UNIVERSITI MALAYSIA PAHANG

DECLARATION OF THESIS / UNDERGRADUATE PROJECT PAPER AND COPYRIGHT

Author's full name : **LYDIAIZNA BINTI ADAM**

Date of birth : **24 APRIL 1992**

Title : **ADVERSE EFFECT OF POOR WASTE WATER MANAGEMENT PRACTISE ON THE TUNGGAK RIVER PAHANG, MALAYSIA**

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)*research
☑	**OPEN ACCESS**	I agree that my thesis to be published as online open access (Full text)

I acknowledge that Universiti Malaysia Pahang reserve 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.

Certified By:

(Student's Signature)	(Signature of Supervisor)
920424-01-6244	**DR. MIR SUJAUL ISLAM**
New IC / Passport Number	**Name of Supervisor**
Date : 26 JUNE 2015	Date : 26 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.

SUPERVISOR DECLARATION

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

Signature :

Name of Supervisor : DR. MIR SUJAUL ISLAM

Position : SENIOR LECTURER

Date : 26 JUNE 2015

STUDENT DECLARATION

I hereby declare that the work in this thesis entitled "*Adverse Effect Of Poor Waste Water Management Practise of Tunggak River Water Quality, Pahang Malaysia*" 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 : LYDIAIZNA BINTI ADAM

ID Number : AA 11130

Date : 26 JUNE 2015

ACKNOWLEDGEMENT

In The Name Of Allah, the Most Gracious and the Most Merciful. I would like to express my grateful to Allah S.W.T to make ease for me to complete this thesis. I am grateful and would like to express my deepest appreciation to my supervisor, Dr. Mir Sujaul Islam for his guidance, continuous encouragement and advices throughout the course of this research. I would like to acknowledge with big appreciation to staffs in environment laboratory for all their assistance throughout this thesis.

My sincere indebtedness and gratitude to my beloved parents, Mr. Adam bin Karim and Mrs Maimon bt Samin for always by my side to support, pray and sacrifice for me. Not forget, I would like to thanks to my only sister, Zuraya bt Adam and my only niece, Mohd Rafiq for their love and support.

I would also like to thanks all Final Students and lecturers of Civil Engineering Faculty for their kindness and support. They make my life in UMP unforgettable and meaningful. Finally, special thanks to Nur Syahida bt Mohamed@Mohd Junid, Nuramalina bt Shamsudin and all my close friends who help me in many ways. Thanks for all your loving and everything.

DEDICATION

This thesis is special dedicated to my family member for support, love and pray,

My beloved Father and Mother,

Adam bin Karim

Maimon Bt Samin

My beloved Sibling

Zuraya bt Adam

To My Supervisor and Lecturers

Also To All My Friends

Thanks for Love, Constant Source of Inspiration and Support. May Allah bless You

ABSTRACT

River is an example of surface water that played as one of the water sources and supply to community. Currently, many rivers in Malaysia have been deteriorated due to a few factors that have exerted immense pressures on water quality. The purposed of this study was to investigate the adverse effect of poor waste water management practise on the Tunggak River water quality. The main objectives of this research was to investigate the status of water quality based on National Water Quality Standard (NWQS) and Water Quality Index (WQI) and also to define the sources of pollutant discharged into the river in order to manage and protect the surface water from contamination. To achieve the objectives, samples from the Tunggak River were collected and involved in situ and ex situ parameters. In situ parameters were dissolved oxygen (DO), Temperature, pH and turbidity while ex situ parameters was biochemical oxygen demand (BOD), chemical oxygen demand (COD), total suspended solids (TSS), ammoniacal nitrogen (AN), sulphate (SO_4^{2-}) and phosphate (PO_4^{-3}). The results showed that Station 1 and 2 was classified as highly polluted (class IV) and Station 3 was classified as class III (polluted) based on WQI. From the results, it is clear that the industrial waste water is one of the main sources of pollutant into the Tunggak River. According to NWQS, water of the Tunggak River cannot be used except proper treatment.

ABSTRAK

Sungai adalah contoh permukaan air yang berperanan sebagai salah satu sumber air bekalan kepada komuniti. Kini, kebanyakkan sungai di Malaysia telah pun merosot kerana beberapa faktor yang telah menekan tahap kualiti air. Tujuan kajian ini ialah untuk menyiasat kesan buruk amalan pengurusan sisa air yg lemah keatas kualiti air Sungai Tunggak. Objektif utama kajian ini ialah untuk mengkaji status kualiti air berdasarkan Piawaian Kualiti Air Negara dan Indeks Kualiti Air dan juga untuk mengenalpasti punca-punca pencemaran yg dilepaskan ke dalam sungai agar dapat mengurus dan menjaga permukaan air dari tercemar. Untuk mencapai objektif-objektif tersebut, sampel dari Sungai Tunggak diambil dan ia melibatkan parameter di tapak stesen dan diluar tapak stesen. Parameter di tapak stesen adalah oksigen terlarut (DO), suhu, pH dan turbiditi manakala ujian di luar tapak stesen adalah oksigen biologi (BOD), oksigen kimia (COD), pepejal tersuspensi (TSS), nitrogen ammoniakal (AN), sulfat (SO_4^{-2}) dan fosfat (PO_4^{3-}). Keputusan menunjukkan Stesen 1 dan 2 adalah dikelaskan sangat tercemar (Kelas IV) dan Stesen 3 pula dikelaskan sebagai Kelas III (tercemar) berdasarkan kepada Indeks Kualiti Air. Dari keputusan tersebut, ia jelas bahawa sisa air industri adalah salah satu punca kepada pencemaran Sungai Tunggak. Berdasarkan kepada Piawaian Kualiti Air Negara, Sungai Tunggak tidak boleh digunakan melainkan rawatan yang selanjutnya.

TABLE OF CONTENTS

CHAPTER 4 RESULTS & DISCUSSIONS

CHAPTER 5 CONCLUSION AND RECOMMENDATIONS

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS

mg/L	-	Milligram per Litre
SO_4^{2-}	-	Sulphate
PO_4^{3-}	-	Phosphate

LIST OF ABBREVIATIONS

INWQS	-	Interim National Water Quality Standard
DOE	-	Department of Environment
WQI	-	Water Quality Index
DO	-	Dissolved Oxygen
BOD	-	Biochemical Oxygen Demand
COD	-	Chemical Oxygen Demand
TSS	-	Total Suspended Solids
AN	-	Ammoniacal Nitrogen
Cu	-	Copper
Zn	-	Zinc
Pb	-	Lead
Fe	-	Iron
Cd	-	Cadmium
mg/L	-	Milligram per Litre
SO_4^{2-}	-	Sulfate
PO_4^{3-}	-	Phosphate

ADVERSE EFFECT OF POOR WASTE WATER MANAGEMENT PRACTISE ON THE TUNGGAK RIVER PAHANG, MALAYSIA

LYDIAIZNA BT ADAM

BACHELOR OF CIVIL ENGINEERING

UNIVERSITI MALAYSIA PAHANG

ADVERSE EFFECT OF POOR WASTE WATER MANAGEMENT PRACTISE ON THE TUNGGAK RIVER PAHANG, MALAYSIA

LYDIAIZNA BT ADAM
AA11130

Thesis submitted in 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

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF THE STUDY

Water is the most valuable resources and the most passionately contested. 71% of the Earth's surface is made up by salt water ocean and the rest percentage consists of continents and islands. Of all the water on earth, only 2.5% is freshwater where 0.77% held in freshwater system as rivers, groundwater, streams, ponds, water spring. Humans need water for drinking, sanitation, washing, food and agriculture, fishing and aquaculture also for wildlife and ecosystem. River is an example of freshwater system. River is an example of surface water that played as one of the water sources and water supply to community. Currently, half of the world's major rivers are being seriously polluted. About 40% of rivers and lakes in the U.S surveyed by EPA are too polluted for swimming or fishing. Increasing of urbanization, agricultural and industrial practice brings an adverse effect on river and the polluted bring the rapidly decreasing of the water quality.

Waste water is one of the factors that give effect on water quality. Waste water is water containing wastes from residential, commercial and industrial practice. Plus, nearly all human activity results in the productions of waste water. Experts have been estimated that globally about 80% of wastewater from human settlements and industrial sources is discharged to the environment without treatment (UNEP & UN-Habitat, 2010). The poor on waste management that been practise by residential, commercial and industrial practice is one of the lead to disposal of waste into the river and this one of the causes of water pollution and give effect on water quality of river.

