ASSESSING THE IMPACT OF ANTHROPOGENIC DISTURBANCES ON WATER QUALITY IN THE SUNGAI NYIOR, KUANTAN.

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ASSESSING THE IMPACT OF ANTHROPOGENIC DISTURBANCES ON WATER QUALITY IN THE SUNGAI NYIOR, KUANTAN.

WAN NUR HAFEZA HASLINDA BINTI WAN HASSAN

Thesis submitted in partial fulfillment of the requirements for the award of the degree of Bachelor of Civil Engineering

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SUPERVISOR'S DECLARATION

I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the degree of Bachelor (Hons.) of Civil Engineering

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This hard work is dedicated to my beloved family especially my mama,
Nik Ramlah Binti Nik Soh,
my respected supervisor , *Dr. Mir Sujaul Islam*,
and my precious friends who love me and support me during my whole journey of education at University of Malaysia Pahang.

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ABSTRACT

Nowadays, the condition of water pollution in Malaysia is becoming more serious because of the water quality is declining due to the anthropogenic activity that was carried out. Sungai Nyior has been chosen for this study of water quality which located in Balok Baru, Kuantan, Pahang with length and wide are 11.3 km and 20 m respectively. The objectives of this study were to evaluate the characteristics of current water quality in the study area based on National Water Quality Standard (NWQS) and Water Quality Index (WQI), Malaysia, to identify the possible factors or sources that influences the water quality of the river system and to make an appropriate suggestion for effective management of the water resources. To achieve the objectives, three times of water samples were collected monthly from September to November 2016. Physical, chemical and biological parameters were analyzed 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), total hardness, selected heavy metal which are cadmium (Cd), copper (Cu) and chromium (Cr) ,total coliform and E.coli,. Result from the study showed the values of WQI at each station were in the range 51.9-76.5 that in the Class III. The WQI score value at Station 1, 2 and 3 were 54.20, 56.19, and 54.21 respectively. The status of this river was in polluted condition. In NWQS, the Sungai Nyior is classified under Class IV. The main factor of anthropogenic activities that influences the degradation of water quality was sewerage and drainage in a residential area, construction activities, livestock, agricultural and forested that near the river. Finally, the monthly monitoring and planning is necessary to improve the quality of the river and make policy to control the water quality.

ABSTRAK

Pada masa kini, keadaan pencemaran air di Malaysia semakin serius kerana kualiti air menurun kerana aktiviti antropogenik yang telah dijalankan. Sungai Nyior telah dipilih untuk kajian ini kualiti air yang terletak di Balok Baru, Kuantan, Pahang dengan panjang dan luas masing-masing 11.3 km dan 20 m. Objektif kajian ini adalah untuk menilai ciri-ciri kualiti air semasa di kawasan kajian berdasarkan Standard Kualiti Air Kebangsaan (NWQS) dan Indeks Kualiti Air (WQI), Malaysia, untuk mengenal pasti faktor-faktor yang mungkin atau sumber yang mempengaruhi kualiti air sistem sungai dan untuk membuat cadangan yang sesuai bagi pengurusan sumber air. Bagi mencapai objektif, tiga kali sampel air telah dipungut setiap bulan dari bulan September hingga November 2016. fizikal, kimia dan parameter biologi dianalisis dengan menggunakan kaedah standard. The WQI dikira berdasarkan kepekatan pH, jumlah pepejal terampai (TSS), ammonia nitrogen (NH3-N), permintaan oksigen kimia (COD), permintaan oksigen biokimia (BOD) dan oksigen terlarut (DO). Parameter lain yang menganalisis dalam kajian ini ialah kekeruhan, suhu, kekonduksian elektrik (EC), jumlah kekerasan, dipilih logam berat yang kadmium (Cd), tembaga (Cu) dan kromium (Cr), jumlah koliform dan E.coli ,. Keputusan kajian menunjukkan nilai-nilai WQI di setiap stesen adalah dalam julat 51,9-76,5 bahawa dalam Kelas III. The WQI nilai skor di Stesen 1, 2 dan 3 masing-masing 54.20, 56.19 dan 54.21. Status sungai ini berada dalam keadaan tercemar. Dalam NWQS, Sungai Nyior adalah dikelaskan di bawah Kelas IV. Faktor utama aktiviti antropogenik yang mempengaruhi penurunan kualiti air adalah pembetungan dan perparitan di kawasan perumahan, aktiviti pembinaan, ternakan, pertanian dan hutan yang berhampiran sungai. Akhir sekali, pemantauan bulanan dan perancangan adalah perlu untuk meningkatkan kualiti sungai dan membuat dasar untuk mengawal kualiti air.

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H2O	Water compound
CO2	Carbon Dioxide
O2	Oxygen gas
H+	Hydrogen ions
OH-	Hydroxide ions
NNO3	Nitric acid
HSO4	Sulphuric acid
Cu	Copper
Pb	Lead
Zn	Zinc
Cr	Chromium
NH3	Ammonia
NH4+	Ammonium
NH3-N	Ammonia Nitrogen
°C	Degree Celsius
°F	Degree Fahrenheit
µS/cm	microsemens per centimetre
mL	millilitre
mg/L	milligram per litre

LIST OF ABBREVIATIONS

H2O	Water compound
CO2	Carbon Dioxide
A-P Test	Absence-Presence Test
AAS	Atomic Absorption Spectroscopy
BOD	Biochemical Oxygen Demand
COD	Chemical Oxygen Demand
DO	Dissolved Oxygen
DOE	Department of Environment
E.coli	Escherichia Coli
EC	Electrical Conductivity
N	Nitrogen
NPS	Nonpoint sources
NWQS	National Water Quality Standard
RAMP	Regional Aquatics Monitoring Programme
TSS	Total Suspended Solid
TDS	Total Dissolved Solid
WQI	Water Quality Index

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Water is an essential element in the maintenance of all forms of life, and most living organisms can survive only for short periods without water. Although the surface of our planet is nearly 71% water, only 3% of it is fresh. Of these 3% about 75% is tied up in glaciers and polar icebergs, 24% in groundwater and 1% is available in the form of fresh water in rivers, lakes and ponds suitable for human consumption (Dugan, 1972).

Water quality can be measure of the compatibility of water for a particular use based on selected physical, chemical and biological characteristics. For each intended use and water quality benefit, there may be different parameters best expressing the quality of water. Water quality is important in drinking water supply, irrigation, fish production, recreation and other purposes to which the water must have been impounded.

Definition of “Anthropogenic” is relating to or resulting from the influence of humans on the nature or human activity such as logging, mining, artificial construction like construct the dam, construction activities, agricultural and industrialization. Meanwhile, “Disturbances” means a change in the position, arrangement and the act of disturbing something or the interruption of a settled and peaceful condition. Anthropogenic disturbances on water quality is the human activities that are change the quality of water.

Impact of an anthropogenic disturbances have led to increased river pollution, degradation of environment and bad impacts on living and non-living resources. River ecosystems are influenced by human activities which are often change the timing or amount of stream flow, increase runoff, erosion, and sedimentation, alter water temperature and chemistry, and introduce contaminants. Contamination of water resources affects standards of human life by lowering its quality and normal functioning, (Falcone et al., 2010).

The status of water quality in Malaysia has always been a reason for concern for several publics, local authorities and government agencies. Besides, our government advised us that we should protect the water resources as water is an essential and valuable resource for our health, communities and lives. Water qualities of rivers are the one of the most common issues in Malaysia. Many rivers in Malaysia are generally considered to be polluted including Sungai Nyior, Pahang.

In Malaysia, there is already a standard that concerning the classification of water quality issued by DOE in relation to water quality. NWQS and WQI which is good water quality benchmarking tools so that river water quality preservation efforts can be executed seamlessly.

1.2 PROBLEM STATEMENT

Nowadays, the condition of water pollution in Malaysia is becoming more serious because the water quality is declining due to the anthropogenic activity that was carried out. As Malaysia is fast becoming an industrial country, many of the rivers have become contaminated due to the many wastes that have been discharged into the rivers. Although water pollution is an age old problem but in this modern age, the variety wastes have polluted our water resources so much so that about 70% rivers and streams not only of Malaysia but of all the countries contain polluted waters. The pollution of the river is apparently obvious because it could easily be judge by the colour, look and odour of the river.

Sungai Nyior has been chosen for the study of water quality because of its importance and function to the communities. This river serves as extremely important natural resources for the people living around the area. This river before it became the location for finding the crabs and fishing for the fisherman and residents.

According to Sinar Harian Newspaper (2016), the river was suspected polluted due to the anthropogenic activities. The residents around the area also complained about the river that is so much polluted because the water turns black and odour. Water polluted affect the local residents such fishing at the river. They are concerned with the situation and wants immediate action taken to address them.

Figure 1.1 : The current physical water of Sungai Nyior.

Source: Sinar Harian Newspaper ,23 March 2016.

From the physical observation, one can assume that something is not right with the current water quality condition of this river. The issues will be questioned as well as how bad is the current water quality condition? What are the required pollution sources that need to be further inspected and controlled? These questions will be answered when the investigation and research was carried out for this study area.

1.3 SIGNIFICANCE OF STUDY

Recently, Water qualities of rivers are the one of the most common issues in Malaysia. That is why this study is important to characterise the current of water quality of the study area. To my knowledge, no study has yet been done to characterise of the Sungai Nyior.

Water Quality of the river has significantly affected by the anthropogenic activities around the study area. Other than that, unsustainable land use pattern within and around the study area has resulted in erosion and sedimentation of the river system that depleting the aquatic biodiversity. Consequently, it is significant to study the level of pollution in the river presently and define the causes of pollution in order to recommend appropriate resolutions to the problem.

1.4 OBJECTIVES

1- To evaluate the characteristics of current water quality in the study area based on NWQS and WQI, Malaysia.
2- To identify the possible factors or sources that influences the water quality of the river system.
3- To make an appropriate suggestion for effective management of the water resources.

1.5 SCOPE OF STUDY

The scope of study in this research is at Sungai Nyior that was located at near Balok Baru at Kuantan, Pahang. This study involves two types of study which are in situ (field) test and ex situ test which is analysis at laboratory for sampling and data collection. The 3 points of samples will be taken a monthly on September until October 2016 at the river.

At in situ, the reading was taken directly at the study area depends on the suitable instrument and method that are used for the river water at each sampling point and the reading was taken. The in-situ tests included pH, EC, DO, temperature and turbidity.

The laboratory testing was carried out for testing several parameters that will be analyse in the laboratory in ascertaining the physical, biological and chemical characteristic of the water which are TSS for physical parameter. Chemical parameters included COD, BOD, NH3-N, total hardness and selected heavy metal such as chromium (Cr), copper (Cu), and cadmium (Cd). Biological parameters also tested such as Total Coliform and E.coli in order to evaluate the characteristics of current water quality in the study area.

These three components of water quality parameters was selected will be analysed based on in situ and laboratory analysis according to DOE used standard for river water quality such as WQI and NWQS.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

A review of the literature was selected to identify to the topic which is assessing the impact of anthropogenic disturbances on water quality in the Sungai Nyior, Kuantan. The source for the literature search was internet article and journal. The emergent themes may divide into impact of anthropogenic disturbance on river, river water quality, river pollution issues and status in Malaysia, type of water pollution, hydrological cycle, water quality parameter that are required for the research, river water quality standard and water resources management.

2.2 IMPACT OF ANTHROPOGENIC DISTURBANCES

Impact Anthropogenic disturbances 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.

Table 2.1: The anthropogenic disturbance by previous researcher.

Author	Year	Title of Paper	Finding
Montagna et.al	1998	Characterization Of Anthropogenic and Natural Disturbance On Vegetated and Unvegetated Bay Bottom Habitats In The Corpus Christi Bay National Estuary Program Study Area	Each kind of anthropogenic disturbance is important in specific sites where the disturbance occurs if the disturbance affects an ecological process or community that is present in the site.
Bonzemo	2013	Assessment Of Water Quality Status Of River Kibisi, Kenya Using The Ephemeroptera, Plecoptera Trichoptera (Ept) Index	High turbidity of river water due to anthropogenic activities and the brown color of the water is as a result of sediment and silt deposition of organic and inorganic materials from the open agricultural farmlands and the river watershed that end up in the river.
Courrat et al.	2009	Anthropogenic disturbance on nursery function of estuarine areas for marine species	Increasing human activities within estuaries and surrounding areas lead to significant habitat loss for the juveniles and decrease the quality of the remaining habitats.
Rehage et al.,	2006	Assessing the net effect of anthropogenic disturbance on aquatic communities in	Anthropogenic alterations of natural hydrology are common in wetlands and often increase water permanence,

		wetlands: community structure relative to distance from canals	converting ephemeral habitats into permanent ones. Since aquatic organisms segregate strongly along hydroperiod gradients, added water permanence caused by canals can dramatically change the structure of aquatic communities.
Falcone et al.	2010	Quantifying human disturbance in watersheds: Variable selection and performance of a GIS-based disturbance index for predicting the biological condition of perennial streams	Stream ecosystems are profoundly influenced by human activities. Disturbances include point-source pollution, conversion of natural vegetation to developed land, nutrient and pesticide input from agricultural and urban sources, mining and mineral extraction operations, channel modification, and water impoundment. These activities often change the timing or amount of stream flow, increase runoff, erosion, and sedimentation, alter water temperature and chemistry, and introduce contaminants

2.3 RIVER WATER QUALITY

Water quality is a term used to express the suitability of water to sustain various uses or processes (Meybeck at.al 1996). The quality of water may be described in terms of the concentration and state the organic and inorganic material present in the water, together with certain physical characteristics of the water. The composition of surface waters is dependent on natural factors in the drainage basin and varies with seasonal differences in runoff volumes, weather conditions and water levels.

Human intervention also has significant effects on water quality. Some of these effects are the polluting activities, such as the discharge of domestic, industrial, urban and other wastewaters into the watercourse (whether intentional or accidental). The principal reason for monitoring water quality has been the need to verify whether the observed water quality is suitable for intended uses. However, monitoring has also evolved to determine trends in the quality of the aquatic environment and how the environment is affected by the release of contaminants, by other human activities.

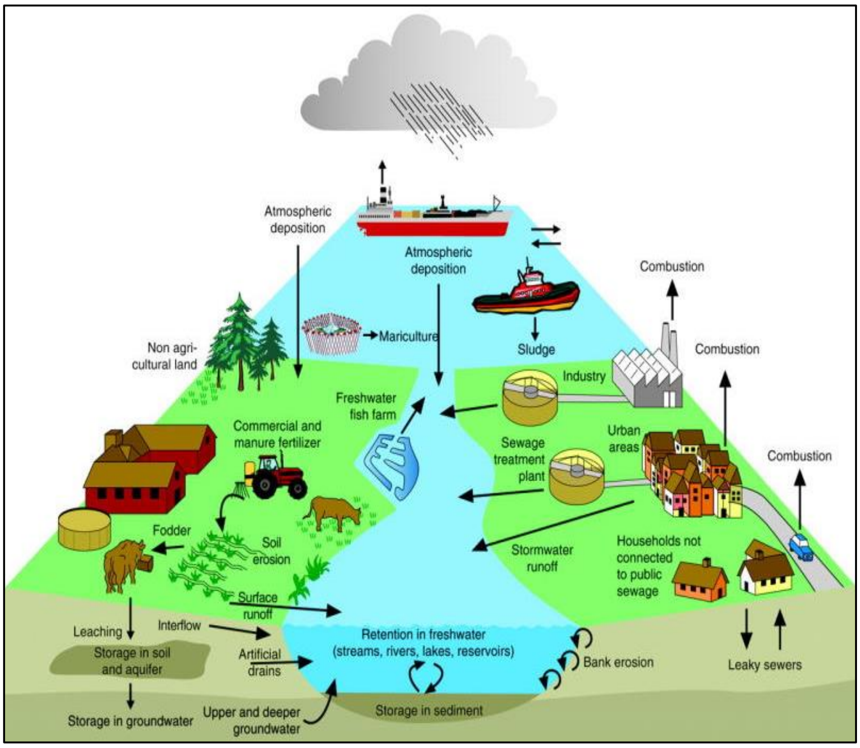

Figure 2.1: Sources that effect Water Quality.

River water quality and pollution control need to be addressed urgently since 98 percent of the total water use originates from the rivers. 70% of the water resources in the country are for the agricultural industry. As river water pollution increases, concentrations of the existing pollutants increase. Consequently, it increases water ‘quantity scarcity’ since good quality water available for use decreases and higher water treatment costs due to the presence of new pollutants. Moreover, the ecological health of the water bodies and the surrounding ecosystems degrade, affecting aquatic lives and habitat, and recreational activities (Huang et al., 2015).

2.4 RIVER POLLUTIONS ISSUES AND STATUS IN MALAYSIA

Water pollution is a serious problem in Malaysia and impacts negatively on the sustainability of water resources. Not only for that, but it is also affects plants and organism living, people's health and the country's economy. It reduces total water availability considerably as the cost of treating polluted waters is too high and in some instances, polluted waters are not treatable for consumption. Most of the sources of pollution have been caused by human activity, although some of them come from natural sources of pollution. The problem of water pollution is now becoming more serious with reports indicating a downward trend year by year. Water pollution however, is not a recent environmental issue as it had been synonymous with urbanization and modernization.

According to Huang et al (2015), in 2012, nine rivers within the Klang River Basin under River of Life Project were added to the national river water quality monitoring programme. The river water quality was assessed based on a total of 5,083 samples taken from a total of 473 rivers. Out of 473 rivers monitored, 278 (59 percent) were found to be clean, 161 (34 percent) slightly polluted and 34 (7 percent) polluted. Figure 1 shows the river water quality trend for 2005-2012.

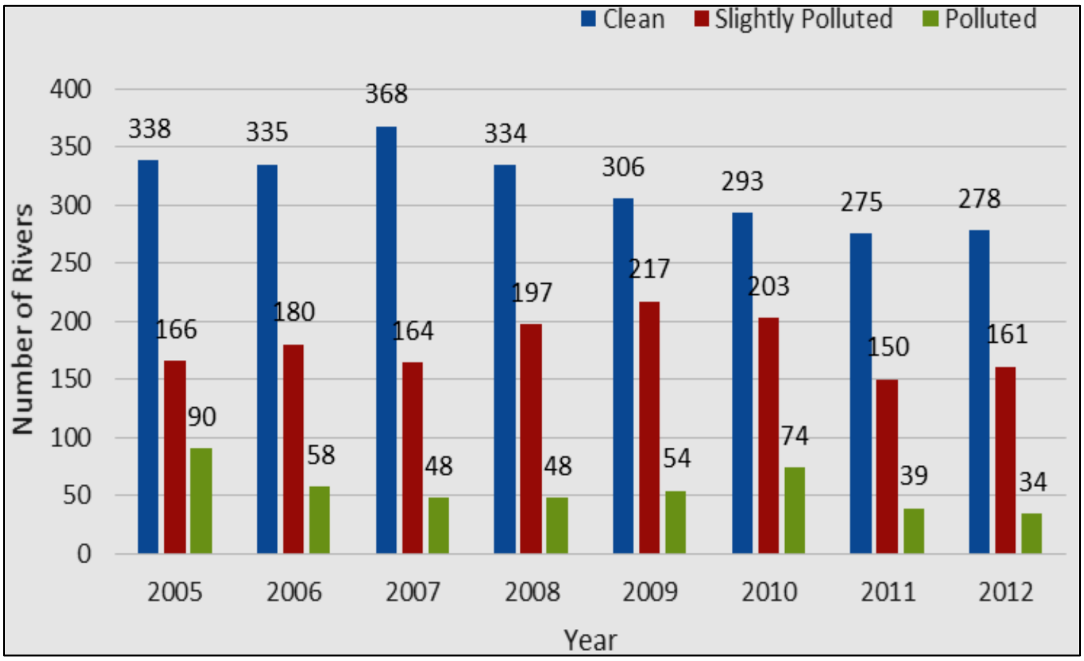

Figure 2.2: River water quality trend for 2005-2012

In 2012, 34 rivers were categorized as being polluted. Out of these, 19 rivers were classified as Class III, 14 rivers as Class IV and one river as Class V. Classification of level pollution by individual pollutant follows the standard set by DOE .Construction activities such as earthworks and land clearing appear to be the main contributor for the sources of SS, whilst the sources for BOD and NH3-N were mostly from agro-based industries and livestock farming, respectively. Pollution of river by untreated or partially treated sewage was also indicated in term of BOD and NH3-N. Besides pollution from organic pollutant, inorganic pollutant especially heavy metals also another crucial contribution. Mercury (Hg), Arsenic (As), Cadmium (Cd), Chromium (Cr), Plumbum (Pb), and Zinc (Zn) were analyzed.

2.4.1 Type of Water pollution

Many natural and anthropogenic factors affect the water pollution. It comes from point sources and non-point sources, population and land use playing an important role in water quality (Dailey, 2013). These activities often change the timing or amount of stream flow, increase runoff, erosion, and sedimentation, alter water temperature and chemistry, and introduce contaminants (Falcone et. al, 2010)

Table 2.2: Difference between Point Source and Non-Point Source of Water Pollution

Point Source	Non-Point Source
Point source come from a single identifiable source.	Non-point sources do not have specific discharge point.
Point source pollutants can be traced to a specific point such as :- ➢ Sewage treatment plants ➢ Industrial waste ➢ Dumping toxins ➢ Factory .	More difficult to trace since they may be carried far from their original source by rain such as:- ➢ surface run-off ➢ Agricultural / Cropland ➢ Animal feedlot ➢ Rural homes ➢ storm drain ➢ urban runoff neither discharged from a pipe nor put down the sewer

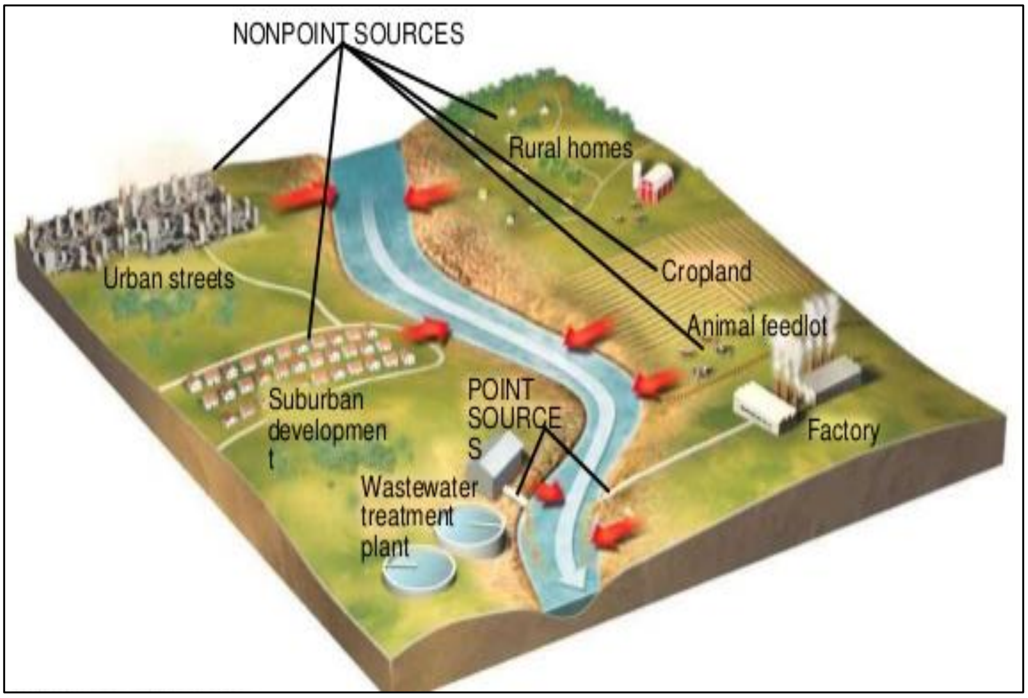

Figure 2.3: Point Source and Non-Point Source representation.

2.5 HYDROLOGICAL CYCLE

The hydrological cycle is usually called a recurring consequence of different forms of movement of water and changes of its physical state in the nature on a given area of the Earth (a river or Lake Basin, a continent, or the entire Earth). The combined effects of urbanization, industrialization and population growth affect natural landscapes and the hydrological response of watersheds (Marsalek et al., 2008). Besides that, climate change nowadays gave a great impact towards hydrological cycle that limits the source of fresh water to living things on earth.

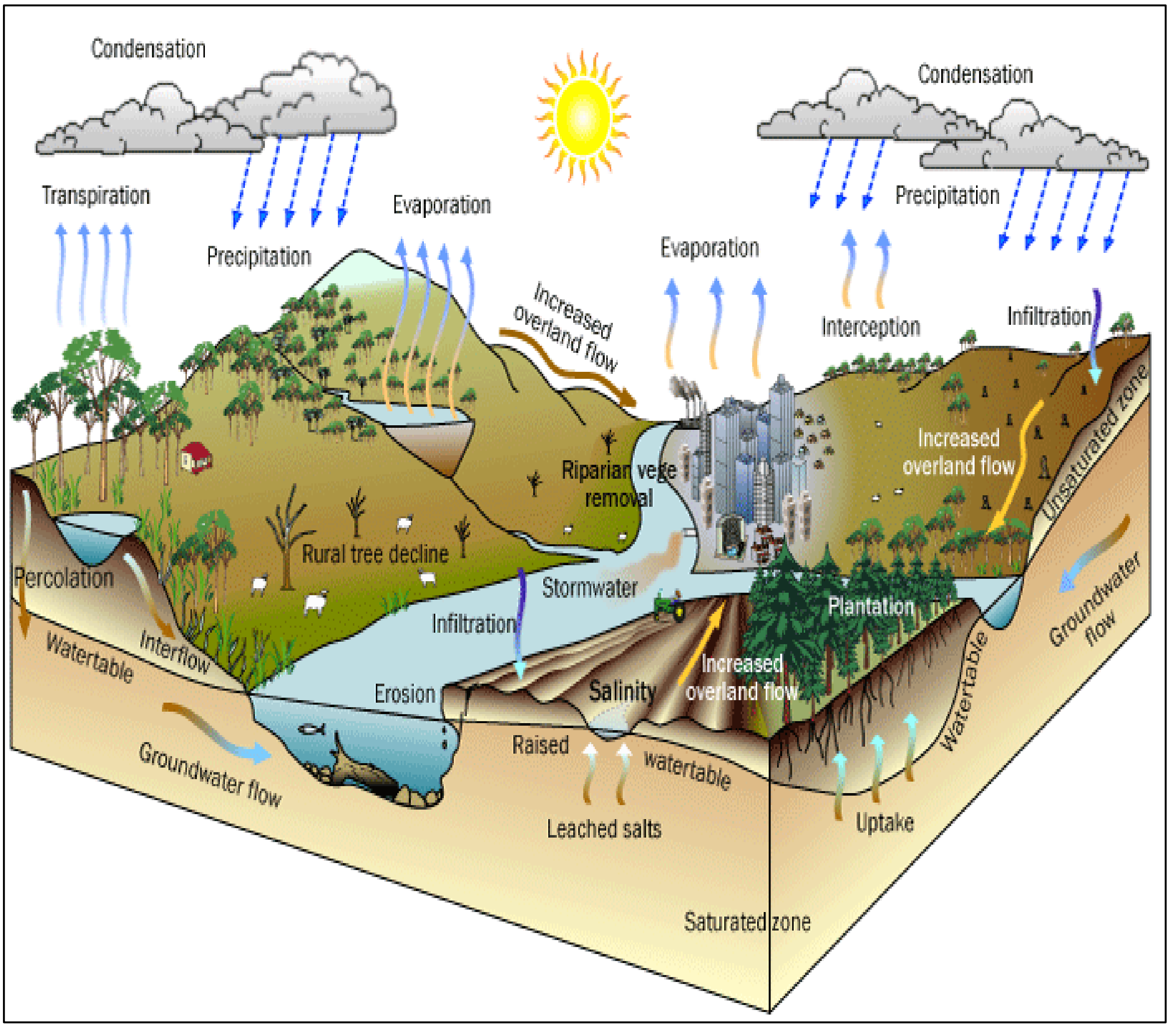

Figure 2.4: Hydrological Cycle representation.

