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ABSTRACT

Due to fast development in Malaysia, the numbers of industrial estates are increasing. Gebeng are the main industrial area in Pahang. The Tunggak River which is adjacent to the area, are receiving lots of industrial wastes. This study was done to assess the water quality based on National Water Quality Standard (NWQS) and Malaysian Water Quality Index (WQI) and the factors that affect the water quality. Sampling was done for three months at five stations. The chemical, and biological parameters were measured. Those parameters are temperature, dissolved oxygen (DO), pH, turbidity, biochemical oxygen demand (BOD), chemical oxygen demand (COD), total suspended solids (TSS), E.Coli, total coliform, ammoniacal nitrogen (NH_3-N) and heavy metal. From the result, the water quality in the study area is in Class III. The high temperatures were resulting to the low value of dissolve oxygen. High concentrations of ammonia were detected in all sampling station indicating that it was rich with industrial wastes. The high concentration of ferum was detected at station 5. The types of industries involved were one of the factors affecting water quality in the study area. In summary, the water quality in the Gebeng area has been degraded and required more attention from all parties involved.

ABSTRAK

Pembangunan yang maju di Malaysia menyebabkan munculnya banyak kawasan perindustrian. Gebeng merupakan kawasan perindustrian yang utama di Pahang. Sungai Tunggak yang bersebelahan dengan kawasan tersebut telah menerima banyak sampah industri. Kajian ini dilakukan untuk mengkaji kualiti air berdasarkan standard kualiti air Malaysia (NWQS) dan Indeks Kualiti Air (WQI) serta faktor yang mempengaruhi kualiti air tersebut. Pensampelan telah dilakukan selama tiga bulan di lima buah stesen. Parameter seperti fizikal, kimia, dan biologi telah dikenalpasti. Parameter tersebut termasuklah suhu, oksigen terlarut (DO), pH, kekeruhan, permintaan oksigen biokimia (BOD), permintaan oksigen kimia (COD), jumlah pepejal terampai (TSS), E-Coli, jumlah koliform dan ammonia nitrogen (NH_3-N) dan logam berat. Daripada kajian yang dijalankan, kualiti air di kawasan tersebut berada di kelas III. Suhu yang tinggi menyebabkan oksigen terlarut menjadi kurang. Kandungan ammonian nitrogen yang tinggi di semua stesen pula menunjukkan ianya kaya dengan sampah industri. Manakala, kandungan ferum yang tinggi dikenalpasti di stesen lima. Antara faktor yang mempengaruhi kualiti air pula adalah jenis industri yang dijalankan. Sebagai kesimpulan, kualiti air di kawasan Gebeng telah merosot dan ianya memerlukan lebih perhatian daripada semua pihak yang terlibat.

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AAS	Atomic absorption spectrophotometer
BOD	Biochemical oxygen demand
COD	Chemical oxygen demand
DO	Dissolved oxygen
DOE	Department of Environment
E- coli	Escherichia Coli
NWQS	National Water Quality Standard
ppm	Parts per million
TSS	Total suspended solids
WQI	Water Quality Index

CHAPTER 1

INTRODUCTION

1.1 Introduction

Water is the most common liquid on our planet, important to all life forms. About 70% of the earth is covered with water. But, not all of the world's water is usable to us. There's only 2.5% as fresh water, but the total fresh water that is accessible for direct human uses is less than 1%. That 1% of the world's water supply is a precious commodity necessary for our survival.

Despite that, quality of water is deteriorating day by days all over the world. Mainly water pollution is usually caused by anthropogenic activities. Rapid growth of industrialization has generated hazardous industrial wastes. The industries are pouring their effluent into the river. River is important in Malaysia since it support about 98% of the country's water requirements. Therefore, any contamination to the river can bring risk to water supply problem.

Due to fast development in Malaysia, the numbers of industrial estates are increasing. Gebeng in Kuantan, Pahang is one of the main industrial areas which are heavy with anthropogenic activities. It's a world-class chemical and petrochemical industrial zone along with other general industries. The industries are generating effluents which contain high concentrations of conventional pollutants (oil and grease), toxic pollutants (heavy metals, volatile organic compounds) or other non-conventional pollutants (ammonia).

Tunggak River, which is adjacent to this area and one of the important rivers in Pahang, is receiving the effluent or the wastes from the industries. Result from the activities, the quality of Tunggak River is deteriorating.

