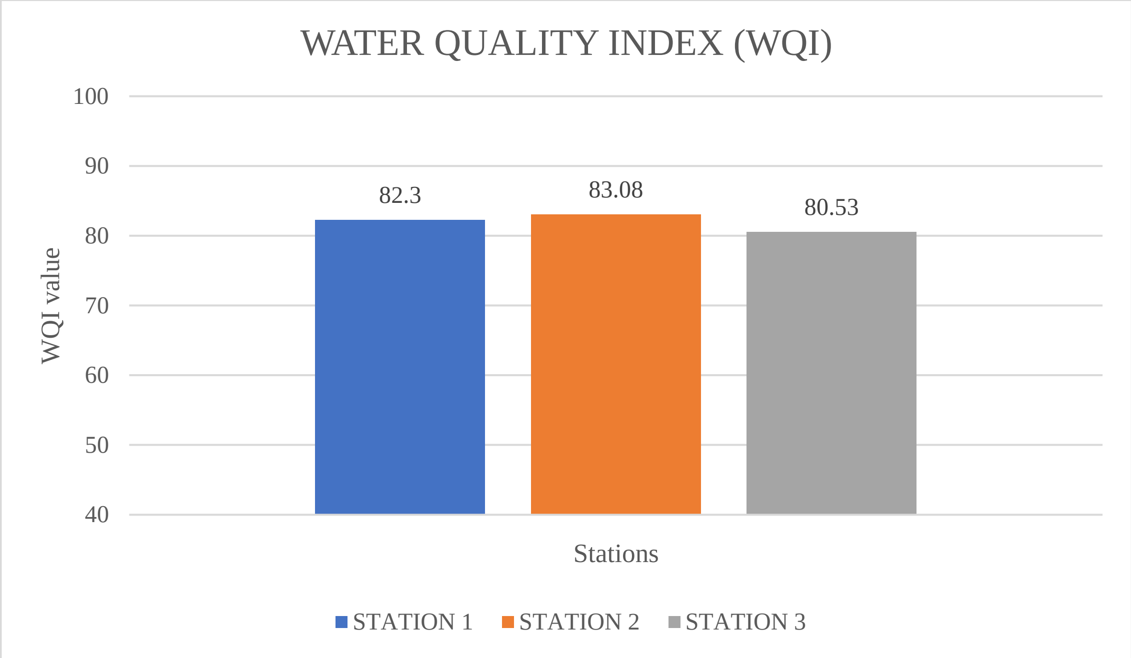

Figure 4.12: WQI value at different station of Kuantan River

Each sub-index for every parameter was calculated to determine the WQI and classify the river under classes as shown in Table 4.1. Figure 4.12 show the WQI value for Kuantan River of each station. The value of WQI for each station are 82.30, 83.08 and 80.53 which in Class II. Station 3 is the lower value because the station has many factors that can pollute the river. There are many motor boat activities and the effluent of sewage from residential area. So that, Station 3 is more polluted than other stations. All stations are clean conditions which in range 80-100.

Even though the WQI values indicate Kuantan River is clean, the quality of this river has been slightly decreases through times. Based on Iranian journal of environmental health science & engineering, there are 56% is industrial, 32% is agricultural and 12% is others land used in Kuantan River Basin. This is shows that many industrial and agricultural activities that can be found along the Kuantan River.

4.2.1 Water pollution problem and sustainable management suggestion

There is water pollution that have been spotted during my research near to the Kuantan River basin which is agricultural runoff, sewage and septic tank, erosion of soil and lack awareness of people about water quality of river. Therefore, sustainable management is suggested to control and prevent from increase the contamination of river as below:

i. Cover crop by planting certain grasses, grain or clovers can help nutrients out of the water because the excess nitrogen will be recycled and reduce the soil erosion.

ii. Applying fertilizers in the proper amount at the right time with the right method can significantly reduce the potential for pollution.

iii. Required to practices good agricultural to manage these activities so that runoff pollutants are minimized.

iv. Some of the measures can be implemented include installing storm water filter to treat drainage and runoff.

v. The regular inspection and maintenance is required to ensure the septic tank is operate properly.

vi. Routine inspection necessary to remove floating debris such as coarse material and grease so there is no blockage at inlet or outlet.

vii. Knowing the land capability and used the land based on its capability. The steeper slopes and shallower soils suitable for growing pastures.

viii. Environmental education plays an important role to educate the people about the important of water quality in river. They need to feel responsibility on water resources so they will protect it.

CHAPTER 5

CONCLUSION

5.1 Introduction

In this chapter, the discussion on result obtained being simplified and recommendations for this study is listed. Water quality on Kuantan River was successfully done and met the objective of the studied.