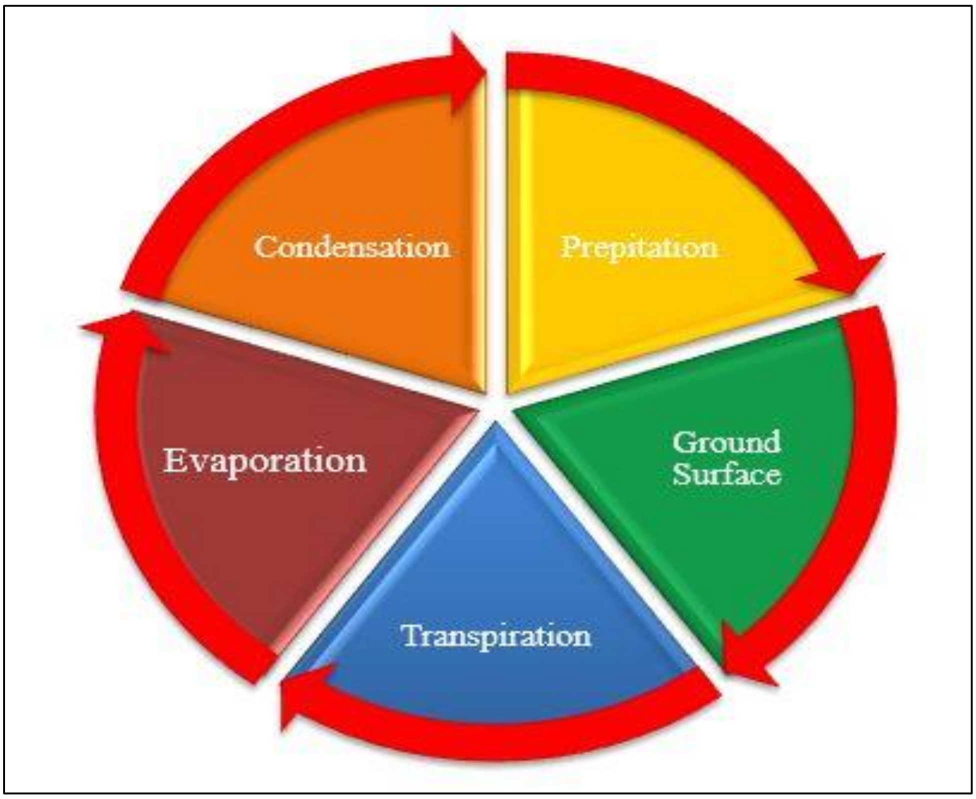

Figure 2.5: Hydrological Cycle Process.

According to Meybeck et al. (1996), anthropogenic activities can enhance natural processes, such as erosion and soil leaching, increase inputs of natural compounds such as mineral salts and inorganic fertilisers to the river system, and add synthetic compounds which are mostly organic and not found in nature, such as solvents, pesticides and aromatic hydrocarbons. The additional materials arising from increases in natural processes follow the same pathways, and behave in the same way, as compounds arising from soil leaching, such as fertilisers and pesticides. However, most urban pollutants enter rivers as point sources, usually as treated or untreated sewage effluents.

According to Kuchment (2004), human influence on the global hydrological cycle is mainly revealed through climate change. Widespread activities such as the construction of reservoirs, abstractions of groundwater, and irrigation, do impact the global hydrological cycle, but these direct effects are small in comparison with the variations caused by climatic oscillations.

2.6 WATER QUALITY PARAMETERS

Having good quality of water is important for a healthy river and ecosystem. Several basic conditions must be met for aquatic life to thrive in the water. When these conditions are not optimal, species populations become stressed. When conditions are poor, organisms may die. Thus, several water quality parameters need to be measured in order to determine the health of the river water so that it is safe to use for any purpose. In order to develop a water quality or river index, there are several parameters that need to be considered. The common parameters and will affect quality of the water which are physical, chemical, and biological. These components of water quality parameters are according to the WQI and NWQS as well.

Table 2.3: Water Quality Parameters

Physical	Chemical	Biological
Temperature	PH	Total coliform
Turbidity	***Inorganic Indicators***	Escherichia coli
Total Suspended	➢ Electrical Conductivity (EC)	(E.Coli)
Solids (TSS)	***Organic Indicators***	
	➢ Biological Oxygen Demand (BOD)	
	➢ Chemical Oxygen Demand (COD)	
	Dissolved Gases	
	➢ Dissolved Oxygen (DO)	
	Nitrogen	
	➢ Ammonia Nitrogen (NH3-N)	
	Hardness	
	➢ Total Hardness	
	Selected Heavy Metals	
	➢ Chromium (Cr)	
	➢ Copper (Cu)	
	➢ Cadmium (Cd)	

2.6.1 Physical Parameters

Physical parameters refer to characteristics of water that respond towards sight, taste, smell and touch. Some of the physical parameters tested were total suspended solids, turbidity and temperature.

2.6.1.1 Temperature

Water temperature is important and has a big effect in lakes and rivers .Temperature is related, usually directly, to all the chemical, physical, and biological properties of water. The ability of water to dissolve or precipitate materials is temperature dependent, the ability of water to transport or deposit suspended material is temperature dependent, and the aquatic life of a lake or stream may thrive or die because of the water temperature (Blakey, 1965). It can determine where in the water certain plants and animals can live. Some plants and animals will become dormant if water temperatures drop very low but will grow extremely quickly during the warmer waters of the summer.

Water temperature can also indicate effects of human activities. According to Dallas (2008) , anthropogenic factors that modify water temperature .The effect of a change in water temperature may be direct including thermal discharges or indirect including land-use changes, agricultural irrigation return-flows, flow modifications (river regulation), inter-basin water transfer, modification to riparian vegetation, and global warming.

2.6.1.2 Turbidity

The rivers have different turbidity. Turbidity is a measure amount of cloudiness or murkiness in the water due to suspended matter such as clay, silt, and organic matter and by plankton and other microscopic organisms that interfere with the passage of light through the water (American Public Health Association, 1998).

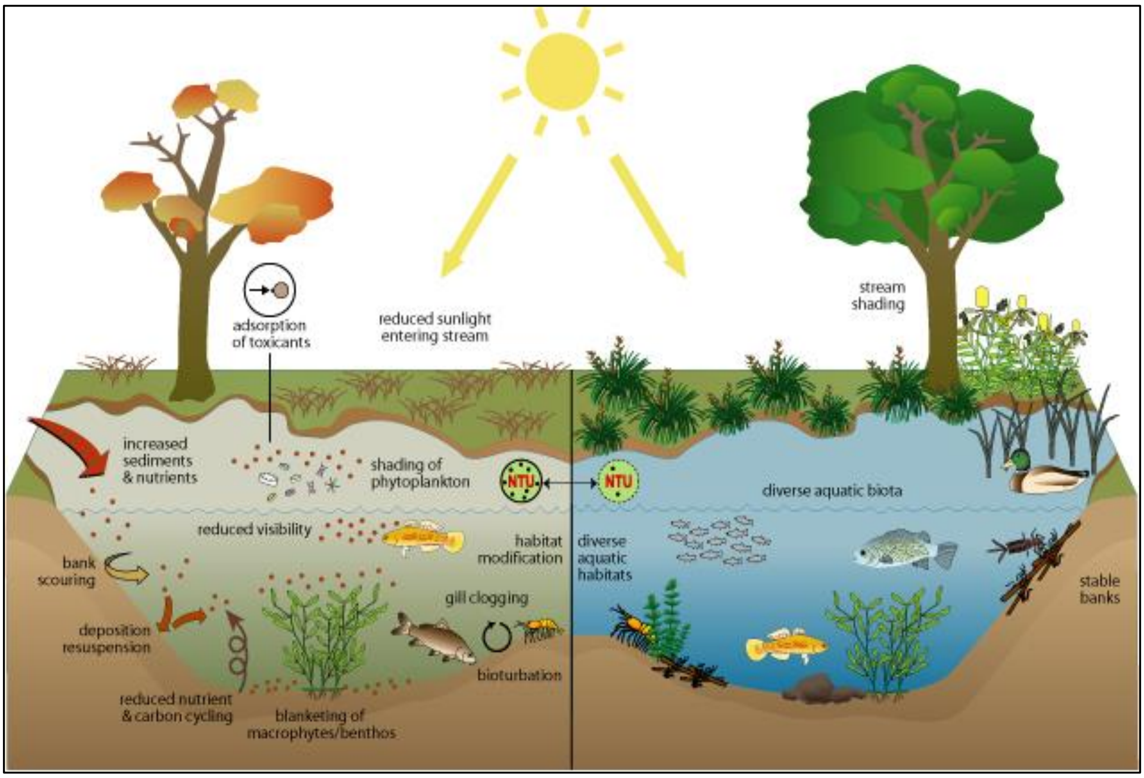

Figure 2.6: Difference between high and low of turbidity.

The quality of water will be affected by the turbidity can make the water a smell, taste and bad look. If the river full of silt and mud, so it would be impossible to see through the water (high turbidity) .Then, if the water is completely clear (low turbidity) as shown in figure 2.6. In addition, soil erosion, urban runoff, high flow rate, wastewater, and bottom-feeding fish may result in turbidity in rivers. Runoffs from snowmelt and storm events in areas burned by forest fires exhibit higher levels of turbidity (Hopkins, 2001). High levels of turbidity can change the diversity of aquatic systems and can shade out aquatic plants and other fauna. Increased turbidity can also affect water temperature and distribution of heat through the water column (Sallam et al., 2015)

In most equipment, turbidity is measured by emitting infrared light from a known source and measuring the amount of backscatter from suspended particles. The greater the backscatter, the higher the turbidity, measured in NTUs (nephelometric turbidity units Surface water can become warmer and subsurface water may become cooler due to the shading action (Sallam et al., 2015) .Turbidity can range from less than 1 NTU to more than 1,000 NTU. At 5 NTU, water is visibly cloudy; at 25 NTU, it is murky.

2.6.1.3 Total Suspended Solid (TSS)

TSS includes all particles suspended in water which will not pass through a filter. TSS is a measure of the sediment suspended in the water. It can include a wide variety of material, such as silt, decaying plant and animal matter, construction sites, agriculture, industrial wastes, and sewage. Figure 2.7 shows the variety of land uses that are produces the TSS. High concentrations of TSS depend on increasing of land use that can cause many problems for stream health and aquatic life. As level of TSS increase, a water body begins to lose its ability to support a diversity of aquatic life. TSS are the result of poorly planned development activities (such as construction and areas under development) that produce large TSS and lack proper erosion control measures, residential activities, as well as from agricultural and logging activities (Zainudin et al., 2009).

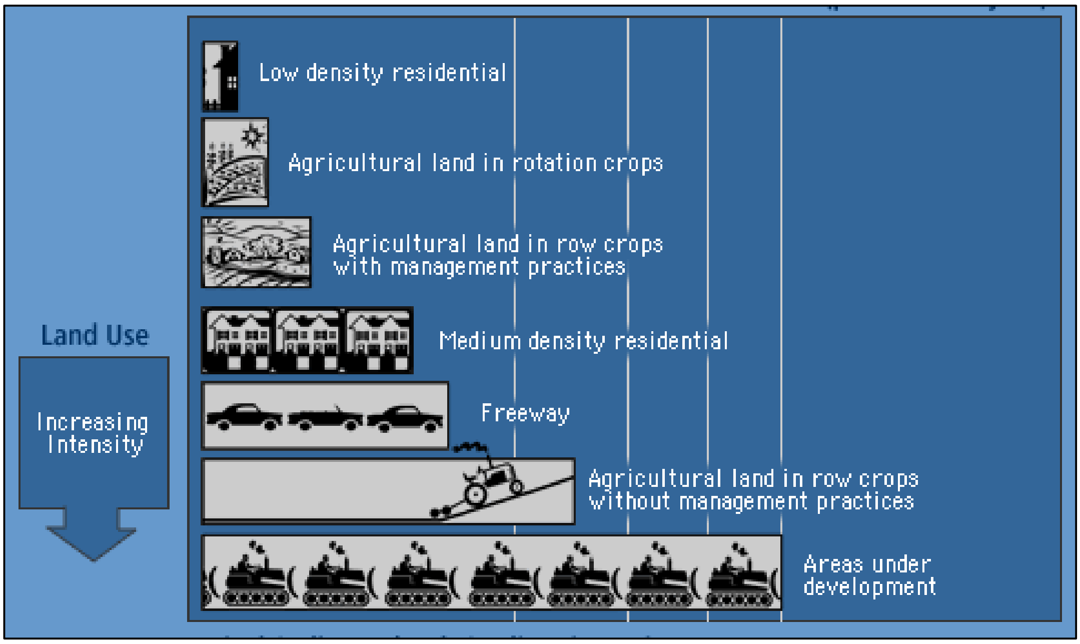

Figure 2.7: Typical Suspended Sediment Load for different Land Uses

Other than that, high TSS can also cause an increase in surface water temperature and subsequently decreases levels of DO (warmer water holds less oxygen than cooler water), because the suspended particles absorb heat from sunlight. High TSS also can block light from reaching submerged vegetation. According to Xiao (2014), photosynthesis also decreases, since less light penetrates the water as less oxygen is produced by plants and algae, there is a further drop in dissolved oxygen levels.

2.6.2 Chemical Parameters

Chemical parameters refer to the characteristics of water that capable to solvent it. Some of the chemical parameters tested were PH, Inorganic Indicators such as, electrical conductivity (EC), Organic indicators such as chemical oxygen demand (COD) and biological oxygen demand (BOD), Dissolved gas such as dissolved oxygen (DO). Ammonia Nitrogen (NH3-N) parts of Nitrogen, Hardness such as Total hardness and Selected Heavy Metal such as Copper (Cu), Cadmium (Cd) and Chromium (Cr).

2.6.2.1 PH

PH levels can indicate healthy waters for plants and animals. Most living things depend on a proper pH level to sustain life. Extremes in pH can make a river inhospitable to life. Too low and too high pH is especially harmful to immature fish and insects like figure 2.9. Acidic water also speeds the leaching of heavy metals harmful to fish. PH is important because pH value can affect the toxicity of many compounds. PH will cycle in the presence of large quantities of algae and macrophytes due to the photosynthetic cycling of CO_2 (Sallam et al., 2015). Acidity and alkalinity are two independent variables which depend upon the quantity of positive and negatively charged ions present in the medium and interaction of both together determines the PH (Shashi et al., 2009).

According to RAMP (2010), a pH value of 7.0 is considered neutral, while values below 7.0 are considered acidic, and above 7.0 are basic. The pH of most natural waters is between 6.0 and 8.5. By implication, the pH of the river is acidic and could have a detrimental effect on some aquatic lives and also affect its suitability for domestic use that can see at figure below. Low pH (acidic) could be caused from acid rain or industrial pollution. High pH values (basic), alkaline could be caused industrial dumping or natural minerals leaching into the water, soaps and detergents. The pH depends on many factors such as stream vegetation, bed geology and the presence of water pollutants.

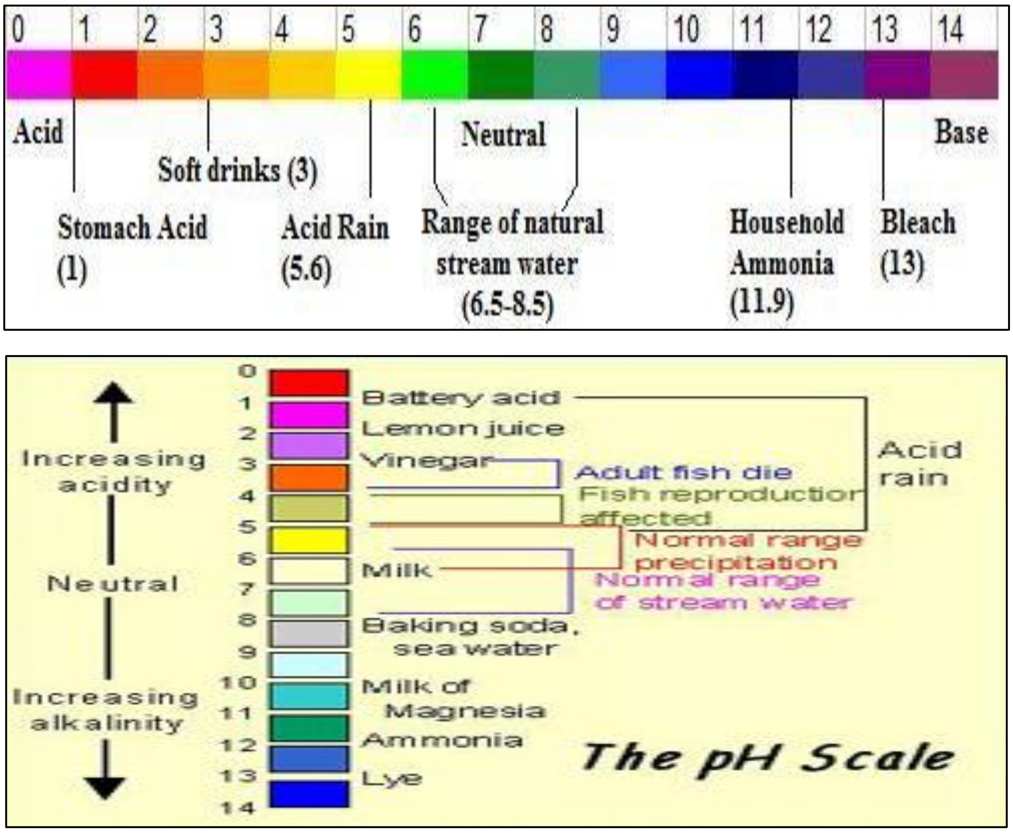

Figure 2.8: PH Scale of Common Substances.

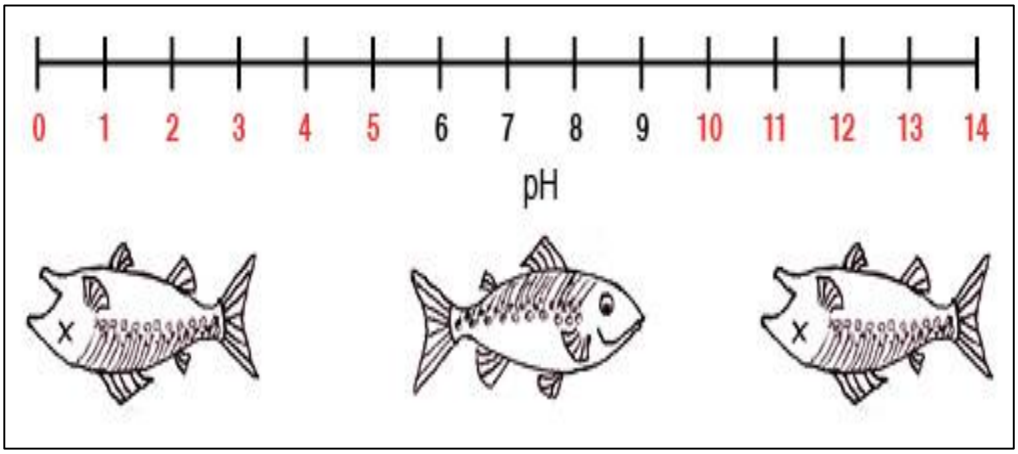

Figure 2.9: pH effect the fish in the river.

2.6.2.2 Electrical Conductivity (EC)

According to Manap (2014), Electrical Conductivity (EC) is a measure of the ability of water to pass an electrical current. Conductivity used microsiemens per centimeter (µS/cm) or micromhos per centimeter (µmhos/cm) as the basic unit of measurement. These two units can be used because they are similar. Conductivity of distilled water is between 0.5 to 3 µS/cm. Based on figure 2.10, most of the streams are in range from 50 to 1500 µS/cm. Freshwater streams is at best if they have a conductivity between 150 to 500 µS/cm in order to support various aquatic life.

Electrical Conductivity is also affected by temperature such as the warmer the water, the higher the conductivity. Few dissolved solids performed as conductor that allowed for conductance. Water with higher level of dissolved solids was potentially unhealthy and unpleasant. This kind of water have an adverse effect on human, crops and animals.

2.6.2.3 Biochemical Oxygen Demand (BOD)

The BOD test is one of the most important parameter and basic tests used in the water pollution control. The quantity of oxygen utilised by a mixed population of microorganism biologically degrade the organic matter in the wastewater under aerobic condition is called BOD. According to Penn et al. (2010), BOD is a measure of the DO consumed by microorganisms during the oxidation of reduced substances in waters and wastes.

BOD is an important water quality parameter because it greatly influences the concentration of DO that will be in the water. Refer to figure 2.10, if level of BOD are high, level of DO is decrease. This because the bacteria is being using the oxygen that is available in that water. Fish and the aquatic organisms may not survive, since less DO is available in the water. Whereas, if there is no organic waste present in the water, there will not be as many bacteria present to decompose it and thus the BOD will tend to be lower and the DO level will tend to be higher. Other than that, if the BOD is high, the quality of water is low.

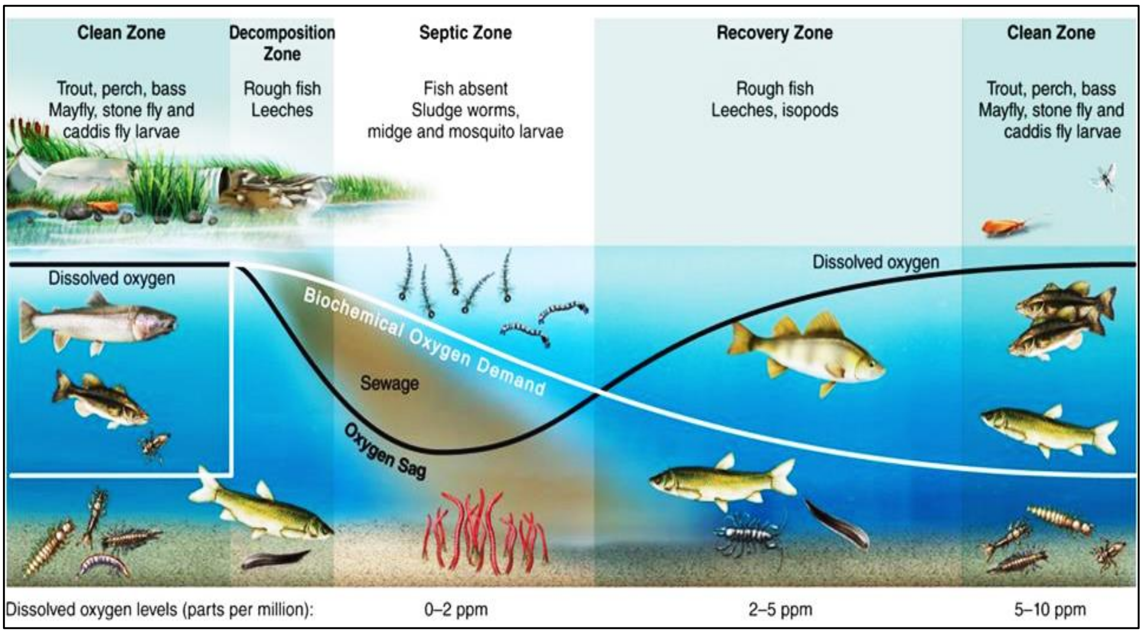

Figure 2.10: BOD curve versus DO of water

Table 2.4: Different of zone based on BOD curve versus DO of water

Clean zone	Decompose zone	Septic Zone	Recovery Zone
DO is high, BOD is low. Very low pollution and means normal life.	Bacteria are using DO to break down pollutants. DO is decreasing BOD is increasing means pollution tolerance life.	DO is too low and BOD is very high for fish to live as de-oxygenated water moves down stream.	DO start to rise as BOD deceases due to pollution decreasing means pollution tolerance life.

2.6.2.4 Chemical Oxygen Demand (COD)

Chemical oxygen demand (COD) is to indicate the level of pollution in the water based on chemical characteristics and is a measure of the amount of oxygen required to oxidize the organic matter chemically by a strong oxidant known as dichromate and sulfuric acid. Chemical oxygen demand (COD) does not differentiate between biologically available and inert organic matter, and it is a measure of the total quantity of oxygen required to oxidize all organic material into carbon dioxide and water. COD values are always greater than BOD values, but COD measurements can be made in a few hours while BOD measurements take five days.

Most applications of COD determine the amount of organic pollutants found in surface water or wastewater, making COD a useful measure of water quality. It is expressed in milligrams per liter (mg/L) also referred to as ppm (parts per million), which indicates the mass of oxygen consumed per liter of solution.