1.2 Background of Study

Malaysia is a country that had lots of water resources. It's contributing to the economic and industrial development of the country. The rapid industrialization is bringing more and more environmental problems. The main problems that heavily affected by the industrial activities are industrial pollution and land development.

According to the Environmental Quality Report 2010, 50% river water of Malaysia is polluted which is higher than previous couple of years. This is mainly because of the industries that discharging their effluent (conventional and nonconventional) into the river. Because of this, water pollution in Malaysia is increasing. It is a serious problem and can bring negative impacts to our health also water supplies.

This study will focused mainly on water pollution caused by anthropogenic activities. Anthropogenic is an effect or object resulting from human activity. The term is often used in the form of chemical or biological wastes that are produced as by-products of otherwise purposeful human activities. Some of anthropogenic sources include industry, agriculture, mining, transportation, construction, habitations and deforestation.

1.3 Problem Statement

There are many industrial areas all over Malaysia, due to the rapid development. Gebeng Industrial area was one of it. Along with the development, the water pollution level also increased. There are lots of effluents were produced every day. Those effluents are discharging to the river every day, which is Tunggak River. Thus, resulting polluting the river water. On the other hands, this industrial wastewater pollution problem not only happened in Malaysia, but also over the world.

There are also some cases industrial effluent in Malaysia occurred. One of the cases is at Seberang Prai, Pulau Pinang. Many industries there are identified as illegal factories. They are operating up to 10 years without licences and certificates of fitness (CF) and also failed to get necessary clearance from the Department of Environment (DOE). The effluent from the factories are contributing into the pollution of Juru River since it is unsure either their water discharge passed the water guidelines or not (The Star's 2008).

Since the effluent is from industry, there might be the presence of heavy metal. Thus, the purpose of this research is to know the impact from those anthropogenic activities. From the data and result, we can know whether the anthropogenic activities affected the water or not. Then, necessary actions can be taken.

1.4 Objectives of Study

The overall objectives of this study are as follows:

a) To assess the water quality based on National Water Quality Standard (NWQS) and Malaysian Water Quality Index (WQI)
b) To determine the factors that affect the water quality in the study area

1.5 Scope of Study

The research will focused on the study of water quality in Gebeng Industrial area, Kuantan, Pahang. There are two types of test will be conducted. The first one is field test which is data of the in-situ parameters will be collected. The second one is ex-situ parameters or laboratory test. Sample of water will be taken back to UMP and test will be conducted at the Environmental Laboratory. From the test, data will be recorded and the water quality will be classified based on Water Quality Index (WQI) and National Water Quality Standard (NWQS)

The parameters that will be analyzed are the physical, biological, chemical and heavy metal characteristic of the sample water. The parameters for in-situ tests are Temperature, Dissolved Oxygen (DO), pH, Turbidity. Meanwhile, the parameters for ex-situ tests are Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Suspended Solids (TSS), E.Coli, Total Coliform, Ammoniacal Nitrogen and Heavy Metal.

1.6 Significance of Study

Water pollution is the major environmental problem in the world right now. The situation needs to be control before it's become more serious. Industrial effluent that discharges into the river is the accumulation of many pollutants, such as toxic metals ions. A polluted river could bring harms and dangers to our health and also the aquatic life that depends on it.

From the study conducted, the effects of anthropogenic activities to the river can be determined along with the water quality status of the river. Based on the result obtained, it can help the policymakers to do their job.

CHAPTER 2

LITERATURE REVIEW

2.1 Industrial Effluent

Industrial effluent or industrial wastewater is a liquid discharged as waste, as from an industrial plant or sewage works. The sources of industrial wastewater are mostly agro-based industries, including animal farms, and the manufacturing industries. This industrial wastewater also may include domestic sewage.

In Malaysia, there 16 types of manufacturing processes that has been identified that contribute to industrial wastewater discharge. The main polluting sources are the food and beverage industry (23.7%), followed by electric and electronic industry (11.4%), chemical based industry (11.2%), paper (8.8%), textile (7.4%), metal finishing & electroplating (5.3%), crude palm oil mills (5.3%) and raw natural rubber factories (2%) (DOE, 2000).