In Malaysia, the rapid growth of development is increasing year by year. As the third world countries, the positive developing is contributing to the economic and industrial development of the country. There is a growing recognition that the management of domestic waste water especially in urban setting has overstressed the river system. Currently, many rivers in Malaysia have been deteriorated due to aforementioned factors which have exerted immense pressures on water quality. Based on Compendium of Environment Statistics Malaysia 2011, the number of clean river basins is decreasing starting 2007 with 91 clean river basins and on 2010 with 65 and until 2014, the number is still in decreasing.

The Tunggak River has been chosen because of its importance and function to community. The Tunggak River is a stream and the originated at the uphill of Gebeng area. Gebeng area is the small town and centre industrial area in Pahang, Malaysia. The town is located near Kuantan Port. Rapid industrialization happened at Gebeng which consist of variety industry such as wood processing industries, metal and works factories and concrete ducting company and industrial of petrochemical. Waste waters from industry always discharge through Tunggak River where the river is joined with another river called Balok River and ultimately flow into South China Sea. Tunggak River has an average elevation of 6 meter of sea level. The area of mildly densely populated with 133 people per km^2. The nearest town larger than 50,000 inhabitants taken about 0: 21 hour by local transportation.

1.2 PROBLEM STATEMENT

Water quality of river becomes serious day by day in Malaysia. This is because some of rivers are severely polluted with wasted and one of the wasted is come from residential, commercial and industrial practise that discharge their disposal to the river. In 1997, identify a total of 4932 factories as sources of river water pollution (Pentas Flora-March 19). Plus, illegal dumping is an ongoing serious problem which this production from 1 final disposal facility that Malaysia still have and the poor of waste water management practise. The publics and government are conscious about the future of rivers since rivers are main water supply to consumer. Effect on water quality may give adverse effect to consumer in health.

Currently for Pahang state unfortunately the information about river water quality is scanty not fairly enough with the rapid industrialization activities. The rapid growth of industrialization especially in Gebeng area give effect on water quality of nearly rivers especially Tunggak river. Plus, poor in waste water management practise by some industrial lead to water pollution in river where the industrial wasted is disposed to the Tunggak River. Thus, this study will be carried out in order to investigate the adverse effect on poor waste water management practise on Tunggak River water quality.

1.3 OBJECTIVES

The objectives of this research are listed below :

i. To investigate the status of water quality based on National Water Quality Standard for Malaysia (NWQS) and Malaysia Water Quality Index (WQI).

ii. To define the sources of pollutant discharged into the river in order to manage and protect the surface water from contamination.

1.4 SCOPE OF STUDY

During the study case, major scopes focus on :

i. The scope of study area is at Tunggak River, located in the Pahang. Location of Tunggak River is in Gebeng area.

ii. The water quality classification will be based on Malaysia Water Quality Index (WQI) and National Water Quality Standard for Malaysia (NWQS)

iii. The parameters are Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), pH, Total Suspended Solids and Ammonia Nitrate.

iv. The parameters involve in in-situ measurement were Dissolved Oxygen (DO), temperature, turbidity and pH.

v. Others parameter such as Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Suspended Solids and Ammonia Nitrate will be tested in environmental laboratory, Faculty of Civil Engineering and Earth Resources.

1.5 SIGNIFICANT OF STUDY

The significant of this study are:

i. To know the status of water quality at the Tunggak River and whether it is suitable to be using or not.

ii. The sources of pollutant discharged into the river can be defined and effective precaution in managing the waste water can be defined to avoid Tunggak River from contamination.

CHAPTER 2

LITERATURE REVIEWS

2.1 INTRODUCTION

The purpose of this chapter is to provide a review of past research efforts related of this research. The reviews is based on journals, articles, and books related to poor on wastewater management in Malaysia, water quality parameters, nutrients, heavy metals, river water quality status in Malaysia, river water quality status in Malaysia, water pollutions and their sources, water quality management in river and effect of poor wastewater management practise. The review is detailed so that the present research effort can be properly modified to add to the present body of literature as well as to justify the scope and direction of the present research effort.

2.2 POOR WASTEWATER MANAGEMENT IN MALAYSIA

Wastewater is any water that has been adversely affected in quality by athropogenic influences. Based on Report of Census 2010 by the Department of Statistic, population of Malaysia is 28.3 million and with this population, wastewater that been generated by municipal and industrial sectors is 2.97 billion cubic meters per year. Wastewater in urban areas and townships must be treated before discharged into surface waters (Jamil Shaari; 2007). The quality of effluent from treatment plants is regulated by Environment Quality Act 1974 and its regulations such as the Environmental Quality (Sewerage) Regulations 2009 and Environment Quality (Industrial Effluent) Regulation 2009. Each industrial facility should review the federal, state and local regulations that apply to its specific wastewater and residual disposal procedures to ensure that all requirements are met and all options that could reduce disposal costs are used.

Industry wastewater management is where industries must utilize methods like example used for advanced treatment of sewage to purify wastewater containing pollutants such as heavy metals and toxic chemicals before it can be discharged. But some of industries in Malaysian, do not have well- management sewage treatment facilities, so this effluents from industries directly discharged in the river.

2.3 WATER QUALITY PARAMETERS

Water quality is a phrase where to define ‘good’ or ‘bad’ water quality in describing the chemical, physical and biological characteristics of water. Water quality parameter is defined by six major parameters that recommended by Department of Environment, Malaysia which consists of dissolved oxygen (DO), biochemical oxygen demand (BOD), chemical oxygen demand (COD), pH, total suspended solid (TSS) and ammonia nitrate. Plus, temperature and turbidity as minor parameters in measuring the water quality of river.

2.3.1 Dissolved Oxygen (DO)

Dissolved oxygen (DO) is the amount of molecular oxygen dissolved in water. Although oxygen is poorly soluble in water, is fundamental to aquatic ecosystem and without free DO, streams and lakes become uninhabitable to aquatic life. Dissolved oxygen is inversely proportional to temperature and maximum amount of oxygen that can be dissolved in water at 0°C is 14.6 mg/L. The saturation value decreases rapidly with increasing water temperature, as shown in Table 1.1. The DO concentration may sag caused by wastewater discharges in which given opportunity to evaluate anthropogenic effects on river water quality (Wellner ; 1989). Previous study from (Nasly M.A., 2013), average value of DO of Tunggak river was recorded 2.24 mg/L and from this research of water quality which indicated the water of the area was highly deoxygenated.

Water Temperature (°C)	Saturation concentration of oxygen in water (mg/L)
0	14.6
2	13.8
4	13.1
6	12.5
8	11.9
10	11.3
12	10.8
14	10.4
16	10.0
18	9.5

20	9.2
22	8.8
24	8.5
26	8.2
28	8.0
30	7.6

Table 1.1: Solubility of Oxygen in Water

Source: Ruth F. Weiner, 2003

2.3.2 Biochemical Oxygen Demand (BOD)

Biochemical oxygen demand is a measure of the amount of oxygen required by bacteria and other microorganisms engaged in stabilizing decomposable organic matter over a specified period of time. The higher the BOD and the oxygen demand, the higher the decomposable matter present (R.K.Kushwah *et al*; 2011).

2.3.3 Chemical Oxygen Demand (COD)

Chemical Oxygen Demand (COD) is an indicator of organics in water and usually used in conjuction with BOD. High organics always contribute to deoxygenation. According to (Bulbul Ahmed ; 2013) in research of a case study : investigate the river water quality parameters, the test of COD has been largely replaced the BOD using potassium permanganate in an acid solution which the advantages in that the results can be obtained in less than 1 hour while BOD test requires at least 5 days. COD also can be measured by dichromate reflux method because its applicability to wide variety of samples (OGU, O.G; 2014). Industry discharge especially some of industry that do not have well- management in sewage treatment facilities directly discharged in the river and this is causes of collection of toxic compounds in COD (OGWO, P.A; 2014)

2.3.4 pH

The pH of a solution is a measure of hydrogen (H^+) ion concentration, which is, in turn, a measure of acidity. pH is including the physical characteristics in measured of water quality. Pure water dissociates slightly into equal concentrations of hydrogen and hydroxyl (OH^-) ions:

$$H_2O \leftrightarrow H^+ + OH^- \qquad (2.2)$$

The measurement of pH is now almost universally done using electronic pH meters. A typical pH meter consists of a potentiometer, a glass electrode and a reference electrode (or a single, “combination” electrode), and a temperature- compensating device. The pH is important in ensuring proper chemical treatment. Aquatic organisms are sensitive to pH changes, as well as to the actual pH of the water. The normal range for pH in surface water systems is 6.5- 8.5 and if its outside normal range, it may cause a nutritional imbalance or may contribute to toxic ion which can give bad affect to aquatic life (Bolawa O.E ; 2012).