2.6.2.5 Dissolved Oxygen (DO)

Dissolved oxygen (DO) is of fundamental importance for all chemical and biochemical processes which take place in natural waters. It is indispensable for the life of fish and other aquatic organisms. DO is measured in milligrams per liter (mg/l) or parts per million (ppm). It can range from 0-18 parts per million (ppm), but most natural water systems require 5-6 parts per million to support a diverse population.

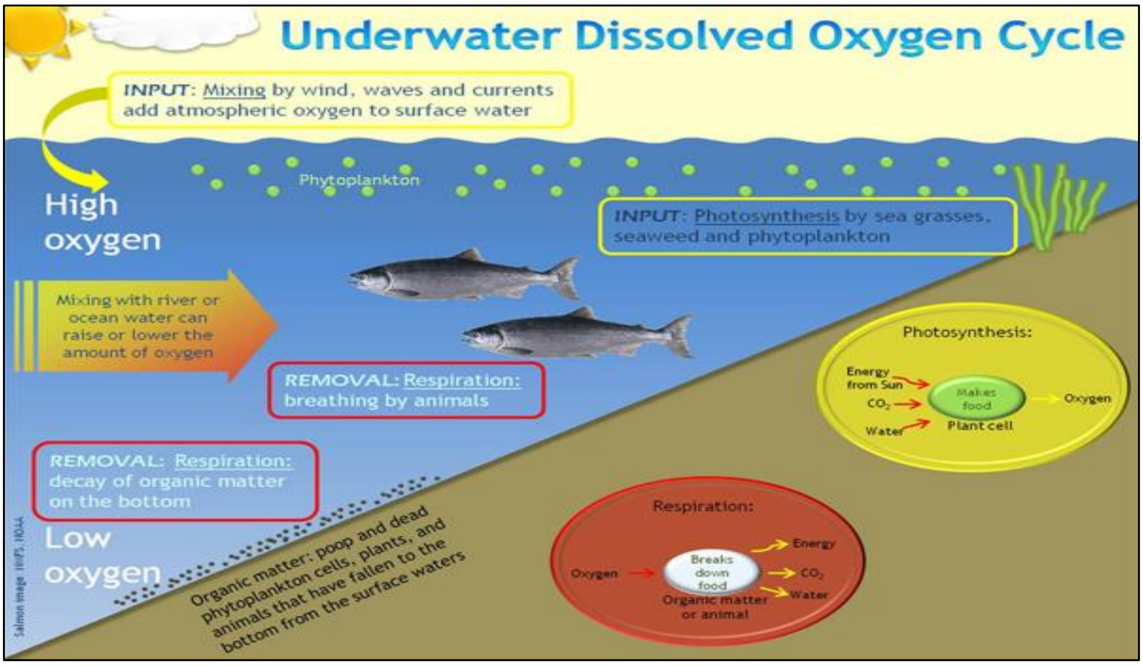

Figure 2.11: Dissolved Oxygen Cycle

According to figure 2.11, input that can produces oxygen is from photosynthesis process by plants. Besides, DO also increase by mixing by wind, waves and current add atmospheric oxygen to surface water. Other than that, when organic matter such as animal waste or improperly treated wastewater enters a body of water, algae growth increases and the dissolved oxygen levels decrease as the plant material dies off and is decomposed through the action of the aerobic bacteria.

Dissolved oxygen levels are reduced by excessive amounts of organic matter such as sewage, manure, or leaves that wash into streams. Warm water released from industrial outlets, flowages, or storm sewers can also reduce dissolved oxygen levels. Erosion from any number of sources is another factor that lowers dissolved oxygen levels. However, good management practices such as planting or maintaining vegetation that filters rainwater runoff and shades the water. (Xiao, 2014) .Changes in dissolved Oxygen concentrations can be an early indication of changing conditions in the water body.

2.6.2.6 Ammonia Nitrogen (NH3-N)

Ammonia is analyzed by chemical titration. The method used in most test kits is called the salicylate method. Always measure pH and temperature when measure ammonia. Without these other measurements it will be difficult to know the toxicity of the ammonia. Results can be expressed as total ammonia (mg/l).

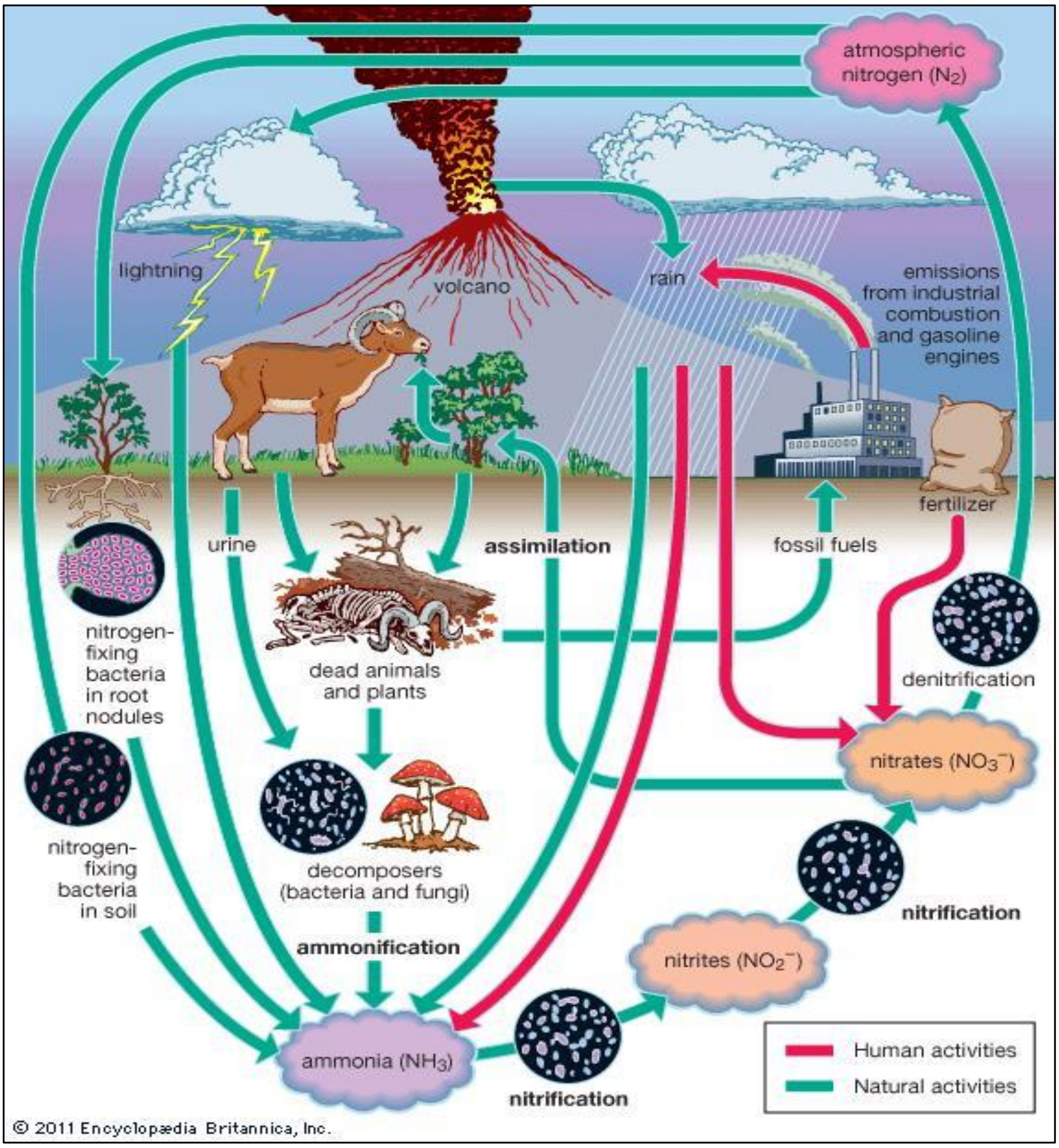

Figure 2.12: Sources of Ammonia.

Ammonia is a nutrient that contains nitrogen and hydrogen. Its chemical formula is NH3 in the un-ionized state and NH4 + in the ionized form. Total ammonia is the sum of both NH3 and NH4 +. Total ammonia is what is measured analytically in water. Ammonia is the preferred nitrogen-containing nutrient for plant growth. In figure 2.12, Ammonia can be converted to nitrite (NO2) and nitrate (NO3) by bacteria, and then used by plants. It also excreted by animals and produced during dead and decomposition of plants and animals, animals waste thus returning nitrogen to the aquatic system. Ammonia is also one of the most important pollutants because it is relatively common but can be toxic, causing lower reproduction and growth, or death. The neutral, unionized form (NH_3) is highly toxic to fish and other aquatic life.

Donald (2012) found that that elevated levels of ammonia is often noted in streams and rivers draining watersheds with high levels of corn production, nitrogen fertilizer application as well as runoffs from uncontained livestock operations. Ammonia Nitrogen also found in Residential which is household use of ammonia-containing cleaning products, on-lot septic systems, and improper disposal of NH3-N products. Besides, livestock waste and continual use fertilizer from agriculture activity that contribute to nutrient input in river, landfill leachate, sewage, liquid fertilizers, and any other liquid organic waste products (Mirmohseni, 2003).

2.6.2.8 Total Hardness

Hardness is traditionally measured by chemical titration. The hardness of a water sample is reported in milligrams per liter (same as parts per million, ppm) as calcium carbonate (mg/l $CaCO_3$). Calcium and Magnesium Hardness Hardness caused by calcium is called calcium hardness, regardless of the salts associated with it. Likewise, hardness caused by magnesium is called magnesium hardness. Since calcium and magnesium are normally the only significant minerals that cause hardness, it is generally assumed that:

Total Hardness = Calcium Hardness + Magnesium Hardness
(mg/L as $CaCO_3$) (mg/L as $CaCO_3$) + (mg/L as $CaCO_3$)

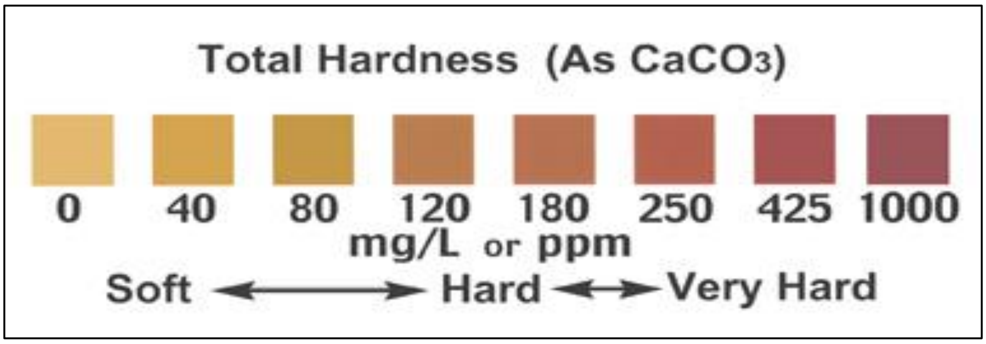

Figure 2.13: Total Hardness Scale

Based on the figure 2.14, Total Hardness have scale from soft water until very hard of water hardness. Total hardness in freshwater is usually in the range of 15 to 375 mg/L as CaCO3. Calcium hardness in freshwater is in the range of 10 to 250 mg/L, often double that of magnesium hardness (5 to 125 mg/L). Typical seawater has calcium hardness of 1000 mg/L, magnesium hardness of 5630 mg/L, and total hardness of 6630 mg/L as CaCO3. According to Exploring the Water Environment (2004), a stream‟s hardness reflects the geology of the catchments area and sometimes provides a measure of the influence of human activity in watershed.

2.6.2.8 Heavy Metal

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 mercury (Hg), cadmium (Cd), arsenic (AS), chromium (Cr) and lead (Pb). Heavy metals are natural components of the earth crust. They cannot be degraded or destroyed. Pollution of heavy metals in aquatic environment is a growing problem worldwide and currently it has reached an alarming rate.

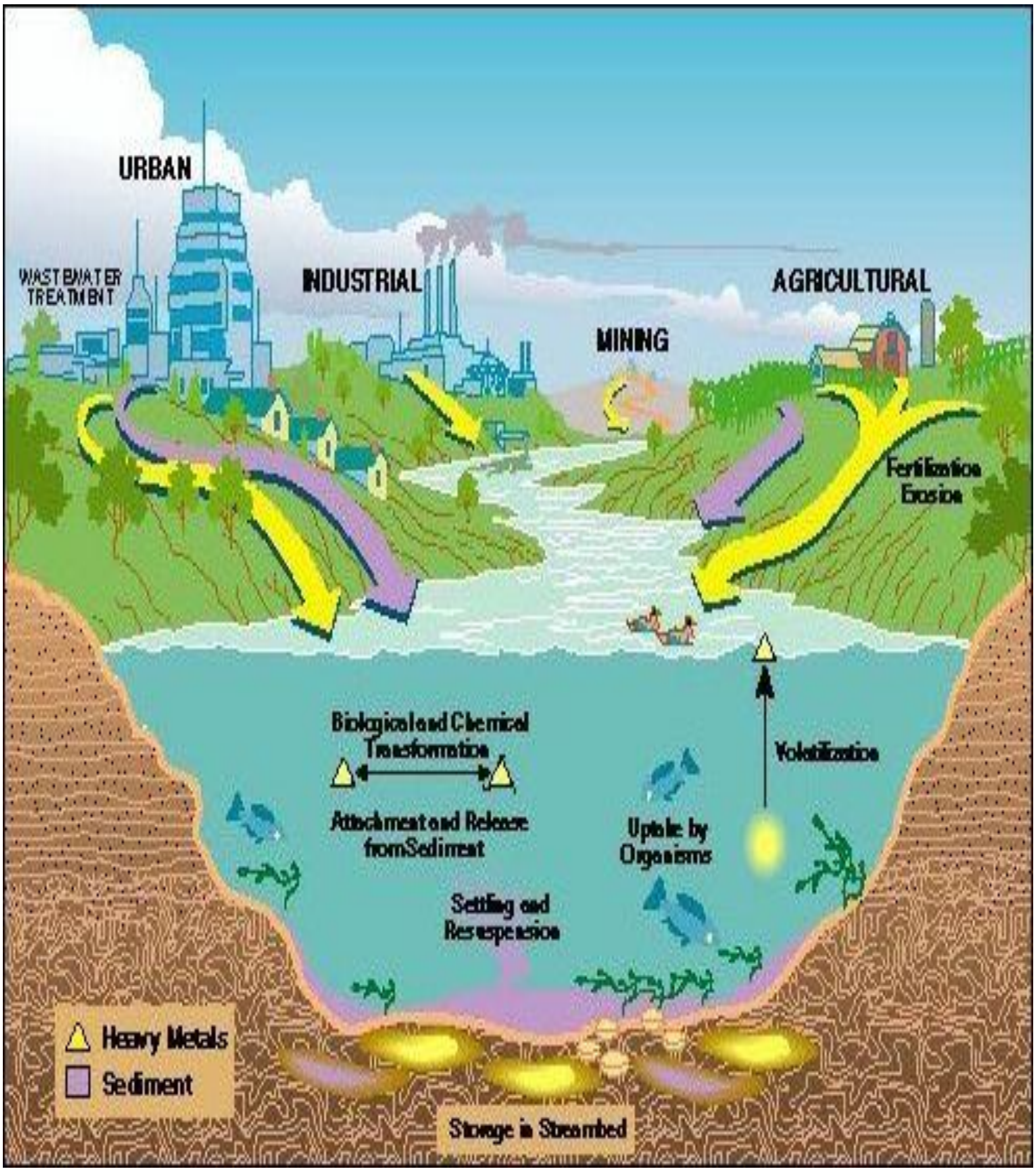

Figure 2.14: Source of Heavy Metal

Based on figure 2.14, 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.

Table 2.5: The research of heavy metal by previous researcher.

Author	Year	Title of Paper	Finding
Zeitoun and Mehana	2014	Impact of Water Pollution with Heavy Metals on Fish Health: Overview and Updates	The anthropogenic sources of cadmium, including industrial emission and application of fertilizers sewage sludge to farmland, may lead to contamination of soils to increase cadmium uptake by crops and vegetables grown for human consumption. Heavy metals are natural trace components of the aquatic environment, but their levels have been increased due to industrial wastes geochemical structure, agricultural and mining activities.
Olade	1987	Heavy Metal Pollution and the Need for Monitoring: Illustrated for Developing Countries in West Africa	Heavy metal produced by industries involved in activities such as battery, paint manufacturing, petroleum refining, cement and ceramic production, steel production.
Nazir et al.,	2015	Accumulation of Heavy Metals in the soil, water and plants and analysis of physicochemical parameters of soil and water.	Draining of sewerage, dumping of hospital wastes and recreational activities increase heavy metal.

2.6.2.8.1 Selected Heavy Metals

The heavy metals to be determined in both the soil and the water samples were copper (Cu), cadmium (Cd) and chromium (Cr).

Table 2.6: Potential Health Effects from Ingestion and Sources of Contaminant of Heavy Metal

Contaminant	Potential Health Effects from Ingestion	Sources of Contaminant
Copper (Cu)	Short term exposure: Gastrointestinal distress Long term exposure: Liver or kidney damage	➢ Corrosion of household plumbing systems ➢ Erosion of natural deposits
Cadmium (Cd)	Kidney damage	➢ Corrosion of galvanized pipes ➢ Erosion of natural deposits ➢ Discharge from metal refineries ➢ Runoff from waste batteries and paints
Chromium (Cr)	Allergic dermatitis	➢ Discharge from steel ➢ Pulp mills erosion of natural deposits

2.6.3 Biological parameters

Biological parameters contained of Total Coliform and E.Coli.

2.6.3.1 Total Coliform and E.Coli

Coliform bacteria are described and grouped, based on their common origin or characteristics, as either Total or Faecal Coliform. The Total group includes Faecal Coliform bacteria such as Escherichia coli (E .coli), as well as other types of Coliform bacteria that are naturally found in the soil. Faecal Coliform bacteria exist in the intestines of warm blooded animals and humans, and are found in bodily waste, animal droppings, and naturally in soil. Most of the Faecal Coliform in faecal material (feces) is comprised of E. coli, and the serotype E. coli 0157:H7 is known to cause serious human illness.

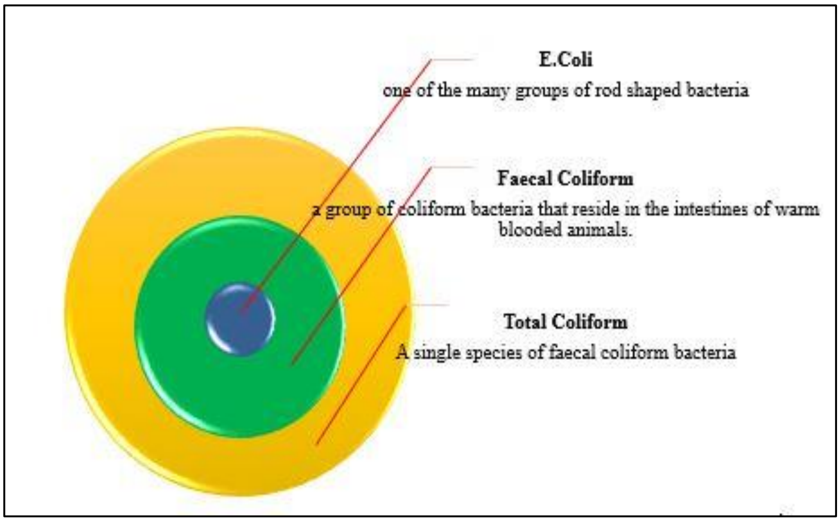

Figure 2.15: The Coliform Group.

According to Young and Thackston (1999), to establish the source of the unexpectedly high bacterial concentrations of rivers and streams near Nashiville, Tennessee. It showed that total coliforms and E.coli concentrations directly relates to the housing density, population, development, imperviousness of roads and streets, animals density; and surface runoff from densely populated, and sewered areas. According to Doyle et al.(2006), that E.Coli can enter rivers through direct discharge of waste from mammals and birds, from agricultural and storm runoff, and from human sewage. In addition, Weiskel et al. (1996) reported that coliforms concentrations in storm water runoff from impervious surfaces were related to the surrounding land use. The highest coliforms yields, from a high – density residential areas were significantly higher.

Table 2.7: High Parameter and Sources

High Parameter	Sources
Turbidity	➢ Land-use changes ➢ Agricultural irrigation return-flows ➢ Construction activity ➢ Industrial Pollution
PH	➢ Industrial dumping ➢ Natural minerals leaching into the water, soaps and detergents ➢ Industrial Pollution
DO	➢ Sewage and Septic System ➢ Industrial Pollution
BOD COD	➢ Agro-based industries ➢ Sewage and Septic System
EC	➢ Septic System ➢ Agricultural
NH3-N	➢ Domestic sewage ➢ Livestock farming ➢ Other liquid organic waste products
TSS	➢ Construction activity ➢ Agricultural ➢ Livestock ➢ Erosion from forested area
Heavy Metal	➢ Industrial Pollution ➢ Agricultural ➢ Corrosion pipe and plumbing system
Total Coliform E.Coli	➢ Wastewater and Septic System Effluent ➢ Animal Waste ➢ Agricultural ➢ Industrial Pollution

2.7 RIVER WATER QUALITY STANDARD

Water Quality Index (WQI) and National Water Quality Standards for Malaysia (NWQS) are used by DOE to evaluate the status of the river water quality. The WQI introduced by DOE is being practiced in Malaysia for about 30 years and serves as the basis for the assessment of environment water quality, while NWQS classifies the beneficial uses of the watercourse based on WQI.

WQI is useful in assessing the suitability of river waters for a variety of uses such as agriculture, aquaculture, and domestic use. WQI is used to relate a group of parameters to a common scale and combining them into a single number .WQI is one of the most effective tools to provide feedback on the quality of water to the policy makers and environmentalists. It determines overall water quality status of a certain time and location. There are several water quality indexes developed to evaluate river water quality all over the world. These indexes use various numbers of water quality parameters (Naubi et al., 2015) .The WQI formula uses six parameters to determine river water quality which are BOD, DO, COD, TSS, NH3-N, and PH.

NWQS defined six classes (I, IIA, IIB, III, IV, and V) for river water classification based on the descending order of water quality, i.e., Class I being the “best” and Class V being the “worst” water quality. 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. NWQS serves as a good benchmarking tool for the beneficial uses stipulated therein, hence it can also form a basis for target water quality in river rehabilitation efforts.

2.8 SUGGESTION FOR EFFECTIVE MANAGEMENT OF THE WATER RESOURCES

Water quality management of water resources in the country has come under close scrutiny and critic by many parties. Being so, whether the public is aware of it or not, various efforts and initiatives have been taken by the government and authorities to preserve, improve and rehabilitate river in Malaysia. In general, to preserve and improve the water quality status of our water bodies, pollution sources that input various constituents into the watercourses need to be appropriately managed and mitigated (control at source).

Public outreach and training are vital elements to the control of septic system failure. Many of the problems associated with improper septic system functioning may be attributed to a lack of homeowner knowledge on operation and maintenance of the system. Educational materials for homeowners and training courses for installers and inspectors can reduce the incidence of failure. Education is most effective when used in concert with other source reduction practices such as phosphate bans and use of low-volume plumbing fixtures.

The government must consider the provision of a comprehensive sewage system. According to Hardoy et al., (2001), sewer systems have three great advantages of eliminating the need for anyone to handle human excreta by removing excreta from the residential area, they need less maintenance since there is no septic tank or pit that has to be emptied and they remove household waste water. The regular inspection and maintenance that is required to ensure proper operation during the design life of the septic system.

Figure 2.16: Agricultural landscape with grass filter strips and other types of conservation buffers.

In figure 2.16, grass filter strips are planted strategically between fields and surface waters (rivers, streams, lakes and drainage ditches) to protect water quality **(**Minnesota Department of Agriculture, 2016). They slow runoff from fields, trapping and filtering sediment, nutrients, pesticides and other potential pollutants before they reach surface waters. They can also be planted around drainage tile inlets for the same purpose. Grass filter strips are also useful in in the Minnesota feedlot rules and agriculture best management practice recommendations for herbicide and pesticide use.

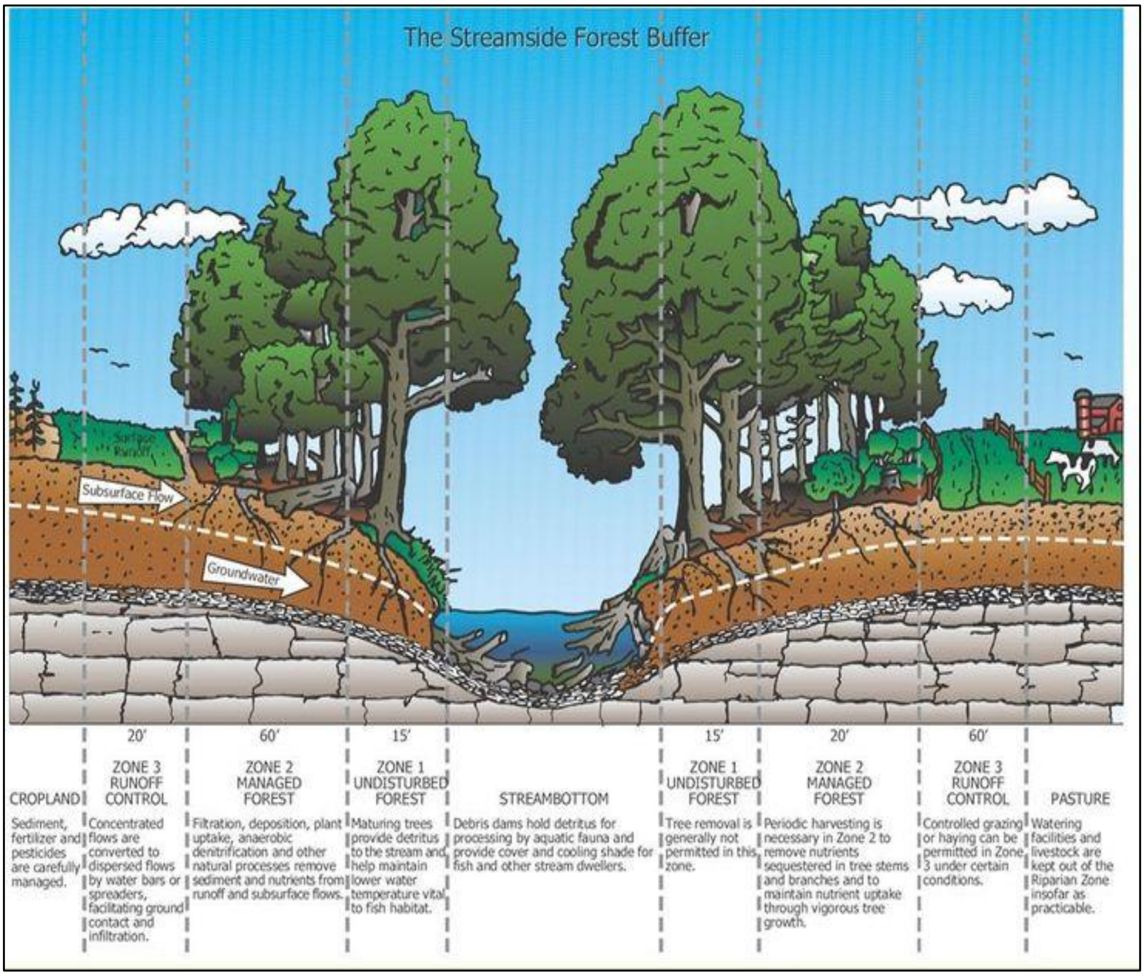

Figure 2.17: Schematic design of a stream buffer.