Industries discharges are extremely variable in quantity and characteristics, and have been the one most contributed to the substantial deterioration of water quality in the rivers, lakes and other receiving water bodies, since there has been little or no treatment of the wastewater at all. From this situation, it is known that the availability of clean water supply whether from surface water or ground water are affected.

2.2 Discharge Sources

Discharges of wastewater are consisting of point sources and non-point sources. Point sources are wastewaters that are discharged from known sources at an identifiable point. It is divided into domestic and industrial sources. Domestic sources include residences and small businesses. It is relatively small sources if compared with industry sources. Industrial sources are relatively large sources that include such sub-categories as the chemical, petrochemical, oil, mining, and metal industries. Because of their size, these sources are generally easier to collect, but harder to treat.

Meanwhile, non-point sources are characterized by multiple discharged points and generally occur from water runoff. They are divided into agricultural, urban, and atmospheric sources. Agricultural sources include farms, which can contribute fertilizers, pesticides, soil erosion, and plant and animal wastes to water runoff. Urban sources include the storm water systems that collect water from the gutters of streets in towns and cities. Atmospheric sources include air pollution's contribution during precipitation such as acid rain.

2.3 Effect of Wastewater Pollutants

The rapid industrialization and globalization in Malaysia contributes mostly in water pollution problems. River plays an important part in human life. It's used as water supply, domestic usage, recreational purpose and others. But, the quality of river water is deteriorating in many ways. It is because the pollutants that is discharges into the river directly.

The pollutants are mainly coming from the anthropogenic activities that generated by human. The industrial wastewaters are discharged to the river. Industrial wastewater are harmful to any living things, because it's contains toxic metal ions. Higher amount of contamination of these heavy metals inside food, drinking water or air would give dangerous effect to human body. Heavy metals such as cadmium, chromium and mercury

could cause hazardous illness such as kidney spoilage, skin lesions, fatigue lung and increased blood pressure. Other metals that can affect the human health is lead where it can alter children's physical and mental development, interferes with growing, decrease attention span, hearing, and interfere with heme synthesis (Arcadio and Gregoria, 2003).

From above, water pollution can really affect human health and maybe average lifespan. The capability to get quality water for daily used also can be affected. Besides that, it also may affect aquatic live and its biodiversities.

2.4 Water Quality Parameter

There are three types of parameter usually analyzed to get water quality status. It can divide as physical, biological, chemical.

2.4.1 Physical

2.4.1.1 Temperature

Temperature can exert great control over aquatic communities. If the overall water body temperature of a system is altered, an aquatic community shift can be expected. In water above 30°C, a suppression of all benthic organisms can be expected.

2.4.1.2 Turbidity

Turbidity may be due to organic and/or inorganic constituents. Organic particulates may harbour microorganisms. Thus, turbid conditions may increase the possibility for waterborne disease. Nonetheless, inorganic constituents have no notable health effects.

2.4.1.3 Total Suspended Solids (TSS)

Total Suspended Solids (TSS) is solid materials, including organic and inorganic, that are suspended in the water. These would include silt, plankton and industrial wastes. High concentrations of suspended solids can lower water quality by absorbing light. Waters then become warmer and lessen the ability of the water to hold oxygen necessary for aquatic life. Because aquatic plants also receive less light, photosynthesis decreases and less oxygen is produced. The combination of warmer water, less light and less oxygen makes it impossible for some forms of life to exist. It comes from erosion from urban runoff and agricultural land, industrial wastes, bank erosion, bottom feeders (such as carp), algae growth or wastewater discharges.

2.4.2 Biological

2.4.2.1 Total Coliform and E.Coli

It is to detect the level of pollutions caused by living thing especially human who live or work in the area especially upstream of the site. These tests are based on coliform bacteria as the indicator organism. The presence of these indicative organisms is evidence that the water has been polluted with faeces of humans or other warm-blooded animals.

2.4.3 Chemical

2.4.3.1 pH

pH is an indicator of the existence of biological life as most of them thrive in a quite narrow and critical pH range. It also measures the degree of acidity or alkalinity relative to the ionization of water sample. If the water becomes very acidic or alkaline than the concentration of microorganism slowly reduce.

2.4.3.2 Dissolved Oxygen

Dissolved Oxygen (DO) is essential for aquatic life. A low DO (less than 2mg/l) would indicate poor water quality and thus would have difficulty in sustaining any sensitive aquatic life.

