ENRICHMENT OF HEAVY METAL AND RISK ASSESSMENT IN SURFACE WATER OF TUNGGAK RIVER, GEBENG, PAHANG

NURHIDAYAH BINTI MOHD ZAINAL

BACHELOR OF CIVIL ENGINEERING

UNIVERSITI MALAYSIA PAHAN

DECLARATION OF THESIS / UNDERGRADUATE PROJECT PAPER AND COPYRIGHT

Author's full name : NURU ZAFIRAH BINTI OTHMAN

Date of birth : 10 MARCH 1992

Title : IMPACT OF INDUSTRIAL EFFLUENT ON WATER QUAITY AT THE BELAT RIVER, KUANTAN

Academic Session : 2014/2015

I declare that this thesis is classified as:

☐	**CONFIDENTIAL**	(Contains confidential information under the Official Secret Act 1972)*
☐	**RESTRICTED**	(Contains restricted information as specified by the organization where research was done)*
√	**OPEN ACCESS**	I agree that my thesis to be published as online open access (full text)

I acknowledged that University Malaysia Pahang reserves the right as follows:

1. The thesis is the property of University Malaysia Pahang.
2. The Library of University Malaysia Pahang has the right to make copies for the purpose of research only.
3. The Library has the right to make copies of the thesis for academic exchange.

_______________________ _______________________

SIGNATURE SIGNATURE OF SUPERVISOR

920310-01-5016 DR. MIR SUJAUL ISLAM

(NEW IC NO. /PASSPORT NO.) NAME OF SUPERVISOR

Date: 25 JUNE 2015 Date: 25 JUNE 2015

NOTES: * If the thesis is CONFIDENTIAL or RESTRICTED, please attach with the letter from the organization with period and reasons for confidentiality or restriction.

ENRICHMENT OF HEAVY METAL AND RISK ASSESSMENT IN SURFACE WATER OF TUNGGAK RIVER, GEBENG, PAHANG

NURHIDAYAH BINTI MOHD ZAINAL

Thesis submitted in partial fulfilment of the requirements

for the award of the degree of

Bachelor of Civil Engineering

Faculty of Civil Engineering and Earth Resources

UNIVERSITI MALAYSIA PAHANG

JUNE 2015

SUPERVISOR'S DECLARATION

We hereby declare that we have checked this thesis and in our opinion, this thesis is adequate in terms of scope and quality for the award of the degree of Bachelor of Civil Engineering.

Signature	:
Name of main supervisor	: DR. MIR SUJAUL ISLAM
Position	: SENIOR LECTURER
Date	: 26 JUNE 2015

STUDENT'S DECLARATION

I hereby declare that the work in this thesis is my own except for quotations and summaries which have been duly acknowledged. The thesis has not been accepted for any degree and is not concurrently submitted for award of other degree.

Signature :
Name : NURHIDAYAH BINTI MOHD ZAINAL
ID Number : AE11013
Date : 26 JUNE 2015

Dedication

This thesis is dedicated to my parents and siblings.
For their endless love, support and encouragement.

ACKNOWLEDGEMENT

Prima facae, I am grateful to Allah for the good health and wellbeing that were necessary to complete this book. I wish to express my sincere thanks and gratitude to my supervisor, the senior lecturer of Universiti Malaysia Pahang, Dr. Mir Sujaul Islam for his germinal ideas, invaluable guidance, continuous support and encouragement in making this research possible. He has always impressed me with his outstanding professional conduct and his tolerance of my naïve mistakes.

My sincere thanks go to all my friends, lab mates and the laboratory assistants of Environmental Laboratory, UMP who helped me in many ways and for their excellent co-operation that made my stay at UMP pleasant and unforgettable.

I take this opportunity to express my sincere indebtedness and gratitude to my parents Mohd Zainal and Siti Zabadah for their love, unceasing encouragement, support and attention. I cannot find the appropriate words that could properly describe my appreciation for their devotion, support and faith in my ability to attain my goals.

I also placed on record, my sense of gratitude to one and all, who directly or indirectly, have lent their hand for the successful completion of this study.

ABSTRACT

Surface water includes all water on surface of the earth that can be found in rivers, streams, canals, lakes, wetlands, coastal, ditches, marshes and ponds waters and also appears as in ice and snow. Industrial activities are the main cause for surface water pollution. Therefore, the objectives of this research were to evaluate the enrichment factor of heavy metal from the surface water and to provide the latest level of water pollution in Tunggak River. To fulfil it, several water quality parameters were analyzed, with collection of data from 3 different stations during February-March 2015 across the river basin. The in-situ parameters were temperature, pH, turbidity, Electric Conductivity and Dissolved Oxygen. Meanwhile, for ex-situ parameters such as Biochemical Oxygen Demand, Chemical Oxygen Demand, Total Suspended Solids, Ammoniacal Nitrogen and selected heavy metal, analysis were conducted by using DR/2500 Spectrophotometer and Atomic Absorption Spectrometer using APHA and HACH standard methods. Later, the results from all the tests were used to calculate the Enrichment Factor, National Water Quality Standard and Water Quality Index to indicate the quality of the study area. The study revealed that some trace metals were found in surface water of the Tunggak River, Gebeng, most probably caused by the industrial activities and the availability of numerous of factories surrounded the river. From the results, the authorities should implement the suitable watershed protection and management system to control the pollution of the surface water.

ABSTRAK

Air di permukaan termasuk semua air di permukaan bumi ini yang boleh didapati di sungai, anak sungai, terusan, tasik, tanah paya, pantai, longkang, paya dan kolam dan juga terdapat dalam ais dan salji. Aktiviti perindustrian adalah punca utama pencemaran air di permukaan. Oleh itu, objektif kajian ini adalah untuk menilai faktor pengayaan logam berat daripada air di permukaan dan untuk menyediakan tahap terkini pencemaran air di Sungai Tunggak. Untuk melaksanakannya, beberapa parameter kualiti air telah dianalisis, pungutan data dari 3 stesen yang berbeza dalam bulan Februari hingga Mac 2015 di seluruh lembangan sungai. Parameter in-situ adalah suhu, pH, kekeruhan, Electric kekonduksian dan oksigen terlarut. Sementara itu, bagi parameter ex-situ seperti Permintaan Oksigen Biokimia, Permintaan Oksigen Kimia, Jumlah Pepejal Terampai, Ammoniakal Nitrogen dan logam berat terpilih, analisis telah dijalankan dengan menggunakan DR / 2500 Spectrophotometer dan Penyerapan Spektrometer Atom menggunakan APHA dan Hach kaedah standard. Kemudian, keputusan daripada semua ujian telah digunakan untuk mengira Factor Pengayaan, National Standard Kualiti Air dan Indeks Kualiti Air untuk menunjukkan kualiti kawasan kajian. Kajian ini mendedahkan bahawa sesetengah logam surih ditemui dalam air di permukaan Sungai Tunggak, Gebeng, kemungkinan besar disebabkan oleh aktiviti perindustrian dan ketersediaan banyak kilang-kilang yang dikelilingi sungai. Daripada keputusan, pihak berkuasa perlu melaksanakan perlindungan kawasan tadahan air dan pengurusan sistem yang sesuai untuk mengawal pencemaran air permukaan.

TABLE OF CONTENTS

CHAPTER 2 LITERATURE REVIEW

CHAPTER 3 METHODOLOGY

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS

˚C	Degree Celsius
mg/L	milligram per meter
NTU	Nephelometric Turbidity Unit
%	Percent
ppm	parts-per-million
µS/cm	micro-Siemens per centimeter
mS/cm	milli-Siemens per centimeter

LIST OF ABBREVIATIONS

AAS	Atomic Absorption Spectrometer
AN	Ammoniacal Nitrogen
As	Arsenic
Ba	Barium
BOD_5	Biochemical Oxygen Demand (5 days)
Cd	Cadmium
Co	Cobalt
Cr	Chromium
Cu	Copper
DO	Dissolved Oxygen
EC	Electrical Conductivity
EF	Enrichment Factor
Hg	Mercury
Ni	Nickel
NWQS	National Water Quality Standards
Pb	Lead
TSS	Total Suspended Solids
WQI	Water Quality Index
Zn	Zinc

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

Surface water includes all water on surface of the earth that can be found in rivers, streams, canals, lakes, wetlands, coastal, ditches, marshes, ponds and marine waters and also appears as in ice and snow. The water of the sea and ocean are excluded to be considered in surface water due to its definition of fresh water. Generally, surface water is well aerated because it condition of water-atmosphere interface. The pollution of the surface runoff in particular mostly contains high level of heavy metals and other harming substances such as nitrogen and phosphorus that had increased the level of contaminants. If surface water pollution sources are derived from groundwater or runoff water from upland soil, the pollutants will directly enter the surface water body over a large area. This shows that the pollutant sources for the surface water diffuse either from the soil surface or groundwater. For the study area, Tunggak River at Gebeng Pahang, the pollutant probably may come from the effluent of industrial and municipal wastewater. The effluents will not only rich in pathogenic bacteria and viruses, organic matter and nutrients, but may also enriched with level of heavy metals.

Zinc, Lead and Copper are the examples of element for the group of heavy metal that always been related with the contamination and the potential toxicity toward environment especially to the surface water. Heavy metal either can be define as a metal with atomic mass that bigger than Sodium or as it have metal density with range of 3.5 – 6.0 g cm^{-3}. Non-industrial human usually find the involvement of the heavy metals dissolved in water, sorbed in the soil or contained in foods. Mostly, heavy metals present as cations in the environment and would occurs naturally in the Earth's crust impurities isomorphously substituted for various macro element constituents in the lattices of many primary and secondary minerals.

1.2 OBJECTIVES OF RESEACRH

There are two main objectives for these research:

a) To determine the pollution level of surface water quality in the Tunggak River, Gebeng , Pahang.
b) To assess the environment risk of heavy metal contaminations in surface water based on the Enrichment Factor.

1.3 PROBLEM STATEMENT

The diffusion of heavy metal into the surface sediment of the soil would directly affect the nearest surface water such as effluent from industrial site. This phenomenon which happened since long time ago probably had affected not only human's health but also the ecosystem cycle.

a) The industrial discharge (anthropogenic sources of heavy metal) cause to pose further toxic towards the aquatic life.
b) The enrichment of heavy metal for a long time from the industrial effluent causing it to accumulated to the environment in various ways.
c) This studies is carried out to monitor the heavy metal contaminations in the surface water of the Tunggak River at Gebeng, Pahang based on the Enrichment Factor.
d) The research is carried out to evaluate the level of pollution of the Tunggak River at Gebeng, Pahang.

1.4 SCOPE OF RESEARCH

The study is conducted at Tunggak River, Pahang that near to Gebeng industrial area. Tunggak River is a class H stream (Hydrographic) in Malaysia with Asia Pacific region font code. This stream located at Pahang with coordinate 3°57’0”N and 103°22’1”E or 3.95 and 103.367 in decimal degrees. The effluent discharges from numerous industrial sites either it’s been treated or untreated is flowing out to the river carrying together the wastewater that may be contains various of substances that probably will increase the contamination level such as organic compounds, phosphorus, nitrogen and heavy metal. This study will carried out by taking the samples from three points at the three different and nearest effluent by the industrial activities at the river. The samples will be test by several of parameters in order to achieve the objectives of this research.

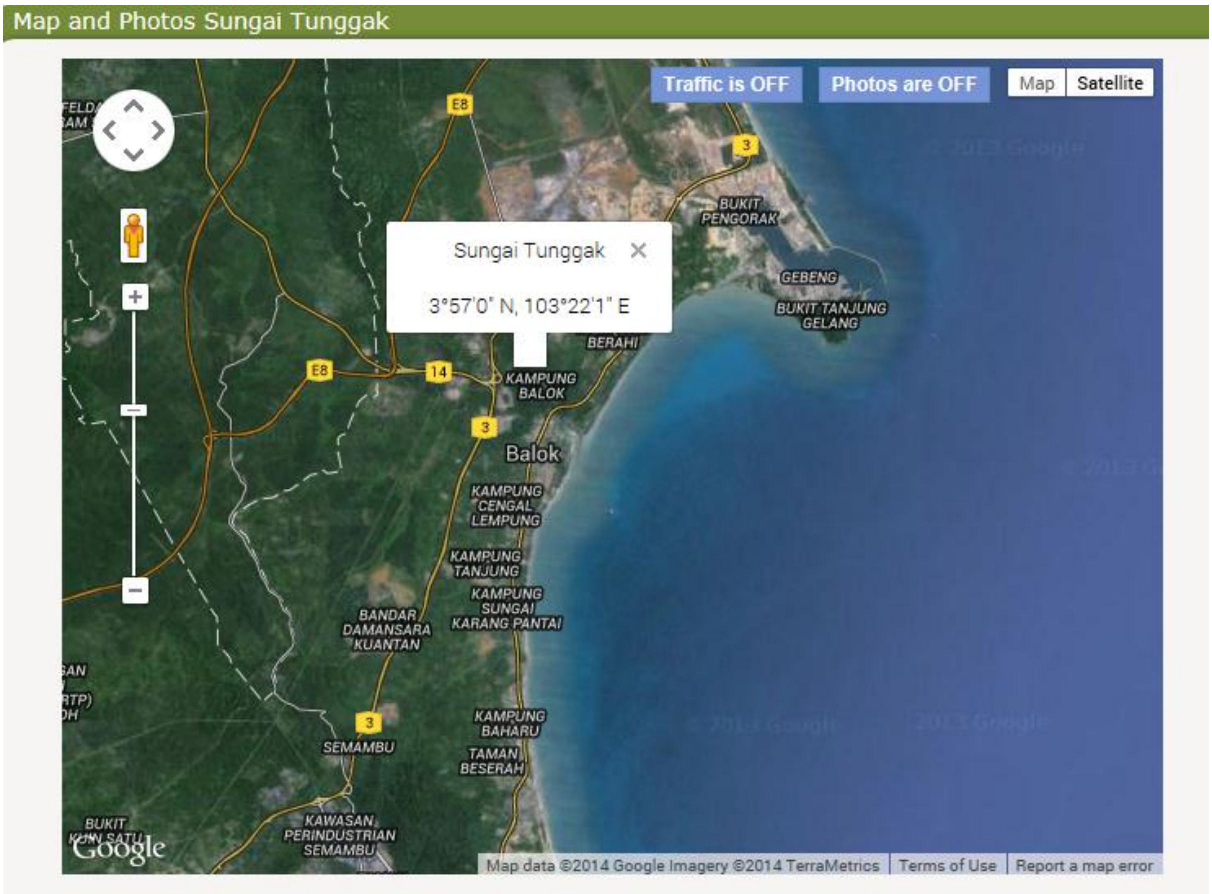


Figure 1.1: Location of Tunggak River.