2.3.5 Total Suspended Solid (TSS)

Total suspended solid (TSS) is an indication of the amount of erosion that took place nearby or upstream. Sources of TSS in water may consist of inorganic or organic particles. The commons solids in surface water are clay, silt as inorganic solids and organic material such as plant fibers and biological solids. These materials are contributing in erosive action of water flowing over surfaces. Domestic wastewater usually contains large quantities of suspended solids that are mostly organic in nature. Industrial may result in a wide variety of suspended impurities of either organic or inorganic nature. Immiscible liquids like oils and greases are often constituents of wastewater. Poor waste disposal and industrial discharge gave huge amounts on organic and inorganic substances and this contributed to increase the TSS in the river (Bashir *et al* ; 2004).

2.3.6 Ammoniacal Nitrate

Ammonia is one of the intermediate compounds formed during biological metabolism and together with organic nitrogen, is considered an indicator of recent pollution. Aerobic decomposition of organic nitrogen and ammonia produces nitrate and finally nitrate. High nitrate concentration, therefore, may indicate that organic nitrogen pollution occurred far enough upstream that the organics have had time to oxidize completely. High levels of nitrate- nitrogen attributed with cancer and blue baby syndrome (Johns *et al* (1973).

2.3.7 Temperature

Temperature is one of the most important parameters in natural surface water systems where given attributed in control aquatic activity. The temperature of natural water system responds to temperature of the surrounding atmosphere. The use of water for dissipation of waste heat in industry and the subsequent discharge of the heated water may result in dramatic, though perhaps localized, temperature changes in receiving streams.

2.3.8 Turbidity (NTU)

Turbidity is a measure of the extent to which light is either absorbed or scattered by suspended material in water. Because absorption and scattering are influenced by both size and surface characteristics of the suspended material, turbidity is not a direct quantitative measurement of suspended solids.

2.4 NUTRIENTS

Nitrogen and phosphorus, two nutrients of primary concern, are considered pollutants when they become too much of a good thing. All living things require these nutrients for growth. Thus, they must be present in rivers and lakes to support the natural food web. Problems arise when nutrients levels become excessive and the food web is grossly disturbed, causing some organisms to proliferate at the expense of others. Excessive nutrients often lead to large growth of algae, which in turn become oxygen-demanding material when they die and settle to the bottom. Some of major sources of nutrients are phosphorus- based- detergents, fertilizers, food- processing wastes, as well as animal and human excrement.

2.4.1 Phosphate

Phosphorus appears exclusively as phosphate (PO_4^{3-}) in aquatic environments. Phosphate is a constituent of soils and is used extensively in fertilizer to replace and or supplement natural quantities on agricultural lands. Also a constituent of animal waste and may become incorporated into the soil in grazing and feeding areas. Runoff from agricultural areas is a major contributor to phosphate in surface waters. Municipal wastewater is another major source of phosphate in surface water. Other sources include industrial waste in which phosphate compounds are used for such purposes as boiler-water conditioning. Maximum limit for phosphate in water system is 0.5 mg/L. Industrial effluents the high levels of phosphate with release the wastewater to the river (OGWO, P.A; 2014). Effects from high level of phosphate in water system is lead to eutrophication problem especially during treatment as filter clogging may occur (Murray *et al*, 2000). Besides that, the growth of blue- green algae lead to release toxic substances (cyanotoxins) into the water system (Holdsworth, 1991).

2.4.2 Nitrate

Nitrate is from nitrogen gas (N_2) combined with oxygen become oxidized to nitrate (NO_3). Nitrate compounds are typically found in wastewater from pharmaceutical manufacturers. Nitrate compounds are also formed during biological nitrification. The principal concern about nitrates in wastewater is that they are a nutrient source for plants and algae. Excessive algae growth, in particular, can cause nuisance conditions in receiving waterbodies and taste and odor problems in drinking water sources. Nitrate poisoning in infant animal, including humans, can cause serious problems and even death.

2.5 HEAVY METALS

Heavy metals enter aquatic environments through discharge of industrial waste and wastewater treatment plant, storm-water runoff, mining operations, smokestack emissions, and other diffuse sources (such as from vehicles). The most commonly occurring heavy metals are arsenic, cadmium, chromium, nickel, lead, mercury and sulphate. As heavy metals persist in the environment, they tend to accumulate in soils, sediments and biota. Heavy metals can also bioaccumulate and biomagnify.

Mining operations have had a very significant impact on water quality. Acid mine drainage is formed by a series of geochemical and microbial reactions that occur when water comes in contact with the pyrite in coal or the overburden of a mine operation. The resulting water has a low pH and high concentrations of such dissolved metals as copper, lead and mercury. Acid mine drainage can result in the contamination of drinking water, destruction of ecosystem and biota, and corrosion of infrastructure such as bridges. Contact with water in the most highly polluted streams can result in skin irritations. Contaminated waters are highly coloured and can stain river structures red.

2.5.1 Cadmium

Cadmium is an element with an average distribution of 0.1 mg/ kg in the earth's crust. High concentrations are found in sulphide ores. Cadmium forms complexes with sulfur groups, e.g., thiocarbamate. The high affinity for such groups has been the basis for many analytical methods. Cadmium is usually found associated with zinc. Cadmium is widely dispersed in the environment.

2.5.2 Lead

Lead (Pb) may be released into the general environment as a result of automobiles using leaded gasoline as an antiknock agent, lead- containing paint, water due to lead solder in water pipe systems and atmospheric emissions of lead for industrial sources such as smelters. In recent years, the atmospheric releases of lead have been reduced in many countries owing to the removal of lead from gasoline and restrictions on the release of lead from point sources. According to researcher of spatial concentrations of lead and copper in bottom sediments of Langkawi Coastal area, Malaysia, they found out that leaking as well as spillage oil from these area might enhanced the Pb concentration in marine ecosystem (B.Y. Kamaruzzaman, 2011)

2.5.3 Copper

Copper is a component of several enzymes and an essential micronutrient mainly involving in electron flow and catalyzing the redox (P. Das, 1998). Copper may becomes toxic at high concentrations where cadmium has no biological function and copper is one of toxic metal that may give harm to aquatic organism (W.X. Wang, 2001).

2.5.4 Sulphate

Sulphur is a non- metallic element occurs in numerous mineral. Sulphate ion is form by combination of hexavalent sulphur and oxygen. Sulphate (SO_4) ion is a polytomic anion. Normally, sulphate occur as microscopic particles resulting from fossil fuel and biomass combustion and also from sea salt over the oceans. Industries such as mining and smelting operations and tanneries use sulphate and sulphuric acid and all this been discharged into surface water. Effect from exposed sulphate to surface water is mining or rock excavation, producing sulphuric acid, which contributes sulphate to ground and surface waters.

2.6 RIVER CLASSIFICATION IN MALAYSIA

According to Malaysia Environmental Report 2010, the Department of Environment (DOE) are responsible department in Malaysia that monitoring programme of river water quality. The objective are to detect changes in river water quality where the Water Quality Index (WQI) was used as basic for assessment of watercourse in relation to pollution load. The National Water Quality Standards for Malaysia (NWQS) also used in designation of classes of beneficial uses of river in

Malaysia. The WQI analyze trends in water quality of rivers based on Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Ammoniacal Nitrogen (NH_3─N), Total Suspended Solid (TSS) and pH. Basically, the data of river water quality will be categories and will be classified in Class I, Class II, Class III, Class IV and Class V based on WQI and NWQS. The river classification based on the DOE- WQI is given in the Table 1.2, 1.3 respectively.

