WATER QUALITY INDEX OF SUNGAI PAHANG

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ABSTRACT

Sungai Pahang is a river in Malaysia that is located at Pahang which is significantly degrading due to human activities as well as urbanization in the area. A study is conducted at selected area of the river to determine the water quality in Sungai Pahang at Kuala Pahang due to the development of Pekan during dry and wet time based on water quality parameters Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Dissolved Oxygen (DO), pH, Suspended Solids (SS) and Ammoniacal Nitrogen (NH_3-N) in order to classify the river based on Water Quality Index (WQI) from the Department of Environment (DOE). DO and pH were analyzed as in-situ measurement while the rest of the parameters were analyzed in the laboratory. The selected stations was at near the restaurant area (Station 1), near to the recreational park (Station 2) and near to the construction site (Station 3). It was found that during dry time, the quality of water degrades significantly compared to during wet time for almost each water quality parameter. During dry time, Sungai Pahang can be classified as Class 2 while during wet time is classified under Class 3. Based on the outcomes, the water quality of Sungai Pahang is slightly polluted based on the calculation of WQI.

ABSTRAK

Sungai Pahang merupakan salah satu sungai di Malaysia yang terletak di Pahang dan semakin tercemar kesan daripada aktiviti manusia dan proses pembangunan di Pekan. Satu kajian dijalankan di sungai ini untuk menganalisis kualiti air Sungai Pahang, Pekan di kawasan yang terpilih semasa hari panas dan hari hujan berdasarkan kepada parameter-parameter kualiti air iaitu DO, BOD, COD, pH, SS dan NH_3-N dengan tujuan untuk mengklasifikasikan sungai ini mengikut WQI-DOE. Parameter DO and pH dianalisa sebagai pengukuran in-situ manakala parameter-parameter lain dianalisa di makmal. Kawasan yang terpilih adalah kawasan sungai yang berdekatan dengan kawasan restauran (Stesen 1), kawasan berdekatan dengan pusat rekreasi (Stesen 2) dan kawasan yang berhampiran dengan kawasan pembinaan (Stesen 3). Setelah menjalankan analisis, didapati bahawa kualiti air merosot semasa hari panas jika dibandingkan dengan kualiti air semasa hari hujan bagi hamper setiap parameter kualiti air. Semasa hari panas, Sungai Pahang boleh dikelaskan sebagai Kelas 2 sementara kualiti air semasa hari hujan ialah berada di dalam kelas 3. Berdasarkan hasil kajian yang dibuat, kualiti air Sungai Pahang ialah sedikit tercemar berdasarkan pengiraan kualiti indek air.

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LIST OF ABBREVIATIONS

BOD	Biochemical Oxygen Demand
COD	Chemical Oxygen Demand
DO	Dissolved Oxygen
DOE	Department of Environment
TDS	Total Dissolve Solids
TSS	Total Suspended Solids
EC	Electrical Conductivity
NWQS	National Water Quality Standard
NH_3-N	Ammonical Nitrogen
NO_3^-	Nitrate
mg/L	Milligram per litre
NTU	Nephelometric Turbidity Units
µs/cm	Microsiemens per centimetre
WQI	Water Quality Index
Fe	Iron
Cu	Copper
Pb	Lead
Mn	Manganese

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Water is a vital resource, necessary for all aspects of human and ecosystem survival and health. In addition, to drink and personal hygiene, water is needed for others uses such as agricultural production, industrial and manufacturing processes, hydroelectric power generation, waste assimilation, recreation, navigation enhancement of fish and wildlife and variety of others purposes (Biswas, 1981).

Water quality is affected by a wide range of natural and human influences. The most important of the natural influences are geological, hydrological and climatic, since these affect the quantity and the quality of water available. Their influence is generally greatest when available water quantities are low and maximum use must be made of the limited.

The effects of human activities on water quality are both widespread and varied in the degree to which they disrupt the ecosystem and/or restrict water use. Pollution of water by human faeces, for example, is attributable to only one source, but the reasons for this type of pollution, its impacts on water quality and the necessary remedial or preventive measures are varied.

1.2 Objective

The objectives of carrying out this study are :

i. To determine the physico-chemical characteristics of Sungai Pahang
ii. To classify the water based on Water Quality Index (WQI)

1.3 Scope of Works

The area of research is based on the water quality index of Sungai Pahang and its tributaries. Sampling points are predetermined for field and laboratory testing. In this research, the various water quality parameters are obtained through field and laboratory testing.