1.5 SIGNIFICANT OF RESEARCH

This study is carried out to evaluate the enrichment of heavy metal and risk assessment in surface water at Tunggak River, Pahang, Malaysia in order to determine the pollution level and the environmental risk from the contamination of heavy metal around that area. The sample of surface water taking from there must be the effluent wastewater either being treated or treated that are flowing out to the Tunggak River.

Generally, every effluent that flows out from industrial area may contains several of harmful substances such as high level of heavy metal diffused from the contaminated soil and also nitrogen and phosphorus. A considerable stock of pollutants may accumulate over the years and finally concentrates towards the surface water. This phenomenon may be really dangerous for human and also the aquatic life because there will be many bad effects towards them due to there are the majority usage of this surface water.

So, the significance of this research would be to provide the latest level of water pollution so that the suitable and efficient ways of the wastewater treatment can be done to this area. It is important to the residents that depends on this source to have a clean and unpolluted water to be used in their daily life. Besides, by having this research, the rate of enrichment factors of the heavy metal that been concentrated inside the surface water will be acknowledged. So, the further research on how to decrease the level of harmful substances inside the water can be done in the future for the sake of our ecosystem.

1.6 EXPECTED OUTCOMES

There are some of expected results to be encountered from this study:

a) The level of water pollution getting from experiments for the sample taken from Tunggak River, Pahang, Malaysia.

b) The enrichment and the assessment rate of heavy metal at the surface water by using Enrichment Factor to test their concentration at the water for years.

c) The risk that the residents near the river the aquatic life faced from the pollution that happened.

CHAPTER 2

LITERATURE REVIEW

2.1 SURFACE WATER POLLUTION

Similar to other water resources, surface water is considered the main source of available water which is polluting all over the world in many ways. One of the main activities that causes the pollution is known as Anthropogenic. The development of industries and their effluents are the major threats to the surface water which become the last destination for the effluents (Moorthy and Jeyabalan, 2012). Besides, the economy trend that increasing rapidly nowadays in Malaysia make the pollution become worst and causes the environmental degradation (Tan and Yap, 2006; Al-Shami et al. 2011). At the same time, the rivers are contributing significantly for the industrial development in Malaysia (Moorthy and Jeyabalan, 2012). So, the surface water pollution can cause serious health risk as well as environmental threats in the country. The major sources of industrial pollution in Malaysia are food & beverage, chemical & petrochemical, palm oil, textile, paper and rubber processing industries (Iyagba et al., 2008). Speedy growth in industrial sector generates more wastes which could damage to the environment without having proper treatment plant. Industrialization with an increasing demand for heavy metals results in a high emission of these pollutants into the biosphere. Water bodies with heavy metal pollution are a serious threat to the aquatic ecosystem, human health as well as environment (Hossain and Sujaul, 2012).

2.2 CONTAMINATION OF HEAVY METAL IN SURFACE WATER

Metal have been used by human beings for more than 10000 years. As an example, copper had been used around 7000-9000 years ago after being found by Ali Kosh at Western Iran and Cayo nu Tepesi near Ergani in Anatolia (Chen.J.P, 2012). Heavy metal is also be known as the group of metals and metalloids with atomic density greater than 5 g/cm^3 and having molecular weight with 40 and above. There are several common characteristics that can be relate with heavy metal:-

a) A good conductor of electricity
b) An electric resistance of a metal that directly proportional to the absolute temperature
c) Is the high thermal conductivity
d) Has malleability and ductility, without which cannot be drawn into sheets and wires
e) Valence or oxidation number as 0, +1, +2, +3 and also +6
f) Zero-valent metal is present in solid form except for Mercury
g) Exist in nature as metal oxides, metal carbonate or metal sulfate

Differ from any ordinary pollutants that able to be degraded for detoxification, heavy metal unfortunately will become harmful and products towards environment. Due to that causes, many countries desperately need to get through this problem either in developed countries or in developing countries especially China that leading in importer of metal ores and products. Construction, electronic and chemical industries are the main consumers of heavy metal contaminations at the stream and surface water.

2.2.1 Copper

Copper is a one of element of heavy metal not only exists in the environment as a mineral in rocks and soil but also can be easily found in natural water resources and human bodies. It is also an element that enable to maintain human's good health by supporting the hemoglobin production for red blood cells in human's circulation system. By this process, the enzymes getting from copper will helps to carry oxygen throughout the body thus, let the tendons and cartilage become stronger. In industrial field, copper are used for piping and plumbing systems at many countries worldwide.

However, once the copper start to corrode, it may cause many problems towards the environment. While the corrosion occur, the potable water resources may be affected due to its safety and quality. Approximately, only 2 to 3 milligrams of copper can be consumed by an adult. If copper being consume in excessive amount, it may be harmed for human an causes for vomiting, nausea, headache and gastric complaints or even causes of liver damage and finally death.

2.2.2 Lead

Lead or written as Pb is an element from carbon group that also be known as Plumbum in Latin. Having atomic number of 82, lead is a metal that is soft, malleable and heavy post-transition metal. The physical appearance is that it has a bluish-white color after being freshly cut, but will be change to a dull grayish color when exposed to air. It also will become a shiny chrome-silver luster when it is melted into a liquid. It is also the heaviest non-radioactive element.

In industrial purposes, lead is used in building construction, lead-acid batteries, bullets and shot, weights, as part of solders, pewters, fusible alloys, and as a radiation shield. Lead accumulates in the bodies of water organisms and soil organisms. These will experience health effects from lead poisoning. Health effects on shellfish can take place even when only very small concentrations of lead are present. Body functions of phytoplankton can be disturbed when lead interferes. Phytoplankton is an important source of oxygen production in seas and many larger sea-animals eat it. That is why we now begin to wonder whether lead pollution can influence global balances.

2.2.3 Zinc

Zinc is a metal. It is called an “essential trace element” because very small amounts of zinc are necessary for human health. It is also used for boosting the immune system, treating the common cold and recurrent ear infections, and preventing lower respiratory infections. It is also used for malaria and other diseases caused by parasites.

Zinc is used to make many useful alloys. Brass, an alloy of zinc that contains between 55% and 95% copper, is probably the best known zinc alloy. Brass was first used about 2,500 years ago and was widely used by the ancient Romans, who used it to make such things as coins, kettles and decorative items. Brass is still used today, particularly in musical instruments, screws and other hardware that must resist corrosion. Zinc is alloyed with lead and tin to make solder, a metal with a relatively low melting point used to join electrical components, pipes and other metallic items. Prestal®, an alloy containing 78% zinc and 22% aluminum, is a strange material that is nearly as strong as steel but is molded as easily as plastic. Nickel silver, typewriter metal, spring brass and German silver are other common zinc alloys.

2.2.4 Arsenic

Arsenic appears in three allotropic forms: yellow, black and grey; the stable form is a silver-gray, brittle crystalline solid. It tarnishes rapidly in air, and at high temperatures burns forming a white cloud of arsenic trioxide. Arsenic is a member of group Va of the periodic table, which combines readily with many elements.

The metallic form is brittle, tarnishes and when heated it rapidly oxidizes to arsenic trioxide, which has a garlic odor. The non-metallic form is less reactive but will dissolve when heated with strong oxidizing acids and alkalis.

The arsenic cycle has broadened as a consequence of human interference and due to this, large amounts of arsenic end up in the environment and in living organisms. Arsenic is mainly emitted by the copper producing industries, but also during lead and zinc production and in agriculture. It cannot be destroyed once it has entered the environment, so that the amounts that we add can spread and cause health effects to humans and animals on many locations on earth.

Plants absorb arsenic fairly easily, so that high-ranking concentrations may be present in food. The concentrations of the dangerous inorganic arsenics that are currently present in surface waters enhance the chances of alteration of genetic materials of fish. This is mainly caused by accumulation of arsenic in the bodies of plant-eating freshwater organisms. Birds eat the fish that already contain eminent amounts of arsenic and will die as a result of arsenic poisoning as the fish is decomposed in their bodies.

2.2.5 Chromium

Chromium is a lustrous, brittle, hard metal. Its color is silver-gray and it can be highly polished. It does not tarnish in air, when heated it burns and forms the green chromic oxide. Chromium is unstable in oxygen, it immediately produces a thin oxide layer that is impermeable to oxygen and protects the metal below.

Chromium main uses are in alloys such as stainless steel, in chrome plating and in metal ceramics. Chromium plating was once widely used to give steel a polished silvery mirror coating. Chromium is used in metallurgy to impart corrosion resistance and a shiny finish; as dyes and paints, its salts color glass an emerald green and it is used to produce synthetic rubies; as a catalyst in dyeing and in the tanning of leather; to make molds for the firing of bricks. Chromium (IV) oxide (CrO2) is used to manufacture magnetic tape.

There are several different kinds of chromium that differ in their effects upon organisms. Chromium enters the air, water and soil in the chromium (III) and chromium (VI) form through natural processes and human activities.

2.2.6 Cadmium

Cadmium is a lustrous, silver-white, ductile, very malleable metal. Its surface has a bluish tinge and the metal is soft enough to be cut with a knife, but it tarnishes in air. It is soluble in acids but not in alkalis. It is similar in many respects to zinc but it forms more complex compounds.

About three-fourths of cadmium is used in Ni-Cd batteries, most of the remaining one-fourth is used mainly for pigments, coatings and plating, and as stabilizers for plastics. Cadmium has been used particularly to electroplate steel where a film of cadmium only 0.05 mm thick will provide complete protection against the sea. Cadmium has the ability to absorb neutrons, so it is used as a barrier to control nuclear fission.

Cadmium waste streams from the industries mainly end up in soils. The causes of these waste streams are for instance zinc production, phosphate ore implication and bio industrial manure. Cadmium waste streams may also enter the air through (household) waste combustion and burning of fossil fuels. Because of regulations only little cadmium now enters the water through disposal of wastewater from households or industries.

2.2.7 Cobalt

Cobalt is a hard ferromagnetic, silver-white, hard, lustrous, brittle element. It is a member of group VIII of the periodic table. Like iron, it can be magnetized. It is similar to iron and nickel in its physical properties. The element is active chemically, forming many compounds. Cobalt is stable in air and unaffected by water, but is slowly attacked by dilute acids.

Most of the Earth's cobalt is in its core. Cobalt is of relatively low abundance in the Earth's crust and in natural waters, from which it is precipitated as the highly insoluble cobalt sulfine (CoS). Although the average level of cobalt in soils is 8 ppm, there are soils with as little as 0.1 ppm and others with as much as 70 ppm. In the marine environment cobalt is needed by blue-green algae (cyanobacteria) and other nitrogen fixing organisms. Cobalt is not found as a free metal and is generally found in the form of ores. Cobalt is usually not mined alone, and tends to be produced Cobalt is an element that occurs naturally in the environment in air, water, soil, rocks, plants and animals. It may also enter air and water and settle on land through wind-blown dust and enter surface water through run-off when rainwater runs through soil and rock containing cobalt.

2.2.8 Barium

Barium is a silvery-white metal that can be found in the environment, where it exists naturally. It occurs combined with other chemicals, such as sulfur, carbon or oxygen. Ii is very light and its density is half that of iron. Barium oxidizes in air, reacts vigorously with water to form the hydroxide, liberating hydrogen. Barium reacts with almost all the non-metals, forming often poisoning compounds.

Barium is surprisingly abundant in the Earth's crust, being the 14th most abundant element. High amounts of barium may only be found in soils and in food, such as nuts, seaweed, fish and certain plants. Because of the extensive use of barium in the industries human activities add greatly to the release of barium in the environment. As a result barium concentrations in air, water and soil may be higher than naturally occurring concentrations on many locations.

Some barium compounds that are released during industrial processes dissolve easily in water and are found in lakes, rivers, and streams. Because of their water-solubility these barium compounds can spread over great distances. When fish and other aquatic organisms absorb the barium compounds, barium will accumulate in their bodies. Because it forms insoluble salts with other common components of the environment, such as carbonate and sulphate, barium is not mobile and poses little risk. Barium compounds that are persistent usually remain in soil surfaces, or in the sediment of water soils. Barium is found in most land soils at low levels. These levels may be higher at hazardous waste and water sites.

2.2.9 Nickel

Nickel is silvery-white, hard, malleable, and ductile metal. It is of the iron group and it takes on a high polish. It is a fairly good conductor of heat and electricity. In its familiar compounds nickel is bivalent, although it assumes other valences. It also forms a number of complex compounds. Most nickel compounds are blue or green. Nickel dissolves slowly in dilute acids but, like iron, becomes passive when treated with nitric acid. Finely divided nickel adsorbs hydrogen.