PARAMETER	UNIT	CLASS				
		I	II	III	IV	V
Ammoniacal Nitrogen	mg/l	< 0.1	0.1 - 0.3	0.3 - 0.9	0.9 - 2.7	> 2.7
Biochemical Oxygen Demand	mg/l	< 1	1 - 3	3 - 6	6 - 12	> 12
Chemical Oxygen Demand	mg/l	< 10	10 - 25	25 - 50	50 - 100	> 100
Dissolved Oxygen	mg/l	> 7	5 - 7	3 - 5	1 - 3	< 1
pH	-	> 7	6 - 7	5 - 6	< 5	> 5
Total Suspended Solid	mg/l	< 25	25 - 50	50 - 150	150 - 300	> 300
Water Quality Index (WQI)	-	< 92.7	76.5 - 92.7	51.9 - 76.5	31.0 - 51.9	> 31.0

Table 1.2 The DOE water Quality Index Classification (DOE, 2010)

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

Table 1.3 DOE Water Quality Classification Based On Water Quality Index (DOE, 2010)

2.7 RIVER WATER QUALITY STATUS IN MALAYSIA

According to DOE where in 2010, out of 1055 monitoring stations in 570 rivers, 527 (50%) were found to be clean, 417 (40%) slightly polluted and 111 (10%) polluted. In 2009, the number of clean rivers decreased from 306 to 293, slightly polluted rivers decreased from 217 to 213 while increasing number on polluted rivers from 54 to 74. This happened based on industries discharge which contributed to high pollution loading. In previous years, the major pollutants detected were BOD, NH_3─N and TSS. The high BOD can be attributed to untreated sewage and discharges from agro- based and manufacturing industries.

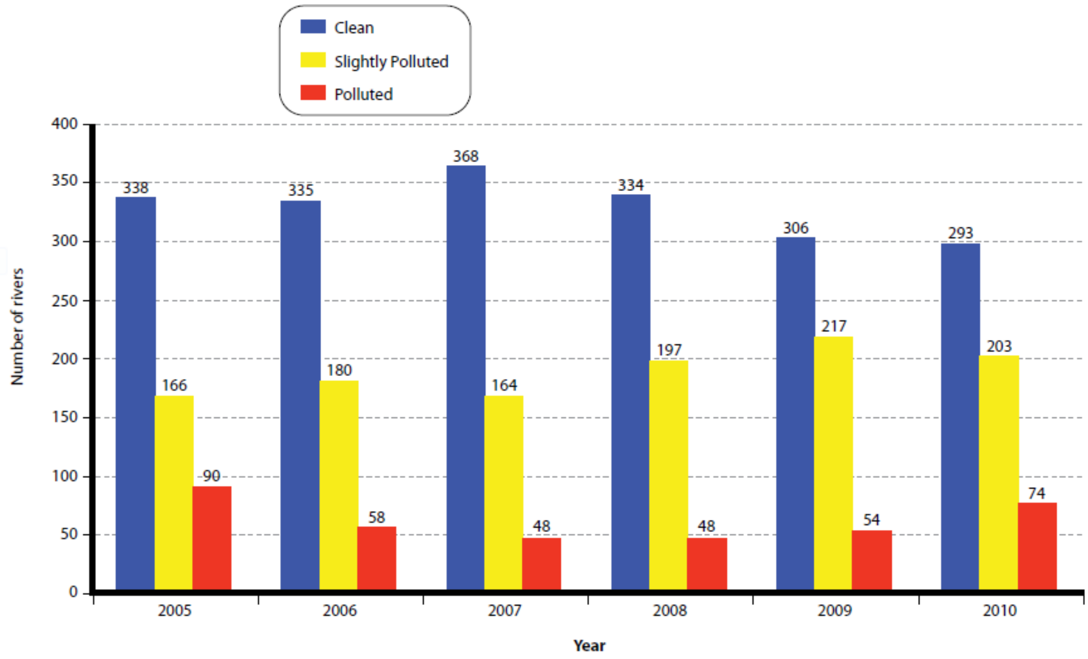


Figure 2.1 Malaysia River Water Quality Trend (DOE 2010)

2.8 WATER POLLUTIONS AND THEIR SOURCES

2.8.1 Point Sources

Domestic sewage and industrial wastes act as point sources because they are generally collected by a network of pipes or channels and conveyed to a single point of discharge into the receiving water. Domestic sewage consists of wastes from homes, schools, office buildings and stores. The term municipal sewage includes domestic sewage along with any industrial wastes that are permitted to be discharged into the sanitary sewers.

2.8.2 Nonpoint Sources

Urban and agricultural runoff are characterized by multiple discharge points and are called nonpoint sources. Often the polluted water flows over the surface of the land or along natural drainage channels to the nearest water body. Even when urban or agricultural runoff waters are collected in pipes or channels, they are generally transported the shortest possible distance for discharge, so that treatment at each outlet is economically feasible. Much of nonpoint source pollution occurs during rainstorms or spring snowmelt, resulting in large flow rates that makes treatment even more difficult. Reduction of agricultural nonpoint source pollution generally requires changes in land use practices and improved education. Urban storm water runoff (including that from streets, parking lots, golf courses, and lawns) can transport pollutants such as nitrogen and phosphorus from fertilizers, herbicides applied to lawns and golf courses, oil, greases, ethylene glycol (used in antifreeze), and cut grass and other organic debris.

2.9 WATER QUALITY MANAGEMENT IN RIVERS

Purpose of water quality management is to control the discharge of pollutants so that water quality is not degraded to an unacceptable extent below the natural background level. The effect of pollution on a river depends both on the nature of the pollutant and the unique characteristics of the individual river. Some of the most important characteristics include the volume and speed of water flowing in the river, the river depth, the type of bottom, and the surrounding vegetation. Other factors include the climate of the region, the mineral heritage of the watershed, land use patterns, and the types of aquatic life in the river.

Water quality management for a particular river must consider all these factors. Some rivers are highly susceptible to pollutants such as sediment, salt, and heat, whereas others can tolerate large inputs of these pollutions without much damage.

2.10 EFFECT OF POOR WASTEWATER MANAGEMENT PRACTISE

Poor on wastewater management practise give contributed in river pollution. This pollution give effect on both environment and human health and serious action must be taken to prevent more serious consequences happened. Among effects of poor wastewater management practise is ecosystem, drinking water, health and economy.

2.10.1 Ecosystems

Poor on wastewater management practise by industrial instant effect on aquatic life. It does not always cause fish death but also the habitat of aquatic life in severely polluted are unsuitable for human consumption. In long term effect, it can disrupt the natural balances between the living thing that live in rivers can seriously affect a number of wildlife species which are directly dependent on the rivers. This also lead to loss of biodiversity and even some species might disappearance from particular areas which can seriously disturb the ecosystem which affects human too because as a part of the ecosystem.

2.10.2 Drinking Water

River are important source of water supply drinking water to human. Water shortage will be happened if river too polluted effect by wastes discharged by industrial without untreated.

2.10.3 Health

Untreated wastes from nonpoint sources of point sources might threatens human health both directly and indirectly. Skin contact with polluted water may cause a skin reaction in the form of rashes, swallowing even the tiniest amount of polluted water likes during sport activities can lead to serious illness. Fish from polluted rivers can cause a number of health problems with severe consequences.

2.10.4 Economy

Even it is often considered as unavailable side effect of economic growth, the effects can seriously decrease hamper economic growth of areas especially those depend on tourism and fishing.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 INTRODUCTION

In this chapter can be explained as well planning for a research from the beginning until the end of the research. This stage is important because the method will affects the results once the data was obtained. Knowing how the data was collected helps the researchers to evaluate the validity and reliability of the results. The methodology adapted in this research was based on theoretical and analysis of the method applied in this field of study. Thus, the methodology will be focus on investigate the status of water quality based on six parameters, selection of sampling locations, methods and defined the sources of pollutant discharge along the research to achieve the objectives. The methodology structure for this research had been modified and design according to the current condition of Tunggak River. The summary of the research methodology is shown schematically in figure 3.2.