There are usually several zones between the stream and the crop or pasture land. Research of Riek et al. (2016), with adequate vegetative cover, a filter strip's effectiveness. The wider the filter strip, the better the filtering action. A filter strip on a flatter slope will be more effective than on a steeper slope. There are good management for water quality.

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

To achieve the aim and objectives of study, we need the research methodology. 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 METHODOLOGY FLOW CHART

Tests that need to be run listed in the flow chart and classified into its own parameter. Figure 3.1 shows the outline research in determining water quality of Sungai Nyior, Kuantan.

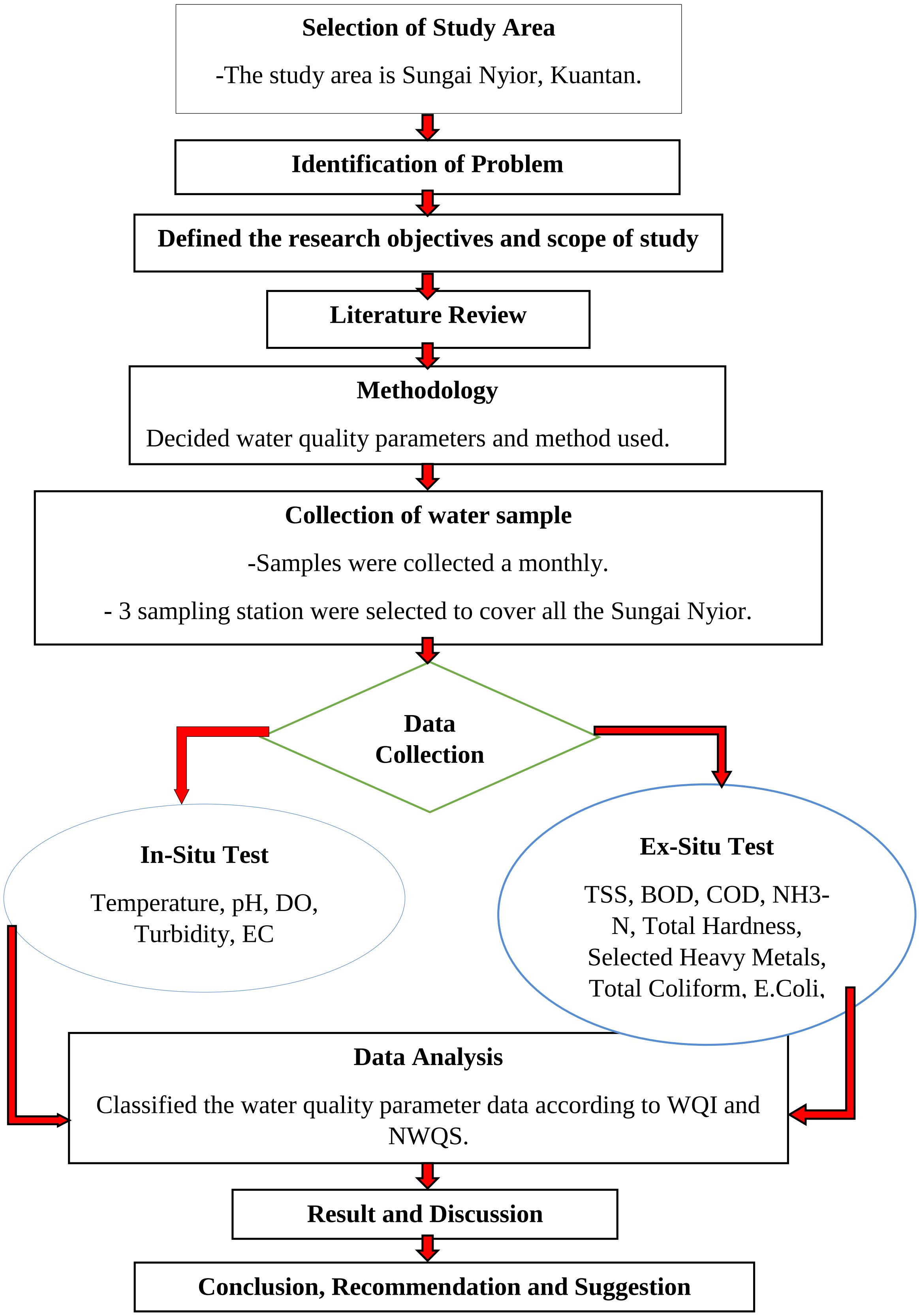

Figure 3.1: Research Outline.

3.3 SAMPLING LOCATION

Kuantan is the state capital of Pahang, the largest state in Peninsular Malaysia. Sungai Nyior is the one of main river basin at Kuantan. It is include in region of Pahang that in the country of Malaysia. The average elevation of the river is -1 meter below sea level. This river is within Balok Baru which is near to Balok Baru Residential area. The figures below is the map of location that is chosen for research study area.

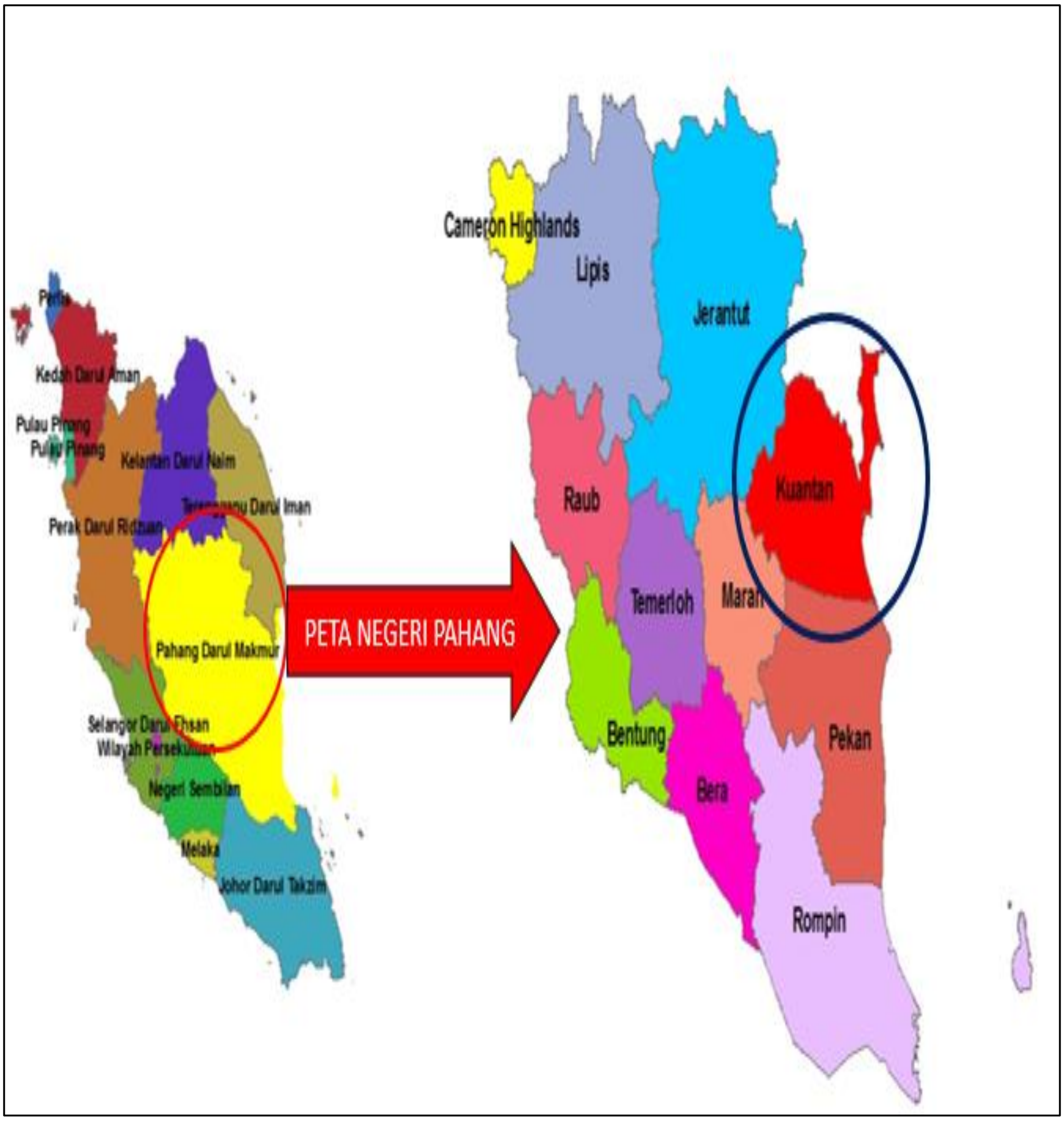

Figure 3.2: Location of study area at Kuantan, Pahang.

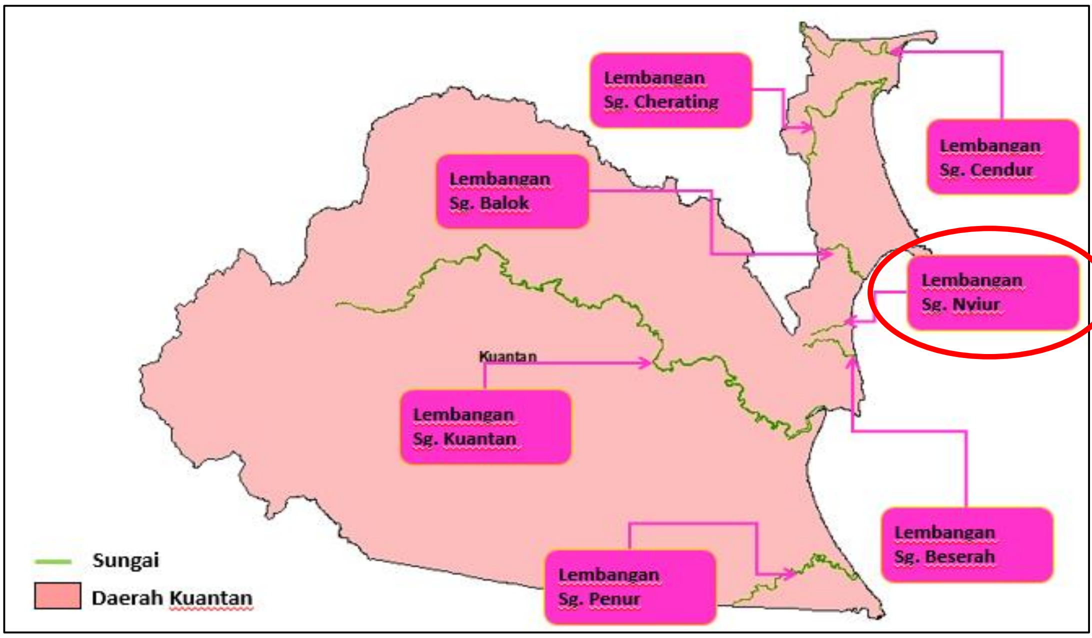

Figure 3.3: The main river Basin in Kuantan and Sungai Nyior was chosen in this study.

Source: Jabatan Pengairan dan Saliran Daerah Kuantan

Figure 3.4: Sungai Nyior plan View

Table 3.1: Sungai Nyior Background

Sungai Nyior Background			
Length	Wide	Reserve each bank	Reserve Overall
11.3 km	20 m	20 m	60 m

There were total of five sampling stations had been selected. Global Positioning System (GPS) was one of the equipment used to determine the actual coordinates of selected sampling stations in order to affirm that the location of each sampling station was same during the subsequent sampling periods.

3.4 PRELIMINARY INVESTIGATION / SITE SURVEY

Before starting the water sampling of Sungai Nyior, a preliminary study was conducted at selected area. I had to check whether there are able for me to collect samples and to confirm visual observations of the area to support the analysis and the purpose of the study. Preliminary investigations is to select the station to take the sample based on human activities. There are some factors that I was considered which included the actual location for sampling, the quantities of samples, the land use pattern and the capability for me to do sampling process.

3.5 SAMPLING COLLECTION

This study involves two types of study which are in situ (field) test and analysis at laboratory for sampling and data collection. The four points of samples will be taken a monthly on September until October 2016 at upstream, downstream and the middle of area. The sampling locations are influenced by the location of human activities that surrounding the river. The information obtained at preliminary survey stage 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 the every station until all water samples from different station was collected. The objectives 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 SAMPLING PRESERVATION

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. The preservation technique shown in table below:

Table 3.2: Preservation techniques and Sample Holding Time

Parameter	Preservation	Max Holding Time
pH	Cool, 4°C	Analyse Immediately
DO	Cool, 4°C	Analyse Immediately
Temperature	Cool, 4°C	Analyse Immediately
BOD	Cool, 4°C	48 hours
COD	Cool, 4°C H_2SO_4 to pH<2	28 days
Ammonia Nitrogen	Cool, 4°C H_2SO_4 to pH<2	28 days
Total Hardness	HNO_2 to pH<2	6 months
Heavy Metal	Cool, 4°C	24 hours
Total Coliform	Cool, 4°C	6 hours
E.Coli	0.008% $Na_2 S_2 O_3$	

3.7 DATA COLLECTION

This study conduct tests that can determine physical, chemical, and biological parameter of Sungai Nyior water bodies. Physical parameter consists of turbidity, temperature, EC, and TSS. Whereas, chemical parameter consists of determination of pH value, DO, BOD, COD, NH3-N, Total Hardness and selected heavy metals. Biological parameter consist only Absence-Presence Test to determine the presence of E. Coli and Total Coliform.

3.7.1 In- Situ Test

3.7.1.1 Temperature, pH, turbidity, EC and DO

In-situ test that been conducted in the field. This test is usually simple and easy to perform. The parameters involved for in situ tests are temperature, turbidity, DO, pH and EC. I used the Horiba Meter 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 UMP Environmental Laboratory. The method is more complex than in situ test .These tests are done according to the standard procedure and under the supervision of lab technician. It is important to make sure to understand all the procedure in order to avoid and minimize mistake done while completing the tests. The BOD, COD, TSS, NH3-N and total hardness and selected heavy metals were measured in accordance with the standard method procedure.

For total coliform and E.Coli, using incubator type 142300 with a long wave ultraviolet 365nm. All ex-situ test parameters will be measure by using Standard Method.

I used some electronic machines for measuring BOD, COD, NH3-N, total hardness and selected heavy metal. AAS for heavy metal, YSI 5100 Dissolved Oxygen Meter for BOD, DR 5000 Spectrophotometer for measure the COD, NH3-N and total hardness. Biological parameter consist only Absence-Presence Test to determine the presence of E. Coli and Total Coliform.

3.7.2.1. Biochemical Oxygen Demand (BOD)

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, the time is taken 3 to 5 days and the temperature 20°C. The test measures the molecular oxygen utilized during a specified incubation period for the biochemical degradation of organic material (carbonaceous demand) and the oxygen used to oxidized inorganic material such as sulphides and ferrous ion. It also may measure the amount of oxygen used to oxidize reduced forms of nitrogen (nitrogenous demand).

$$BOD_t = \frac{DO_i - DO_t}{P}$$

Where:

BOD_t	Biochemical oxygen demand, mg/L
DO_i	Initial DO of the diluted waste water sample about 15 minute after preparation, mg/L
DO_t	Final DO of the diluted waste water sample after incubation for t days, mg/L
P	Dilution factor $P = \frac{\forall_s}{\forall_s + \forall_{DW}}$ $\forall_s = Volume\ of\ sample$ $\forall_{DW} = Volume\ of\ Dillution\ Water$

3.7.2.2. Chemical Oxygen Demand (COD)

The COD test only requires 2-3 hours, while the BOD test requires 5 days. It measures all organic contaminants, including those that are not biodegradable. There is a relationship between BOD and COD for each specific sample, but it must be established empirically. COD test results can then be used to estimate the BOD of a given sample. Unlike for the BOD test, toxic compounds (such as heavy metals and cyanides) in the samples to be analyzed do not have an effect on the oxidants used in the COD test. Therefore, the COD test can be used to measure the strength of wastes that are too toxic for the BOD test. Some organic molecules (e.g., benzene, pyridine) are relatively resistant to dichromate oxidation and may give a falsely low COD.

3.7.2.3. Total Suspended Solid (TSS)

Total Suspended Solids is the term applied to the material residue left in the vessel after evaporation of a sample and its subsequent drying in an oven at a defined temperature (103^0C-105^0C). Total suspended solids refer to the not filterable residue retained by a standard filter disk and dried at 103^0C-105^0C.

The environmental impacts of solids are that solids in all forms have detrimental effects on quality since they cause putrifaction problems. Suspended solids exclude light, thus reducing the growth of oxygen producing plants. Solids impair aesthetic acceptability of water.TSS of a water sample is determined by pouring a carefully measured volume of water (typically one litre) but less if the particulate density is high, or as much as two or three litres for very clean water) through a pre-weighed filter of a specified pore size, then weighing the filter again after drying to remove all water. Filters for TSS measurements are typically composed of glass fibres. The gain in weight is a dry weight measure of the particulates present in the water sample expressed in units derived or calculated from the volume of water filtered (typically milligrams per litre or mg/L).

$$\text{Total Suspended Solid, mg/l} = \frac{(A-B) \times 1000}{C}$$

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 (NH3-N)

NH3-N test conducted according to the standard method which are Method 8155 or Salicylate Method. The concentration of NH3-N is determined using Spectrophotometer DR5000 with Ammonium Salicyte and Ammonium Cyanurate as reagents. Green colour shows positive presence of NH3-N. Samples are diluted before testing since this method is only applicable for NH3-N concentration of 0.01 – 0.50 mg/L.

3.7.2.5 Total Hardness

A 100 ml of the water sample was measured into a conical flask using a measuring cylinder. 1 ml of Calcium and Magnesium using measuring drop. Add 1.0 mL of Alkali solution for Calcium and Magnesium test using measuring drop and stopper several times. Then pour 25mL of the solution into such of three sample cells. After that drop of 1 drop EDTA solution for blank .This colour changed to sea purple blue and add 1 drop of EGTA solution for next cell. For third cell no need to add anything then recorder the readings of hardness.

3.7.2.6 Selected Heavy Metal

In this study, heavy metals consist of chromium (Cr), cadmium (Cd), and copper (Cu). A set of standard solution of these 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.

AAS method was used in estimate the concentration of heavy metal (mg/L) in the water. Calibration Standard that I prepared in my research included 0.25N,0.50N, 0.75 N, 1.0N and 2.0N 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.

3.7.2.7 Total Coliform and E.Coli

Total coliforms are group of bacteria commonly found in the environment for example in soil or vegetation as well as the intestines of mammals which including humans. In fact, most of which are not dangerous to human health. However, these bacteria are not naturally present in groundwater and are an indication that more harmful organism might be present. Faecal Coliform and E.Coli are subgroups within the Total Coliform group which primarily come from the feces of warm blooded animals. Presence of E.Coli indicates that the water has been exposed to feces and an immediate risk to human health exists.

E.Coli and Total Coliform presence test experimental procedures begin with Collection of 100 mL of sample in a sterile container. Use aseptic technique to prevent contamination. If the sample has been disinfected, use a container that contains a dechlorinating agent. After that, add the sample to the fill line of a P/A bottle. Incubate the sample at 35 ± 0.5 °C (95 ± 0.9 °F) for 24 hours. After 24 hours, look for a colour change. If there is no colour change, incubate the sample for an additional 24 hours. If there is no colour change after 48 hours, the test result is negative. If there is a colour change, the test result is presumptive positive.

3.8 TEST PARAMETERS AND INSTRUMENTS USED

Table 3.3: In-Situ Test Parameter and Instrument used.

In-Situ Test Parameters	Units	Test	Instrument
Temperature	ºC	Temperature test	
Turbidity	NTU	Turbidity test	
DO	mg/L	DO test	
			Horiba Meter
PH	-	pH test	
EC	uS/cm	EC test	
	The reading was taken directly at the study area. The instrument was inserted in the river water at each sampling point and the reading was taken.		

Table 3.4: Ex-Situ Test Parameter, Method and Instrument used.

Ex-Situ Test Parameters	Units	Method	Instrument
TSS	mg/L	Standard Method USEPA Gravimetric method (1992) mg/l = $\frac{(A-B)x\ 1000}{C}$ 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*	Desiccator Filter and aluminium dish Vacuum flask Vacuum Filtration apparatus Pipette Incubator Analytical Balance

BOD	mg/L	Standard Method -APHA 5210 B (5-day BOD Test) $BOD_t = \frac{DO_i - DO_t}{P}$	DO Meter YSI 5100 Measuring Cylinder Beaker BOD bottles BOD incubator HACH BOD reactor Aeration Pump
COD	mg/L	Standard Method -Method 8000 (Reactor Digestion Method)	Spectrophotometer Model HACH DR5000 COD Reactor Pipette Stirrer Test Tube Rack Blender
NH3-N	mg/L	Standard Method -Method 8155 (Salicylate Method)	Spectrophotometer Model HACH DR5000
Total Hardness	mg/L	Standard Method	Conical flask Burette Pipette Measuring cylinder Spectrophotometer DR5000
Selected Heavy Metals	mg/L	Standard Method	Atomic Absorption Spectrophotometers (AAS)
Total Coliform E. Coli		Standard Method E.Coli and Total Coliform Presence Test	Quanti-Tray Sealer Incubator type 142300 Quanti-Tray

3.9 STATISTICAL ANALYSIS

All the data that obtained through the in situ test and ex situ were analysed by using Microsoft Excel in order to achieve objectives throughout this study. The objectives that to be achieved were to determine the characteristic of water quality in the Sungai Nyior as well as to obtain the water quality classification based on WQI. All the result from the data analysis was showed and discussed more detail in Chapter 4 (Result and Discussion).

Statistical method used to evaluate and classify raw data. There are many statistical method that can be used in order to organize the raw data to become informative data. Table 3.4 shows various statistical methods that can be used to analyse the data in this study.

Table 3.5: Statistical Methods Use to Evaluate Data

Statistical Method	Description
Mean	The mean is the most widely used measure of central tendency
Variance	The variance is the mean of the squares of the deviations. The most efficient, unbiased estimate of the population variance, s2, is the sample variance s2.
Standard deviation	The standard deviation (denoted s) is the positive square root of the variance.
Deviation	The deviation is the quantity by which each individual data point differs from the arithmetic mean of the sample.

3.10 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 WQI 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 Index.

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

Where;

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

After the value of WQI were calculated, I were compared the result based on WQI and NWQS table which is already mentioned at Chapter 2 (Literature Review) to identify the class of the river water quality.

CHAPTER 4

RESULT 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 Sungai Nyior within Balok Baru, Kuantan. Three samples was taken to be analyzes based on their different station. The sampling conducted three times and monthly test from September to December 2016.

Water Quality Parameters are classified into physical, chemical, and biological. Parameters that have been test for each sample are turbidity, temperature and TSS for physical water quality. pH, DO, EC, BOD, COD, NH3-N, total hardness and selected heavy metal such as cadmium (Cd) , chromium (Cr), and copper(Cu) for chemical water quality. Biological parameter is determination of microorganism presence that consists of E.coli and total coliform.

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 Sungai Nyior.

Table 4.1: Weather a day after Sampling was taken for Sungai Nyior.

Sampling Station	**Sampling 1 21 September 2016**	**Sampling 2 22 October 2016**	**Sampling 3 21 November 2016**
Water Condition	Low Tide	Low Tide	Low Tide
Station 1	Sunny 28.1 °C	Drizzling Rain 27.6 °C	Heavy Rain 27.5 °C
Station 2	Sunny 28.0 °C	Drizzling Rain 27.7 °C	Heavy Rain 27.4 °C
Station 3	Sunny 28.2 °C	Drizzling Rain 27.9 °C	Heavy Rain 27.4 °C

4.2 RESULTS AND DISCUSSION

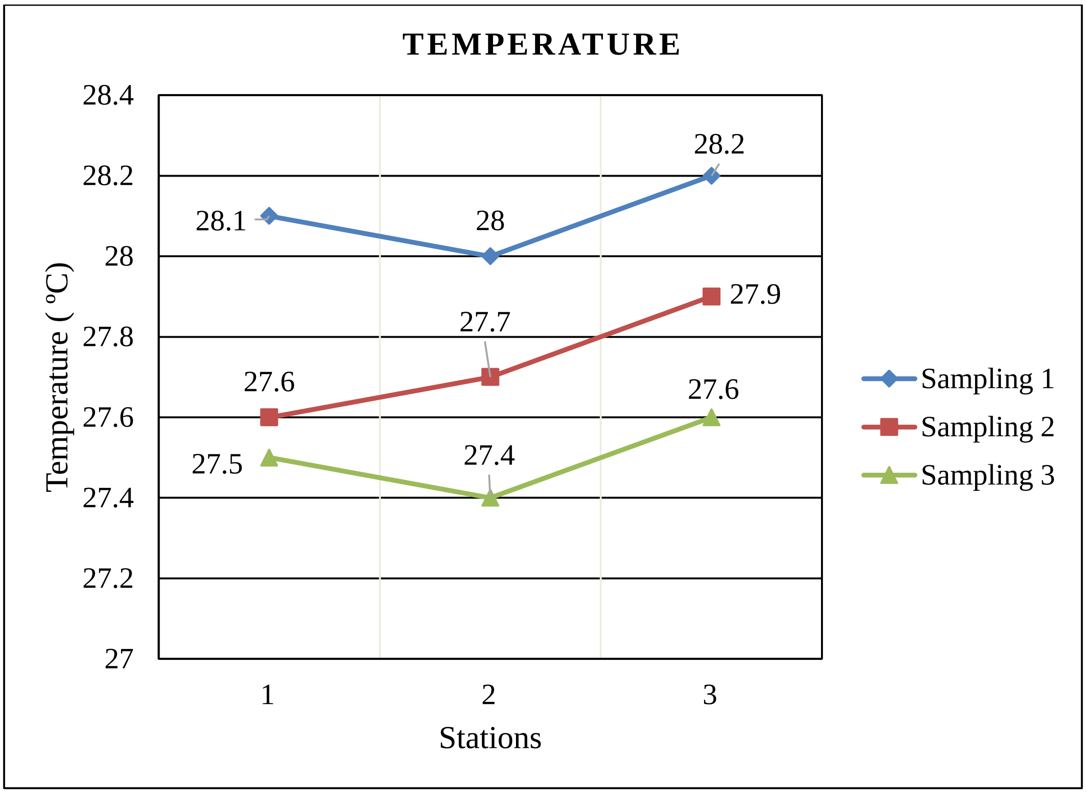

Figure 4.1: Value of temperature at different station.