Most nickel on Earth is inaccessible because it is locked away in the planet's iron-nickel molten core, which is 10 % nickel. The total amount of nickel dissolved in the sea has been calculated to be around 8 billion tons. Organic matter has a strong ability to absorb the metal which is why coal and oil contain considerable amounts. The nickel content in soil can be as low as 0.2 ppm or as high as 450 ppm in some clay and loamy soils. The average is around 20 ppm. Nickel occurs in some beans where it is an essential component of some enzymes. Another relatively rich source of nickel is tea which has 7.6 mg/kg of dried leaves.

2.2.10 Mercury

Mercury is the only common metal which is liquid at ordinary temperatures. Mercury is sometimes called quicksilver. It is a heavy, silvery-white liquid metal. It is a rather poor conductor of heat if compared with other metals but it is a fair conductor of electricity. It alloys easily with many metals, such as gold, silver, and tin. These alloys are called amalgams.

2.3 HEAVY METAL ASSESSMENT RESOURCES

Rapid humans activities near the coastal and sub tidal habitats especially freshwater areas nowadays had causes many environmental problem especially towards human which use the water as for drinking and other purposes of life.

Table 2.3: Sources and Effect of Heavy Metal Assessment

Sources	Effect
1. Reclamation and Dredging - Due to rapid recreational and industrial activities.	- Heavy metal level increases. - Biodiversity, richness and biomass of aquatic life reduced. - Disturbing food web and affect human health.
2. Sewage Discharges - Major source getting from factories and other activities near the Tunggak River.	- Contain high in nutrients (eg: ammonia, nitrate, phosphate) - Pollution by biological, chemical and heavy metals. - Degradation and reduce human water source for food and drinking.
3. Industrial Effluents - Rapid industrial growth (eg: oil refining and petrochemical)	- Discharging wastewater containing chemicals such as heavy metals and hydrocarbon compounds (Sale et al.,2010) - Increasing pollution towards the water.
4. Desalination Plants - Population and industrial growth that increases the fresh water needs (Smith et al., 2007).	- Water rejection due to plants desalination decrease percentage of fresh water (Lattemann and Hopner 2008a).

2.4 ENRICHMENT FACTOR OF HEAVY METAL

Enrichment Factor is used to describe bodies of mineral ore such as elements of heavy metals. It is defined as the minimum factor by which the weight percent of mineral in an ore body is greater than the average occurrence of that mineral in the Earth's crust. It can be identified at the surface water or effluent of industries to evaluate the percent of different heavy metals available at the surface water.

The calculation for getting enrichment factor of the heavy metal is based on the following formula:

$$EF = \frac{(Metal/Fe)\ Sample}{(Metal/Fe)\ Background}$$

The enrichment factor for heavy metal will be compare with different classes of quality, depends on the value getting after being calculated. By using this table, the level of an element that available at the surface water can be acknowledge and decided either it pollute the surface water or not.

Table 2.4: Enrichment Factor Classes of Quality Level of Heavy Metal Content.

EF Classes	**Quality**
EF < 1	No enrichment
EF < 3	Minor enrichment
EF 3-5	Moderate enrichment
EF 5-10	Moderate severe enrichment
EF 10-25	Severe enrichment
EF 25-50	Extremely severe enrichment

2.5 NATIONAL WATER QUALITY STANDARD FOR SURFACE WATER

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

Table 2.5: Water Use Classes in the National Water Quality Standards.

Class	Uses
CLASS I	- Conservation of natural environment water supply 1 - practically no treatment necessary. - Fishery 1 - very sensitive aquatic species
CLASS IIA	- Water Supply II - conventional treatment required - Fishery ll - sensitive aquatic species
CLASS IIB	- Recreational use with body contact
CLASS III	- Water Supply lll - extensive treatment required - Fishery lll - common, of economic value, and tolerant species livestock drinking
CLASS IV	- Irrigation
CLASS V	- None of the above

2.6 WATER QUALITY INDEX

The WQI is an analysis to calculate dimensionless number that combines multiple water quality factors into a single number by normalizing values to subjective rating curves based on the results of nine chemical and physical tests:

1. Dissolved Oxygen (DO)
2. Fecal Coliform (FC)
3. pH
4. Biochemical Oxygen Demand (BOD)
5. Temperature Change
6. Total Phosphates
7. Nitrates
8. Turbidity
9. Total Dissolved Solids (TDS)

These tests or parameters were chosen because they significantly impact aquatic organisms and are more economical to be performed. These data analysis getting from these tests are measured in different ranges resulting in different unit. However, for each test, the Q-value is assigned from graph and chart, and then compare with the following WQI Quality Scale:

Table 2.6: The WQI Scale for Water Quality Level.

WQI Scale	Quality Level
91-100	Excellent
71-90	Good
51-70	Medium or average
26-50	Fair
0-25	Poor

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

The escalating environmental contamination of the environment by toxic substances is of growing concern especially in our country which developed rapidly these days. A wide range of contaminants are recently introduced into the aquatic environment mainly due to increased rate of industrialization, technological development, growing human population, oil exploration and exploitation, agricultural and domestic wastes run-off (Lima et al., 2008). Among these contaminants, heavy metals constitute one of the most dangerous groups because of their persistent nature, toxicity, tendency to accumulate in organisms and undergo food chain amplification and they are non-degradable. When released into the environment, heavy metals find their way into the aquatic systems and deposited in aquatic organisms like fishes through the effects of bio-concentration, bioaccumulation and the food chain process and eventually threaten the health of humans that consume them.

Heavy metals concentrations in aquatic ecosystems are usually monitored by measuring their concentrations in water, sediments and biomass. Bioaccumulation is the building up of a chemical to a toxic level in an organism's body (Ezemonye and Enuneku, 2012). Fishes are notorious for their ability to concentrate heavy metals in their muscles and since they play important role in human nutrition, they need to be carefully screened to ensure that unnecessarily high level of some toxic trace metals are not being transferred to man through fish consumption (Adeniyiet et al., 2008). Several studies have indicated enhanced level of both essential and nonessential heavy metal load in muscle and liver tissues of fishes (Obasohan, 2007; Adeniyiet et al., 2008).

Assessment of toxic heavy metals in fishes can serve as a bio-indicator of their impacts on these organisms as well as give an insight to the degree of pollution of the water body in particular. The aim of this study is to determine the concentration of heavy metals (Iron, Zinc, Manganese and Nickel) in surface water and bioaccumulation of these metals in fish of River Owan.

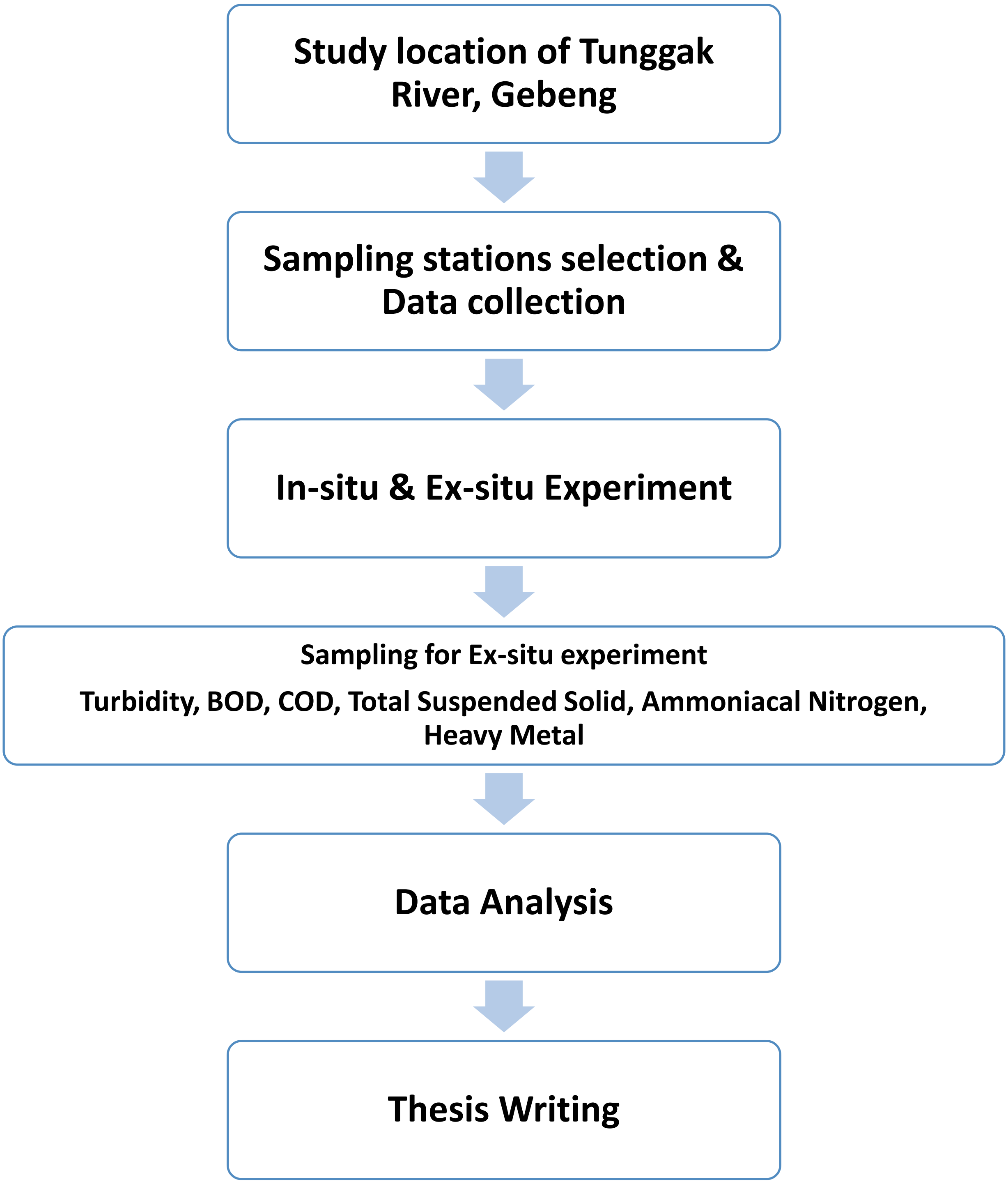
3.2 STUDY AREA DESCRIPTION

Sungai Tunggak is situated in between 30 56′06″ to 30 59′44″ N and 1030 22′42″ to 1030 24′47″ E adjacent to the Gebeng industrial town which is located at 3° 55' 39" N to 4° 00' 10" N and 103° 22' 42" E to 103° 26' 30" E (Fig. 1). The area is near the Kuantan Port. The selection of monitoring stations were done based on location, land use pattern and site elevation. The Global Positioning System (GPS) was used to determine the actual coordinate of monitoring stations and it was reconfirm during the subsequent sampling periods. A total of 3 monitoring stations were selected across the river basin for sampling.

Figure 3.2.1: Station 1 of Tunggak River.

Figure 3.2.2: Station 3 of Tunggak River.

3.3 FLOW CHART OF THE RESEARCH METHODOLOGY



3.4 SAMPLE COLLECTION

From the research location, specific amount of water samples will be collected monthly from February- May 2015. Water from about 10 cm below the water surface will be collected using 1000ml HDPE bottles. For BOD samples the dark BOD bottles (300 ml) were used.

In-situ parameters such as temperature, pH, dissolved oxygen (DO), turbidity and total dissolved solids (TDS) were measured during sampling. Collected samples will be preserved and transported to the laboratory for analysis following standard procedure (APHA, 2005; HACH, 2003). The samples will be analyzed in laboratory for measuring selected ex-situ parameters in accordance with APHA and HACH standard methods (APHA, 2005; HACH, 2003). The selected heavy metals will be determined using Atomic Absorption Spectrometry (AAS). The Assessment of all of heavy metal that will be identified will be compare according to the enrichment factor for each element.

3.5 MATERIALS AND METHODS

3.5.1 In-situ Tests

Table 3.5.1: List of Methods and Instruments for In-situ Parameters.

No.	Parameters	Methods	Instruments
1	Temperature	EPA method 180	Horiba Water Quality Checker
2	pH	EPA method 180	Horiba Water Quality Checker
3	Turbidity	EPA method 180	Horiba Water Quality Checker
4	Dissolved Oxygen	EPA method 180	Horiba Water Quality Checker
5	Total Dissolved Solid	EPA method 180	Horiba Water Quality Checker

Figure 3.5.1: Horiba Water Quality Checker.

3.5.2 Ex-situ Tests

Table 3.5.2: List of Methods and Instruments for Ex-situ Parameters.

No.	Parameters	Methods	Instruments
1	BOD Test	APHA 5210B	✓ BOD bottles ✓ BOD incubator (Temperature =20^{o}C)
2	COD Test	APHA 5220 D Reactor Digestion Method	✓ COD Reactor ✓ Magnetic stir plate
3	Total Suspended Solids	APHA 2450D	✓ Analytical balance ✓ Glassware ✓ Thermo Oven
4	Ammoniacal Nitrogen	Salicylate Method	DR/2500 Spectrophotometer
5	Heavy Metal	APHA 3110	✓ Atomic Absorption Spectrometer

3.6 LABORATORY ANALYSIS

3.6.1 Biochemical Oxygen Demand (BOD)

BOD test basically a test which can determine the relative oxygen requirements of wastewaters, effluents and polluted waters. It is being utilized during incubation period and the oxygen used several chemicals such as sulfides and ferrous iron to oxidize inorganic material. Measurements of oxygen consumed in a 5-day test period (5-d BOD or BOD5, 5210B), oxygen consumed after 60 to 90 days of incubation (ultimate BOD or UBOD, 5210C), and continuous oxygen uptake (respirometric method, 5210D) are identified. Many other variations of oxygen demand measurements exist, including using shorter and longer incubation periods and tests to determine rates of oxygen uptake.