2.4.3.3 Biochemical Oxygen Demand

Biochemical oxygen demand (BOD) is usually defined as the quantity of oxygen utilized by a mixed population of micro – organisms to biologically degrade the organic matter in the wastewater under aerobic condition. This is very important parameter in water pollution control. It is used as a measure of organic pollution as a basis for estimating the oxygen needed for biological processes and as an indicator of process performance. High BOD is an indication of poor water quality.

2.4.3.4 Chemical Oxygen Demand

COD is an indicator of organics in the water, usually used in conjunction with BOD. High organic inputs trigger deoxygenation. If excess organics are introduced to the system, there is potential for complete depletion of dissolved oxygen. Without oxygen, the entire aquatic community is threatened. The only organisms present will be air- breathing insects and anaerobic bacteria.

If all oxygen is depleted aerobic decomposition ceases and further organic breakdown is accomplished anaerobically. Anaerobic microbes obtain energy from oxygen bound to other molecules such as sulphate compounds. Thus, anoxic conditions result in the mobilization of many otherwise insoluble compounds.

2.4.3.5 Ammoniacal Nitrogen

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

2.4.3.6 Heavy Metal

Heavy metals are natural components of the Earth's crust. They cannot be degraded or destroyed to a small amount. They enter our bodies via food, drinking water and air. As trace elements, some heavy metals are essential to maintain the metabolism of the human body. But at higher concentrations they may caused to poisoning.

Therefore, heavy metal can enter a water supply by industrial, or even from acidic rain breaking down soils and releasing heavy metals into streams, lakes, rivers, and groundwater. All of these would bring a lot of environmental and health hazard to human health.

2.5 Anthropogenic Factors That Affects the Water Quality

The term anthropogenic means is an effect or object resulting from human activity. Human practices are the main source of many water-quality contaminants over the world. Agricultural runoff, urban runoff, point discharges of municipal and industrial wastes, mine drainage, septic-system effluent, landfill leachate, and contaminated atmospheric deposition are all sources of anthropogenic contamination. These sources are directly related to population density, land cover and land use, water use, and waste disposal.

CHAPTER 3

METHODOLOGY

3.1 Study Area

Gebeng industrial estate located near Kuantan Port. It consist various of industries such as metal, chemical, petrochemical, polypropylene, polymer, palm oil, food, mining, wooden and gas and power industries. Tunggak River which is the adjacent river to Gebeng industrial estate is the main river that carries maximum wastes from the area. The Tunggak River originated at the uphill of Gebeng area. At near Angler marine centre it joined with another river namely Balok and ultimately flows into South China Sea. Considering the land use pattern, point sources of pollution and river network, five monitoring station will be selected for sampling using GPS.