Water quality parameters involved for the in situ testing is dissolved oxygen (DO) and pH while laboratory testing include biological oxygen demand (BOD), chemical oxygen demand (COD), ammoniacal nitrogen (NH_3-N) & total suspended solid (TSS).

Physico-chemical characteristic parameters involved for my study are nitrate (NO_3), turbidity, total dissolve solid (TDS), temperature, electricity conductivity (EC), dissolve oxygen (DO), pH and heavy metals that consists of lead (Pb), iron (Fe), manganese (Mn) and copper (Cu).

1.4 Problem Statements

Due to the rapid development and urbanization process around the area, the water quality of Sungai Pahang is significantly degrading. The pollution of the river is seemingly obvious because it could be easily judged by the look, colour and smell of the river. The residents around the area also complained that the river is much polluted.

It is important to study the level of pollution in the river currently and determine the causes of pollution in order to recommend suitable solutions to the problem. This can be done by identifying the major constituents degrading the quality of the water in Sungai

Pahang. All this is ensure clean water supply and to protect the health of the people around the area besides preserving the environment of the ecosystem of the river. The need to collect data is to document existing water quality conditions in Sungai Pahang which could be useful for future reference.

Quality water of Sungai Pahang effect by human activities such as construction site, restaurant area and recreational park.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Rivers are a very important natural resource to our country. Not only majority of our water supply comes from rivers, but in fact rivers also provide us with food as well as generate income for the country through its aesthetic values. Therefore each and every one of us needs to play a part in protecting our rivers. As can be seen in the diagram below, only 3% of water on the earth is fresh water such as lakes, rivers and groundwater, which is the only source of water available for human consumption while the rest consist of sea water (Connell, 1974).

A river is a large natural waterway. The source of a river may be a lake or spring known as headwaters. From their source, all rivers flow downhill, typically terminating in the ocean. Smaller side streams that join a river are tributaries. The area drained by a river and its tributaries is called its watershed. The flora and fauna of rivers are much different from those of the ocean because the water is fresh or non-salty water (Da Cunha, 1985).

The most common point source of pollutant is probably sewage piped into rivers, but chemical pollution is also common, and industrial accidents account for significant destruction of aquatic life. Non-point source pollutants such as diffuse pollution from agriculture, urbanization and construction activity are all recognized as sources of sediment and other pollutants. Malaysia, in its objective to become a highly developed nation in the near future, carries out many development activities currently which pose threat to the environment.

2.2 Cause of River Pollution

River pollution is any human-caused contamination of water and river that reduces its usefulness to humans and other organisms in nature. When our water supply is contaminated, it is a threat to human, animal, and plant health unless it goes through a costly purification procedure. According to Tchobanoglous and Schroeder (1985), urbanization and uncontrolled development generally contributes significantly to river pollution. There are many specific causes of water pollution, but firstly, it's important to understand two broad categories of water pollution which are point source pollution and non-point source pollution.

2.2.1 Point Source Pollution

Point source pollution occurs when harmful substances are emitted directly into a body of water. An example of a point source of water pollution is a pipe from an industrial facility discharging effluent directly into a river. These effluents contain chemical and toxic waste which endangers living things. People throwing rubbish into the river is also considered as point source pollution (McCaull and Crossland, 1974).

2.2.2 Non-Point Source Pollution

Non-point source delivers pollutants indirectly through transport or environmental change. An example of a non-point-source of water pollution is when fertilizer from a farm field is carried into a stream by rain through surface runoff (Whipple and Hunter, 1977).

2.3 Water Quality Status in Malaysia

DOE's National River Water Quality monitoring started in 1978. It has now been privatized to Syarikat Alam Sekitar Malaysia (ASMA). In 2001, a total of 931 stations located within 120 river basins in Malaysia were monitored. Water samples taken from these monitoring stations were analyzed to compute the Water Quality Index (WQI) based on the following parameters such as BOD, COD, AN, pH, DO and SS. Other parameters such as heavy metals and bacteria were also analyzed depending on site requirements.

It was found that 489 of the rivers were considered clean, 303 rivers were slightly polluted and 139 rivers were polluted (DOE, 2004). In other words, 28% were clean, 62% was slightly polluted and 10% was polluted. Figure 2.6 shows the water quality trend of the river basins in Malaysia.