3.6.2 Chemical Oxygen Demand (COD)

This test is a test to determine and measure the level of organic matter that been oxidized in the water sample. Potassium dichromate as the acidic solution helps the sample to react with the presence of catalyst, then been digested for 2 hours at the temperature of 150^{o}C. Along the experiment, the oxidizable organic compounds will reduce the dichromate ion ($Cr_2O_7^{2-}$) to dichromic ion (Cr^{3+}), later using colorimetry to measure the products. The results finally are expressed as the number of miligrams of oxygen consumed per liter of the water sample (mg/Liter COD)

3.6.3 Total Suspended Solid (TSS)

This test is important to determine the suspended solids that available in surface water and domestic industrial wastewater. For that reason, the sample must be based upon filtration of the raw, untreated sample through the 0.45 µm nylon membrane filter. The filter paper the, will be dried at temperature of 105^{o}C and weight to know the TSS value.

3.6.4 Ammoniacal Nitrogen

Ammonia that occurs in water is the product of nitrogenous organic and inorganic matters that been breaking down, nitrogen gas reduction that caused by microorganisms and also from gas exchanging with the contact of atmosphere. The range for this test to determine NH_3 that present at the water is approximately around 0.01 to 2.0 mg/L.

To run this test, the sample used must be buffered at the pH of 9.5 to decrease hydrolysis of cyanates and organic nitrogen compounds, then being distilled solution of boric acid. The blue form of indophenol produced after the reaction of ammonia with alkaline phenol. It is measured colorimetrically to determine ammonia rate from the sample.

At the end of the experiment, the data analysis is getting by plotting the response of the instrument against the standard concentration. From that, a curve will produced that shows the result of the test been done. The report only can conclude those values that fall between the lowest and the highest calibration standards. If the samples exceeding the highest standard, it should be diluted and reanalyzed, if needed. The unit use for the result is in mg NH_3-N/L.

3.6.5 Heavy Metal

Atomic absorption spectroscopy (AAS) is a spectro analytical procedure for the quantitative determination of chemical elements using the absorption of optical radiation (light) by free atoms in the gaseous state.

In analytical chemistry the technique is used for determining the concentration of a particular element especially heavy metals in a sample to be analyzed. AAS can be used to determine over 70 different elements in solution or directly in solid samples used in pharmacology, biophysics and toxicology research.

3.7 STATISTICAL ANALYSIS

- ✓ Use Microsoft Excel to discrete the data getting from all in-situ and ex-situ tests.
- ✓ The data will be analyzed by the Microsoft Excel Software in terms of charts, line and plotted graphs.

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 INTRODUCTION

For this study, the results of water quality and heavy metal assessment at the Tunggak River is classified using 10 different parameters. All those parameters were including temperature, pH, turbidity, Dissolved Oxygen, Biochemical Oxygen Demand, Chemical Oxygen Demand, Ammoniacal Nitrate, Total Suspended Solids, Electrical Conductivity and heavy metal concentration analysis using Atomic Absorption Spectrometer. The results were presented in graphical form such as bar chart and table of data to be viewed clearly, so that the water quality and heavy metal assessment can be determined successfully.

4.2 LAND USE ANALYSIS

There are several analysis can be made with the land condition that near to the Tunggak River. There are several of activities going on along the river. From the observation and survey being done before, the activities or the land use can be categorized as industrial, residential and commercial usage. All these activities had causes the land near the study area to grow their population rapidly thus, making the urbanization happened over the year.

4.2.1 Industrial

Most of development happened at city of Kuantan were knowingly caused by massive numbers of industrial activities that can be seen at Gebeng Industrial area and also the controversial of chemical project, Lynas. The positive values of these activities that brought huge development to this city can also bring effect towards the environment such as river due to uncontrolled chemical release done by irresponsible parties and would probably effect the environmental quality, especially to the water quality.

4.2.2 Residential

It is well known that uncontrolled population can cause major contribution to the degradation of water quality (Meybeck, 2009). Due to the high population growth at Kuantan, especially along the Kuantan River, the degradation of the quality seems to be more rapid causing by the domestic waste that been released. Majority of the people living there dump their sewerage and solid waste directly into water bodies in results of lack of proper sewerage treatment system and solid waste collection system.

4.2.3 Commercial

The commercial used of land near the study area also can be identified. There are restaurants, workshops, hospitals and hotels that build near Tunggak River. These activities tends to release pollutions from dumping of food wastes, chemicals substances from hospitals and oil wastes from workshops. The wastes probably would been dump into the river and causes the increasing chemicals level and decreasing the water quality.

4.3 WATER QUALITY PARAMETERS RESULT

The parameters of the water that were taken for two batch of sampling from February 2015 to March 2015 and being analyzed to get the latest water quality index from three selected stations of Tunggak River, Kuantan. **Table 4.3** shows the result of water quality parameters along the stations at Tunggak River in February to July 2012 (Hossain.et al. 2013). These data obtained were used to calculate the subindex for each parameters and water quality index (DOE, 2010). The importance of analyzing all the parameters are divided to three, which was included to get the Enrichment Factor of selected heavy metal, National Water Quality Standard from each parameters and Water Quality Index from 6 selected parameters. The results from previous study are being compared to this present study to evaluate the status of water quality and the rate of pollution at Tunggak River. **Table 4.3.1** is the result of the latest water quality parameters of Tunggak River.

(Refer to Appendix C1 and C2)

4.4 HEAVY METAL CONCENTRATION ANALYSIS

The analysis of heavy metal concentration is important for this study in order to calculate the Enrichment Factor of the selected heavy metal and to determine the level of pollution they accumulated in the Tunggak River. The heavy metal that is being tested for this research are Cadmium, Copper, Lead and Zinc. These concentration can be seen from **Table 4.4** that are getting from the Atomic Absorption Spectrometer method.

(Refer to Appendix A1)

4.4.1 Enrichment Factor of Copper

The Enrichment Factor of copper can be referred from **Figure 4.4.1** which showed that the highest enrichment was at station 1 at the 2nd sampling with moderate enrichment (3.18), while the lowest was at station 3 at 2nd sampling which has no enrichment at all (0.422). During the 1st sampling on February 2015, the enrichment range was increased over the station with the range 0.936-1.848. Different from the previous sampling, the 2nd sampling which was in March 2015 showed opposite results. The enrichment changed with range 0.422 to 3.18 which was increasing rapidly compared to February 2015. This proved that the assessment and enrichment of copper was increasing over the time at the selected stations of Tunggak River which can pollute and effect the environment.

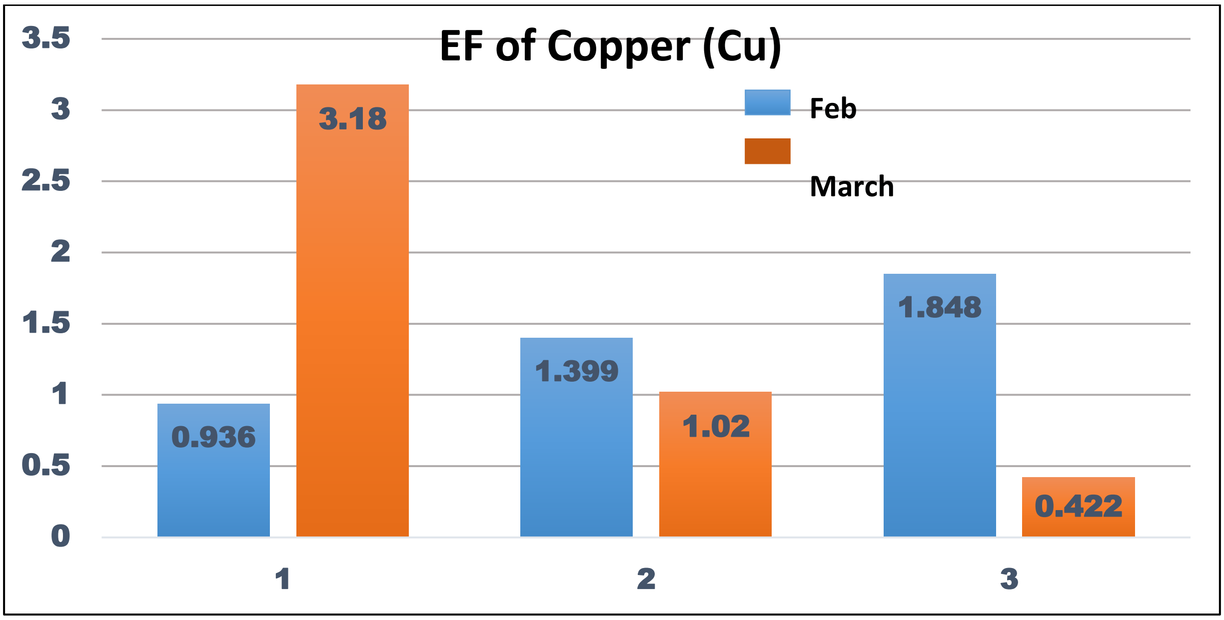


Figure 4.4.1: The Enrichment Factor of Copper from February to March 2015 at 3 stations.

4.4.2 Enrichment Factor of Cadmium

Figure 4.4.2 showed the Enrichment Factor of cadmium at each stations. It identified that the highest enrichment was recorded at station 1 at the 1st sampling with moderate enrichment (3.66), while the lowest was at station 3 at 2nd sampling which has no enrichment at all (0.12). Both sampling period on February and March showed the decreasing pattern over the stations. During the 1st sampling on February 2015, the enrichment range was 0.71-3.66, meanwhile, the 2nd sampling which was in March 2015 showed range of 0.12-0.65. From the results, it proved that assessment and enrichment of copper was decreasing over two months' time at the selected stations of Tunggak River.

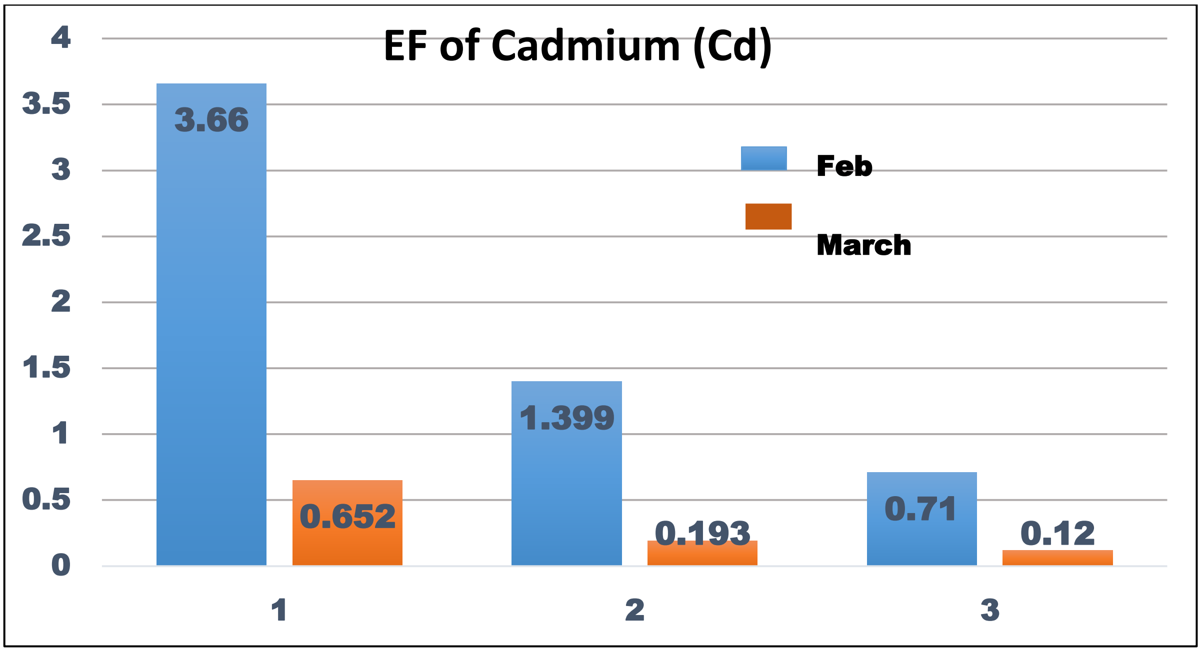


Figure 4.4.2: The Enrichment Factor of Cadmium from February to March 2015 at 3 stations.

4.4.3 Enrichment Factor of Lead

Figure 4.4.3 showed the Enrichment Factor of lead at each stations. It identified that the highest enrichment was recorded at station 3 at the 2nd sampling with minor enrichment (1.009), while the lowest was at station 2 at 1st sampling which has no enrichment at all (0.173). Both sampling period on February and March showed the unstable pattern over the stations. During the 1st sampling on February 2015, the enrichment range was 0.173-0.932, meanwhile the 2nd sampling which was in March 2015 showed range of 0.361-1.009. From the results, it proved that assessment and enrichment of lead was not stable during the sampling period at the selected stations of Tunggak River.