3.2 THE STUDY AREA

The study area for this research is at Tunggak River where Tunggak River is a stream in region of Pahang Malaysia. This river has an average elevation of 6 meter above the sea level. The coordinate of Tunggak River is 3°57’0” North and 103°22’1” East in DMS (Degrees Minutes Seconds) or 3.95and 103.367 in decimal degree. This river originated at the uphill of Gebeng area where the coordinate of Gebeng area is 3°55'0"N to 4°01'0"N and 103°22'0"E to 103°22'0"E. Plus, Tunggak river is joined with another river called Balok river and ultimately flow into South China Sea. The importance of Tunggak river to human and nature is the consideration of the chosen study area for this research. Plus, the location of Tunggak river that surrounded with industrial area which consider as the discharge place for wastewater. The figure 3.1 shows the map of Tunggak River.

Figure 3.1 The map of study area

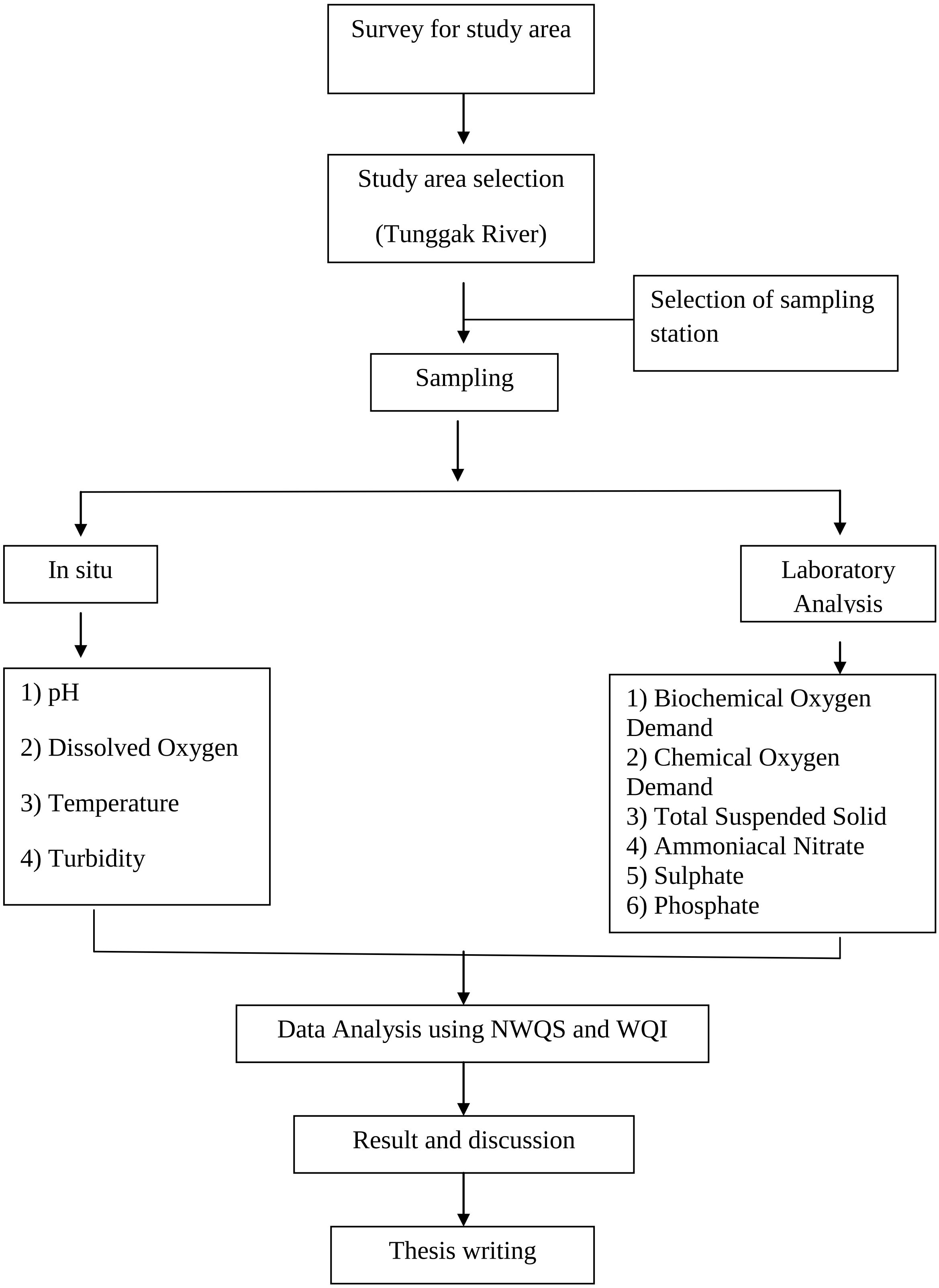


Figure 3.2 : Flowchart of research

3.3 SAMPLING

The sampling for this research is collecting the water sample at 3 different locations at Tunggak River. The location of selected stations is based on point sources of pollution, land use-pattern and river network. First station will be located near wooden industry, second station near the residential area and third station is the water river sample at near residential and retrieved from fishing location. Water sample will be collected in February and March respectively once. To achieve the objectives, each of the experiment or test will be conducted in two duplicate and the average will be taken after all the result will be analysis or be calculated.

3.4 IN- SITU PARAMETER

Parameters involve in-situ is pH, DO, temperature, turbidity and electrical conductivity (EC). Data of the parameters will be recorded during the sampling. The equipment will be involved in- situ parameters are YSI. YSI equipment will be brought at three selected station and normally directly the result can be obtain.

3.5 LABORATORY ANALYSIS

Others parameters such as biochemical oxygen demand, chemical oxygen demand, total suspended solid and ammonia nitrate will be conducted at the lab with all apparatus, equipment and reagent is prepared at environment laboratory, Faculty of Civil Engineering and Earth Resources, UMP.

3.5.1 BOD Parameter

Instruments that be used in this test are BOD bottles and BOD incubator like shown in Appendices E. The method of this test is APHA 5210B. The standard of BOD test, a 300 ml BOD bottle is used and the sample is incubated at 20 °C for 5 days. Light must be excluded from the incubator to prevent algal growth that may produce oxygen in the bottle. The BOD of a diluted sample is calculated by :

$$BOD = \frac{DO_I - DO_F}{P} \quad (3.1)$$

Where DO_I and DO_F is initial and final dissolved oxygen concentrations (mg/L) and P is the decimal fraction of the sample in the 300 mL bottle.

3.5.2 COD Parameter

Instruments that be used in this test is COD digestion vials and COD reactor like shown in Appendices E. Reactor Digestion Method (HACH Method 430, ULR) are used. The standard COD test uses a mixture of potassium dichromate and sulphuric acid to oxidize the organic matter (HCOH), with silver (Ag^+) added as a catalyst.

3.5.3 TSS Parameter

TSS using standard method and the instruments involve is analytical balance, glassware and thermo oven like shown in Appendices E. The standard test is filtering the water sample, drying the residue and filter to a constant weight at 104 °C. The calculation involved in this test are:

$$TSS = \frac{A-B}{C} \quad (3.2)$$

Where A = Total solids after dried 104 °C

B = Suspended solids content of water sample

C = volume of water sample

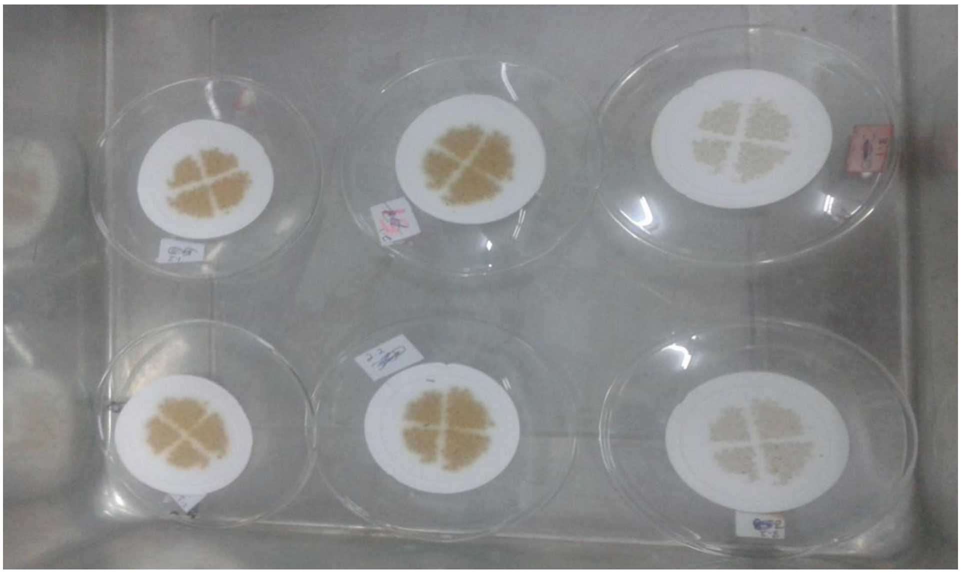


Figure 3.2: Total Suspended Solids

3.5.4 Ammoniacal Nitrate Parameter

The method that be used are Nessler Method with HACH method 380. Spectrophotometer are instruments to indicator the value of ammoniacal nitrate on the water samples.