Kuantan River is one of the largest rivers of the Peninsular Malaysia that flows from northwest to east coast in Kuantan. The Kuantan river also is the major source of water supply for domestic, industrial, and agricultural purposes that provides 350 000 cubic meters per day and covers 1630 km^2 of catchment area. Water sampling was done in between Mac to May 2017 with three sampling of each stations. All samples were contributed with the in-situ test by using Horiba Meter instrument and analyse at ex-situ tests. All these results were compared to WQI and NWQS to determine the water quality status for each station.

5.2 Conclusion

From the research results, the objective one is to determine the characteristic of water quality based on NWQS and WQI, Malaysia has been achieved. Water parameter of Kuantan River consist of turbidity, temperature, TSS, pH, EC, DO, BOD, COD, Ammonia Nitrogen, Cadmium and Copper. The result obtained were analysed and classified based on WQI and NWQS Guidelines.

It found that Station 1, Station 2 and Station 3 of WQI is 82.30, 83.03 and 80.53 respectively. The Reducing the value of the WQI indicate that level of pollution in river. All station in Class II-III which indicated that Kuantan River is Clean and

Slightly polluted condition. According to NWQS Malaysia, Kuantan River was classified in I-III where it can conclude as extensive treatment required for water supply.

Second objective is to identify to identify the possible cause and source pollutant for sustainable management of the Kuantan industrial area also has achieved. The main factor of anthropogenic activities that influences the water quality of Kuantan River is because sewerage and drainage in a residential area near the river that poorly maintained that discharged to the river. Agricultural and livestock also effect the water quality that use of fertilizer and pesticide and waste from animals. Other than that, unsustainable land use pattern within and around has resulted in erosion and sedimentation of the river system that depleting the aquatic biodiversity because the area is surrounding of forest. The suggestion for sustainable management is to preserve and improve the water quality status of water bodies.

5.3 Recommendation

A few recommendations should be taken for the solution of the problem that arise in order to obtain more accurate data for this research in the future after conducting and obtaining the result from the experiments. Recommendations that are suggested will help to increase and sustain the water quality of Kuantan river for the future research. These are some of the recommendation that can be done:

i. Add the other parameters such as physical parameters such as salinity, total dissolved solid (TDS), colour, E-coli, chemical parameters include the more metals and non-metals such as nitrate, magnesium, chromium and others.
ii. Increase the number of sampling station to get the better quality of surface water resources that the sources of anthropogenic disturbances of surrounding can be known in order to conserve the good water quality in Kuantan river.
iii. For the further study, sampling can be taken and conduct the experiment more than 3 times to get accurate value for water quality in Kuantan river.
iv. To get better sources of anthropogenic activities surrounding, determine all the type of heavy metal contain in the sampling area by conduct all the experiment of heavy metal.

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APPENDIX A

National Water Quality Standards

Parameters	Unit	Classes					
		I	IIA	IIB	III	IV	V
Ammoniacal Nitrogen	mg/l	0.1	0.3	0.3	0.9	2.7	>2.7
BOD	mg/l	1.0	3.0	3.0	6.0	12.0	>12.0
COD	mg/l	10.0	25.0	25.0	50.0	100.0	>100.0
DO	mg/l	7.0	5.0-7.0	5.0-7.0	3.0-5.0	<3.0	<1.0
pH	-	6.5-8.5	6.0-9.0	6.0-9.0	5.0-9.0	5.0-9.0	-
Colour	TCU	15.0	150.0	150.0	-	-	-
Electrical Conductivity*	umhos/ cm	1,000.0	1,000.0	-	-	6,000.0	-
Floatables	-	n	n	n	-	-	-
Odour	-	n	n	n	-	-	-
Salinity	%	0.5	1.0	-	-	2.0	-
Taste	-	n	n	n	-	-	-
Total Dissolved Solid	mg/l	500.0	1,000.0	-	-	4,000.0	-
Total Suspended Solid	mg/l	25.0	50.0	50.0	150.0	300.0	300.0
Temperature	°C	-	Normal +2°C	-	Normal +2°C	-	-
Turbidity	NTU	5.0	50.0	50.0	-	-	-
Faecal Coliform **	counts/ 100 mL	10.0	100.0	400.0	5,000.0 (20,000.0)[a]	5,000.0 (20,000.0)[a]	-
Total Coliform	counts/ 100 mL	100.0	5,000.0	5,000.0	50,000.0	50,000.0	>50,000.0
Iron	mg/l	Natural levels or absent	1.0	1.0	1.0	1.0 (Leaf) 5.0 (Others)	Levels above IV
Manganese	mg/l		0.1	0.1	0.1	0.2	
Nitrate	mg/l		7.0	7.0	-	5.0	
Phosphorous	mg/l		0.2	0.2	0.1	-	
Oil & Grease	mg/l		0.04; N	0.04; N	N	-	

Notes:

n : No visible floatable materials or debris or No objectionable odour, or No objectionable taste.
* : Related parameters, only one recommended for use.
** : Geometric mean.
a : maximum not to be exceeded.
N : Free from visible sheen, discolouration and deposits.