Figure 4.1 shows that temperature reading for all samplings and stations. For all sampling stations, the water temperature ranged from 27.40 to 28.20˚C. The average of each station were 27.73, 27.70 and 27.83 ºC. Moreover, the average of each sampling were 28.10, 27.73 and 27.43 ºC. It is clearly that the temperature values of sampling 3 was lower than sampling 1 and sampling 2. Refer to NWQS, temperature reading for all stations indicated that the river is in Class II which range Normal +2˚C.

Station 2 during sampling 3 recorded the lowest value which is 27.4 ºC in the wet season and Station 3 during sampling 1 recorded the highest value, 28.2˚C in the dried season. The value of temperature all stations was different because sampling 1 was taken during sunny day, sampling 2 was taken a day after drizzling rain and sampling 3 was taken a day after heavy rain. According to Mustapha (2008), dry season temperature was significantly higher than the wet season.

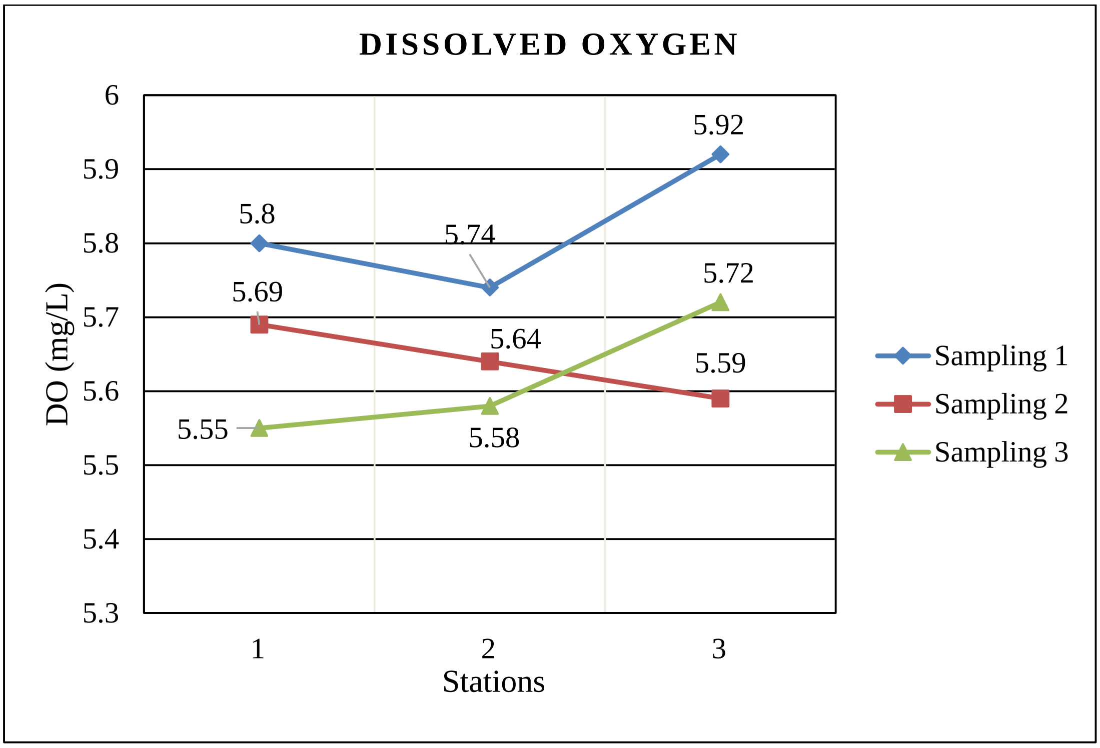

Figure 4.2: Concentration of DO at different station

The average value of DO in the study area was recorded as 5.65- 5.74 mg/L, which indicated that the river water was quite good for aquatic life. The average concentration of DO for each sampling were 5.82, 5.64 and 5.61 mg/L. The average for each station were 5.68, 5.65 and 5.74 mg/l. The value of DO was higher during sampling 1 compare to the other two samplings which is 5.92 mg/L at Station 3. The higher of DO value because of the station was near to the forested area that produced amount of the oxygen.

While the concentration of DO was recorded low at Station 1 during sampling 3 with 5.55 mg/L which indicated that the water of that area was highly deoxygenated. The lower value of DO may be due to the discharge of residential sewage such as septic tank, agricultural and run off. It may increase the number of bacteria and amount of BOD which related to DO. This also resulted high reading of BOD during the Sampling 3 on that stations. Based on NWQS and WQI, the standard value of DO in this river indicated in Class II which in range 5-7 mg/L.

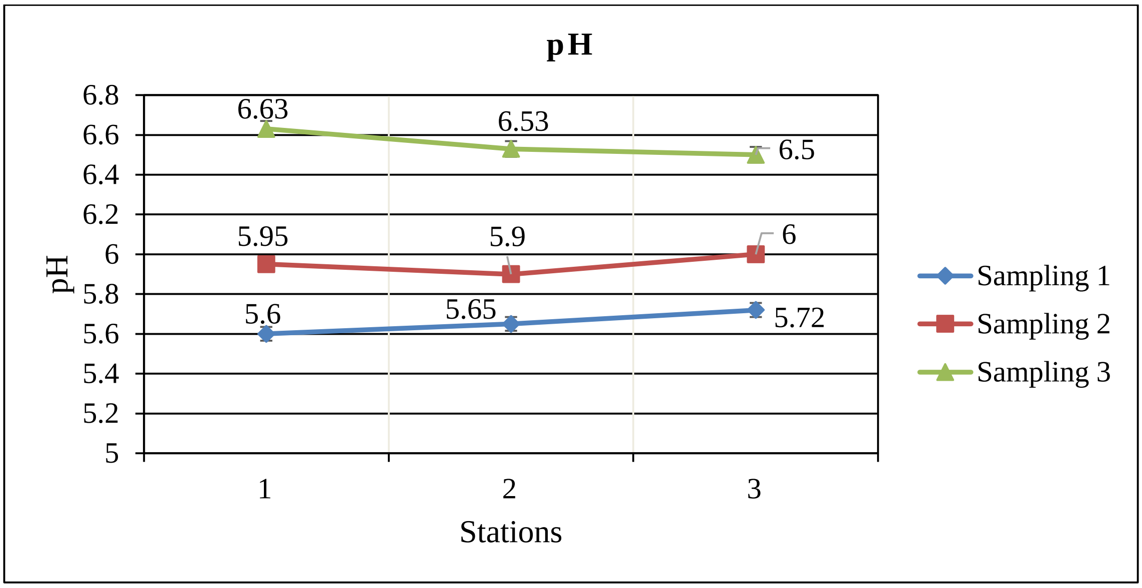

Figure 4.3: Concentration of pH value at different station

Based on the Figure 4.3, pH was not a problem for the collected water samples as it ranged between 5.5 and 6.63 mg/L. The average pH values at every station for this river were 6.06, 6.03 and 6.07 mg/L. The average values for each sampling were 5.66, 5.95 and 6.55 mg/L. Sungai Nyior pH for all stations indicated in Class II based on NWQS which in range 6-9 mg/L whereas, this river also in Class II based on WQI with range 6.0-7.0 mg/L. The lowest value of pH is during sampling 1 at Station 1 which is 5.6 mg/L. The pH values for Station 2 are between 5.65- 6.53 mg/L. Meanwhile, the highest pH value was indicated at Station 1 during sampling 3.

The lowest and the highest pH at Station 1 was recorded due to the sewage effluents or discharge effluent of those residential areas contained acidic and alkalinity substances and agricultural runoff. Moreover, sampling 3 was taken when heavy rains caused all of the substance were carried out by the river. Based on Shashi et al. (2009), the higher value of pH was due to the addition of fertilizers and other organic components from the agricultural run-off. During rainy season the increase in pH of river water could be attributed towards the addition of street runoff, nitrogenous waste washing from open fields at the bank of the river. Comparatively, lower pH may be due to the reaction of acidic components with pollutants at these sites which lowers the pH.

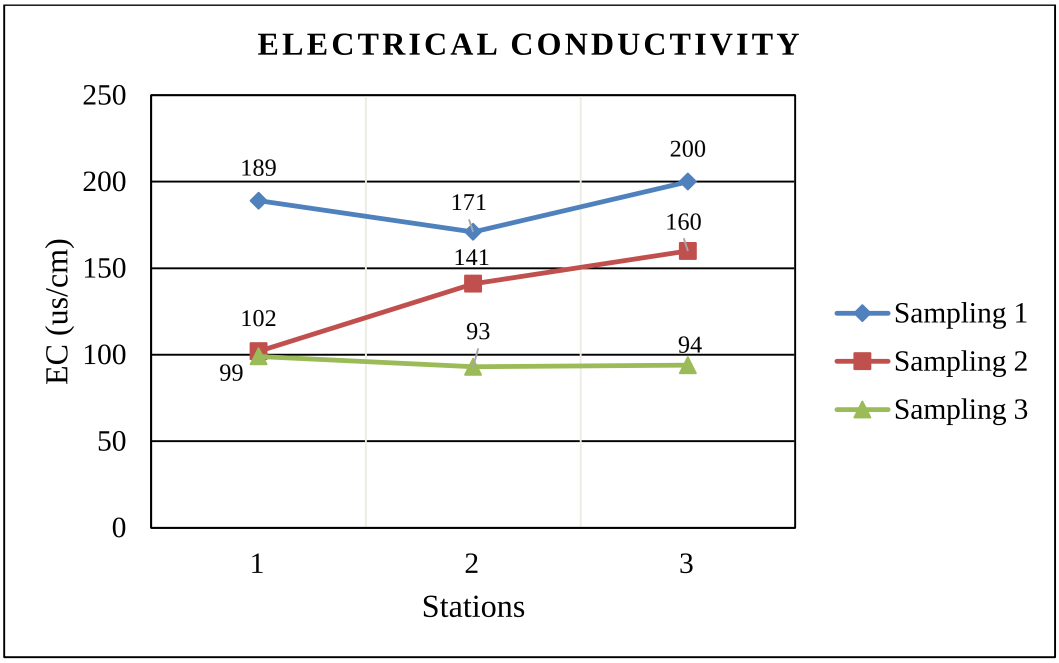

Figure 4.4: Concentration of EC value at different station

Figure 4.4 shows that EC readings for all samplings and stations. The average of each station were 130, 135 and 151 (µS/cm). While the average of each sampling were 187, 134 and 95 (µS/cm). Sampling 1 showed the highest reading of EC compared to the other two samplings which was 200 (µS/cm). The lowest reading of EC were found in Station 2 with 93 (µS/cm) during sampling 3 because heavy rainy a day after sample was taken. According to NWQS, this river is in Class I for all stations which in range 1000 (µS/cm).

EC was affected by temperature which means if temperature is high, EC also high. The warmer the water, the higher EC. Other than that, activities in a watershed that may raise the conductivity of surface waters include residential sewage and septic, agricultural accompanying fertilizers, pesticides application. Detenbeck *et al.* (1996) found a failing septic system near a surface water body could raise the conductivity of that surface water due to the presence of chloride, phosphate, and nitrate. Even a properly working septic system can affect the conductivity of nearby surface water.

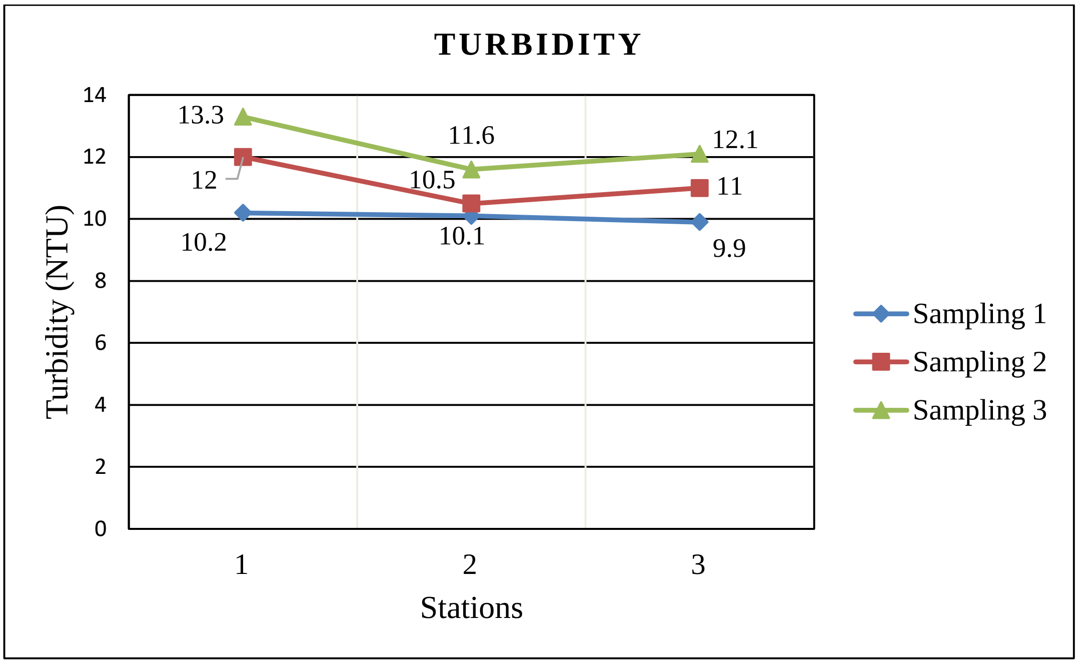

Figure 4.5: Concentration of Turbidity value at different station.

Figure 4.5 shows that turbidity readings for all samplings were increase. The average of each station were 11.83, 10.73 and 11.00 NTU. Moreover, the average of each sampling were 10.07, 11.17 and 12.33 NTU. It is clearly that the value of sampling 3 was higher than other two samplings and turbidity was high value at Station 1 for all samplings. The highest turbidity value was noted in Station 1 which gave value 13.3 NTU during Sampling 3. The lowest value was 9.9 NTU at Station 3 during sampling 1. Refer to NWQS, turbidity readings for all stations indicate that the river was in Class II which range 50NTU. It is because the range of turbidity for Sungai Nyior between 9.9 to 13.3 NTU.

High turbidity in Sungai Nyior caused by natural occurrences such as heavy rains, construction activities, agriculture farmland, non-point source and forested area that will increase the soil erosion and bank erosion. According to (American Public Health Association 1998) 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.

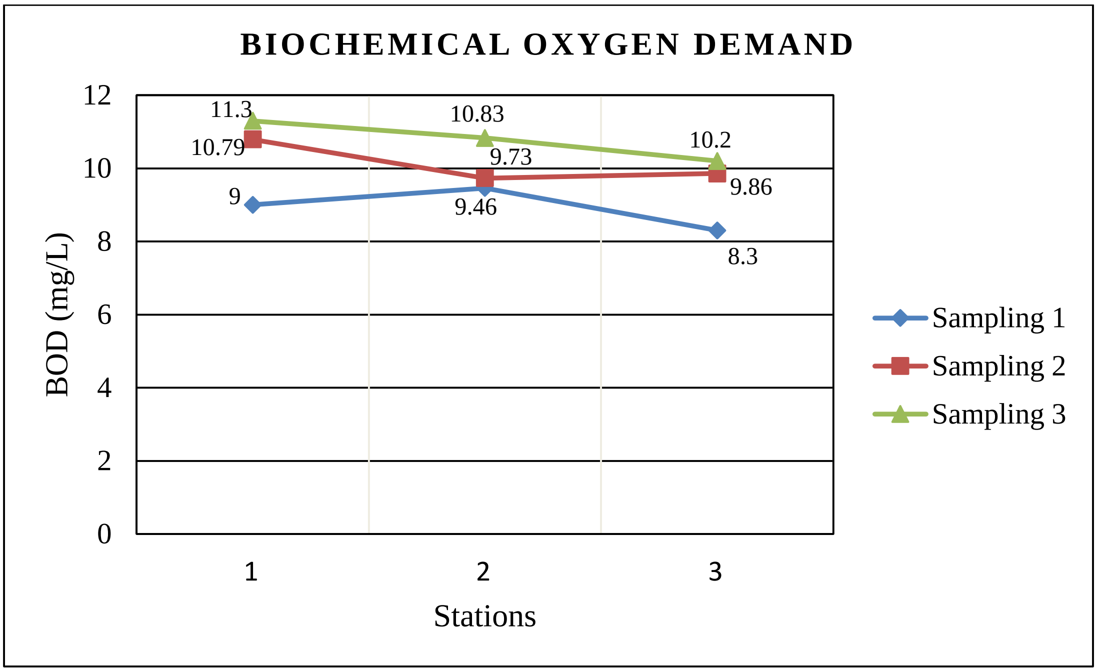

Figure 4.6: Concentration of BOD at different station

In Figure 4.6, it shows that Sampling 3 was recorded as highest BOD5 which gives values 11.3, 10.83 and 10.2 mg/L of each Station. The lowest value of BOD5 is Sampling 1 which are 9.0, 9.46 and 8.3 mg/L. Station 3 shows lowest value of BOD with 8.3 mg/L during Sampling 1. Low BOD readings shown less contaminated since it contain higher contains of DO which is 5.92 mg/l. The results of BOD reading are vice versa to DO reading due to oxygen that is available in the water being consumers by the bacteria or microorganisms. The average BOD5 value for each sampling are 8.92, 10.13 and 10.78 mg/L. The average BOD5 value for each station are 10.36, 10.01 and 9.45 mg/L. The Class of this river based on NWQS and WQI, Malaysia is Class IV of all stations.

Station 1 shows the highest value of BOD during Sampling 3 with 11.3 mg/L concentration. High BOD indicated high organic matter in water and caused by waste contains chemical capable of suppressing microbiological growth. This happened due to Station 1 located that passes and carries different types of effluents such as discharge of residential sewerage and septic. Besides, agricultural that are use fertilizer and runoff by heavy rain. This is also supported by Amneera et al.(2013), which said that the water is considered, polluted if the BOD concentration is high.

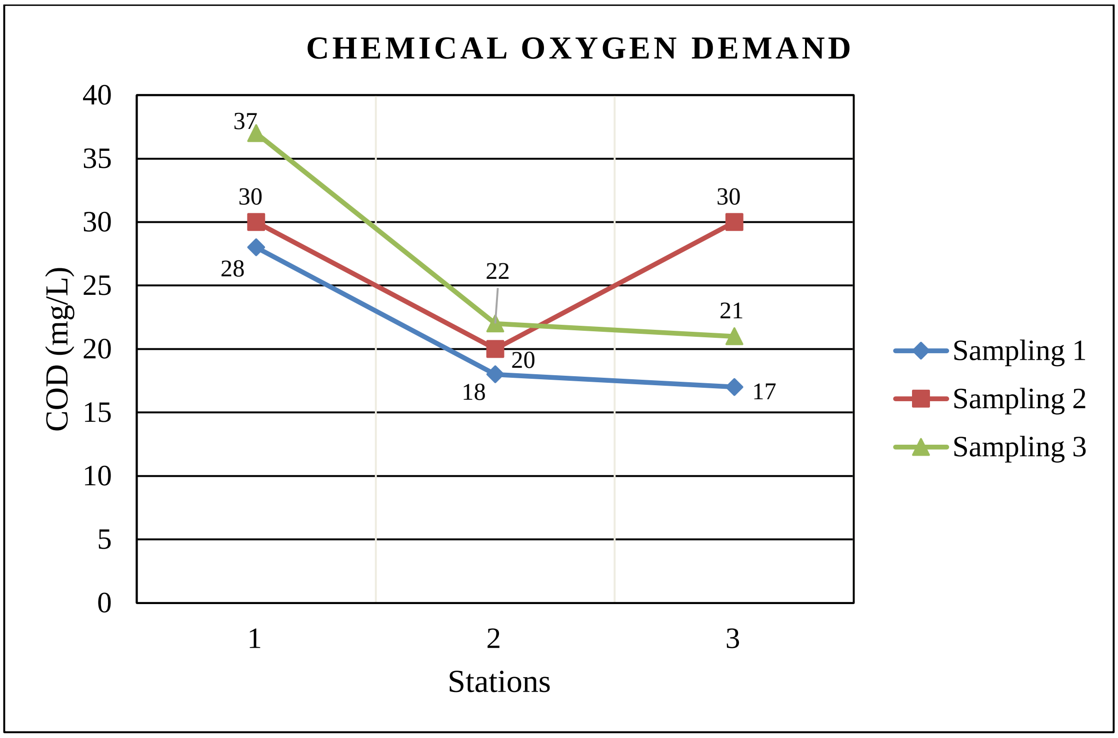

Figure 4.7: Concentration of COD at different station

Figure 4.7 shows the COD values at different station. When the concentration of COD was higher, the water is considered contaminated or polluted. The lower value of COD was 17 mg/L at Station 3 during sampling 1. The trend of COD was almost similar as BOD. However, COD values are always greater than BOD values. In NWQS and WQI, Station 1 was in Class III whereas Station 2 and Station 3 were in Class II.

The average for COD values for each sampling were 21, 23 and 27 mg/L. Moreover, the average of COD values of each station were 32, 20 and 19 mg/L. Based on the graph, it is clearly that Station 1 during sampling 3 was polluted due to higher value of COD wit 37 mg/L. It was due to high quantity of oxygen required to oxidize all organic material into carbon dioxide and water. It cause by sewage and septic of residential area. It proved by Chemical, Forensic, Food & Environmental Technology, (2009) found high COD amount of organic contamination in waste water that water contaminated with sewage, water from food processing plants, textile factories or water containing organic chemicals.

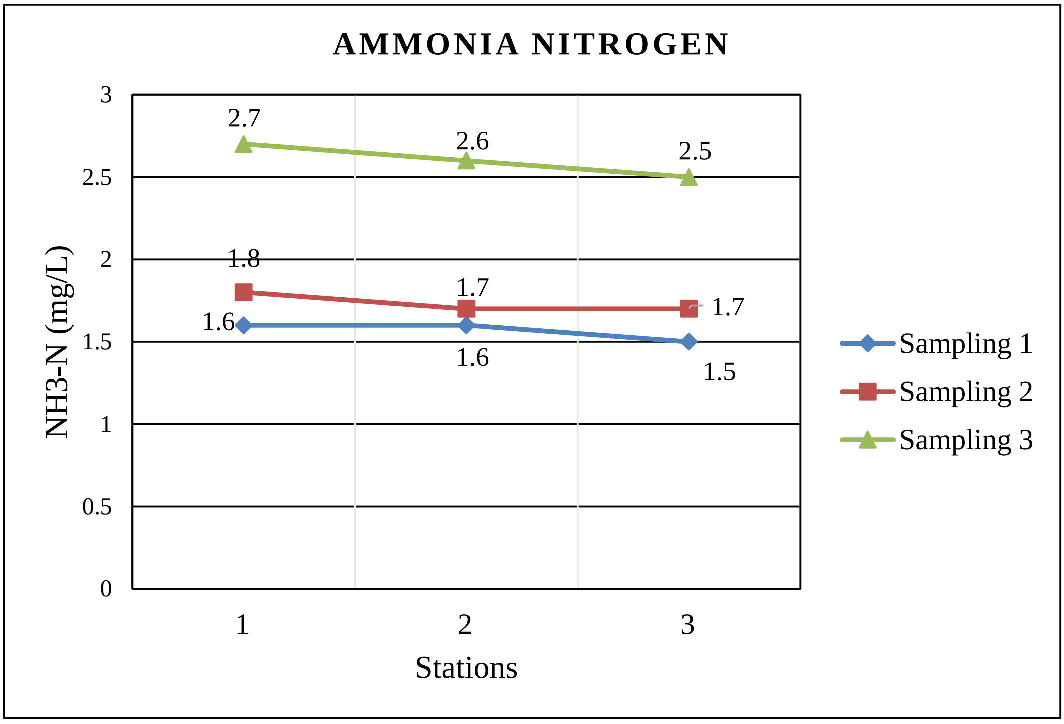

Figure 4.8: Concentration of NH3-N at different station

Based on the graph in figure 4.8, it shows that the increasing the concentration of NH3-N of each sampling. The average of each sampling were 1.57, 1.73 and 2.58 mg/L whereas, the average of each station were 2.01, 1.97 and 1.90 mg/L. Station 1 is the highest value of NH3-N which was 2.7 mg/L during sampling 3. Meanwhile, the lowest value at Station 3 during sampling 1 which was 1.5 mg/L. Sampling 3 recorded the higher value of NH3-N compare to the other two samplings because the sample was taken after a day rainy.

The higher value of NH3-N because of livestock, agricultural, sewage and septic and runoff. Based on (Mirmohseni, 2003), NH3-N from animals and runoff from agricultural lands. Residential which is household use of ammonia-containing cleaning products, on-lot septic systems, and improper disposal of NH3-N products. Besides, livestock waste and continual use fertilizer from agriculture activity that contribute to nutrient input in river. Sungai Nyior belongs to Class IV based on WQI which in range 0.9-2.7 mg/L. According to NWQS, all stations in the river is in Class IV because the value is 2.7 mg/L concentration.