3.2 RESEARCH METHODOLOGY FLOW CHART

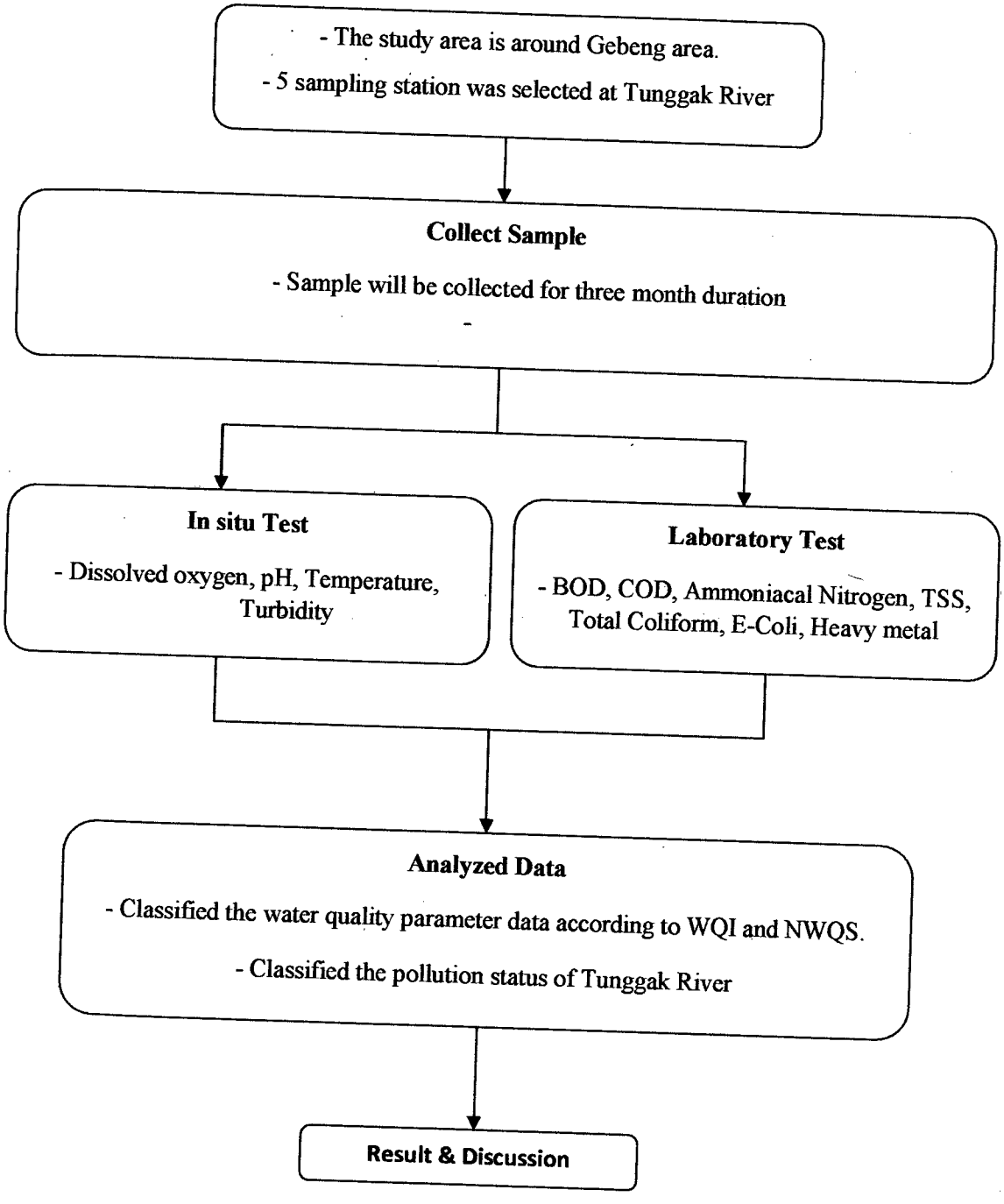

Figure 3.1: Flowchart of research methodology

3.3 SAMPLING LOCATION

The study area of this research is Gebeng area which the river is Tunggak River. There was five sampling stations was selected. To make sure that the locations of each sampling location are same, GPS were used to determine the actual sampling station and to re-confirm the location of stations during the sampling periods.

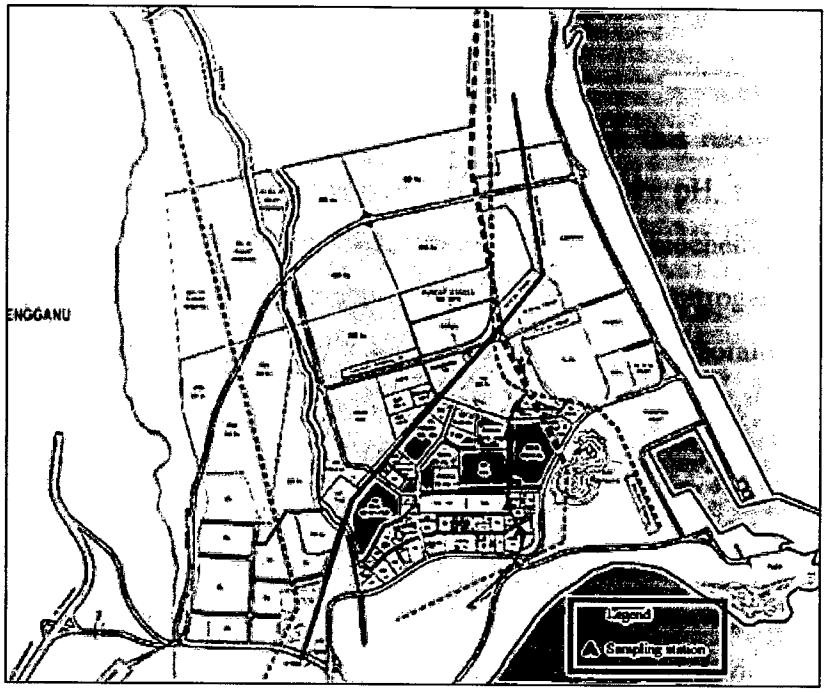

Figure 3.2: Map and sampling station in study area

3.4 PREPARATION FOR SAMPLING COLLECTION

The sample will be collected from 5 different stations. Therefore, the bottle sample needs to label according to the sample station. The bottle sample needs to be clean with distilled water beforehand.