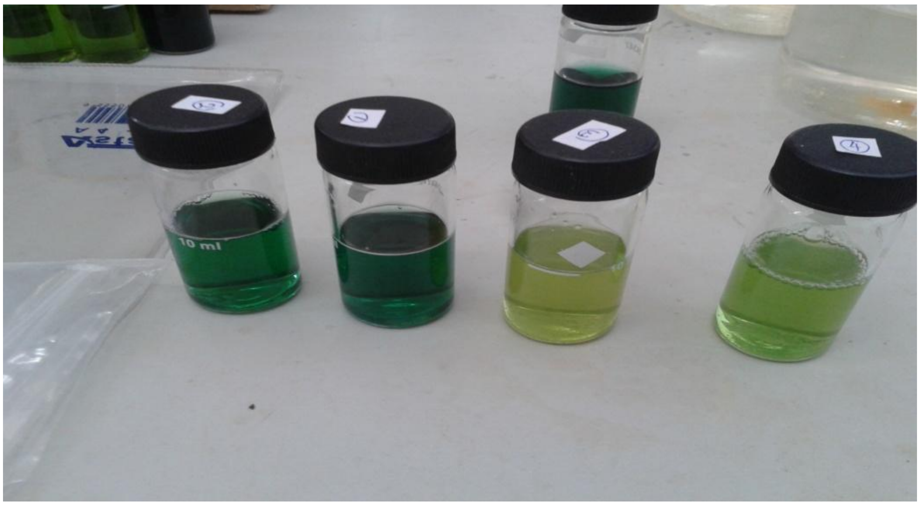


Figure 3.4: Ammoniacal Nitrate

3.5.5 Phosphate Parameter

The method that be used are ascorbic acid method and spectrophotometer are the instruments that indicator phosphate value on the water samples.

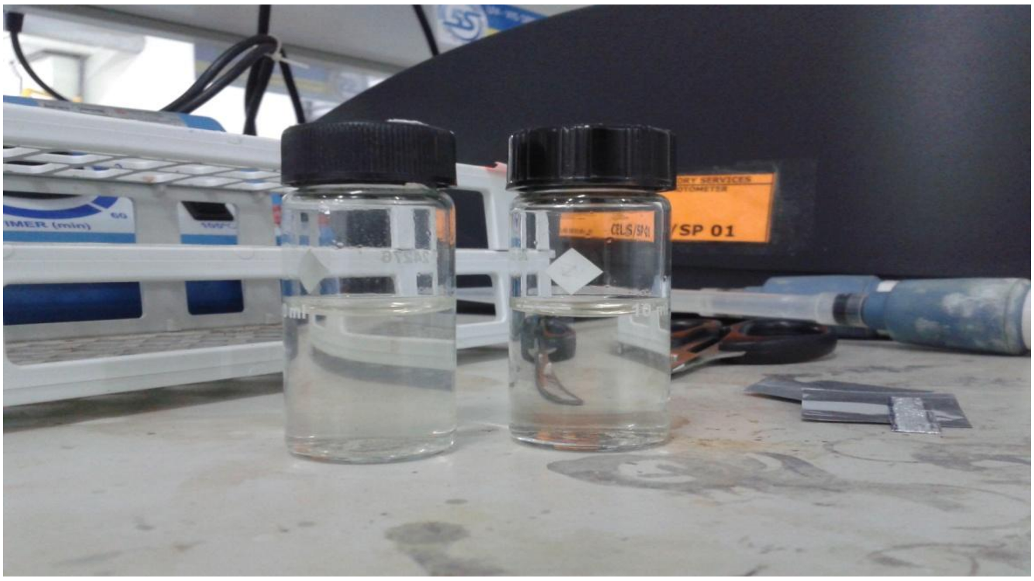


Figure 3.5: Phosphate Parameter

3.5.6 Sulphate Parameter

The method that be used for indicator sulphate value are sulfaver 4 with HACH Method 680 and using spectrophotometer as the instruments.

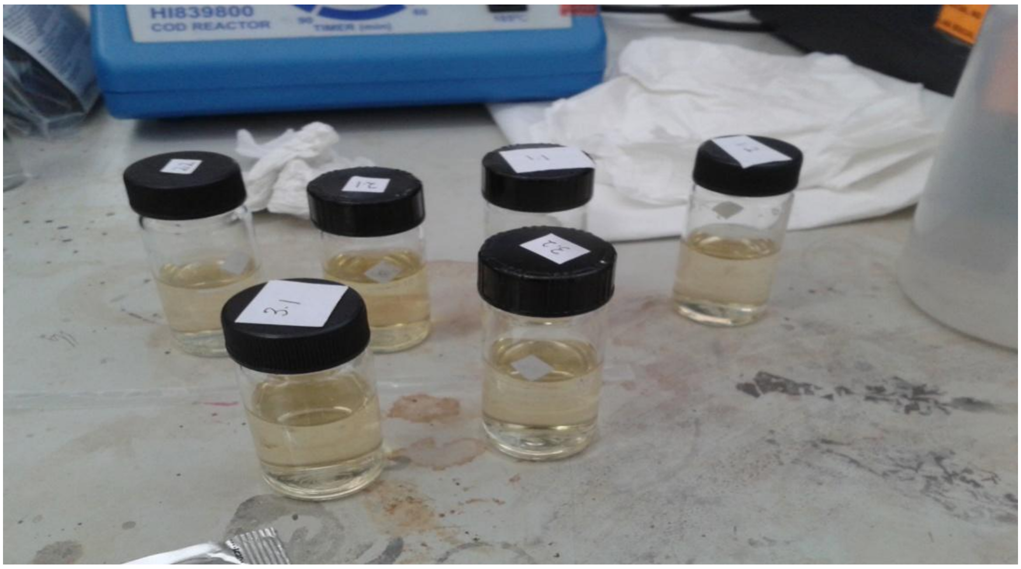


Figure 3.6: Sulphate Parameter

3.5.7 Heavy Metal test

Instrument involved in this test are atomic absorption spectrometer and method that will be used is APHA 3110. The standard test for heavy metal is in flame atomic absorption (AA) a solution of lanthanum chloride are added to the sample, and that sample are sprayed into a flame using an atomizer. Each metallic element in the sample imparts a characteristic color to the flame, whose intensity is then measured spectrophotometrically.