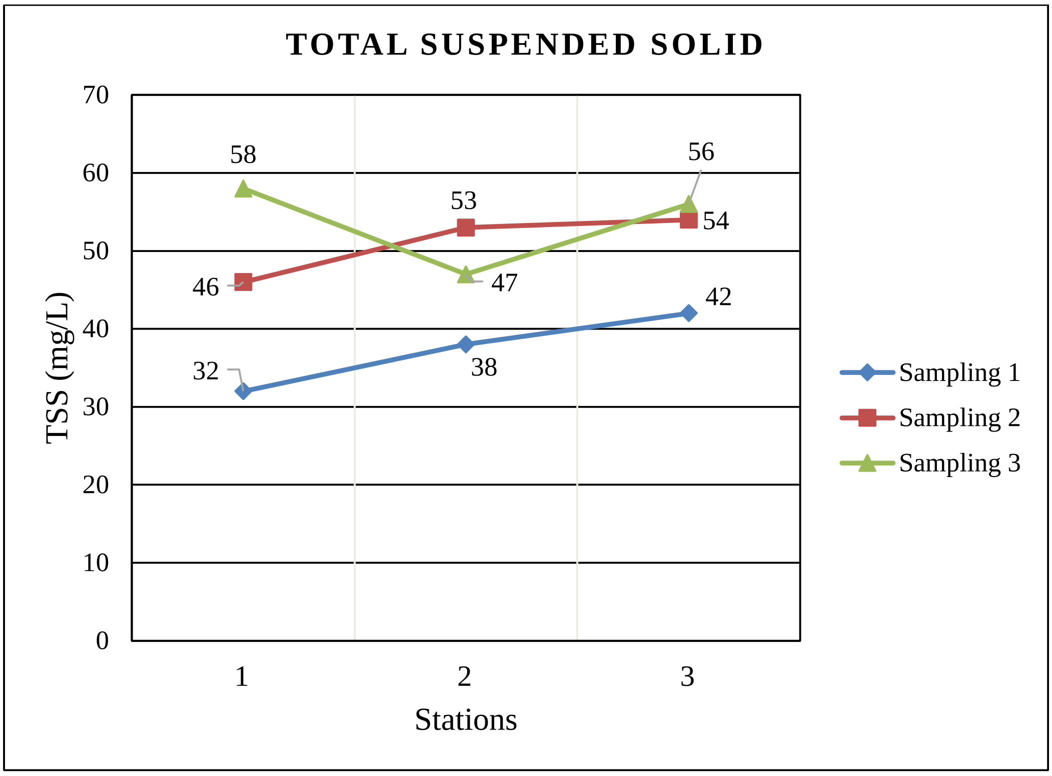

Figure 4.9: Concentration of TSS at different station

According to figure 4.9, it shown that TSS average of each sampling were 37, 51 and 54 mg/L. It is clearly that the value of sampling 3 was higher than other two samplings. The highest TSS value was noted at Station 1 which gave value 58 mg/L during sampling 3. Refer to NWQS and WQI, Station 1 and Station 2 were in Class II which range 50 mg/L whereas Station 3 was in Class III which in range 50-150 mg/L.

The highest value of TSS at Station 1 during sampling 3 was due to anthropogenic activities such as construction and residential activities affected by 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. As stated earlier, Sampling 3 was taken after the heavy raining day, so resulting in a higher value of TSS compare to Sampling 1 and Sampling 2. TSS are the result of poorly planned development activities (such as construction) that lack proper erosion control measures, as well as from agricultural and logging activities. Non-point source pollution from palm oil plantations also incur high ammonia, nitrate and phosphorous in the runoff stream, which can result in eutrophication of water bodies (Zainudin et al., 2009).

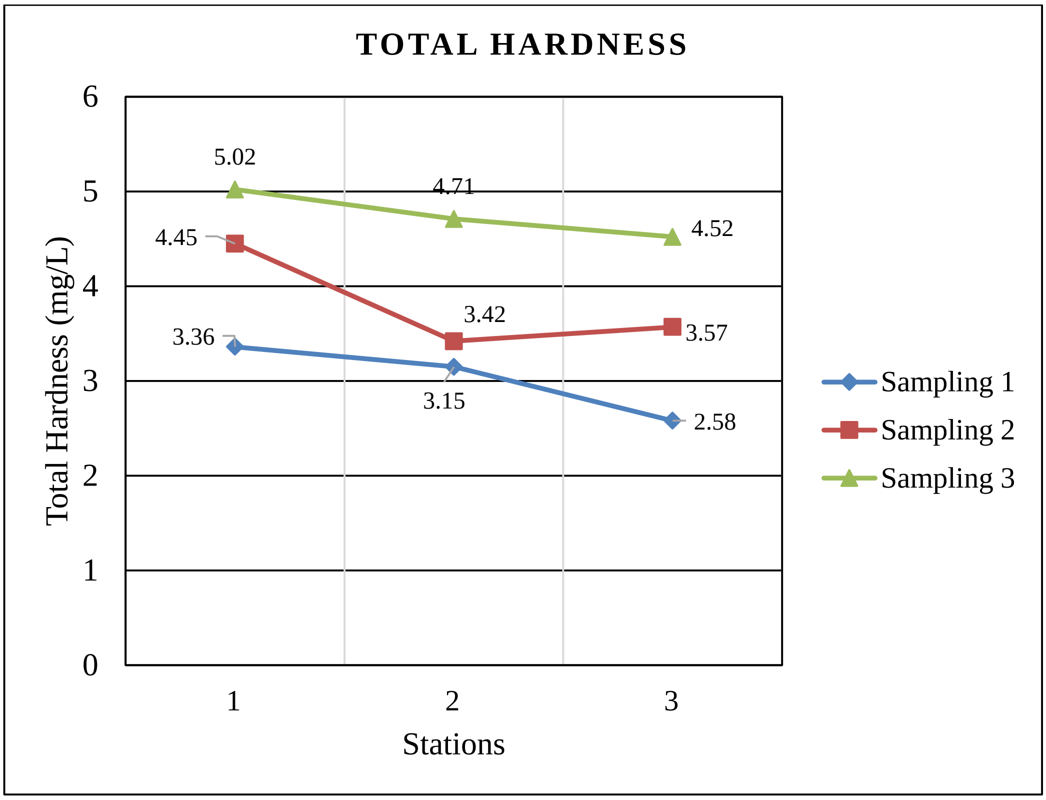

Figure 4.10: Total Hardness Concentration at Different Stations

Based on the figure 4.10, the average concentration of total hardness for each sampling were 3.03, 3.81 and 4.75 mg/L. The average for each station were 4.28, 3.76 and 3.56 mg/L. While the concentration of total hardness was recorded low at Station 3 during sampling 1 with 2.58 mg/L. While the highest value was 5.03 mg/L at Station 1 during sampling 3. According to NWQS and WQI, this river indicated that in Class III for all stations.

Water containing low concentrations of calcium or magnesium is called soft water. The reading of Sungai Nyior was recorded in soft water level. According to Sheila (2007) when total hardness in water is too low, the water is referred as fresh, soft water. The low total hardness may be due to the composition of the minerals present in the earth in which the aquifer containing the water is located, or underlying bedrock of the river.

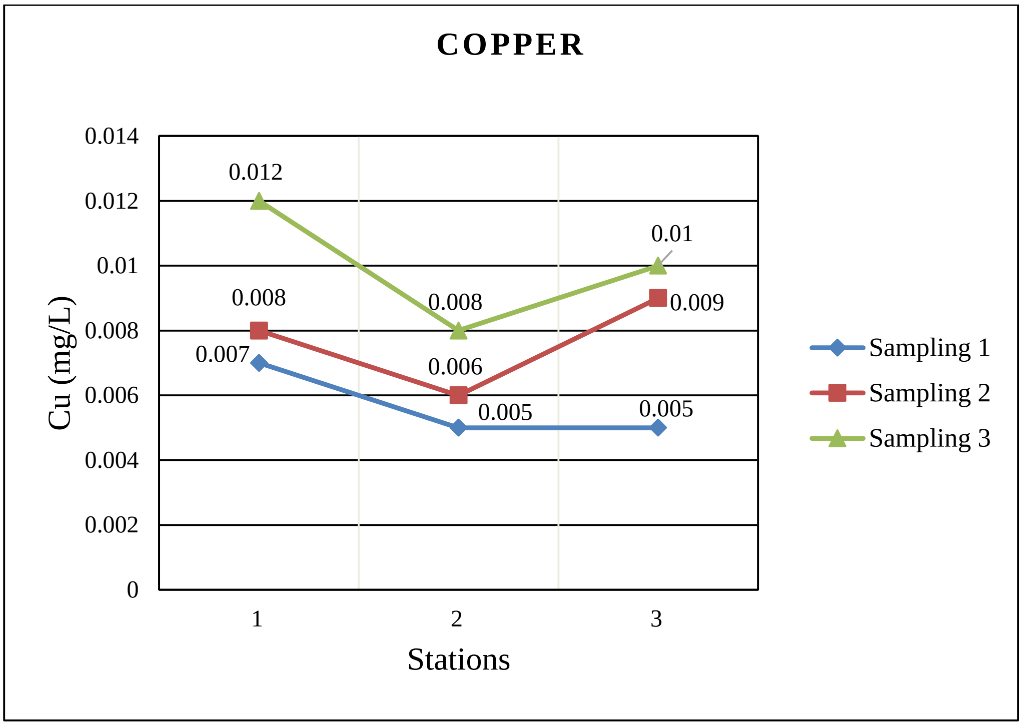

Figure 4.11: Copper Concentration at Different Sampling Stations

Figure 4.11 show the concentration of copper in Sungai Nyior for each station. The copper values are range between 0.005 mg/L to 0.012 mg/L for overall stations and samplings. The average of each station were 0.009, 0.006 and 0.009 mg/L. Meanwhile, the average of each sampling were 0.006, 0.007 and 0.010 mg/L. During sampling 1, Station 2 and Station were recorded the same values and low which are 0.005mg/L. Then, the highest concentration of copper recorded at Station 1 during sampling 3 which is 0.012 mg/L. Refer to NWQS, copper reading for all stations indicated that the river was in Class II which range 0.02mg/L.

As shown from the result, the concentration of copper is high at Station 1 because of the corrosion of household plumping system with poor maintenance. Besides, agricultural that are of metals and metal-containing compounds, fertilizer and pesticides. Fertilizers and pesticides used may contribute to small amount of Copper into Sungai Nyior. Other than that, discharge from residential septic. This can be proved from study by Perwak et al. (1980) which showed discharges of copper into sewer systems from residential areas to be significant.

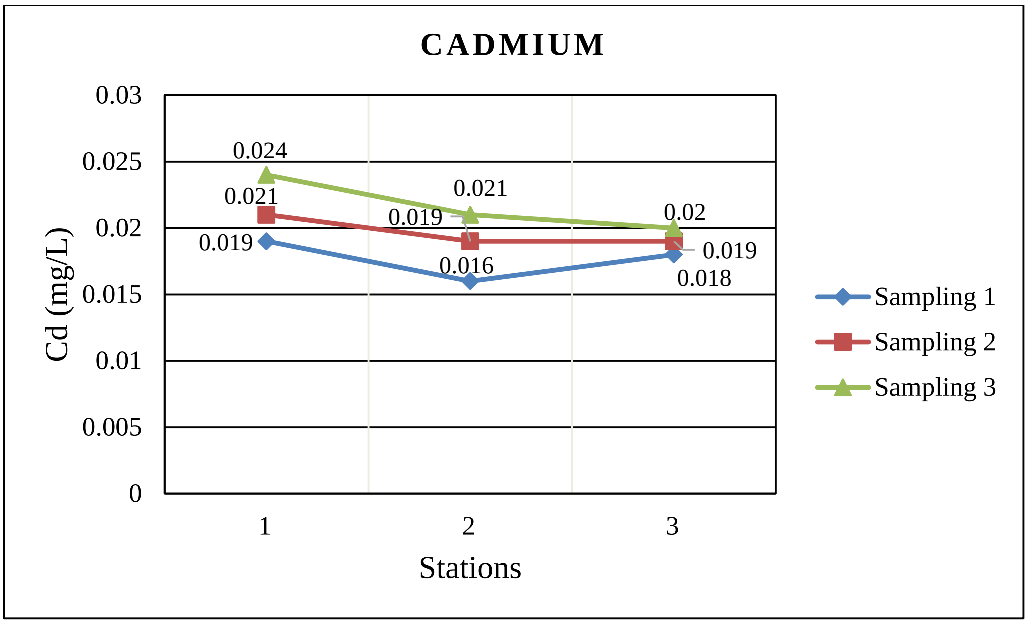

Figure 4.12: Cadmium Concentration at Different Stations

Figure 4.12 show the concentration of cadmium in Sungai Nyior for each station. The cadmium values are range between 0.016 mg/L to 0.024 mg/L for overall stations and samplings. The average of each station are 0.021, 0.019 and 0.019 mg/L. Meanwhile, the average of each sampling were 0.018, 0.020 and 0.023 mg/L. The highest concentration of cadmium was recorded at Station 1 during sampling 3 which was 0.024 mg/L. Then, the lowest value was recorded at Station 2 during sampling 1 which was 0.016 mg/L. Refer to NWQS, cadmium reading for all stations indicate that the river was in Class IV.

The highest value of cadmium cause of residential or abandoned house which has corrosion of pipes and poor maintenance. Besides, construction of building which has waste paint are carried by runoff during heavy rains. Other than that, agricultural that are of metals and metal-containing compounds, fertilizer and pesticides (Zeituon and Mehana, 2014) found that the anthropogenic sources of cadmium from application of fertilizers sewage sludge to farmland, may lead to contamination of soils to increase cadmium uptake by crops and vegetables grown for human consumption, cigarette smoking, stabilizers in PVC product, color pigments, anticorrosion agent, and rubber tires on road surface.

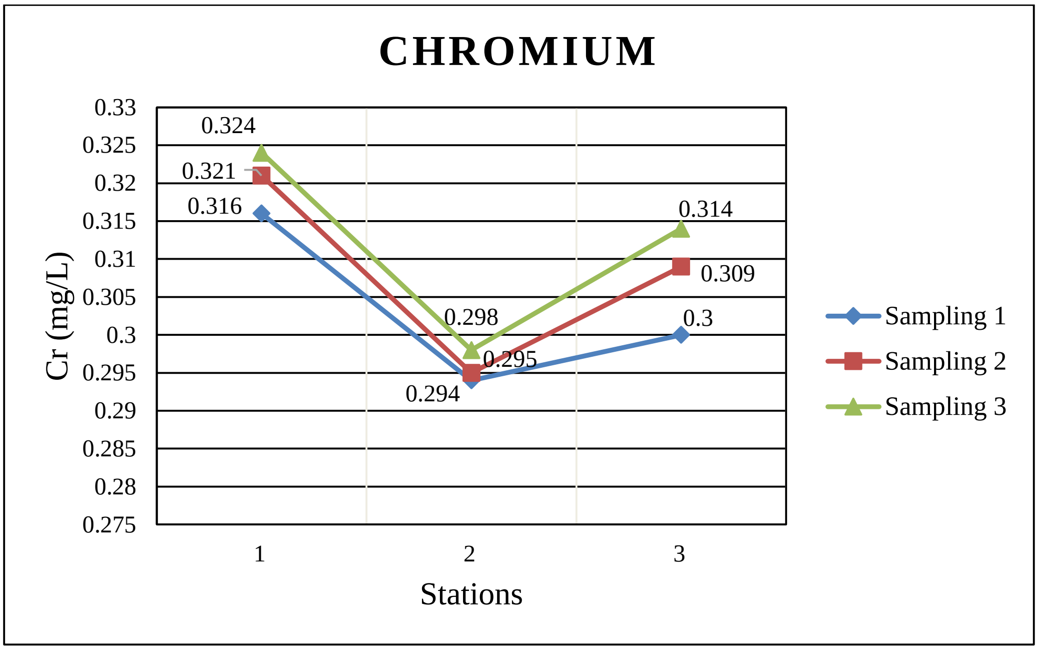

Figure 4.13: Chromium Concentration at Different Stations

Concentration range of chromium for all stations and samplings were between 0.294 mg/L to 0.324 mg/L. The average of each station were 0.320, 0.296 and 0.308 mg/L. Meanwhile, the average of each sampling were 0.303, 0.308 and 0.312 mg/L. Sampling 3 showed the highest reading of chromium compared to the other two samplings because sampling conducted after a rainy day which increases the concentration level of chromium in the river which recorded in Station 1 which was 0.324 mg/L. The lowest reading of chromium was found at Station 2 with 0.294mg/L during sampling 1. According to NWQS, this river is in Class III for all stations which in range 2.5 mg/L.

The highest value of chromium caused of agricultural that are of metals and metal-containing compounds, fertilizer and pesticides. Chromium can be found in many consumer products, including wood treated with copper dichromate, leather tanned with chromic sulfate, and stainless steel cookware (U.S Dep. of Health, 2008). Other than that, chromium in water may come from natural sources such as leaching from topsoil and rocks.

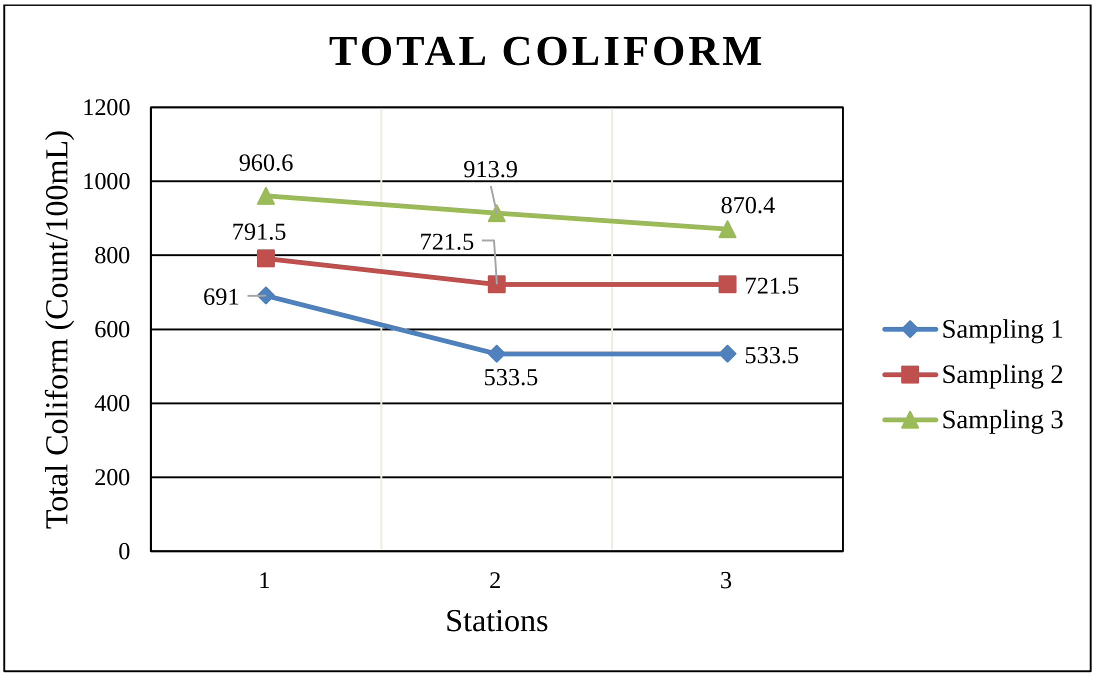

Figure 4.14: Total Coliform versus Sampling Station

Figure 4.14 shows the count of total coliform at different stations. The range of Total Coliform between 533.5 – 960.6 count/100mL. The highest Total Coliform presence at Station 1 during Sampling 3 with 960.6 count/100mL. The lowest value was recorded at Station 2 and Station 3 which is 533.5 count/100mL during Sampling 1. The average for all stations are 814.37, 727.47 and 708.47 count/100mL. Based on the average each station, Station 1 was the highest. While the average of each Sampling are 586, 744.83 and 914.97 count/100mL. According to NWQS, presence of total coliform at Sungai Nyior for all stations are belong to Class II which is in range 5000 (count/100ml).

The main of presence the Total Coliform in Sungai Nyior is same with E.coli which were residential failing sewage and septic systems, agricultural runoff and animals wastes (Young and Thackston, 1999), to establish the source of the unexpectedly high bacterial concentrations of rivers and streams near Nashiville, Tennessee. It showed that total coliforms directly relates to the housing density, population, development, imperviousness of roads and streets, animals density; and surface runoff from densely populated, and sewered areas.

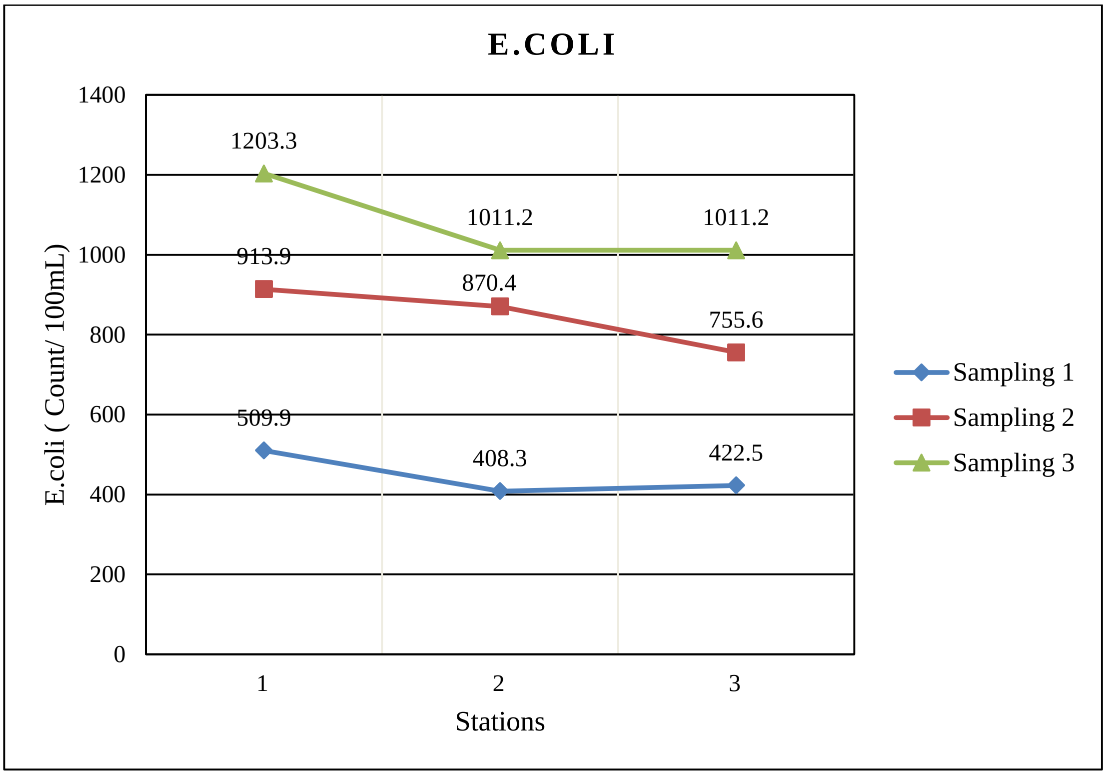

Figure 4.15: Value of E.Coli at different station.

Figure 4.15 shown that E.Coli readings for all samplings and stations. The average values of each station were 875.70, 763.30 and 729.77 count/100 mL. Besides, the average values of each sampling were 446.9, 846.63 and 1075.23 count/100 mL. The lowest value presence of E.Coli was at Station 2 during sampling 1 which was 408.5 count/100 mL. While highest value during sampling 3 which is Station 1 with 1203.3 count/100 mL. Based on NWQS, this river is in Class III for all stations which in range 5000 (20000) (count/100ml).

The main factor that contributed to the presence of E.coli in the Sungai Nyior were residential sewage and septic systems, livestock and agricultural. This agrees with the findings of (Doyle et al., 2006), that E.Coli can enter rivers through direct discharge of waste from mammals and birds, from agricultural and storm runoff, and from human sewage. In addition, (Weiskeh et al. 1996) reported that coliforms concentrations in storm water runoff from impervious surfaces were related to the surrounding land use. The highest coliforms yields, from a high – density residential areas were significantly higher.

Table 4.2: Sub-Indexes of WQI for Sungai Nyior at different station.

`	STATION 1	STATION 2	STATION 3
SIDO	25.53	25.50	25.50
SIBOD	60.05	61.28	63.28
SICOD	61.43	72.50	73.83
SIAN	29.66	30.55	32.15
SISS	74.18	73.74	71.62
SIpH	91.78	91.34	91.93
WQI	54.19	56.19	54.21
CLASS	III	III	III
CONDITION	Polluted	Polluted	Polluted

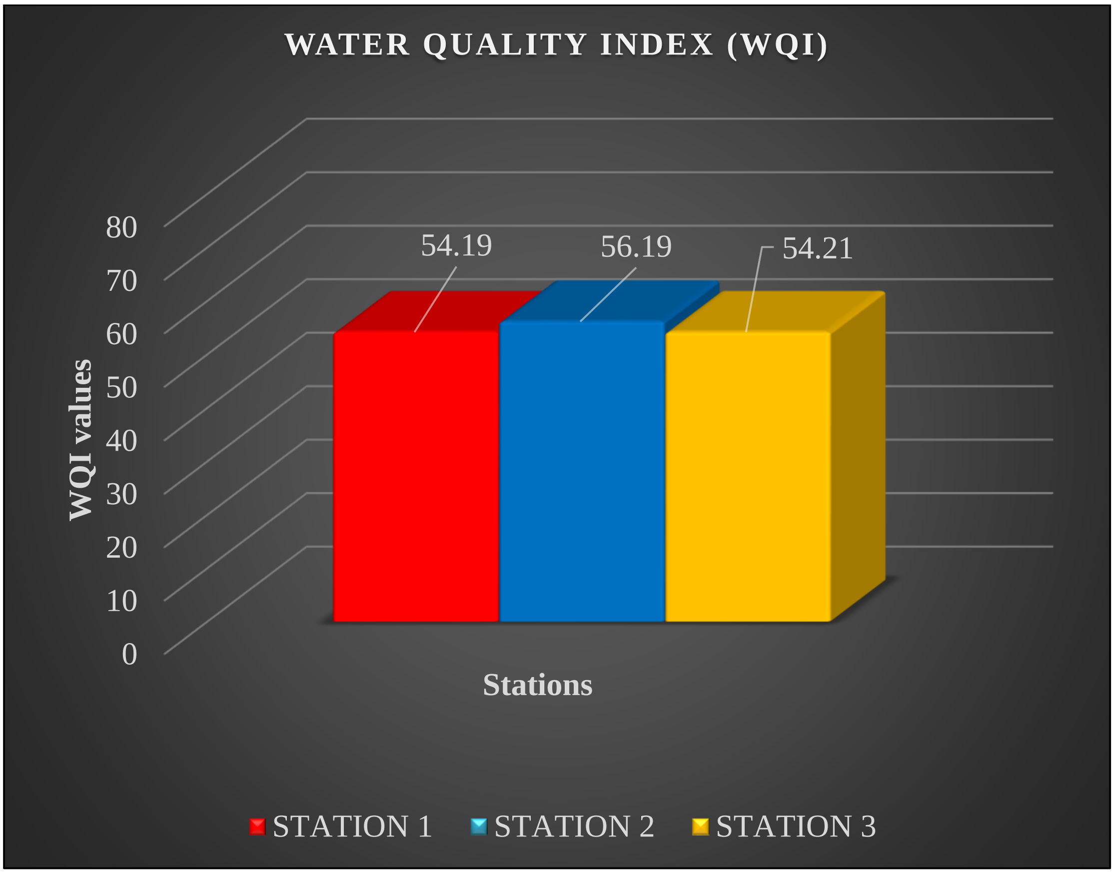

Figure 4.16: WQI value at different station of Sungai Nyior.