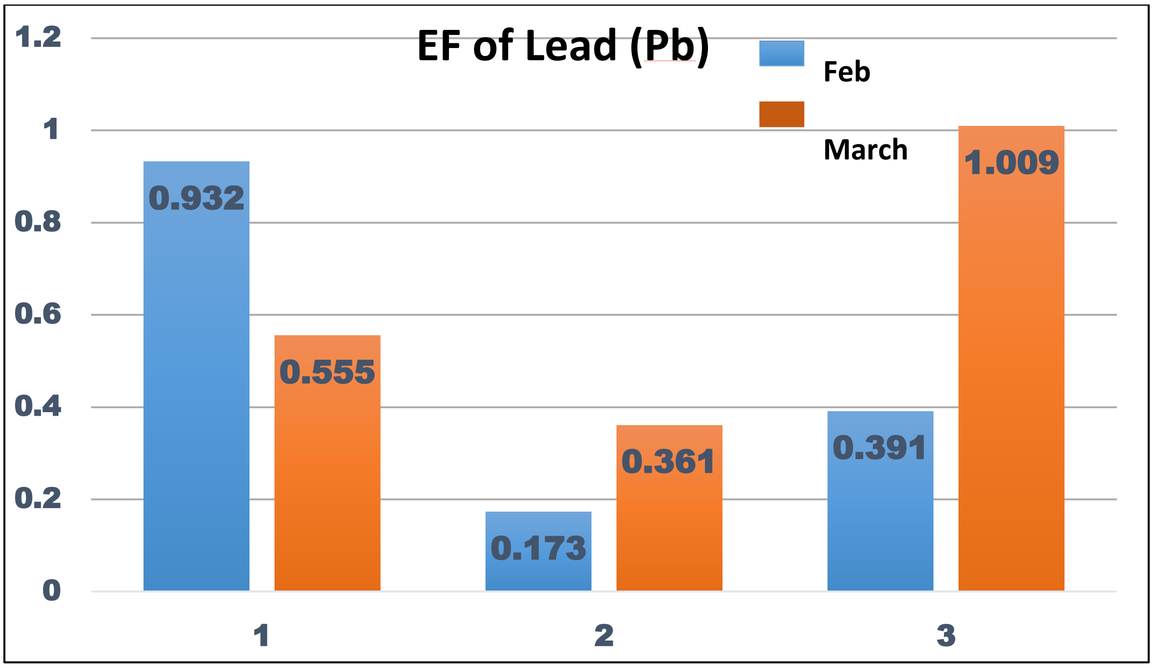


Figure 4.4.3: The Enrichment Factor of Lead from February to March 2015 at 3 stations.

4.4.4 Enrichment Factor of Zinc

Figure 4.4.4 showed the Enrichment Factor of zinc at each stations. It identified that the highest enrichment was recorded at station 2 at the 1st sampling with moderate enrichment (3.26), while the lowest was at station 3 at 2nd sampling which has no enrichment at all (0.601). For sampling period on February 2015, unstable pattern was recorded over the stations with a high range of 1.04-3.26. During the 2nd sampling on March 2015, the pattern was decreased over the stations and the enrichment starting to be lowered with range of 0.601-1.314. The results recorded had proved that assessment and enrichment of zinc seemed to be decreased after the sampling in March 2015 at the Tunggak River.

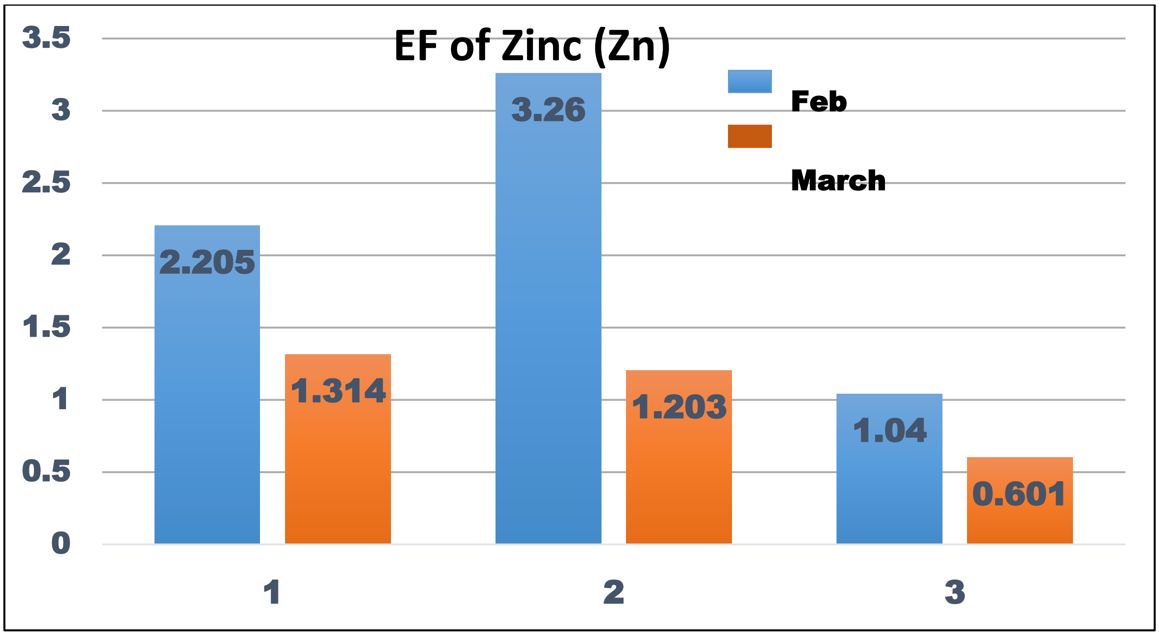


Figure 4.4.4: The Enrichment Factor of Zinc from February to March 2015 at 3 stations.

4.5 NATIONAL WATER QUALITY STANDARD ANALYSIS

National Water Quality Standard is a standard that been made as the steps to control, prevent, abate the pollution and enhance the environment that closely related to the Environmental Quality Act 1974. NWQS is a regulations that each parties that release industrial wastes to the river need to follow to keep the pollution from occurred. This standard can be applied to surface water like Tunggak River and can ordains standard values of up to 72 parameters, thus classified them into 6 level water use classes. The standard need to meet the objective, that to improve water quality of the surface water after meeting certain water class (EPA., 2008).

4.5.1 Temperature

The results of temperature that recorded from two months period at 3 selected stations of Tunggak River was showed in **Figure 4.5.1**. From the graph, it was stated clearly that the temperature was slightly higher in March 2015 sampling than the temperature on the 1st sampling in February 2015. The temperature range at the 1st sampling was 25.2^{o}C-27.9^{o}C, while on the 2nd sampling was 28.5^{o}C-29.5^{o}C. Regarding to NWQS, all the stations involved were classified as Class III which was a sign that the surface water need an extensive treatment due to pollution that occurred.

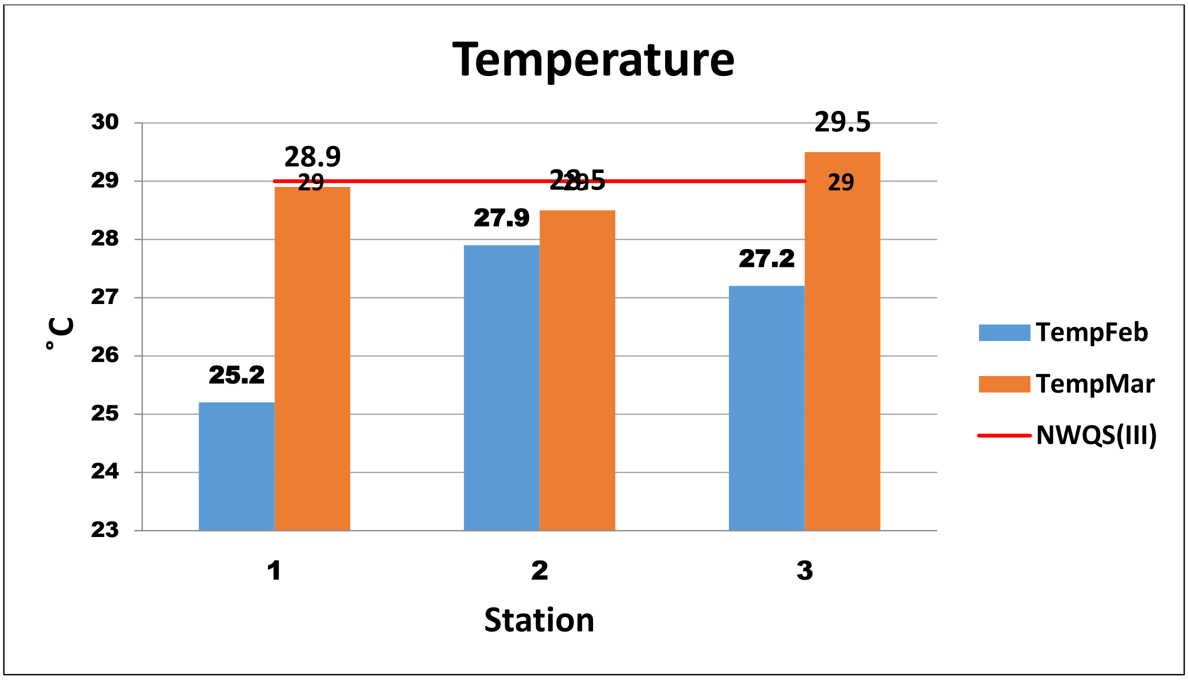


Figure 4.5.1: Results of Temperature from February to March 2015 at 3 stations.

4.5.2 pH

The results of pH that recorded from two months period at 3 selected stations of Tunggak River was showed in **Figure 4.5.2**. From the graph, it was stated that pH in March 2015 sampling was higher than pH on the 1st sampling in February 2015. The range of pH value at the 1st sampling was 5.99-6.45 and was increased over the stations, while on the 2nd sampling was 7.89-8.26 which showed unstable trend. The results had identified that the 1st sampling recorded more acidic content than in 2nd sampling. Based on NWQS, for the 1st sampling, all those 3 stations were classified in Class III while on 2nd sampling recorded with less polluted class which was in Class II.

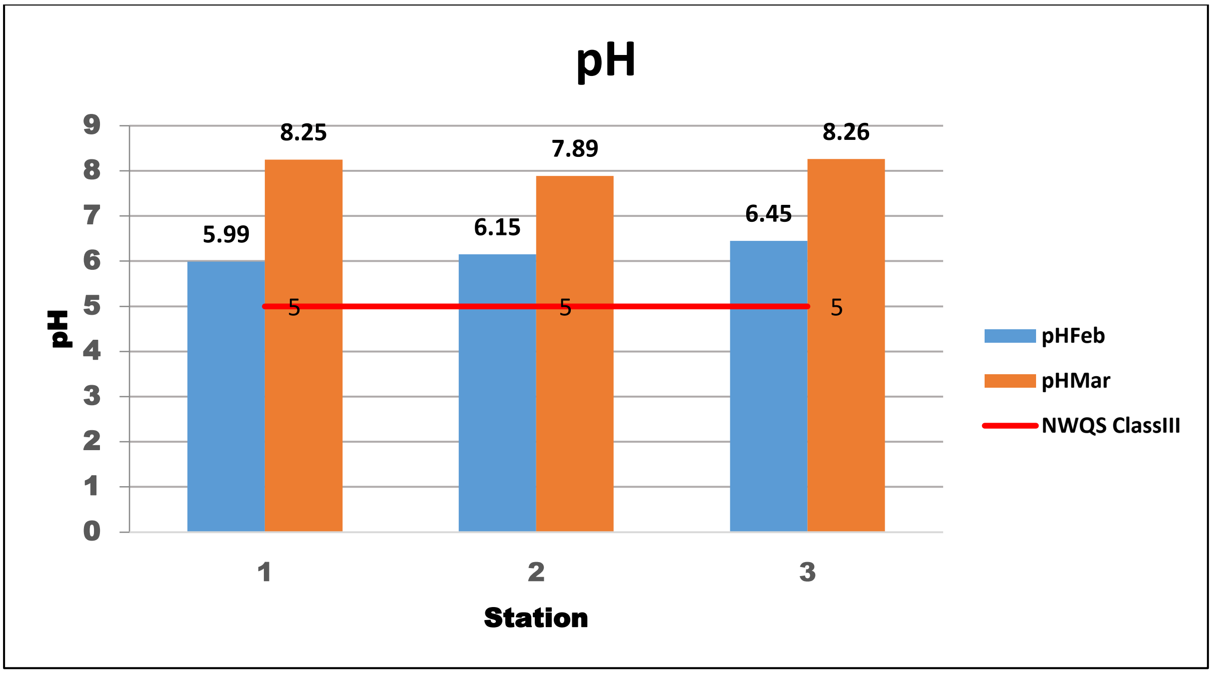


Figure 4.5.2: Results of pH from February to March 2015 at 3 stations.

4.5.3 Electrical Conductivity

The results of electrical conductivity that recorded from two months period at 3 selected stations of Tunggak River was showed in **Figure 4.5.3**. From the graph, it was stated clearly that the electrical conductivity was recorded in increasing trend on both months. The electrical conductivity range at the 1st sampling was 0.17 (µS/cm)x10^3 – 13.2 (µS/cm)x10^3, while on the 2nd sampling was 3.78 (µS/cm)x10^3 – 49.18 (µS/cm)x10^3. Regarding to NWQS, only station1 and 1 and station 2 on the 1st sampling passed the requirement of Class IIA, while for others, were classified in a bad class whish was Class V.

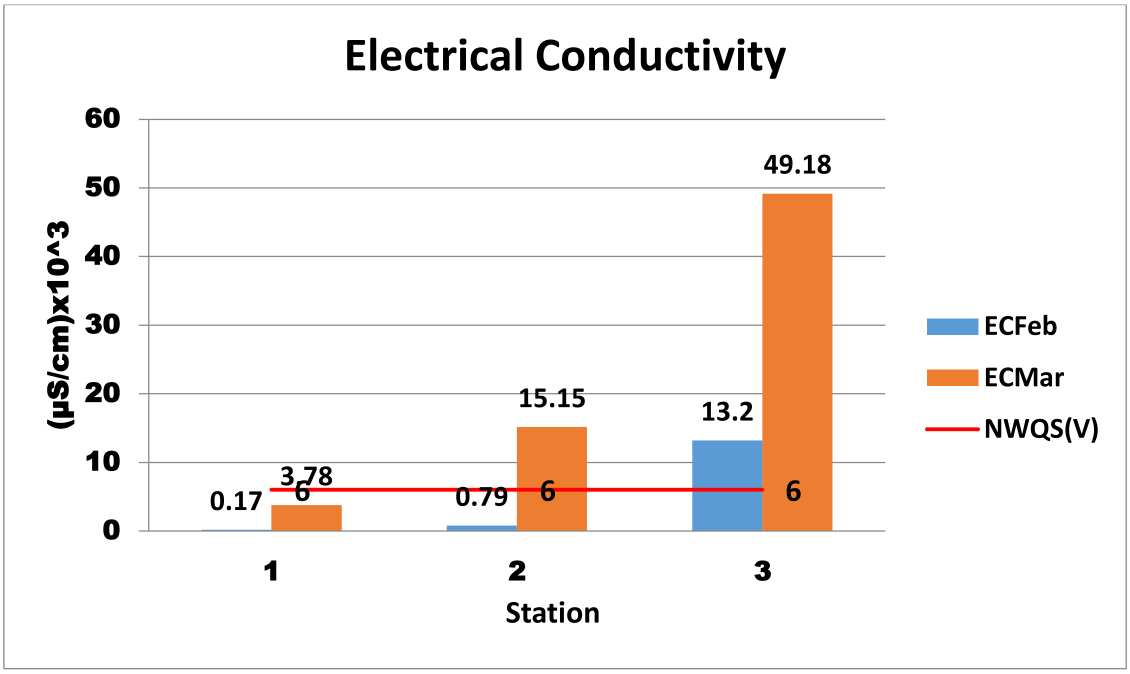


Figure 4.5.3: Results of Electrical Conductivity from February to March 2015 at 3 stations.