3.5.8 Water Quality Index

In order to achieve the objectives, the data or the result for each test will be analysis or calculated follow the standard of Department of Environment (DOE) where the formula for water quality index for the river are:

WQI = (0.22* SlDO) + (0.19*SIBOD) + (0.16*SICOD) + (0.15*SIAN) + (0.16 * SISS) + (0.12 * SipH) (3.3)

Where :

SIDO = Sub lndex DO (% saturation)
SIBOD = Sub lndex BOD
SICOD = Sub lndex COD
SIAN = Sub lndex NH_3-N
SISS = Sub lndex SS
SipH = Sub lndex pH
$0 \le WQI \le 100$

Sub lndex for DO (In % saturatlon)	
SIDO = 0	for x ≤8
SIDO = 100	for x ≤92
SIDO = -0.395 + 0.030x^2 - 0.00020x^3	for 8 < x < 92
Sublndex for BOD	
SIDOD = 100.4 - 4.23x	for x ≤ 5
SIDOD = 108* exp(-0.055x) - 0.1x	for x > 5
Sublndex for COD	
SICOD = -1.33x + 99.1	for x ≤ 20
SICOD = 103* exp(-0.0157x) - 0.04x	for x > 20

Sublndex for NH3-N	
SIAN = 100.5 - 105x	for $x \leq 0.3$
SIAN = 94* exp(-0.573x) - 5* I x - 2 I	for $0.3 < x < 4$
SIAN = 0	for $x \geq 4$
Sublndex for SS	
SISS = 97.5* exp(-0.00676x) + 0.05x	for $x \leq 100$
SISS = 71* exp(-0.0061x) + 0.015x	for $100 < x < 1000$
SISS = 0	for $x \geq 1000$
Sublndex for pH	
SlpH = 17.02 - 17.2x + $5.02x^2$	for $x < 5.5$
SlpH = -242 + 95.5x - $6.67x^2$	for $5.5 \leq x < 7$
SlpH = -181 + 82.4x - $6.05x^2$	for $7 \leq x < 8.75$
SlpH = 536 - 77.0x + $2.76x^2$	for $x \geq 8.75$

Note: *means multiply with

Table 3.1: Calculation of Sub Index Properties for Each Parameter (DOE, 2010)

Each parameters of water quality index have their own calculation and plug in all into the formula of WQI to obtain the data of river water quality. The data analysis will be obtains the classification of the water river quality based on NWQS as shown in Appendices A where this standard has been standardization for Malaysian standard river water quality. The water classes and uses are shown in Appendices B.

3.6 DATA ANALYSIS

The results on Appendices F are tabulated in Microsoft Excel where be used for standard aviation and average.

CHAPTER 4

RESULTS & DISCUSSIONS

4.1 INTRODUCTION

The results of this water quality are accordance to the Water Quality Index which involved the six parameters which were Dissolved Oxygen, Biochemical Oxygen Demand, Chemical Oxygen Demand, Total Suspended Solids, pH and Ammoniacal nitrogen. Included others parameter result such as turbidity, sulphate and five of heavy metals (Cu, Fe, Zn, Cd and Pb). These results were presented in graphical and table form to show cleared results of parameters in accordance to achieve the objectives of this research. The results explained on how the adverse effect of poor waste water management been practises by industry were influenced the water quality of Tunggak River.

4.2 WATER QUALITY PARAMETERS ANALYSIS

The analysis results for the water samples of the Tunggak River included Dissolved Oxygen, Biochemical Oxygen Demand, Chemical Oxygen, Total Suspended Solids, pH and Ammonia Nitrate. These parameters are important in determined effect of water quality of the river (Liza Evianti Tanjung, 2013). Both in situ and laboratory testing were conducted in order to obtain the objectives. Also these analysis included turbidity, sulphate and phosphate.

4.2.1 Dissolved Oxygen (DO)

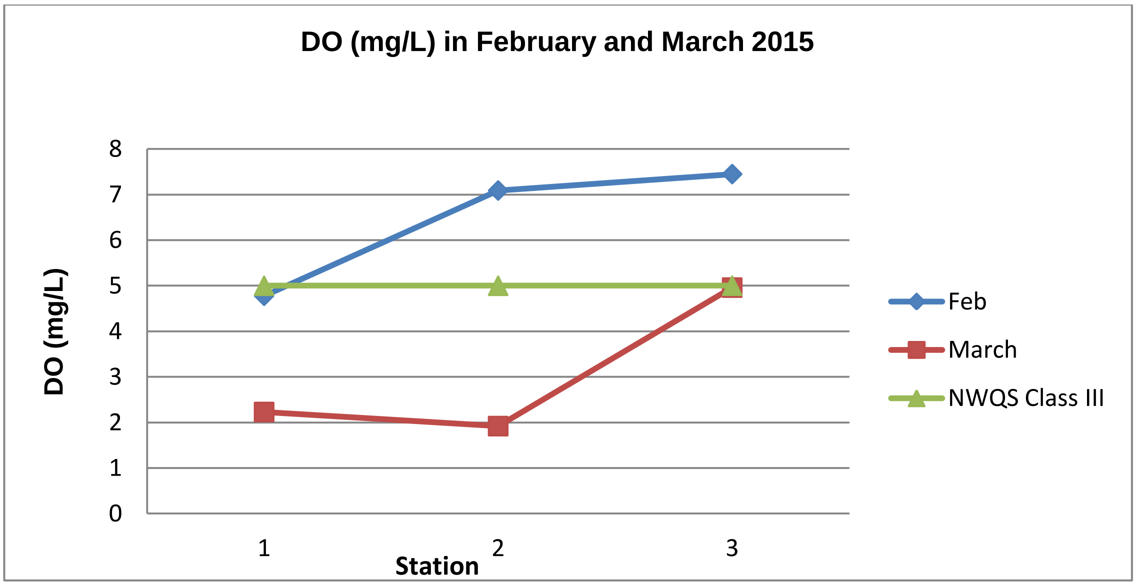


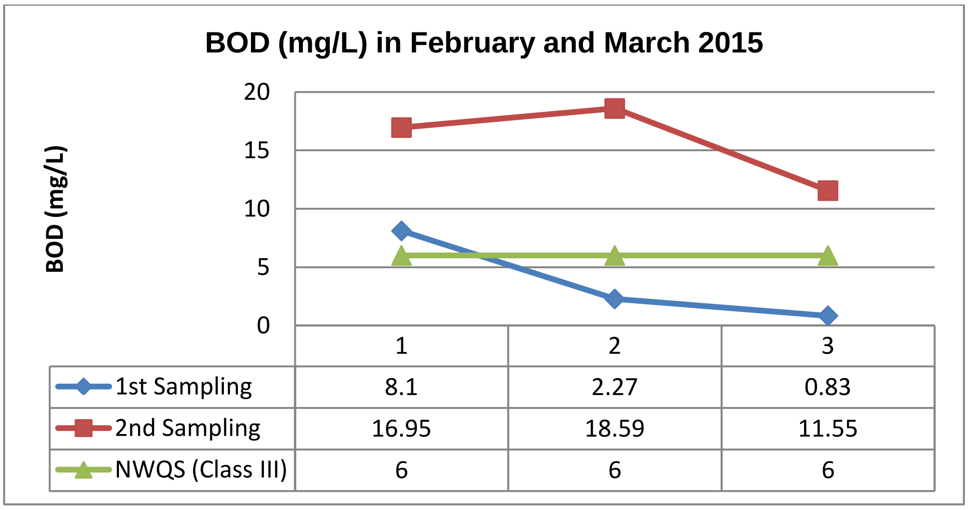
Figure 4.1: DO Concentration in the Tunggak River on February and March 2015

Figure 4.1 showed the concentration of DO at each sampling on February and March. The DO concentration on February showed more increased compare on March sampling. This may due to factor of rainy seasons made concentration of DO on February tent to be higher. Compared with the class III standard the National Water Quality Standard for Malaysian river were the range was 3-5 mg/L, sampling on

February showed exceed the standard except for station 1. The DO on station 1 was 4.78 mg/L and it ranged in Class III. While the concentration of station 2 was 7.09 mg/L and station 3 were 7.45 mg/L. These two station in the range of class I. The DO concentration for three stations on March showed decrease compare to last month. 2.33 mg/L was the concentration of DO for station 1. Station 2 and station 3 were recorded the concentration with 1.92 mg/L and 4.96 mg/L respectively. Station 1and 2 was in range class IV which in irrigation status. While for station 3 was in range of class III.

High concentration of DO is important to maintain higher life forms. Fish and other aquatic animal species require oxygen and a stream must have a minimum 2 mg/L of dissolved oxygen. At least 4 mg/L of dissolved oxygen is required for game fish and some species may require more. Below that standard Class IV which 3 mg/L may contribute to hardly survive of some fish species. Besides of maintaining life- sustaining aspect, oxygen is important because the end products of chemical and biochemical reactions in anaerobic systems often produce aesthetically displeasing colors, tastes and odors in water.