Each sub-indexes for every parameter was calculated to determine the WQI and classify the river under classes as shown in Table 4.2. Figure 4.15 show the WQI value for Sungai Nyior of each station. The value of WQI for each station are 54.19, 56.19 and 54.21 which in Class III. Station 1 is the lower value because the station was directly of the effluent of sewage from residential area. So that, Station 1 is more polluted than other stations. All stations are in polluted conditions which in range 0-59.

Based on Samplings, Sampling 3 is more high values of water parameters than Sampling 1 and Sampling 2 because the sample was taken a day after heavy rains which was affected the values of WQI. According to NWQS Malaysia, Sungai Nyior was classified under Class IV based on all stations which concluded that the river can be used for irrigations.

CHAPTER 5

CONCLUSION AND RECCOMENDATION

5.1 INTRODUCTION

In this chapter, the discussion on results obtained being simplified and recommendations for this study being list out. Water quality assessment for Sungai Nyior successfully done and met the objective studied.

Sungai Nyior is one of the most polluted river in Pahang which is adversely affected by surrounding activities and land use. This river also has been an issue of River Water Pollution that are state in Sinar Harian Newspaper 2016. Water sampling was done in the period of time between September to November and it had been involved with three sampling stations. All the samples was contributed with the in-situ test by using Horiba Meter instrument and analyse at ex-situ tests. All these results are discussed in Chapter 4. Each of the result was compared to WQI and NWQS to determine the water quality status for every station.

5.2 CONCLUSION

From the research results, the objective one there is to evaluate the characteristics of current water quality in the study area based on NWQS and WQI, Malaysia has been achieved. Water quality parameter of Sungai Nyior that consists of turbidity, temperature and TSS for physical water quality. pH, DO, BOD, COD, NH3-N, selected heavy metal which is cadmium (Cd), chromium (Cr), and copper(Cu) for chemical water quality.

Biological parameters is determination of microorganism presence that consists of E.Coli and total coliform. The results obtained were analyzed and classified based on WQI and NWQS Guidelines.

It found that Station 1, Station 2 and Station 3 of WQI as 54.19, 56.19 and 54.21 respectively. Essentially, reducing the value of the WQI, indicate that the level of water pollution in the river is higher. All stations in Class III which indicated that Sungai Nyior is in polluted condition. According to NWQS Malaysia, Sungai Nyior which was classified in Class IV for all stations. Class IV it was concluded that the river can be used for irrigation.

Second Objective is to identify the possible factors or sources that influences the water quality of the river system also achieved. The main factor of anthropogenic activities that influences the degradation of water quality of Sungai Nyior was because of sewerage and drainage in a residential area near the river. It is from septic tanks or sewerage poorly maintained that discharge to the river. Besides, there are also have the construction of residential area. The activities of construction development give bad impact to the existing drainage system. 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.

Last objective is to make an appropriate suggestion for effective management of the water resources. In general, to preserve and improve the water quality status of our water bodies, pollution sources that input various constituents into the watercourses need to be appropriately managed and mitigated (control at source).

Table 5.1: The Water Pollution Problem and Management Suggestion

Problem	Control / management Suggestion
Water quality problem	The authorities should implement and enforce appropriate strategy to monitor, control and protect the river area. Monthly monitoring, planning and preventing control should be conducted to minimize the pollution and bad effect throughout the degradation of water quality of the river.
Forested area runoff	Good forestry practices are required to minimize soil erosion and siltation, destabilisation of stream banks and disruption of river habitats.
Erosion of soil	Control measures are necessary to be imposed on developers to comply with the “Erosion of Soil and Control Plan” made by the Drainage and Irrigation Department and also the “Guidelines for Prevention and Control of Soil Erosion and Siltation” issued by the DOE
Agricultural runoff -pesticide spraying, fertilizing, planting, harvesting, cropland, grazing, plowing and irrigation.	Good agricultural practices are required to manage these activities so that runoff pollutants are minimized. Some of the measures that can be implemented include installing storm water filter to treat drainage and runoff, construction of grass filter trap at appropriate places, maintaining vegetation as filters along contours constructing wetlands wherever feasible as a good revegetation practice to improve river water quality

Construction activities	construction of grass filter trap
Livestock	Livestock management to avoid the entry of manure contaminated runoff into waterways. Keep domestic animals and/or livestock out of waterways (or reduce their exposure). Dispose of dead animals properly.
Sewage and Septic	The regular inspection and maintenance that is required to ensure proper operation during the design life of the septic system.
No awareness of people about water quality	Increasing public awareness such as Campaign, environmental education. Citizen should practice higher sense of responsibility to ensure that water resources are protected. Environmental education plays an important role in educating the people. Of environmental education, citizen will learn to understand the concept of conservation and can use the simple conservation measures in their life.

5.3 RECOMMENDATION

After conducting the experiments and obtaining the result, there are a few recommendation should be taken to resolution the problem that arise in order to obtain more exact data for this study in the future. These suggested recommendations will assist to increase and sustain the water quality of Sungai Nyior for future research. These are some of the measures that can be done:

i. Increase the number of sampling station to drawn better quality of surface water resources that can know the source of anthropogenic disturbances of surrounding in order to conserve the good water quality in Sungai Nyior.

ii. Sampling can also be done or conduct more than 4 times to get a more accurate value for effluent quality and accurately studied.

iii. Distances for sampling from discharge point, accessibility and safety to sampling point and monitoring period should take into account as to determine accurate water quality index.

iv. Further study by adding other parameters such as physical parameters such as salinity, total dissolved solid (TDS), chemical parameters: include more metals and non-metals like nitrate, lead, zinc and others.

v. Add the new equipment and apply new technology to conduct the test of research.

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APPENDIX A1

NATIONAL WATER QUALITY STANDARD FOR MALAYSIA (NWQS)

National Water Quality Standard for Malaysia (INWQS)

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

APPENDIX A2

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 A3

WATER CLASSES AND USES FOR NWQS

Water Classes and Uses for NWQS

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. Fishery II - Sensitive aquatic species.
CLASS IIB	Recreational use 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 A4

WQI FORMULA AND SUB-INDEX CALCULATION

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 = $94 * \exp(-0.573x) - 5 * \mid x - 2 \mid$	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 A5

WATER QUALITY INDEX AND GENERAL RATING SCALE

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 A6

TOTAL COLIFORM AND E.COLI TABLE

IDEXX Quanti-Tray/2000 MPN Table

# Large Wells Positive	# Small Wells Positive																								
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
0	<1	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0	11.0	12.0	13.0	14.1	15.1	16.1	17.1	18.1	19.1	20.2	21.2	22.2	23.3	24.3
1	1.0	2.0	3.0	4.0	5.0	6.0	7.1	8.1	9.1	10.1	11.1	12.1	13.2	14.2	15.2	16.2	17.3	18.3	19.3	20.4	21.4	22.4	23.5	24.5	25.6
2	2.0	3.0	4.1	5.1	6.1	7.1	8.1	9.2	10.2	11.2	12.2	13.3	14.3	15.4	16.4	17.4	18.5	19.5	20.6	21.6	22.7	23.7	24.8	25.8	26.9
3	3.1	4.1	5.1	6.1	7.2	8.2	9.2	10.3	11.3	12.4	13.4	14.5	15.5	16.5	17.6	18.6	19.7	20.8	21.8	22.9	23.9	25.0	26.1	27.1	28.2
4	4.1	5.2	6.2	7.2	8.3	9.3	10.4	11.4	12.5	13.5	14.6	15.6	16.7	17.8	18.8	19.9	21.0	22.0	23.1	24.2	25.3	26.3	27.4	28.5	29.6
5	5.2	6.3	7.3	8.4	9.4	10.5	11.5	12.6	13.7	14.7	15.8	16.9	17.9	19.0	20.1	21.2	22.2	23.3	24.4	25.5	26.6	27.7	28.8	29.9	31.0
6	6.3	7.4	8.4	9.5	10.6	11.6	12.7	13.8	14.9	16.0	17.0	18.1	19.2	20.3	21.4	22.5	23.6	24.7	25.8	26.9	28.0	29.1	30.2	31.3	32.4
7	7.5	8.5	9.6	10.7	11.8	12.8	13.9	15.0	16.1	17.2	18.3	19.4	20.5	21.6	22.7	23.8	24.9	26.0	27.1	28.3	29.4	30.5	31.6	32.8	33.9
8	8.6	9.7	10.8	11.9	13.0	14.1	15.2	16.3	17.4	18.5	19.6	20.7	21.8	22.9	24.1	25.2	26.3	27.4	28.6	29.7	30.8	32.0	33.1	34.3	35.4
9	9.8	10.9	12.0	13.1	14.2	15.3	16.4	17.6	18.7	19.8	20.9	22.0	23.2	24.3	25.4	26.6	27.7	28.9	30.0	31.2	32.3	33.5	34.6	35.8	37.0
10	11.0	12.1	13.2	14.4	15.5	16.6	17.7	18.9	20.0	21.1	22.3	23.4	24.6	25.7	26.9	28.0	29.2	30.3	31.5	32.7	33.8	35.0	36.2	37.4	38.6
11	12.2	13.4	14.5	15.6	16.8	17.9	19.1	20.2	21.4	22.5	23.7	24.8	26.0	27.2	28.3	29.5	30.7	31.9	33.0	34.2	35.4	36.6	37.8	39.0	40.2
12	13.5	14.6	15.8	16.9	18.1	19.3	20.4	21.6	22.8	23.9	25.1	26.3	27.5	28.6	29.8	31.0	32.2	33.4	34.6	35.8	37.0	38.2	39.5	40.7	41.9
13	14.8	16.0	17.1	18.3	19.5	20.6	21.8	23.0	24.2	25.4	26.6	27.8	29.0	30.2	31.4	32.6	33.8	35.0	36.2	37.5	38.7	39.9	41.2	42.4	43.6
14	16.1	17.3	18.5	19.7	20.9	22.1	23.3	24.5	25.7	26.9	28.1	29.3	30.5	31.7	33.0	34.2	35.4	36.7	37.9	39.1	40.4	41.6	42.9	44.2	45.4
15	17.5	18.7	19.9	21.1	22.3	23.5	24.7	25.9	27.2	28.4	29.6	30.9	32.1	33.3	34.6	35.8	37.1	38.4	39.6	40.9	42.2	43.4	44.7	46.0	47.3
16	18.9	20.1	21.3	22.6	23.8	25.0	26.2	27.5	28.7	30.0	31.2	32.5	33.7	35.0	36.3	37.5	38.8	40.1	41.4	42.7	44.0	45.3	46.6	47.9	49.2
17	20.3	21.6	22.8	24.1	25.3	26.6	27.8	29.1	30.3	31.6	32.9	34.1	35.4	36.7	38.0	39.3	40.6	41.9	43.2	44.5	45.9	47.2	48.5	49.8	51.2
18	21.8	23.1	24.3	25.6	26.9	28.1	29.4	30.7	32.0	33.3	34.6	35.9	37.2	38.5	39.8	41.1	42.4	43.8	45.1	46.5	47.8	49.2	50.5	51.9	53.2
19	23.3	24.6	25.9	27.2	28.5	29.8	31.1	32.4	33.7	35.0	36.3	37.6	39.0	40.3	41.6	43.0	44.3	45.7	47.1	48.4	49.8	51.2	52.6	54.0	55.4
20	24.9	26.2	27.5	28.8	30.1	31.5	32.8	34.1	35.4	36.8	38.1	39.5	40.8	42.2	43.6	44.9	46.3	47.7	49.1	50.5	51.9	53.3	54.7	56.1	57.6
21	26.5	27.9	29.2	30.5	31.8	33.2	34.5	35.9	37.3	38.6	40.0	41.4	42.8	44.1	45.5	46.9	48.4	49.8	51.2	52.6	54.1	55.5	56.9	58.4	59.9
22	28.2	29.5	30.9	32.3	33.6	35.0	36.4	37.7	39.1	40.5	41.9	43.3	44.8	46.2	47.6	49.0	50.5	51.9	53.4	54.8	56.3	57.8	59.3	60.8	62.3
23	29.9	31.3	32.7	34.1	35.5	36.8	38.3	39.7	41.1	42.5	43.9	45.4	46.8	48.3	49.7	51.2	52.7	54.2	55.6	57.1	58.6	60.2	61.7	63.2	64.7
24	31.7	33.1	34.5	35.9	37.3	38.8	40.2	41.7	43.1	44.6	46.0	47.5	49.0	50.5	52.0	53.5	55.0	56.5	58.0	59.5	61.1	62.6	64.2	65.8	67.3
25	33.6	35.0	36.4	37.9	39.3	40.8	42.2	43.7	45.2	46.7	48.2	49.7	51.2	52.7	54.3	55.8	57.3	58.9	60.5	62.0	63.6	65.2	66.8	68.4	70.0
26	35.5	36.9	38.4	39.9	41.4	42.8	44.3	45.9	47.4	48.9	50.4	52.0	53.5	55.1	56.7	58.2	59.8	61.4	63.0	64.7	66.3	67.9	69.6	71.2	72.9
27	37.4	38.9	40.4	42.0	43.5	45.0	46.5	48.1	49.6	51.2	52.8	54.4	56.0	57.6	59.2	60.8	62.4	64.1	65.7	67.4	69.1	70.8	72.5	74.2	75.9
28	39.5	41.0	42.6	44.1	45.7	47.3	48.8	50.4	52.0	53.6	55.2	56.9	58.5	60.2	61.8	63.5	65.2	66.9	68.6	70.3	72.0	73.7	75.5	77.3	79.0
29	41.7	43.2	44.8	46.4	48.0	49.6	51.2	52.8	54.5	56.1	57.8	59.5	61.2	62.9	64.6	66.3	68.0	69.8	71.5	73.3	75.1	76.9	78.7	80.5	82.4
30	43.9	45.5	47.1	48.7	50.4	52.0	53.7	55.4	57.1	58.8	60.5	62.2	64.0	65.7	67.5	69.3	71.0	72.9	74.7	76.5	78.3	80.2	82.1	84.0	85.9
31	46.2	47.9	49.5	51.2	52.9	54.6	56.3	58.1	59.8	61.6	63.3	65.1	66.9	68.7	70.5	72.4	74.2	76.1	78.0	79.9	81.8	83.7	85.7	87.6	89.6
32	48.7	50.4	52.1	53.8	55.6	57.3	59.1	60.9	62.7	64.5	66.3	68.2	70.0	71.9	73.8	75.7	77.6	79.5	81.5	83.5	85.4	87.5	89.5	91.5	93.6
33	51.2	53.0	54.8	56.5	58.3	60.2	62.0	63.8	65.7	67.6	69.5	71.4	73.3	75.2	77.2	79.2	81.2	83.2	85.2	87.3	89.3	91.4	93.6	95.7	97.8
34	53.9	55.7	57.6	59.4	61.3	63.1	65.0	67.0	68.9	70.8	72.8	74.8	76.8	78.8	80.8	82.9	85.0	87.1	89.2	91.4	93.5	95.7	97.9	100.2	102.4
35	56.8	58.6	60.5	62.4	64.4	66.3	68.3	70.3	72.3	74.3	76.3	78.4	80.5	82.6	84.7	86.9	89.1	91.3	93.5	95.7	98.0	100.3	102.6	105.0	107.3
36	59.8	61.7	63.7	65.7	67.7	69.7	71.7	73.8	75.9	78.0	80.1	82.3	84.5	86.7	88.9	91.2	93.5	95.8	98.1	100.5	102.9	105.3	107.7	110.2	112.7
37	62.9	65.0	67.0	69.1	71.2	73.3	75.4	77.6	79.8	82.0	84.2	86.5	88.8	91.1	93.4	95.8	98.2	100.6	103.1	105.6	108.1	110.7	113.3	115.9	118.6
38	66.3	68.4	70.6	72.7	74.9	77.1	79.4	81.6	83.9	86.2	88.6	91.0	93.4	95.8	98.3	100.8	103.4	105.9	108.6	111.2	113.9	116.6	119.4	122.2	125.0
39	70.0	72.2	74.4	76.7	78.9	81.3	83.6	86.0	88.4	90.9	93.4	95.9	98.4	101.0	103.6	106.3	109.0	111.8	114.6	117.4	120.3	123.2	126.1	129.2	132.2
40	73.8	76.2	78.5	80.9	83.3	85.7	88.2	90.8	93.3	95.9	98.5	101.2	103.9	106.7	109.5	112.4	115.3	118.2	121.2	124.3	127.4	130.5	133.7	137.0	140.3
41	78.0	80.5	83.0	85.5	88.0	90.6	93.3	95.9	98.7	101.4	104.3	107.1	110.0	113.0	116.0	119.1	122.2	125.4	128.7	132.0	135.4	138.8	142.3	145.9	149.5
42	82.6	85.2	87.8	90.5	93.2	96.0	98.8	101.7	104.6	107.6	110.6	113.7	116.9	120.1	123.4	126.7	130.1	133.6	137.2	140.8	144.5	148.3	152.2	156.1	160.2
43	87.6	90.4	93.2	96.0	99.0	101.9	105.0	108.1	111.2	114.5	117.8	121.1	124.6	128.1	131.7	135.4	139.1	143.0	147.0	151.0	155.2	159.4	163.8	168.2	172.8
44	93.1	96.1	99.1	102.2	105.4	108.6	111.9	115.3	118.7	122.3	125.9	129.6	133.4	137.4	141.4	145.5	149.7	154.1	158.5	163.1	167.9	172.7	177.7	182.9	188.2
45	99.3	102.5	105.8	109.2	112.6	116.2	119.8	123.6	127.4	131.4	135.4	139.6	143.9	148.3	152.9	157.6	162.4	167.4	172.6	178.0	183.5	189.2	195.1	201.2	207.5
46	106.3	109.8	113.4	117.2	121.0	125.0	129.1	133.3	137.6	142.1	146.7	151.5	156.5	161.6	167.0	172.5	178.2	184.2	190.4	196.8	203.5	210.5	217.8	225.4	233.3
47	114.3	118.3	122.4	126.6	130.9	135.4	140.1	145.0	150.0	155.3	160.7	166.4	172.3	178.5	185.0	191.8	198.9	206.4	214.2	222.4	231.0	240.0	249.5	259.5	270.0
48	123.9	128.4	133.1	137.9	143.0	148.3	153.9	159.7	165.8	172.2	178.9	186.0	193.5	201.4	209.8	218.7	228.2	238.2	248.9	260.3	272.3	285.1	298.7	313.0	328.2
49	135.5	140.8	146.4	152.3	158.5	165.0	172.0	179.3	187.2	195.6	204.6	214.3	224.7	235.9	248.1	261.3	275.5	290.9	307.6	325.5	344.8	365.4	387.3	410.6	435.2

Quanti-Tray and Defined Substrate Technology are trademarks or registered trademarks of IDEXX Laboratories, Inc. in the United States and/or other countries. Covered by U.S. Patent Numbers 4,925,789; 5,429,933; 5,518,892. Other patents pending.

APPENDIX A7

CONTINUED

IDEXX Quanti-Tray/2000 MPN Table

# Large Wells Positive	# Small Wells Positive 25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
0	25.3	26.4	27.4	28.4	29.5	30.5	31.5	32.6	33.6	34.7	35.7	36.8	37.8	38.9	40.0	41.0	42.1	43.1	44.2	45.3	46.3	47.4	48.5	49.5
1	26.6	27.7	28.7	29.8	30.8	31.9	32.9	34.0	35.0	36.1	37.2	38.2	39.3	40.4	41.4	42.5	43.6	44.7	45.7	46.8	47.9	49.0	50.1	51.2
2	27.9	29.0	30.0	31.1	32.2	33.2	34.3	35.4	36.5	37.5	38.6	39.7	40.8	41.9	43.0	44.0	45.1	46.2	47.3	48.4	49.5	50.6	51.7	52.8
3	29.3	30.4	31.4	32.5	33.6	34.7	35.8	36.8	37.9	39.0	40.1	41.2	42.3	43.4	44.5	45.6	46.7	47.8	48.9	50.0	51.2	52.3	53.4	54.5
4	30.7	31.8	32.8	33.9	35.0	36.1	37.2	38.3	39.4	40.5	41.6	42.8	43.9	45.0	46.1	47.2	48.3	49.5	50.6	51.7	52.9	54.0	55.1	56.3
5	32.1	33.2	34.3	35.4	36.5	37.6	38.7	39.9	41.0	42.1	43.2	44.4	45.5	46.6	47.7	48.9	50.0	51.2	52.3	53.5	54.6	55.8	56.9	58.1
6	33.5	34.7	35.8	36.9	38.0	39.2	40.3	41.4	42.6	43.7	44.8	46.0	47.1	48.3	49.4	50.6	51.7	52.9	54.1	55.2	56.4	57.6	58.7	59.9
7	35.0	36.2	37.3	38.4	39.6	40.7	41.9	43.0	44.2	45.3	46.5	47.7	48.8	50.0	51.2	52.3	53.5	54.7	55.9	57.1	58.3	59.4	60.6	61.8
8	36.6	37.7	38.9	40.0	41.2	42.3	43.5	44.7	45.9	47.0	48.2	49.4	50.6	51.8	53.0	54.1	55.3	56.5	57.7	59.0	60.2	61.4	62.6	63.8
9	38.1	39.3	40.5	41.6	42.8	44.0	45.2	46.4	47.6	48.8	50.0	51.2	52.4	53.6	54.8	56.0	57.2	58.4	59.7	60.9	62.1	63.4	64.6	65.8
10	39.7	40.9	42.1	43.3	44.5	45.7	46.9	48.1	49.3	50.6	51.8	53.0	54.2	55.5	56.7	57.9	59.2	60.4	61.7	62.9	64.2	65.4	66.7	67.9
11	41.4	42.6	43.8	45.0	46.3	47.5	48.7	49.9	51.2	52.4	53.7	54.9	56.1	57.4	58.6	59.9	61.2	62.4	63.7	65.0	66.3	67.5	68.8	70.1
12	43.1	44.3	45.6	46.8	48.1	49.3	50.6	51.8	53.1	54.3	55.6	56.8	58.1	59.4	60.7	62.0	63.2	64.5	65.8	67.1	68.4	69.7	71.0	72.4
13	44.9	46.1	47.4	48.6	49.9	51.2	52.5	53.7	55.0	56.3	57.6	58.9	60.2	61.5	62.8	64.1	65.4	66.7	68.0	69.3	70.7	72.0	73.3	74.7
14	46.7	48.0	49.3	50.5	51.8	53.1	54.4	55.7	57.0	58.3	59.6	60.9	62.3	63.6	64.9	66.3	67.6	68.9	70.3	71.6	73.0	74.4	75.7	77.1
15	48.6	49.9	51.2	52.5	53.8	55.1	56.4	57.8	59.1	60.4	61.8	63.1	64.5	65.8	67.2	68.5	69.9	71.3	72.6	74.0	75.4	76.8	78.2	79.6
16	50.5	51.8	53.2	54.5	55.8	57.2	58.5	59.9	61.2	62.6	64.0	65.3	66.7	68.1	69.5	70.9	72.3	73.7	75.1	76.5	77.9	79.3	80.8	82.2
17	52.5	53.9	55.2	56.6	58.0	59.3	60.7	62.1	63.5	64.9	66.3	67.7	69.1	70.5	71.9	73.3	74.8	76.2	77.6	79.1	80.5	82.0	83.5	84.9
18	54.6	56.0	57.4	58.8	60.2	61.6	63.0	64.4	65.8	67.2	68.6	70.1	71.5	73.0	74.4	75.9	77.3	78.8	80.3	81.8	83.3	84.8	86.3	87.8
19	56.8	58.2	59.6	61.0	62.4	63.9	65.3	66.8	68.2	69.7	71.1	72.6	74.1	75.5	77.0	78.5	80.0	81.5	83.1	84.6	86.1	87.6	89.2	90.7
20	59.0	60.4	61.9	63.3	64.8	66.3	67.7	69.2	70.7	72.2	73.7	75.2	76.7	78.2	79.8	81.3	82.8	84.4	85.9	87.5	89.1	90.7	92.2	93.8
21	61.3	62.8	64.3	65.8	67.3	68.8	70.3	71.8	73.3	74.9	76.4	77.9	79.5	81.1	82.6	84.2	85.8	87.4	89.0	90.6	92.2	93.8	95.4	97.1
22	63.8	65.3	66.8	68.3	69.8	71.4	72.9	74.5	76.1	77.6	79.2	80.8	82.4	84.0	85.6	87.2	88.9	90.5	92.1	93.8	95.5	97.1	98.8	100.5
23	66.3	67.8	69.4	71.0	72.5	74.1	75.7	77.3	78.9	80.5	82.2	83.8	85.4	87.1	88.7	90.4	92.1	93.8	95.5	97.2	98.9	100.6	102.4	104.1
24	68.9	70.5	72.1	73.7	75.3	77.0	78.6	80.3	81.9	83.6	85.2	86.9	88.6	90.3	92.0	93.8	95.5	97.2	99.0	100.7	102.5	104.3	106.1	107.9
25	71.7	73.3	75.0	76.6	78.3	80.0	81.7	83.3	85.1	86.8	88.5	90.2	92.0	93.7	95.5	97.3	99.1	100.9	102.7	104.5	106.3	108.2	110.0	111.9
26	74.6	76.3	78.0	79.7	81.4	83.1	84.8	86.6	88.4	90.1	91.9	93.7	95.5	97.3	99.2	101.0	102.9	104.7	106.6	108.5	110.4	112.3	114.2	116.2
27	77.6	79.4	81.1	82.9	84.6	86.4	88.2	90.0	91.9	93.7	95.5	97.4	99.3	101.2	103.1	105.0	106.9	108.8	110.8	112.7	114.7	116.7	118.7	120.7
28	80.8	82.6	84.4	86.3	88.1	89.9	91.8	93.7	95.6	97.5	99.4	101.3	103.3	105.2	107.2	109.2	111.2	113.2	115.2	117.3	119.3	121.4	123.5	125.6
29	84.2	86.1	87.9	89.8	91.7	93.7	95.6	97.5	99.5	101.5	103.5	105.5	107.5	109.5	111.6	113.7	115.7	117.8	120.0	122.1	124.2	126.4	128.6	130.8
30	87.8	89.7	91.7	93.6	95.6	97.6	99.6	101.6	103.7	105.7	107.8	109.9	112.0	114.2	116.3	118.5	120.6	122.8	125.1	127.3	129.5	131.8	134.1	136.4
31	91.6	93.6	95.6	97.7	99.7	101.8	103.9	106.0	108.2	110.3	112.5	114.7	116.9	119.1	121.4	123.6	125.9	128.2	130.5	132.9	135.3	137.7	140.1	142.5
32	95.7	97.8	99.9	102.0	104.2	106.3	108.5	110.7	113.0	115.2	117.5	119.8	122.1	124.5	126.8	129.2	131.6	134.0	136.5	139.0	141.5	144.0	146.6	149.1
33	100.0	102.2	104.4	106.6	108.9	111.2	113.5	115.8	118.2	120.5	122.9	125.4	127.8	130.3	132.8	135.3	137.8	140.4	143.0	145.6	148.3	150.9	153.7	156.4
34	104.7	107.0	109.3	111.7	114.0	116.4	118.9	121.3	123.8	126.3	128.8	131.4	134.0	136.6	139.2	141.9	144.6	147.4	150.1	152.9	155.7	158.6	161.5	164.4
35	109.7	112.2	114.6	117.1	119.6	122.2	124.7	127.3	129.9	132.6	135.3	138.0	140.8	143.6	146.4	149.2	152.1	155.0	158.0	161.0	164.0	167.1	170.2	173.3
36	115.2	117.8	120.4	123.0	125.7	128.4	131.1	133.9	136.7	139.5	142.4	145.3	148.3	151.3	154.3	157.3	160.5	163.6	166.8	170.0	173.3	176.6	179.9	183.3
37	121.3	124.0	126.8	129.6	132.4	135.3	138.2	141.2	144.2	147.3	150.3	153.5	156.7	159.9	163.1	166.5	169.8	173.2	176.7	180.2	183.7	187.3	191.0	194.7
38	127.9	130.8	133.8	136.8	139.9	143.0	146.2	149.4	152.6	155.9	159.2	162.6	166.1	169.6	173.2	176.8	180.4	184.2	188.0	191.8	195.7	199.7	203.7	207.7
39	135.3	138.5	141.7	145.0	148.3	151.7	155.1	158.6	162.1	165.7	169.4	173.1	176.9	180.7	184.7	188.7	192.7	196.8	201.0	205.3	209.6	214.0	218.5	223.0
40	143.7	147.1	150.6	154.2	157.8	161.5	165.3	169.1	173.0	177.0	181.1	185.2	189.4	193.7	198.1	202.5	207.1	211.7	216.4	221.1	226.0	231.0	236.0	241.1
41	153.2	157.0	160.9	164.8	168.9	173.0	177.2	181.5	185.8	190.3	194.8	199.5	204.2	209.1	214.0	219.1	224.2	229.4	234.8	240.2	245.8	251.5	257.2	263.1
42	164.3	168.6	172.9	177.3	181.9	186.5	191.3	196.1	201.1	206.2	211.4	216.7	222.2	227.7	233.4	239.2	245.2	251.3	257.5	263.8	270.3	276.9	283.6	290.5
43	177.5	182.3	187.3	192.4	197.6	202.9	208.4	214.0	219.8	225.8	231.8	238.1	244.5	251.0	257.7	264.6	271.7	278.9	286.3	293.8	301.5	309.4	317.4	325.7
44	193.6	199.3	205.1	211.0	217.2	223.5	230.0	236.7	243.6	250.8	258.1	265.6	273.3	281.2	289.4	297.8	306.3	315.1	324.1	333.3	342.8	352.4	362.3	372.4
45	214.1	220.9	227.9	235.2	242.7	250.4	258.4	266.7	275.3	284.1	293.3	302.6	312.3	322.3	332.5	343.0	353.8	364.9	376.2	387.9	399.8	412.0	424.5	437.4
46	241.5	250.0	258.9	268.2	277.8	287.8	298.1	308.8	319.9	331.4	343.3	355.5	368.1	381.1	394.5	408.3	422.5	437.1	452.0	467.4	483.3	499.6	516.3	533.5
47	280.9	292.4	304.4	316.9	330.0	343.6	357.8	372.5	387.7	403.4	419.8	436.6	454.1	472.1	490.7	509.9	529.8	550.4	571.7	593.8	616.7	640.5	665.3	691.0
48	344.1	360.9	378.4	396.8	416.0	436.0	456.9	478.6	501.2	524.7	549.3	574.8	601.5	629.4	658.6	689.3	721.5	755.6	791.5	829.7	870.4	913.9	960.6	1011.2
49	461.1	488.4	517.2	547.5	579.4	613.1	648.8	686.7	727.0	770.1	816.4	866.4	920.8	980.4	1046.2	1119.9	1203.3	1299.7	1413.6	1553.1	1732.9	1986.3	2419.6	>2419.6