Class	Uses
Class I	: Conservation of natural environment. Water Supply 1 – practically no treatment necessary. Fishery 1 – 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 A
CONTINUED

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	-	-	
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)	
Pd	mg/l	Natural Level or Absent	0.05	0.02* (0.01)	5	
Mn	mg/l		0.1	0.1	0.2	Level Above
Hg	mg/l		0.001	0.004 (0.0001)	0.002	
Ni	mg/l		0.05	0.9*	0.2	
Se	mg/l		0.01	0.25 (0.04)	0.02	
Ag	mg/l		0.05	0.0002	-	
Sn	mg/l		-	0.004	-	
U	mg/l		-	-	-	
Zn	mg/l		5	0.4*	2	
B	mg/l		1	(3.4)	0.8	
Cl	mg/l		200	-	80	
Cl_2	mg/l		-	(0.02)	-	
CN	mg/l		0.02	0.06 (0.02)	-	
F	mg/l		1.5	10	1	

APPENDIX A
CONTINUED

Water Quality Index

Parameter	**Unit**	**Classes**				
		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	mg/L	>7.0	6.0-7.0	5.0-6.0	<5.0	>5.0
Total Suspended Solids	mg/L	<25	25-50	50-150	150-300	>300
Water Quality Index	**mg/L**	**>92.7**	**76.5-92.7**	**51.9-76.5**	**31.0-51.9**	**<31.0**

General Rating Scale for the Water Quality Index (WQI)

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 A
CONTINUED

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 NH3-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 B
WATER QUALITY RESULT

Point / Parameters	Station 1 / Sample 1	Station 2 / Sample 1	Station 3 / Sample 1
pH	6.22	6.24	6.18
BOD (mg/L)	3.45	3.54	3.85
COD (mg/L)	12	11	15
TSS (g)	43	42	48
Turbidity (NTU)	13.5	12.3	14.6
Temperature (°C)	29.6	29.9	29.8
DO (mg/L)	5.58	5.33	5.26
Electrical Conductivity (µS/cm)	150	163	175
Ammoniacal Nitrogen (mg/L)	0.30	0.25	0.28
Cadmium (mg/L)	0.003	0.002	0.005
Copper (mg/L)	0.010	0.008	0.012

APPENDIX B
CONTINUED

Point / Parameters	Station 1 / Sample 2	Station2 / Sample 2	Station 3 / Sample 2
pH	6.43	6.52	6.35
BOD (mg/l)	3.65	3.92	4.12
COD (mg/l)	15	13	14
TSS (g)	25	21	29
Turbidity (NTU)	11.3	10.5	12.6
Temperature (°C)	30.0	30.3	30.4
DO (mg/l)	5.45	5.27	5.24
Electrical Conductivity (EC)	165	178	205
Ammoniacal Nitrogen (mg/L)	0.15	0.12	0.17
Cadmium (mg/L)	0.003	0.001	0.006
Copper (mg/L)	0.006	0.004	0.008

APPENDIX B
CONTINUED

Point / Parameters	Station 1 / Sample 3	Station 2 / Sample 3	Station 3 / Sample 3
pH	6.38	6.45	6.27
BOD (mg/l)	3.89	3.95	4.35
COD (mg/l)	17	16	20
TSS (g)	32	26	37
Turbidity (NTU)	11.5	10.9	13.5
Temperature (°C)	30.2	30.4	30.6
DO (mg/l)	5.25	5.22	5.16
Electrical Conductivity (EC)	183	195	218
Ammoniacal Nitrogen (mg/L)	0.18	0.15	0.19
Cadmium (mg/L)	0.004	0.002	0.008
Copper (mg/L)	0.007	0.005	0.010

APPENDIX C
STUDY AREA

Figure F1: Station 1 view

Figure F2: Station 2 view

Figure F3: Station 3 view

APPENDIX C
IN-SITU AND EX-SITU TEST

Figure F4: in-situ test reading taken

Figure F5: Total suspended solid test

Figure F6: Atomic Absorption Spectrophotometric method