4.5.4 Dissolved Oxygen

The results of dissolved oxygen that recorded from February 2015 to March 2015 at 3 selected stations of Tunggak River was showed in **Figure 4.5.4**. As been shown in the graph, it was stated that dissolved oxygen in March 2015 sampling was lower than dissolved oxygen on the 1st sampling in February 2015. The range of dissolved oxygen value at the 1st sampling was 4.78 mg/L-7.45 mg/L and was increased over the stations, while on the 2nd sampling was 1.92 mg/L-4.96 mg/L which showed unstable trend. The results had identified that the 1st sampling recorded more acidic content than in 2nd sampling. Based on NWQS, for the 1st sampling, only station 1 was classified as Class III while others was in a better class which was Class I. For the 2nd sampling, all the stations were recorded in a bad condition which all 3 stations were classified in Class III and Class IV that showed sign of irrigation happened.

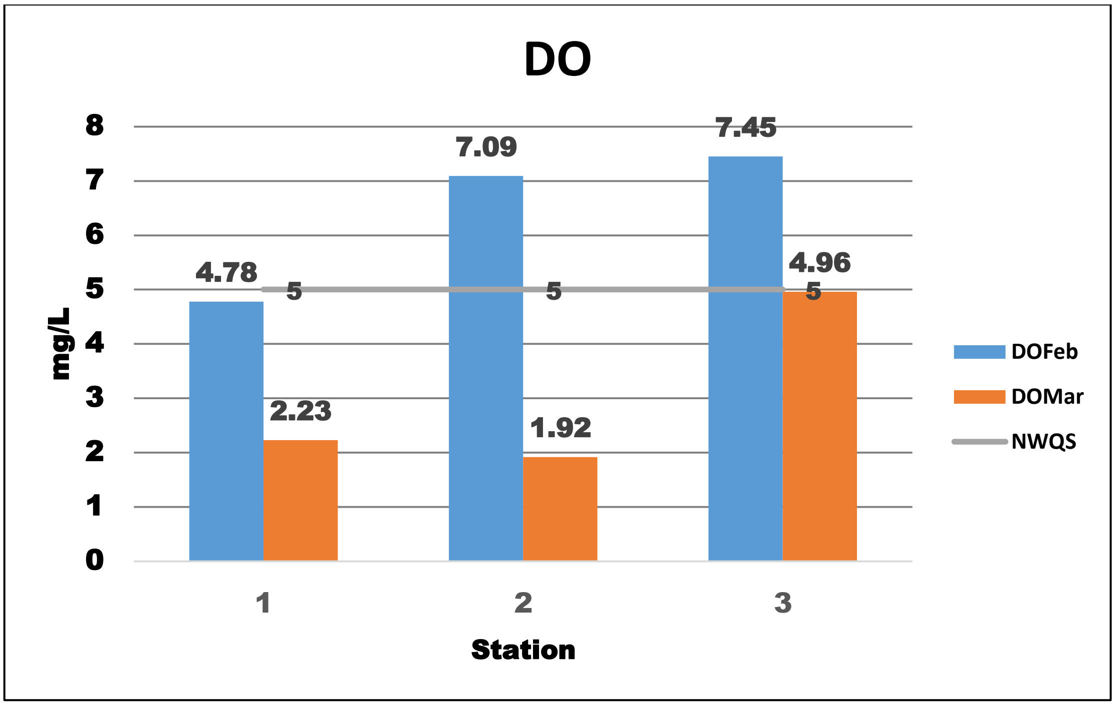


Figure 4.5.4: Results of Dissolved Oxygen from February to March 2015 at 3 stations.

4.5.5 Turbidity

The turbidity recorded two months period at 3 selected stations of Tunggak River was showed in **Figure 4.5.5**. From the figure, it was stated that the turbidity for all stations at both sampling months were in a good class which was Class II. The turbidity trend was recorded in an unstable trend on both months. The range at the 1st sampling was 8.14 mg/L-20.48 mg/L, while on the 2nd sampling was 17.97 mg/L-19.7 mg/L. This result showed that the turbidity at the study area was in a controlled amount and does not pollute the surface water.

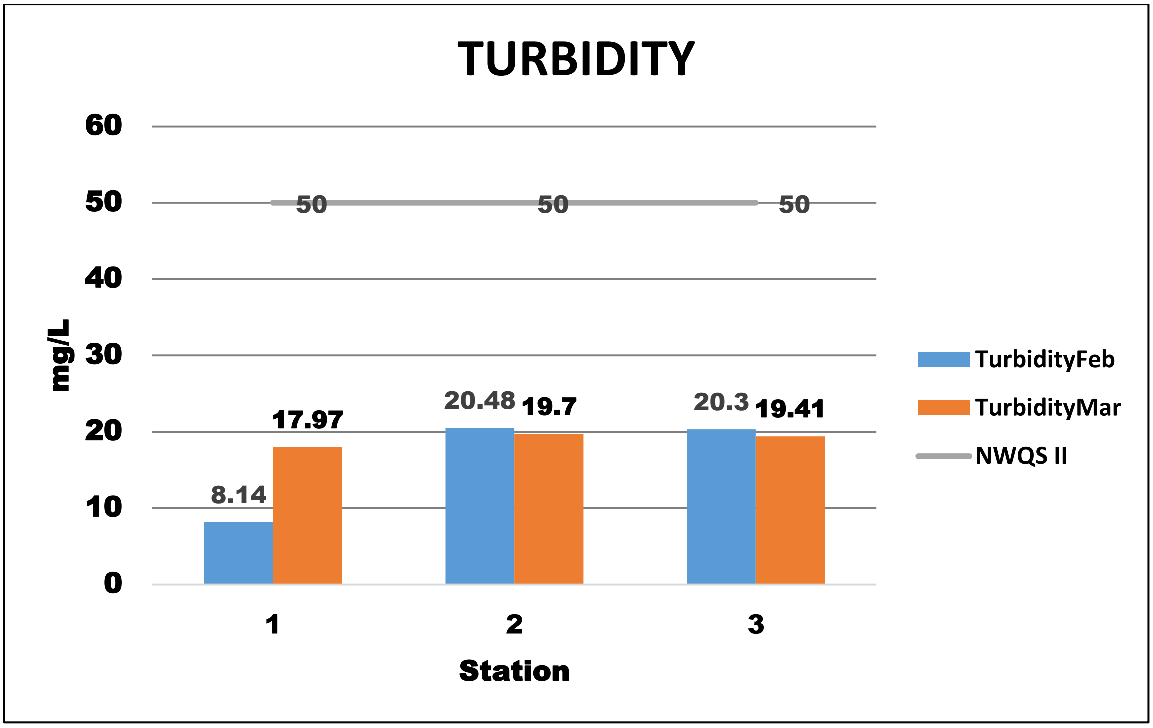


Figure 4.5.5: Results of Turbidity from February to March 2015 at 3 stations.

4.5.6 Ammoniacal Nitrogen

The results of ammoniacal nitrogen that recorded from February 2015 to March 2015 at 3 selected stations of Tunggak River was showed in **Figure 4.5.6**. Based on the graph, it was stated that ammoniacal nitrogen in March 2015 sampling was lower than ammoniacal nitrogen on the 1st sampling in February 2015. The range of ammoniacal nitrogen value at the 1st sampling was 1.1 mg/L-4.95 mg/L, while on the 2nd sampling was 0 mg/L-2.75 mg/L. The results had identified that the 1st sampling recorded more polluted condition because only station 3 was classified in a better class which was Class III, while for remaining stations were in Class V. Different from results on February 2015, the ammoniacal nitrogen for the following month showed a positive value which located all the all the stations in Class III.

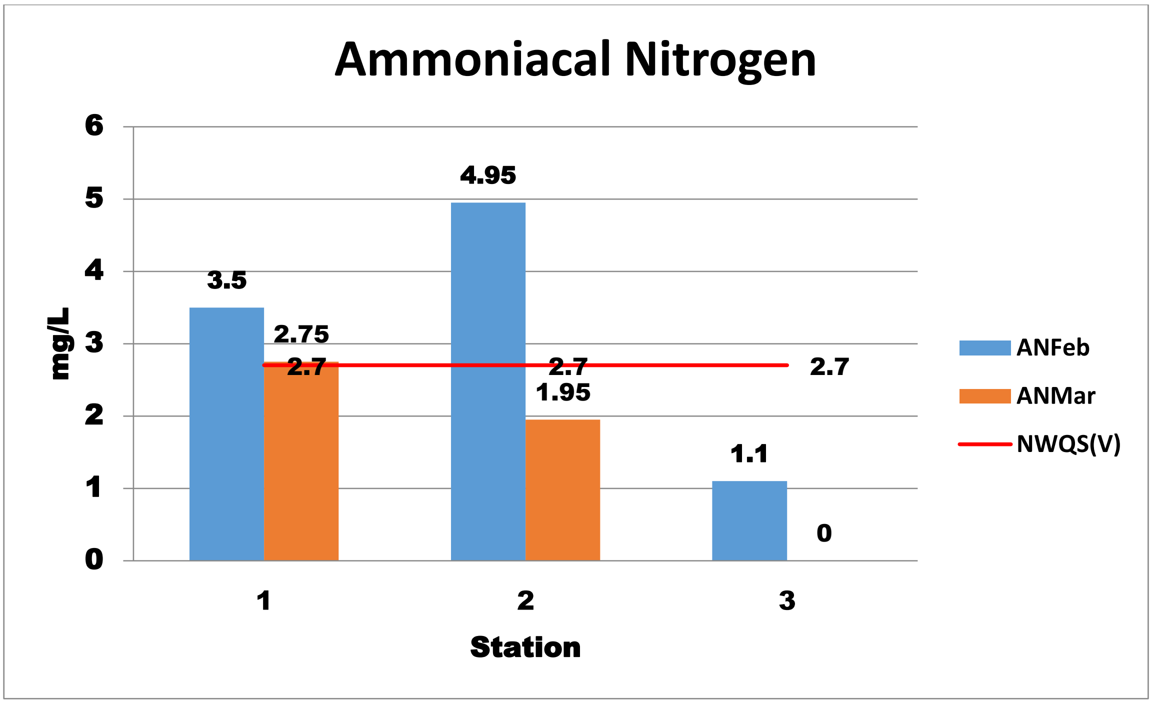


Figure 4.5.6: Results of Ammoniacal Nitrogen from February to March 2015 at 3 stations.

4.5.7 Total Suspended Solids

The results of total suspended solids that recorded from two months period at 3 selected stations of Tunggak River was showed in **Figure 4.5.7**. From the graph, it stated clearly that the electrical conductivity was recorded in increasing trend on both months. The range at the 1st sampling was 12 mg/L-14.5 mg/L, while on the 2nd sampling was 27 mg/L-88 mg/L. Regarding to NWQS, for 1st sampling, all stations were in a best class which in Class I while for 2nd sampling station 1 and station 2 were still maintained the class from previous month, while for station 3, the class changed to bad which was Class II.

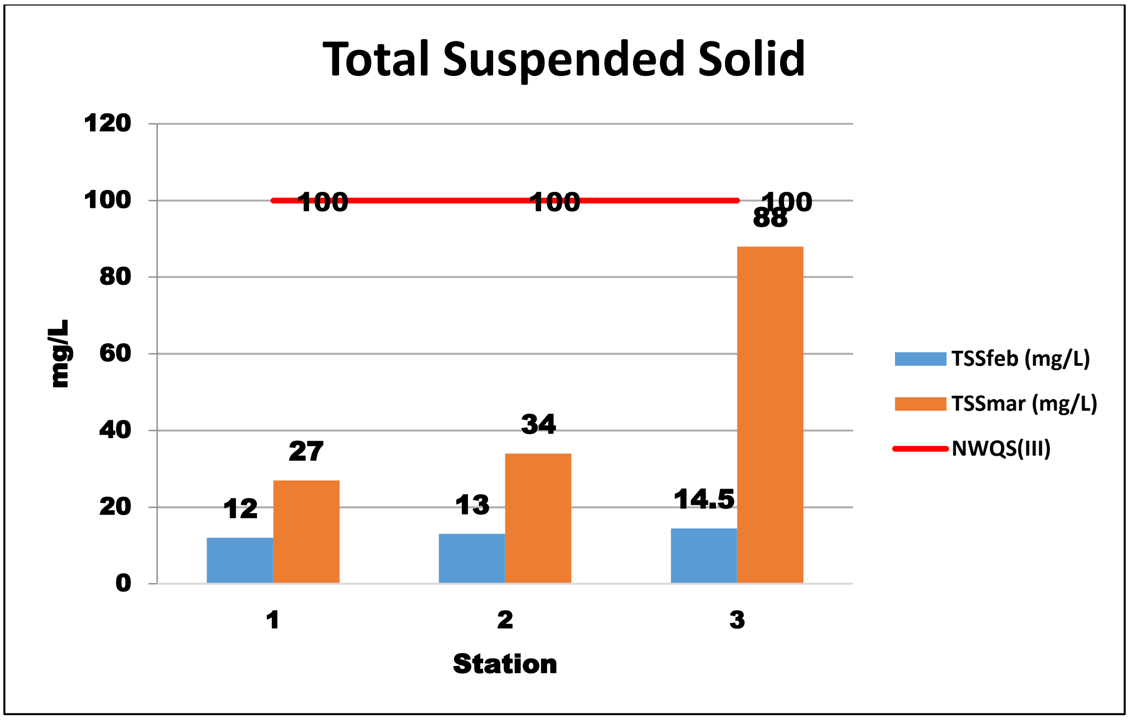


Figure 4.5.7: Results of Total Suspended Solid from February to March 2015 at 3 stations.