APPENDIX B1

WATER QUALITY RESULTS

pH	Sampling 1	Sampling 2	Sampling 3	Average (Stations)
Station 1	5.60	5.95	6.63	6.06
Station 2	5.65	5.90	6.53	6.03
Station 3	5.72	6.00	6.50	6.07
Average (Sampling)	5.66	5.95	6.55	

DO (mg/L)	Sampling 1	Sampling 2	Sampling 3	Average (Stations)
Station 1	5.80	5.69	5.55	5.68
Station 2	5.74	5.64	5.58	5.65
Station 3	5.94	5.59	5.72	5.74
Average (Sampling)	5.82	5.64	5.61	

Temperature ºC	Sampling 1	Sampling 2	Sampling 3	Average (Stations)
Station 1	28.10	27.60	27.50	27.73
Station 2	28.00	27.70	27.40	27.70
Station 3	28.20	27.90	27.40	27.83
Average (Sampling)	28.10	27.73	27.43	

APPENDIX B2

CONTINUED

EC	Sampling 1	Sampling 2	Sampling 3	Average (Stations)
Station 1	189.00	102.00	99.00	130.00
Station 2	171.00	141.00	93.00	135.00
Station 3	200.00	160.00	94.00	151.00
Average (Sampling)	187.00	134.00	95.00	

NH3-N (mg/L)	Sampling 1	Sampling 2	Sampling 3	Average (Stations)
Station 1	1.60	1.80	2.65	2.01
Station 2	1.60	1.70	2.60	1.97
Station 3	1.50	1.70	2.50	1.90
Average (Sampling)	1.57	1.73	2.58	

COD (mg/L)	Sampling 1	Sampling 2	Sampling 3	Average (Stations)
Station 1	28.00	30.00	37.00	32.00
Station 2	18.00	20.00	22.00	20.00
Station 3	17.00	19.00	21.00	19.00
Average (Sampling)	21.00	23.00	27.00	

APPENDIX B3

CONTINUED

BOD (mg/L)	Sampling 1	Sampling 2	Sampling 3	Average (Stations)
Station 1	9.00	10.79	11.30	10.36
Station 2	9.46	9.73	10.83	10.01
Station 3	8.30	9.86	10.20	9.45
Average (Sampling)	8.92	10.13	10.78	

TSS (mg/L)	Sampling 1	Sampling 2	Sampling 3	Average (Stations)
Station 1	32.00	46.00	58.00	45.30
Station 2	38.00	53.00	47.00	46.00
Station 3	42.00	54.00	56.00	51.00
Average (Sampling)	37.30	51.00	54.00	

Cu (mg/L)	Sampling 1	Sampling 2	Sampling 3	Average (Stations)
Station 1	0.0070	0.0080	0.0120	0.0090
Station 2	0.0050	0.0060	0.0080	0.0060
Station 3	0.0050	0.0090	0.0100	0.0090
Average (Sampling)	0.0060	0.0070	0.0100	

APPENDIX B4

CONTINUED

Cd (mg/L)	Sampling 1	Sampling 2	Sampling 3	Average (Stations)
Station 1	0.0190	0.0210	0.0240	0.0210
Station 2	0.0160	0.0190	0.0210	0.0190
Station 3	0.0180	0.0190	0.0200	0.0190
Average (Sampling)	0.0180	0.0200	0.0230	

Cr (mg/L)	Sampling 1	Sampling 2	Sampling 3	Average (Stations)
Station 1	0.3160	0.3210	0.3240	0.3200
Station 2	0.2940	0.2950	0.2980	0.2960
Station 3	0.3000	0.3090	0.3140	0.3080
Average (Sampling)	0.3030	0.3080	0.3120	

Turbidity NTU	Sampling 1	Sampling 2	Sampling 3	Average (Stations)
Station 1	10.20	12.00	13.30	11.83
Station 2	10.10	10.50	11.60	10.73
Station 3	9.90	11.00	12.10	11.00
Average (Sampling)	10.07	11.17	12.33	

APPENDIX B5

CONTINUED

Total Coliform Count/100mL	Sampling 1	Sampling 2	Sampling 3	Average (Stations)
Station 1	691.00	791.50	960.60	814.37
Station 2	533.50	721.50	913.90	727.47
Station 3	533.50	721.50	870.40	708.47
Average (Sampling)	586.00	744.83	914.97	

E.Coli Count/100mL	Sampling 1	Sampling 2	Sampling 3	Average (Stations)
Station 1	509.90	913.90	1203.30	875.70
Station 2	408.30	870.40	1011.20	763.30
Station 3	422.50	755.60	1011.20	729.77
Average (Sampling)	446.90	846.63	1075.23	

Total Hardness mg/L	Sampling 1	Sampling 2	Sampling 3	Average (Stations)
Station 1	3.36	4.45	5.02	4.28
Station 2	3.15	3.42	4.71	3.76
Station 3	2.58	3.57	4.52	3.56
Average (Sampling)	3.03	3.81	4.75	

APPENDIX B6

WATER CLASS BASED ON NWQS AND WQI FOR EACH PARAMETER OF STATION 1

Parameter	Unit	Value	NWQS	WQI
Temperature	˚C	27.73	II	-
DO	mg/L	5.68	II	II
pH	-	6.06	II	II
EC	µS/cm	130.00	I	-
Turbidity	NTU	11.83	II	-
BOD	mg/L	10.36	IV	IV
COD	mg/L	31.62	III	III
NH3-N	mg/L	2.01	IV	IV
TSS	mg/L	45.33	II	II
Total Hardness	mg/L	4.28	II	-
Cu	mg/L	0.0090	II	-
Cd	mg/L	0.0190	IV	-
Cr	mg/L	0.3080	III	-
Total Coliform	Count/100mL	814.37	II	-
E.Coli	Count/100mL	875.70	III	-

APPENDIX B7

WATER CLASS BASED ON NWQS AND WQI FOR EACH PARAMETER OF STATION 2

Parameter	Unit	Value	NWQS	WQI
Temperature	˚C	27.70	II	-
DO	mg/L	5.65	II	II
pH	-	6.03	II	II
EC	µS/cm	135.00	I	-
Turbidity	NTU	10.73	II	-
BOD	mg/L	10.01	IV	IV
COD	mg/L	20.00	II	II
NH3-N	mg/L	1.97	IV	IV
TSS	mg/L	46.00	II	II
Total Hardness	mg/L	3.76	II	-
Cu	mg/L	0.0090	II	-
Cd	mg/L	0.0210	IV	-
Cr	mg/L	0.2960	III	-
Total Coliform	Count/100mL	727.47	II	-
E.Coli	Count/100mL	763.30	III	-

APPENDIX B8

WATER CLASS BASED ON NWQS AND WQI FOR EACH PARAMETER OF STATION 3

Parameter	Unit	Value	NWQS	WQI
Temperature	˚C	27.83	II	-
DO	mg/L	5.74	II	II
pH	-	6.07	II	II
EC	µS/cm	151.33	I	-
Turbidity	NTU	11.00	II	-
BOD	mg/L	9.45	IV	IV
COD	mg/L	19.00	II	II
NH3-N	mg/L	1.90	IV	IV
TSS	mg/L	51.00	III	III
Total Hardness	mg/L	3.56	II	-
Cu	mg/L	0.0060	II	-
Cd	mg/L	0.0190	IV	-
Cr	mg/L	0.320	III	-
Total Coliform	Count/100mL	708.47	II	-
E.Coli	Count/100mL	729.77	III	-

APPENDIX C1

STUDY AREA (PHOTOS)

Figure C1: Sungai Nyior view.

Figure C2: Residential of Balok Baru, Kuantan.

Figure C4: Agricultural

Figure C5: Construction activities

Figure C6: Livestock

APPENDIX C2

IN-SITU AND EX-SITU TEST

Figure C7 : Sampling process at the river in-situ test

Figure C8: Horiba Meter used for

Figure C9: Solutions for total hardness

Figure C10: Stopper the cylinder

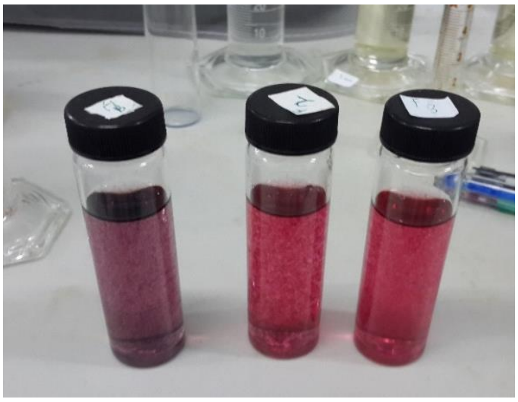


Figure C11: samples after drop EDTA and EGTA

Figure C12: NH3-N test powders

Figure C13 : Waiting for added powder

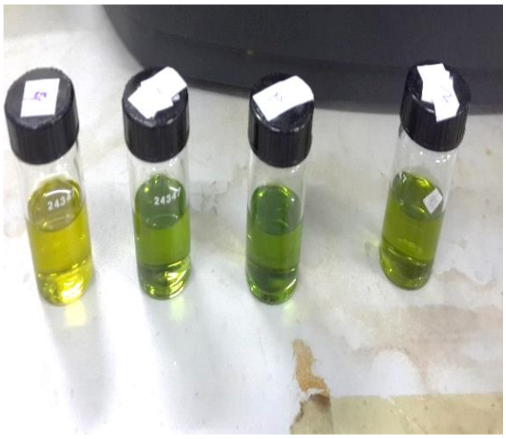


Figure C14 : Green colour that presence of NH3-N.

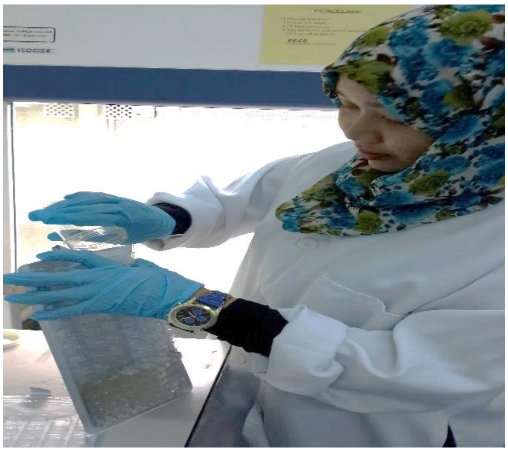


Figure C15 : Poured samples into Quanti-Tray

Figure C16 : Quanti-Tray sealed

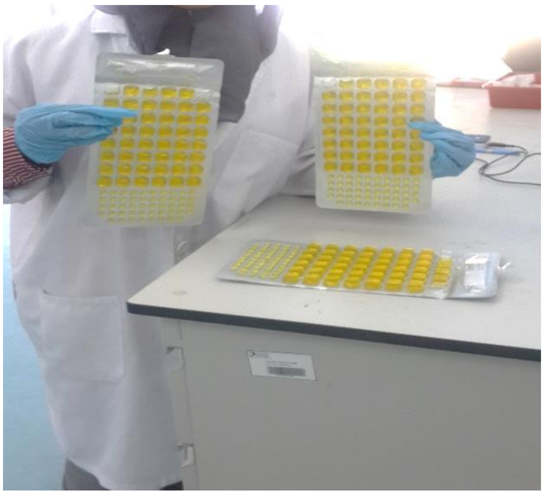


Figure C17 : Total Coliform and E.coli presence

Figure C18: heavy metal setting

Figure C19 and C20 : Parameter of heavy metal lamp installed in AAS.

Figure C21: Testing using AAS

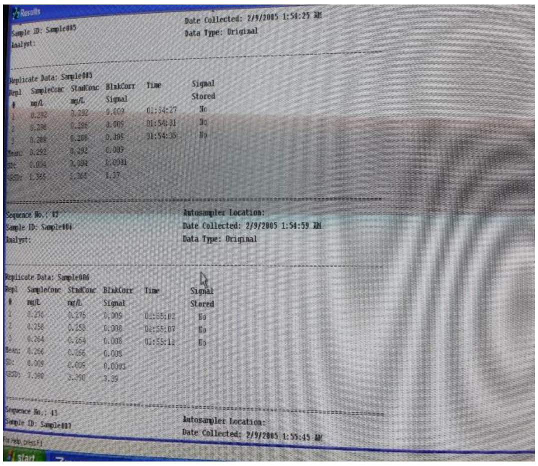


Figure C22: Reading for heavy metal

On computer screen

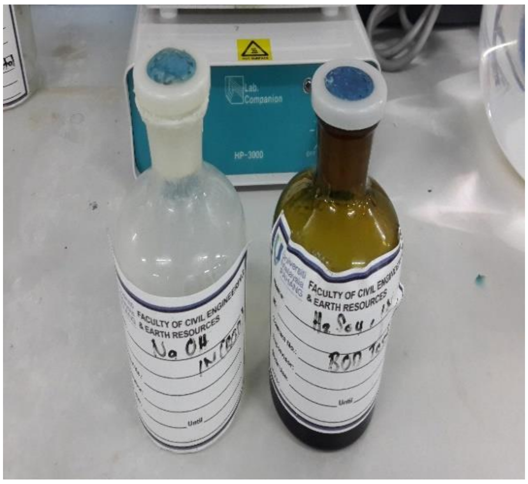


Figure C23: NaOH and H2SO4

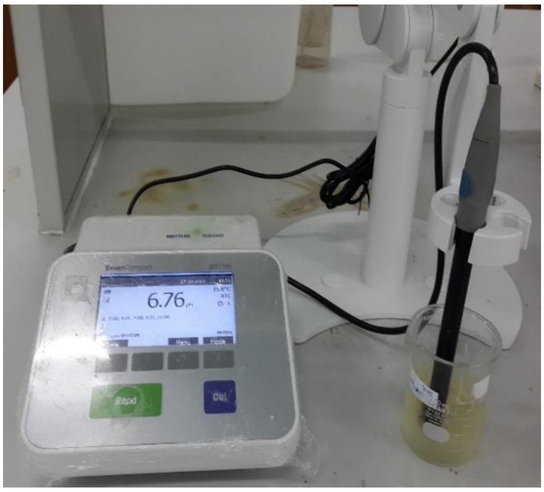


Figure C24 : Adjusted pH by NaOH,

H2SO4

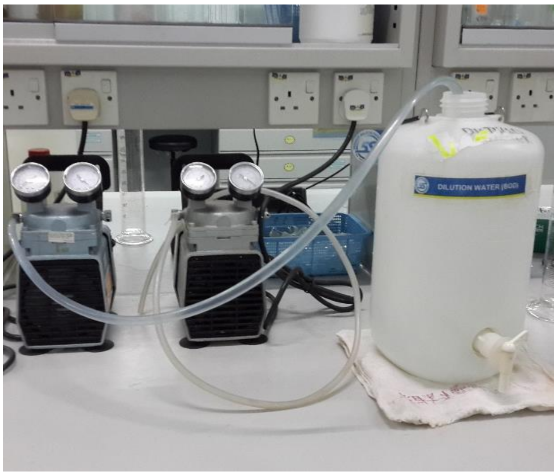


Figure C25: BOD Nutrient Buffer Pillow

Figure C26 :Bubbling compressed air in BOD dilution water

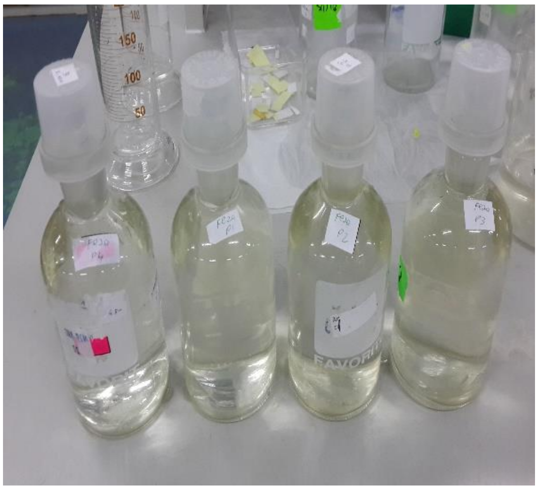
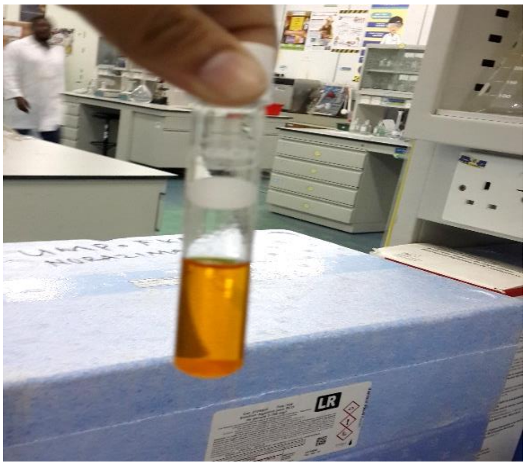


Figure C27 and C28: BOD results after 5days using YSI 5100 Dissolved Meter.



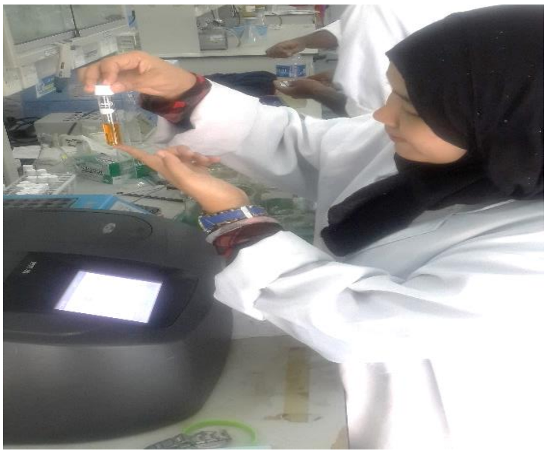
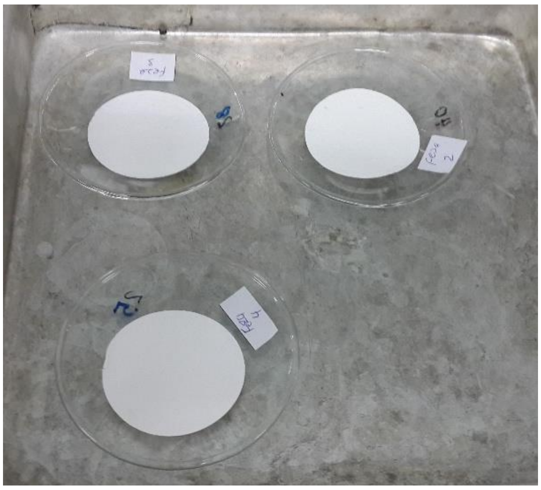


Figure C28: High Range (HR) COD Digestion of COD using Reagent Vials

Figure C29: Recorded the reading DR 500 Spectrophotometer.

Figure C30: Filter 100mL samples

Figure C31: Put in dessicator 30minutes after incubated I hour



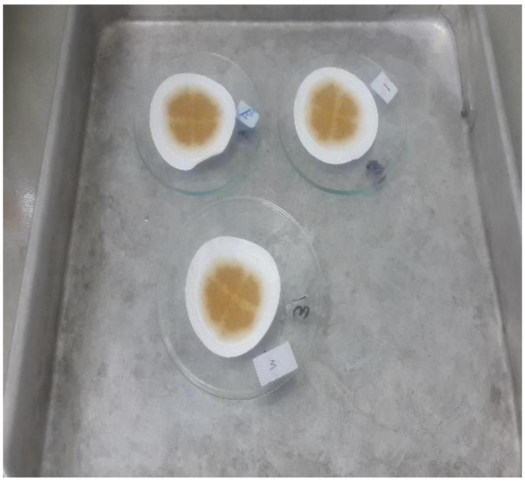


Figure C32 and C33: Filter disc (before and after put specimens)

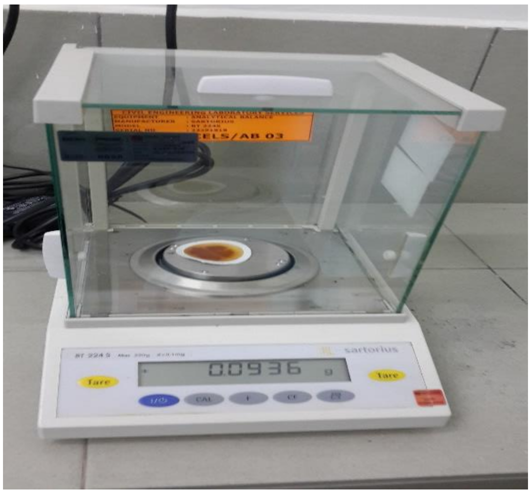


Figure C34: Balanced the samples, recorded the readings.