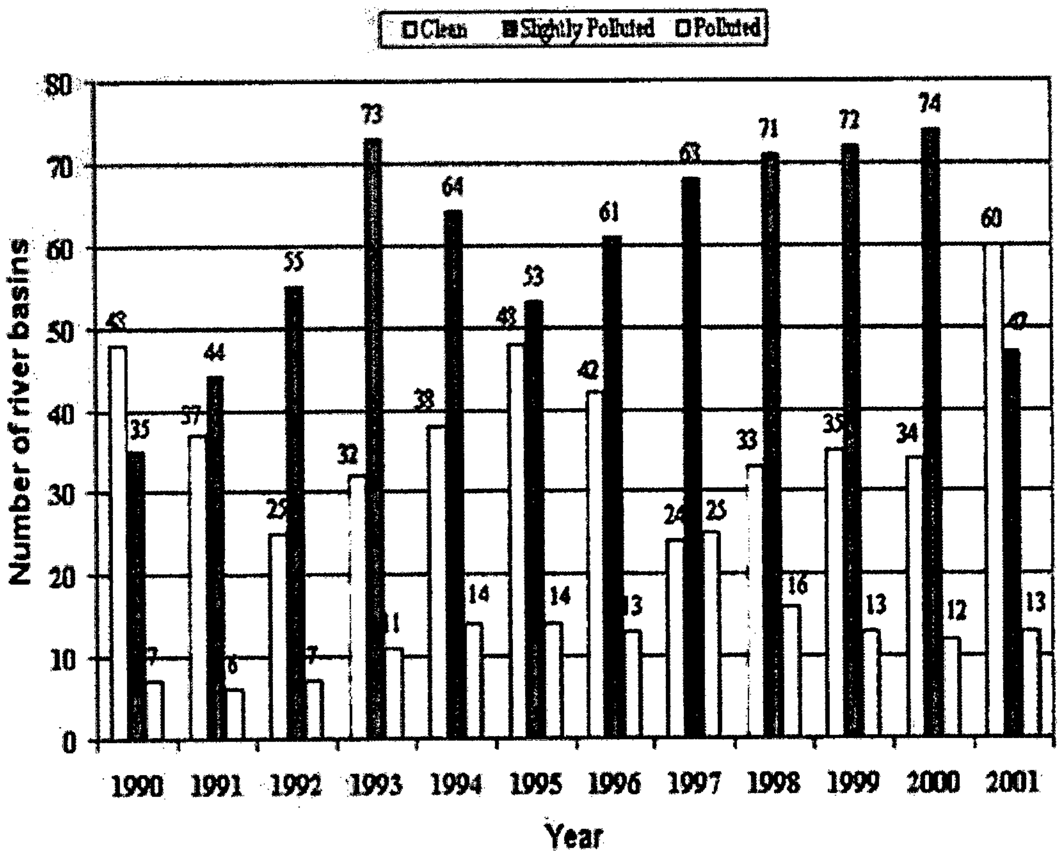

Figure 2.1: Number of River Basins Monitored Each Year and Classification of River Basins Water Quality Trends (1990-2001), (DOE, 2001)

2.4 Water Quality Parameters

Water quality is another aspect to be considered of in any assessment of quality in any water body. The water quality parameters that will affect quality of the water body such as DO, BOD, COD, pH, SS and AN. These 6 water quality parameters are according to the DOE-WQI.

2.4.1 Dissolved Oxygen

Water should contain sufficient dissolved oxygen to maintain aerobic conditions. It generally has been considered as significant in the protection of aesthetic qualities of water as well as for the maintenance of fish and other aquatic life. The amount of dissolved oxygen (DO) in water bodies is dependent upon temperature, salinity, turbulence and atmospheric pressure. The concentration of dissolved oxygen is subject to great variability due to temperature fluctuations, river discharge, biodepletion and re-aeration processes. Gas solubility increases with decreasing temperature and salinity (Meybeck et. al., 1989).