4.5.8 Biochemical Oxygen Demand

The results of total BOD that recorded from two months period at 3 selected stations of Tunggak River was showed in **Figure 4.5.8**. From the figure, it stated clearly that the BOD was recorded in decreasing trend on 1st sampling and an unstable trend for the next sampling month. The range at the 1st sampling was 2.28 mg/L-13.43 mg/L, while on the 2nd sampling was 18.45 mg/L-30.28 mg/L. Regarding to NWQS, for 1st sampling, station 3 had the best standard which in Class I, station 3 in medium range that is Class II and the worst class, Class V for station 1. For 2nd sampling, all stations were recorded to be in the worst class that is Class V.

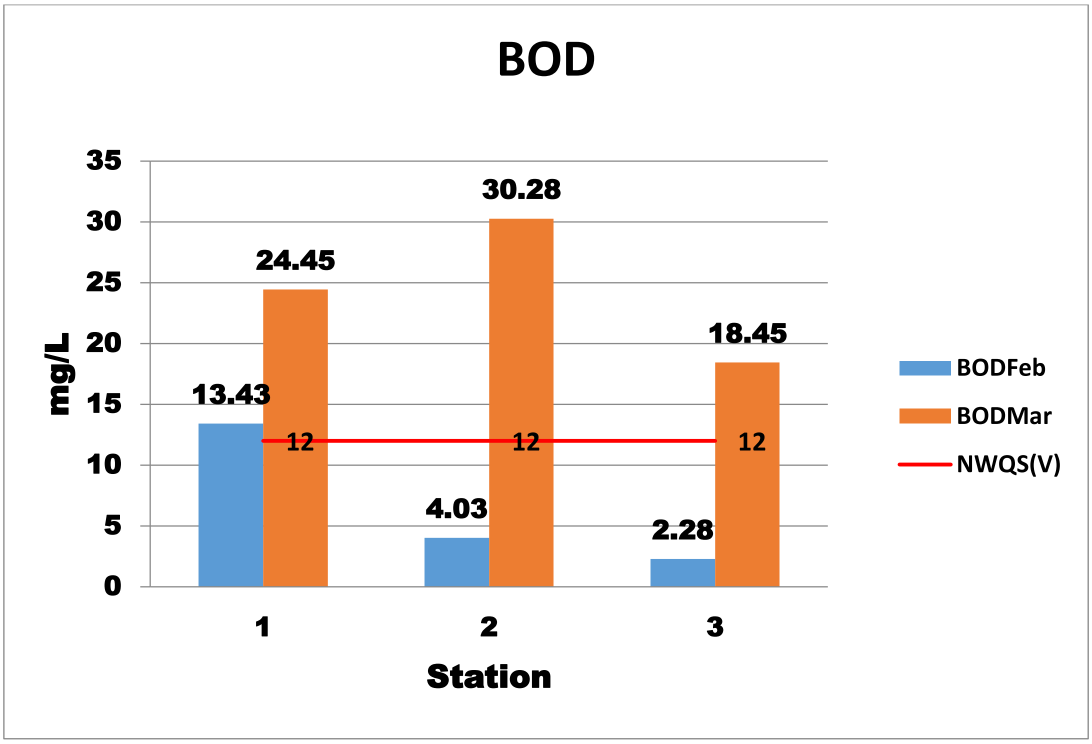


Figure 4.5.8: Results of Biochemical Oxygen Demand from February to March 2015 at 3 stations.

4.5.9 Chemical Oxygen Demand

The results of COD that recorded from February 2015 to March 2015 at 3 selected stations of Tunggak River was showed in **Figure 4.5.9**. Based on the graph, it was stated that BOD in March 2015 sampling was higher in range than BOD on the 1st sampling in February 2015. The range value at the 1st sampling was 26.34 mg/L-112.83 mg/L, while on the 2nd sampling was 26.83 mg/L-191.5 mg/L. The results had identified that the 1st sampling recorded more polluted condition at station 1 and station 2 which classified them into Class III and Class V compared to station 3 which was in Class II. For results on March 2015, the trend was increased over the stations which placed station 1, station 2 and station 3 into Class II and Class V.

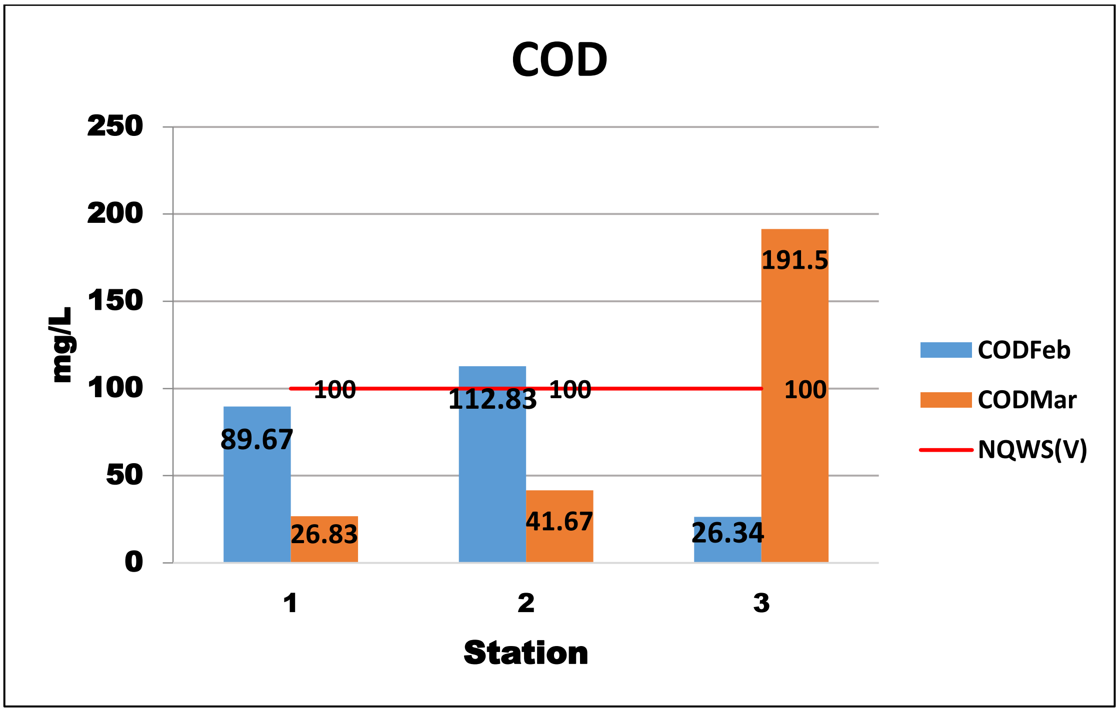


Figure 4.5.9: Results of Chemical Oxygen Demand from February to March 2015 at 3 stations.

4.6 WATER QUALITY INDEX ANALYSIS

A Water Quality Index (WQI) describes quality value to an aggregate set of measured parameters. It usually consists of sub-index values assigned to each pre-identified parameter by comparing its measurement with a parameter-specific rating curve, optionally weighted, and combined into the final index. The purpose of a WQI is to summarize large amounts of water quality data for a specific river into simple terms (i.e. one number and a statement such as “good”). This makes it easily understandable for communities in the river basin and for river basin management. (Zainudin, 2010).

For WQI analysis for these three selected stations of Tunggak River, **Figure 4.6** was being referred to see the trend between selected stations over two months’ time. **Table 4.6** showed the simplified WQI calculation and classification based on the parameters tested.

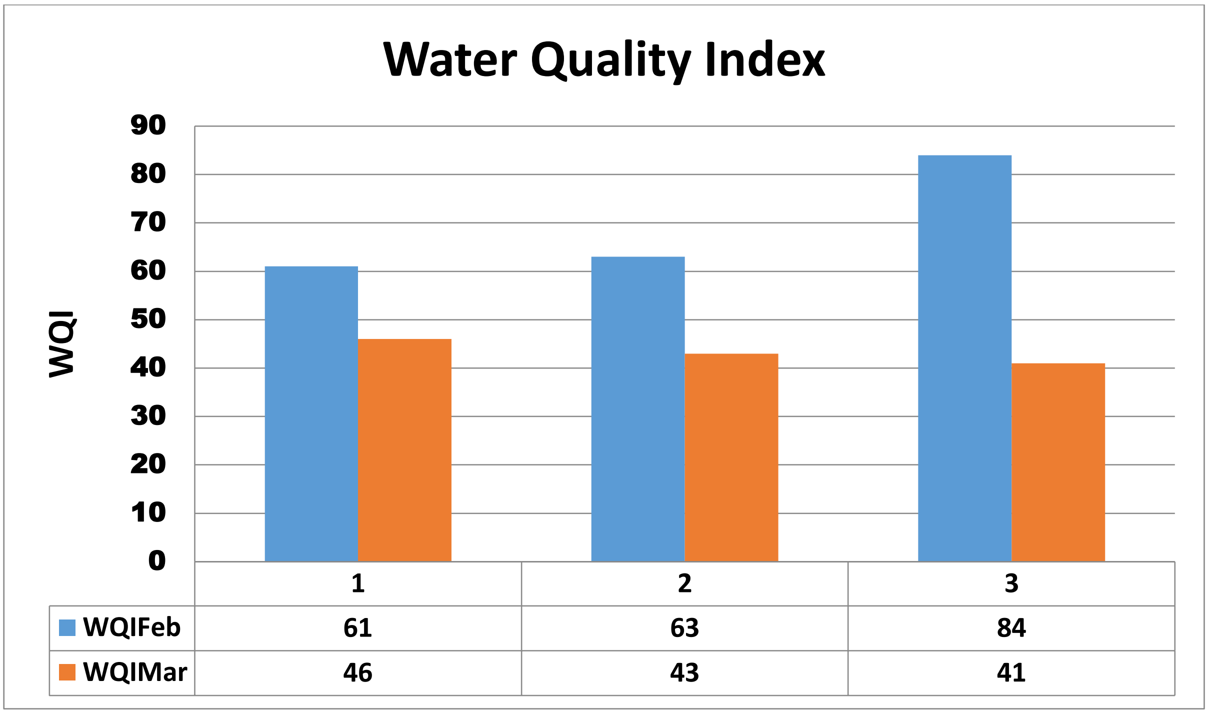


Figure 4.6: Water Quality Index of Tunggak River from February to March 2015 at 3 stations.

Table 4.6: Water Quality Index for each station according to sampling month

Station No.		SIDO	SIBOD	SICOD	SIAN	SISS	SIpH	WQI
Station 1	Feb	100	51.5	21.61	5.15	89.3	90.72	61 (MEDIUM)
	Mar	19.72	28.05	66.52	15.67	79.88	87.02	46 (BAD)
Station 2	Feb	96.9	83.35	13.01	-9.24	88.65	93.05	63 (MEDIUM)
	Mar	14.82	20.32	51.88	31	75.78	92.51	43 (BAD)
Station 3	Feb	100	90.76	67.06	54.55	87.67	96.49	84

.

							(GOOD)
Mar	70.88	39.05	-2.57	0	49.38	86.85	41 (BAD)

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 INTRODUCTION

This chapter is all about concluding the results getting from the research and identified either the objectives stated at the beginning of the research were achieved or not. Besides, this chapter also included some recommendations to the research and for the parties out there to find the better solutions in the future relating to the pollution and heavy metal assessment problems. Summarization of the research topic is being concluded in this chapter to explain the findings performances and results.

5.2 CONCLUSION

Based on the overall results presented in previous chapter, there will be three main things to be concluded that will lead this study to its main objectives. There are the selected heavy metal enrichment factor, National Water Quality Standard and Water Quality Index. All those aspects are important for the research to determine the pollution level of surface water quality and the heavy metal contamination rate at the study area.

From the findings performances, the Enrichment Factor of four heavy metal that are Cu, Cd, Pb and Zn tested on the samples based on the station are:

- Station 1 (ppm) = Pb(0.74) < Zn(1.76) < Cu(2.06) < Cd(2.16)
- Station 2 (ppm) = Pb(0.27) < Cd(0.80) < Cu(1.21) < Zn(2,23)
- Station 3 (ppm) = Cd(0.42) < Pb(0.70) < Zn(0.82) < Cu(1.14)

Based on the information above, the highest EF was from Cd in Station 1, while the smallest enrichment was also came from Cd in Station 3.

For all parameters involved in this research, standard from NWQS was compared to the results. From all analysis, the range classes of all parameters were from Class II – Class V. The calculation of getting WQI for surface water quality at the study area were using the results from certain parameters. Therefore, from the analysis been done, the surface water quality of all stations was concluded had been in a bad quality index.