3.5 SAMPLING PRESERVATION

The water samples are collected about 10cm below the water surface using a 1L HDPE bottle. The sample are stored in cool box below 4°C and transported back to the laboratory for analysis on the same day. The sample bottles must be close tightly to avoid from any external contaminants.

3.6 STUDY APPROACHES

There are two types of test that was conducted in this research, in-situ test and laboratory test. The parameters involved for in-situ test are pH, temperature, dissolved oxygen and turbidity. For laboratory test, the parameters are biochemical oxygen demand, total suspended solid, chemical oxygen demand, ammoniacal nitrogen, total coliform, E-Coli and heavy metals are conducted in UMP's Environmental Laboratory.

3.6.1 In-situ Test

The parameters involved for in-situ test are pH, temperature, dissolved oxygen and turbidity. The test was conducted by using Horiba Multi Parameter Water Quality. The detector rode is placed in the water and the value appeared on the device display.

3.6.2 Laboratory Analysis

The test involved are biochemical oxygen demand, total suspended solid , chemical oxygen demand, ammoniacal nitrogen, total coliform and E-Coli will be measured in accordance with standard procedures. The selected heavy metals will be determined using Atomic Absorption Spectrophotometer (AAS).

3.6.2.1 Biochemical Oxygen Demand

Biochemical oxygen demand is a measure of the amount of oxygen that bacteria will consume while decomposing organic matter under aerobic conditions. The method consists of filling dilution water with sample into an airtight bottle of the specified size and incubating it at the specified temperature for 5 days. Dissolved oxygen is measured initially and after incubation, and the BOD is computed from the difference between initial and final DO.

The calculation to obtain BOD_5 in water sample is as below:

$BOD_5 = DO_i - DO_5 / P$

Where:

DO_i = DO of diluted sample about 15 min. after preparation, mg/L

DO_5 = DO of diluted sample after 5 days incubation, mg/L

P = decimal volumetric fraction of sample used

3.6.2.2 Chemical Oxygen Demand

Chemical oxygen demand is used to measure the total quantity of oxygen-consuming substances in the complete chemical breakdown of organic substances in water. It does not differentiate between biologically available and inert organic matter. For this procedure, the low range vial was used. 2mL sample were add into the vial and is heated for two hours. By using HACH DR 5000 the result can be obtained. For low range, the result supposed to range between 3-150 mg/L.

3.6.2.3 Total Suspended Solids

Total suspended solids (TSS) include all particles suspended in water which will not pass through a filter. Suspended solids are present in industrial wastewater and also from

soil erosion which originated from agricultural and construction sites. As TSS increased, aquatic life in the water body cannot survive as DO are lower.

For this procedure, the sample is filtered through a weighed standard glass-fiber filter and the residue retained on the filter is dried to a constant weight at 103-105 ^{0}C. The increase in weight of the filter represents the total suspended solids.

The calculation to obtain total suspended solid in water sample is as below:

Total Suspended Solids (mg/l) = (A–B) X 1000/ S

Where;

A = weight of residue + dish, mg

B = weight of dish, mg and

S = sample volume, 100ml

3.6.2.4 Ammoniacal Nitrogen

Ammoniacal nitrogen is an inorganic dissolved form of nitrogen that can be found in water. It is a reduced form of nitrogen. The value of ammoniacal nitrogen depends on temperature and pH, high levels of ammonia can be toxic to aquatic life. For this procedure, sample and distilled water are added together into 10mL bottle. The Ammonia Salicylate pillow was added and a three minutes reaction begins. After three minutes, the Ammonia Cyanurate pillows were added later for a fifteen minutes reaction. Then, by using HACH DR 5000 the result can be obtained.

3.6.2.5 Total Coliform and E-Coli

Total coliforms are a group of bacteria commonly found in the environment, for example in soil or vegetation, as well as the intestines of mammals, including humans.