Dissolved oxygen in water bodies used for municipal water supplies is desirable as an indicator of satisfactory water quality in terms of low residuals of biologically available organic materials. The introduction of excess organic matter may result in a depletion of oxygen from an aquatic system. According to McCaull and Crossland (1974), dissolved oxygen levels below 3 mg/l are harmful to most of the water life. Figure 2.2 below shows how the oxygen levels in the water drop as a result of a rise in organic matter levels (at the point of discharge), and then rise as the organic matter is broken down. As the bacteria degrade the organic materials, they produce mineral salts as a by-product as shown in Figure 2.3. These mineral salts, including nitrates and phosphates, can be used by macrophytes; which are larger plants in the water body; as a source of nutrients. (Da Cunha, 1985)

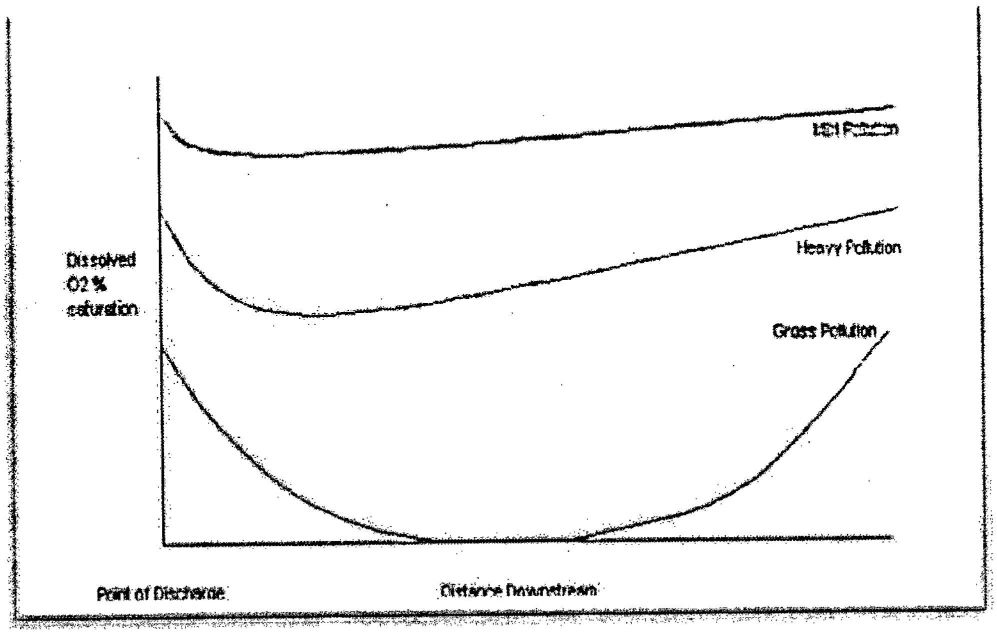

Figure 2.2: Oxygen sag curve based on pollution loading (NERC, 2005)

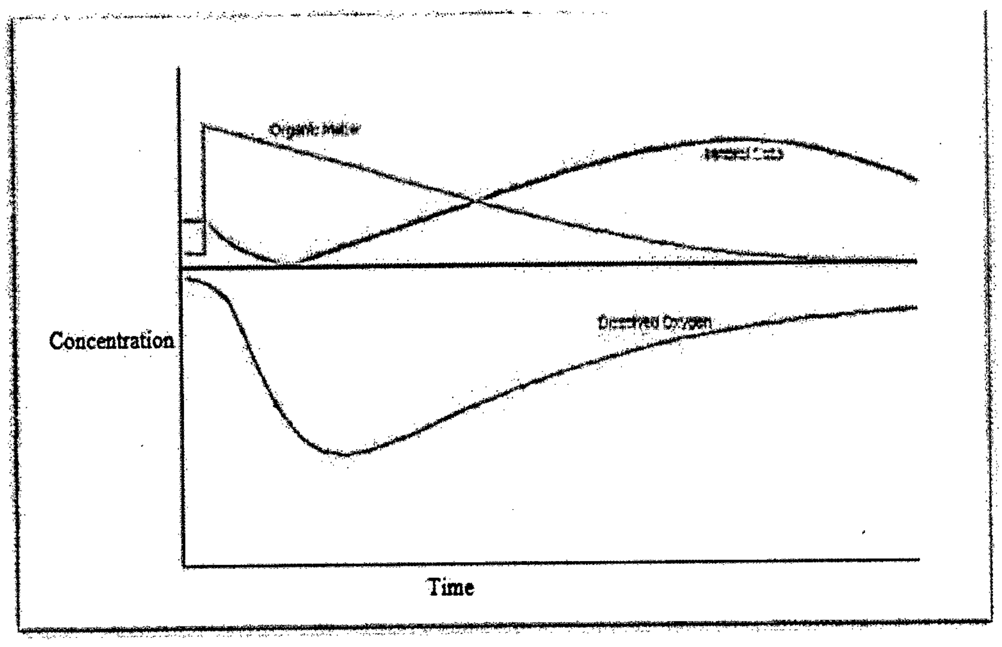

Figure 2.3: Oxygen sag curve constituents (NERC, 2005)