As the conclusion, The pollution level according to the Enrichment Factor, National Water Quality Standard and Water Quality Index for all three researched stations, there had proved that Tunggak River have slightly serious pollution problems. Even though the EF analysis showed medium enrichment, the other water quality benchmarking had already gave a bad quality results of the stations involved. However, there will be a thing to be reminded that EF, NWQS and WQI as a good pollution benchmarking tools although there are certain limitations that might occurs during the implementation.

5.3 RECOMMENDATION

While research is conducted, lots of effort need to be used in order to ensure the objectives of the research can be successfully achieved. So, there will be so many things that should be improved so that research can run smooth and sound. In addition, water quality research need to be updated by time to acknowledge the latest status of the surface water around the world. There are few of suggestion that need to take to make the research going efficiently for future usage:

- Study the previous status of research area in terms of parameters results and water quality status.
- Prepare the research site plan to get clearer distance between the stations.
- Get a better understanding for the whole processes and precautionary steps for water quality parameters to ensure the information getting from the experiments is accurate.

For the authorities, several recommendation have been analyzed for them in order to fix the pollution that happened based on this research. These recommendations do not only to recover the pollution of Tunggak River, but also can be applied to other polluted river all over the world. The recommendation are:

- Implement watershed protection management and system to monitor the effluent that flow from the industrial and commercial area.
- Develop and implement water resources monitoring system and also pollution prevention water resources management to ensure the quality of the surface water at the area is in standard level.
- Educate public about the eternal impact of environmental pollution and teach them how to conserve it.

REFERENCES

Abdel-Baki, A.S., Dkhil, M.A. and Al-Quraishy, S. 2011. Bioaccumulation of Some Heavy Metals in Tilapia Fish Relevant to Their Concentration in Water and Sediment of Wadi Hanifah, Saudi Arabia . *African Journal of Biotechnology Vol.10(13)*, 2541-2547.

Adeniyiet, A,Owoade, O.J. and Ibukun, O.S. 2008. Monitoring metals pollution using water and sediments collected from Ebute Ogbo river catchments, Ojo, Lagos, Nigeria. *African Journal of Pure and Applied Chemistry Vol. 5(8)*, 219-223.

Al-Shami, S.A., Rawi, C.S.M, Ahmad, A.H. and Suhaila, A.H. 2011. Influence of agricultural, industrial, and anthropogenic stresses on the distribution and diversity of macroinvertebrates in Juru River Basin, Penang, Malaysia. Ecotoxicol. Environ. Saf. 74(5), 1195-1202.

Chen, J.P. 2012 "Decontamination of Heavy Metals: Processes, Mechanisms, and Applications" ,CRC Press/Taylor and Francis Group.

Department of Environment Malaysia, "Malaysia Environmental Quality Report 2006", In : Chapter 3 : River Water Quality, Sasyaz Holdings Sdn Bhd, 2007, pp. 24.

DOE, 2008. Interim National Water Quality Standards for Malaysia. Department of Environment, Kuala Lumpur, Malaysia.

Ezemonye, L. and Enuneku, A. 2012. Evaluation of Acute Toxicity of Cadmium and Lead to Amphibian Tadpoles (Toad: Bufo maculatus and frog: Ptychadena bibroni). *Journal of Aquatic Sciences Vol.20(1)*, 33-38.

HACH, 2003. The Handbook of DR/2500 Laboratory Spectrophotometer. Loveland, CO: HACH Company.

Haris, H. and Maznah, W.O.W. (2008). "The effects of tidal events on water quality in the coastal area of Petani River Basin, Malaysia." Proceeding of international conference on environmental research and technology (ICERT 2008); Park Royal Penang, Malaysia, 595- 599.

Hossain, Amjed.M., Sujaul, I.M, Nasly and Ali, M. 2013. Water Quality Assessment of Tunggak River, Gebeng, Pahang, Malaysia. *4th International Conference on Water & Flood Management 2013.* University Malaysia Pahang, Pahang, Malaysia: Faculty of Civil Engineering and Earth Resources .

Hossain, M.A. and Sujaul, I.M. 2012. "Spatial variation of water quality parameters at Gebeng industrial estate, Pahang, Malaysia" Proceeding of the National Conference on Postgraduate Research'12, UMP, P-12.

Iyagba, M. A., Adoki, A., and T.G. Sokari. 2008. Testing biological methods to treat rubber effluent. Afr. J. Agric. Res. 3(6), 448-454.

Lima, D., Santos, M. M., Ferreira, A. M., Micaelo, C. and Reis-Henriques. 2008. The use of the shannyLipophryspholis for pollution monitoring; A new sentinel species for the northwestern European marine ecosystems. Environment International, 34: 94 – 101.

Meybeck, N. E. 2009. Water Quality Degradation Effects on Freshwater Availability: Impacts of Human Activities. *Water International. Volume 25, Issue 2*, 185-193.

Moorthy, J and Jeyabalan, G. 2012. Ethics and Sustainability: A Review of Water Policy and Management. *American Journal of Applied Sciences*, 24-31.

Obasohan, E.E. 2007. Heavy metals concentrations in the offal, gill, muscle and liver of a freshwater mudfish Parachanaobscura from Ogba River, Benin City, Nigeria. African Journal Biotechnology, 6(22): 2620 –2627.

Oguzie, F. A. 2003. Heavy metals in fish, water and effluents of lower Ikpoba River in Benin City,Nigeria. Pakinstan Journal of Science and Industrial Research, 46 (3): 156 – 160.

Oyekunle, J.A.O., Adekunle, A.S., Ogunfowokan, A.S., Akanni, M.S. and Coker, O.S. 2012. Agama Lizard: A potential biomarker of Environmental Heavy metal pollution Assessment. African Journal of Environmental Science and Technology, 6 (12):458 –463.

Perk, M. V. 2006. *Soil and Water Contamination.* Utrecht University, The Netherlands: Taylor & Francis Group.

Ping, C. J. 2012. *Decontamination of Heavy Metals.* New York, USA: CRC Press.

Sen, M. V. 2011. Assessment of Nurient and Heavy Metal Contamination in Surface Water and Sediments of The Upper Tigris River, Turkey.

Wang, L. K. P., Chen, J. P. Hung, Y. T. and Shammas, N. K. 2009. eds., "Heavy Metals in the Environment", CRC Press/Taylor and Francis Group, ISBN-10: 1420073168, ISBN-13: 9781420073164.

Yap, C.K and Tan, S.G. 2006. Biochemical and molecular indicators in aquatic ecosystems: current status and further applications in Malaysia. Aquat. Ecosyst. Health Manage.9, 227– 236.

Zahra, A., Hashmi, M.Z., Malik, R.N. and Ahmed, Z. 2013. Enrichment and Geo-Accumulation of Heavy Metals and Risk Assessment of Sediments of The Kurang Nallah-Feeding Tributary of The RAwal Lake Reservoir, Pakistan. *Science of The Total Environment*, 925-933.

Zainudin, Z. 2010. Benchmarking River Water Quality in Malaysia. *JURUTERA*, pp. 12-15.

APPENDICES

APPENDIX A1

Table 4.4: The concentration of heavy metal from the water sample from February to March 2015.

Station		Cu (ppm)	Cd (ppm)	Pb (ppm)	Zn (ppm)
1	Feb	0.016±0.009	0.006±0.003	0.053±0.056	0.029±0.012
	Mar	0.014±0.002	0.025±0.011	0.090±0.007	0.037±0.004
2	Feb	0.010±0.003	0.010±006	0.318±0.279	0.010±0.001
	Mar	0.022±0.001	0.047±0.001	0.158±0.006	0.044±0.014
3	Feb	0.020±0.001	0.030±0	0.128±0.015	0.024±0.010
	Mar	0.062±0.001	0.167±0.004	0.052±0.002	0.052±0.009

APPENDIX B1

Table 4.5.1: National Water Quality Standards

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

APPENDIX B2

Table 4.5.2: Water Quality Classification Based On Water Quality Index

SUB INDEX & WATER QUALITY INDEX	INDEX RANGE		
	CLEAN	**SLIGHTLY POLLUTED**	**POLLUTED**
Biochemical Oxygen Demand(BOD)	91 -100	80 – 90	0 -79
Ammoniacal Nitrogen(NH3-N)	92 -100	71 – 91	0 – 70
Suspended Solids(SS)	76 – 100	70 – 75	0 – 69
Water Quality Index(WQI)	81 - 100	60 -80	0 – 59

APPENDIX C1

Table 4.3: The range, SD and mean value of parameters at different monitoring stations of Tunggak River from February to July 2012 (Hossain.M.A, I. a., 2013).

Station No.		Temperature (˚C)	pH	Conductivity (µS/cm)	DO (mg/L)	TDS (mg/L)	Turbidity (NTU)
1	Range	27.05-30.17	5.66-7.02	14200-27080	2.62-4.40	9040-24300	7.69-22.50
	Mean	28.78±1.07	6.23±0.52	18013±4946	3.30±0.61	16137±769	16.66±6.41
2	Range	28.04-29.2	6.97-7.71	7700-13660	1.10-2.17	5160-7270	10.05-24.70
	Mean	28.55±0.59	7.28±0.34	10880±2836	1.58±0.41	6250±1088	17.72±5.81
3	Range	29.01-29.81	7.32-8.40	1244-1800	1.33-1.80	650-869	9.78-20.70
	Mean	29.34±0.38	7.69±0.38	1395±207	1.69±0.36	767±112	13.70±3.90
4	Range	30.92-32.57	7.51-8.51	1119-1320	1.62-4.12	527-821	10.05-17.27
	Mean	31.74±0.75	7.95±0.35	1212±95	2.71±0.96	613±108	14.14±3.42
5	Range	30.92-33.1	6.96-8.95	1380-1630	1.93-3.91	642-748	11.26-34.50
	Mean	31.98±1.07	7.96±0.99	1505±107	3.12±0.91	700±50	23.44±12.03
6	Range	31.63-34.14	7.25-9.12	1423-1740	1.56-3.16	649-778	11.73-28.80
	Mean	32.88±1.35	8.01±0.76	1585±164	2.32±0.79	715±68	20.98±8.01
7	Range	33.2-35.24	6.77-8.60	923-1210	2.85-3.93	203-529	6.69-12.35
	Mean	33.78±0.88	7.65±0.62	1068±149	3.28±0.51	365±171	9.82±2.30
8	Range	32.5-34.1	4.66-5.42	51-58	2.78-4.25	19.6-24.8	4.83-10.06
	Mean	33.27±0.56	4.96±0.29	55±3.31	3.38±0.59	21.78±2.25	6.59±1.81

APPENDIX C2

Table 4.3.1: The result of the latest water quality parameters of Tunggak River in February to March 2015 (DOE, 2010).

Station		Temperature (˚C)	pH	Conductivity (mS/cm)	DO (mg/L)	Turbidity (NTU)
1	1ST	25.2±0.00	5.99±0.05	0.17±0.0007	4.78±0.04	8.14±0.16
	2ND	28.9±0.00	8.25±0.38	3.78±0.24	2.23±0.10	17.97±1.22
2	1ST	27.9±0.07	6.15±0.01	0.79±0.04	7.09±0.13	20.48±1.87
	2ND	28.5±0.35	7.81±1.02	15.15±0.78	1.92±0.08	19.7±0.1461
3	1ST	27.2±0.07	6.45±0.21	13.2±3.11	7.45±0.55	20.3±4.95
	2ND	29.5±0.00	8.26±0.73	49.18±0.04	4.96±0.16	19.41±10.92

APPENDIX C3

WQI FORMULA AND CALCULATION

FORMULA

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

where;

SIDO = Sub index DO (% saturation)

SIBOD = Sub index BOD

SICOD = Sub index COD

SIAN = Sub index NH3-N

SISS = Sub index SS

SipH = Sub index pH

$0 \leq WQI \leq 100$

BEST FIT EQUATIONS FOR THE ESTIMATION OF VARIOUS SUBINDEX VALUES

Sub index for DO (In % saturation)

SIDO = 0 for $x \leq 8$

SIDO = 100 for $x \leq 92$

SIDO = -0.395 + 0.030x2 - 0.00020x3 for $8 < x < 92$

Sub index for BOD

SIDOD = 100.4 - 4.23x for $x \leq 5$

SIDOD = 108* exp(-0.055x) - 0.1x for $x > 5$

Sub index for COD

SICOD = -1.33x + 99.1 for x ≤ 20

SICOD = 103* exp(-0.0157x) - 0.04x for x > 20

Sub index for NH_3-N

SIAN = 100.5 - 105x for x ≤ 0.3

SIAN = 94* exp(-0.573x) - 5* I x - 2 I for 0.3 < x < 4

SIAN = 0 for x ≥ 4

Sub index for SS

SISS = 97.5* exp(-0.00676x) + 0.05x for x ≤ 100

SISS = 71* exp(-0.0061x) + 0.015x for 100 < x < 1000

SISS = 0 for x ≥ 1000

Sub index for pH

SlpH = 17.02 - 17.2x + 5.02x2 for x < 5.5

SlpH = -242 + 95.5x - 6.67x2 for 5.5 ≤ x < 7

SlpH = -181 + 82.4x - 6.05x2 for 7 ≤ x < 8.75

SlpH = 536 - 77.0x + 2.76x2 for x ≥ 8.75

Note:

*means multiply with

APPENDIX C4

Table 4.6.1: Water Quality Index Classification

SUB INDEX & WATER QUALITY INDEX	**INDEX RANGE**		
	CLEAN	**SLIGHTLY POLLUTED**	**POLLUTED**
Biochemical Oxygen Demand(BOD)	91 -100	80 – 90	0 -79
Ammoniacal Nitrogen(NH_3-N)	92 -100	71 – 91	0 – 70
Suspended Solids(SS)	76 – 100	70 – 75	0 – 69
Water Quality Index(WQI)	81 - 100	60 -80	0 – 59