If all oxygen is depleted, aerobic decomposition ceases and further organic breakdown is accomplished anaerobically. Anaerobic microorganisms obtain energy from oxygen bound to other molecules such as nitrates and sulfates. The oxygen- free conditions result in the mobilization of many otherwise insoluble compounds. As sulfate compounds break down, the water may smell like rotten eggs (Tchobanoglous and Edward, 1985).

2.4.2 Biochemical Oxygen Demand

Most organic materials such as those from waste water treatment plants, industrial effluents and agricultural run-off are biodegradable. The amount of oxygen used in the metabolism of biodegradable organics is termed biochemical oxygen demand. When organic matter decomposes, microorganisms such as bacteria and fungi feed upon it and eventually it becomes oxidized. Biochemical oxygen demand (BOD) is a measure of the quantity of oxygen used by these microorganisms in the aerobic oxidation of organic matter (Train, 1979).

When aquatic plants die, aerobic bacteria feed upon them and nutrients, such as nitrates and phosphates, are released into the body of water, stimulating plant growth. Eventually, more plant growth leads to more plant decay. Nutrients can be a prime contributor to high biochemical oxygen demand in rivers. In rivers with high biochemical oxygen demand levels, aerobic bacteria consume much of the available dissolved oxygen, robbing other aquatic organisms of the oxygen they need to live. Basically, the reaction for biochemical oxidation may be written as:

$$\text{Oxidizable material} + \text{bacteria} + \text{nutrient} + O_2 \rightarrow CO_2 + H_2O + \text{Oxidized inorganics such as } NO_3 \text{ or } SO_4 \qquad \ldots(2.1)$$

BOD is typically divided into two parts which is carbonaceous oxygen demand and nitrogenous oxygen demand. Carbonaceous biochemical oxygen demand (CBOD) is the result of the breakdown of organic molecules such a cellulose and sugars into carbon dioxide and water. Nitrogenous oxygen demand is the result of the breakdown of proteins. Proteins contain sugars linked to nitrogen. After the nitrogen is "broken off" a sugar molecule, it is usually in the form of ammonia, which is readily converted to nitrate in the environment. The conversion of ammonia to nitrate requires more than four times the amount of oxygen as the conversion of an equal amount of sugar to carbon dioxide and water (Tchobanoglous and Schroeder, 1985).

2.4.3 Chemical Oxygen Demand

Chemical oxygen demand (COD) is a water quality parameter 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. COD is therefore an estimate of the amount of organic and reduced matter present in the water or better known as the amount of oxygen needed to chemically decompose the organic matter in the water (Klein, 1957). Oxidizable chemicals introduced into natural water will initiate chemical reactions. Those chemical reactions create what is measured in the laboratory as the COD. Oxygen consumption by reducing chemicals such as sulfides and nitrites is typified as follows:

$$S^{2-} + 2\,O_2 \rightarrow SO_4^{2-} \quad \ldots (2.2)$$

$$NO_2^- + \tfrac{1}{2}\,O_2 \rightarrow NO_3^- \quad \ldots (2.3)$$

Both the BOD and COD tests are a measure of the relative oxygen-depletion effect of a waste contaminant. Both have been widely adopted as a measure of pollution effect. The BOD test measures the oxygen demand of biodegradable pollutants whereas the COD test measures the oxygen demand of biodegradable pollutants plus the oxygen demand of non-biodegradable oxidizable pollutants. COD almost always exceeds BOD in water. The ratio of COD to BOD also indicates to what extent a wastewater is amenable to biological treatment methods. (Tchobanoglous et. al., 2003)

2.4.4 pH

pH is a key parameter in water quality. pH is closely linked to biological productivity in aquatic systems and is a limiting factor for certain water uses. The acidity and alkalinity of the water is affected by the presence of mineral salts such as chlorides, sulfates and phosphates (Chipman, 1934). pH is a measure of the hydrogen ion activity in water according to the expression below where [H+] is the hydrogen ion activity:

$$pH = -\log 10\ [H+] \quad \ldots (2.4)$$

pH is important because the toxicity of many compounds is affected by pH value. In addition, pH also affects the solubility of heavy metal compounds in water (Jones, 1964). pH in raw water used for public water supplies has to be adjusted to a suitable level because it may be corrosive and adversely affect treatment processes. According to Train (1979), the normal range of pH values for most rivers should be between 6.4 and 8.3 whereby it is also the suitable range of pH value for the survival of most aquatic organisms and species.

2.4.5 Ammoniacal Nitrogen

Ammonia is the form of nitrogen present in aquatic systems that is the most reactive. The principal sources of ammonia nitrogen (NH3-N) come from soil mineralization, fertilizer, animal wastes, atmospheric deposition, and municipal and industrial point sources. It can adhere to soils and sediment and can be toxic to aquatic organisms at high concentrations. Young (1980) reported that the toxicity of ammonia nitrogen to aquatic organisms depends on the pH and temperature of the water; for most waters, hundreds of parts per million are needed for toxic effects. At the temperature and pH range typical of most rivers and lakes, ammonia exists predominantly in the ionized form (NH4+). As pH and temperature increase, the ionized ammonia changes to un-ionized ammonia gas (NH3).

Generally, ammonia nitrogen is quickly taken up by phytoplankton or other aquatic plants or transformed to nitrate-nitrogen. Once in the water, nitrates can stimulate excessive plant and algae growth. Decomposition of the plant and algal material by bacteria can deplete DO, adversely impacting fish and other aquatic animals. It has been known that ammonia nitrogen is toxic to fishes and that the toxicity varies with the pH of the water (Chipman, 1934). According to Wood (1974), measurements of values of total ammonia nitrogen in the range of 0.02 mg/L NH3 are well within current analytical capability and suitable for freshwater aquatic life.

2.4.6 Suspended Solids

The amount of particles that suspend in a sample of water is called total suspended solids (TSS). It is important in drinking water quality and has significant impact on fish and other aquatic life. SS are also a major carrier of inorganic and organic pollutants and other nutrients. To remain permanently suspended in the river, particles must have relatively low density, small in size, and have a surface area that is large in relation to their weight. The greater the TSS in the water, the higher its turbidity and the lower its transparency (McCaull and Crossland, 1974)

According to Martin and Meybeck (1979), the major sources of sediment come from natural erosion due to rainfall, running water and wind which will carry the sediments to the water body. Activities such as urbanization, construction and mining operations also greatly contribute to sediment runoff through surface runoff (McCaull and Crossland, 1974).

CHAPTER 3

METHODOLODY

3.1 Introduction

The accuracy of the results are dependent upon the samples which are taken, thus very special attention must be given to the organization of the collection and sampling techniques. This means that samples must be collected and stored in such a way that the parameters measured in the sample have the same values as those in the river itself. Furthermore, the sampling place and time must be chosen in such a way that the analytical results reflect the temporal or local variations during the period of investigation (Rump and Krist, 1992).

3.2 Data Collection

Data collection focuses on the methods to gather data needed for the study of water quality in Sungai Pahang.

3.3 Preliminary Investigation

Before starting the sampling of water from Sungai Pahang, a preliminary study was conducted at selected are. This is 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. From there, suitable sampling locations and monitoring media will be selected and water quality parameters identified.

3.4 Sample Collection

The sampling points are selected randomly. 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 three 3 stations that been selected is near to restaurant area (Station 1), near to recreational park (Station 2) and near to the construction site (Station 3).

The sampling taking for two types of weather that during the dry and wet day. Weather influenced the result value because of sample that been collect during rainy days are different compared to sample that been taken during sunny day. During rainy days, runoff water will flow through and transport together sort of material from the upper surface of the river bank. This situation will give impact to the result values and it will may probably different during normal day.

3.5 Sample Preservation

Water sample collected at 10cm below the surface water using 1l HDPE bottle. The sample need to store in ice box at temperature 4°C and transported to laboratory for analysis. The water sample preservation based on the test will be conducted. The preservation technique shown in table below:

Table 3.1 Preservation techniques

Parameter	Container	Preservation	Max Holding Time
Biochemical Oxygen Demand	P,G	Cool, 4°C	48 hours
Chemical Oxygen Demand	P,G	Cool, 4°C H_2SO_4 to pH<2	28 days
Heavy Metal	P,G	HNO_3 to pH<2	28 days
Nitrate	P,G	Cool, 4°C	48 hours
Ammoniacal Nitrogen	P,G	Cool, 4°C	28 days