4.2.2 Biochemical Oxygen Demand (BOD)



	1	2	3
1st Sampling	8.1	2.27	0.83
2nd Sampling	16.95	18.59	11.55
NWQS (Class III)	6	6	6

Figure 4.2: The Average Concentration of BOD at 3 station

Based on figure 4.2, it is found that the BOD concentration on 2nd sampling was higher compare to 1st sampling. Station 1 shown increasing in concentration of BOD from 8.1 mg/L to 16.95 mg/L. Meanwhile, station 2 on 2nd sampling showed higher concentration compare to all the stations with 18.59 mg/L. This is due to less rain on March, decreasing in concentration of DO, therefore lead to increasing in BOD concentration. Station 3 was recorded with lowest concentration on both sampling with 0.83 mg/L on 1st sampling and 11.55 mg/L on 2nd sampling. All the concentration for 3 stations on 2nd sampling was exceed with the standard of Class III but on 1st sampling, only station 2 and station 3 are below with the standard of INWQS.

The concentration of BOD above 6 mg/L indicated as polluted. BOD values indicate a possible of organic polluted effect the river (A. H. M. J. Alobaidy *et al*, 2010). BOD directly affected by amount of dissolved oxygen in the river. The lower the concentration of DO, the higher the concentration of BOD. This means less oxygen is available to higher forms of aquatic life.

4.2.3 Chemical Oxygen Demand (COD)

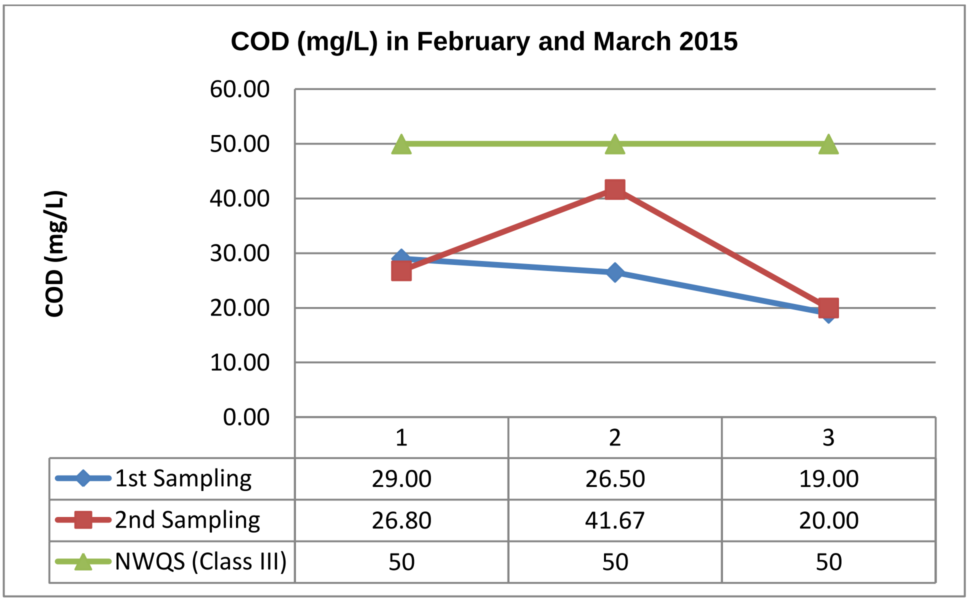


Figure 4.3: The Average Concentration of COD at 3 sampling stations

From figure 4.3, the concentration of COD showed decreasing at station 1 which on 1st sampling was recorded as 29.00 mg/L and 2nd sampling was 26.80 mg/L while the concentration of station 2 and 3 increased between 1st sampling and 2nd sampling. Concentration of COD of station 2 was 26.50 mg/L on 1st sampling and increasing until 41.67 mg/L. Station 3 was recorded 19.00 mg/L for 1st sampling and it increased 1 mg/L on 2nd sampling. Based on the standard class III on NWQS, all the station on 1st and 2nd sampling were not exceed the limit standard.

There are correlation between DO, BOD and COD. Usually COD is more greater than BOD for any given sample and is typically less than 20 mg/L in unpolluted waters. Human activities at industrial and residential area contributed the higher concentration of COD. Residual food waste and wood pulping waste is one of an example that which compounds such as cellulose are easily oxidized chemically and this lead to higher in concentration.

4.2.4 Total Suspended Solids (TSS)

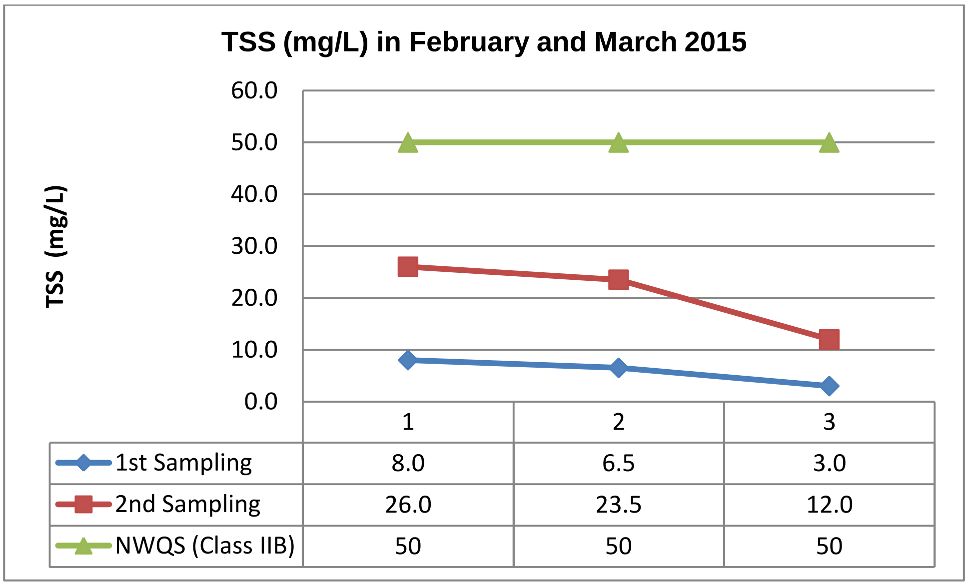


Figure 4.4: The Average Concentration of TSS at 3 sampling stations

Based on the graph, it shown the value of total suspended solids on 2nd sampling was higher compare to 1st sampling. Station 1 was recorded as the higher value on 1st and 2nd sampling with 8.0 mg/L and 26.0 mg/L respectively. Meanwhile, station 2 shown increased in value of TSS from 6.5 mg/L to 23.5 mg/L and station 3 also shown increased from 3.0 mg/L to 12.0 mg/L. All the value of three stations on both sampling was not exceed the standard Class IIB of INWQS.

According to Department of Health, high concentrations of total suspended solids can lower the water quality by absorbing light. Waters will become warmer and the ability of the water to hold oxygen for aquatic life became less. Industrial and wastewater from household discharged are one of the lead to total suspended solids came from. Since station 1 and station 2 are located near with wooden industry and residential area that lead to the higher value of TSS on that station.

4.2.5 Ammoniacal Nitrogen (AN)

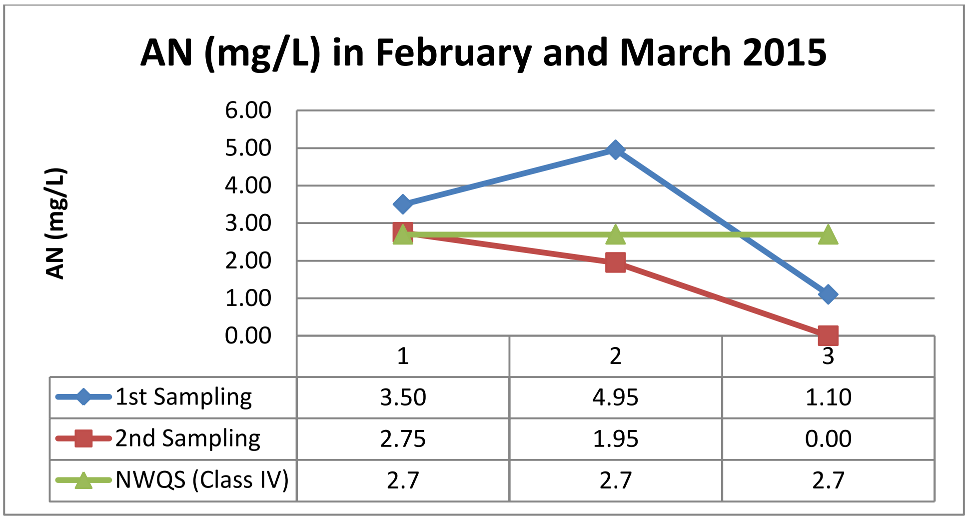
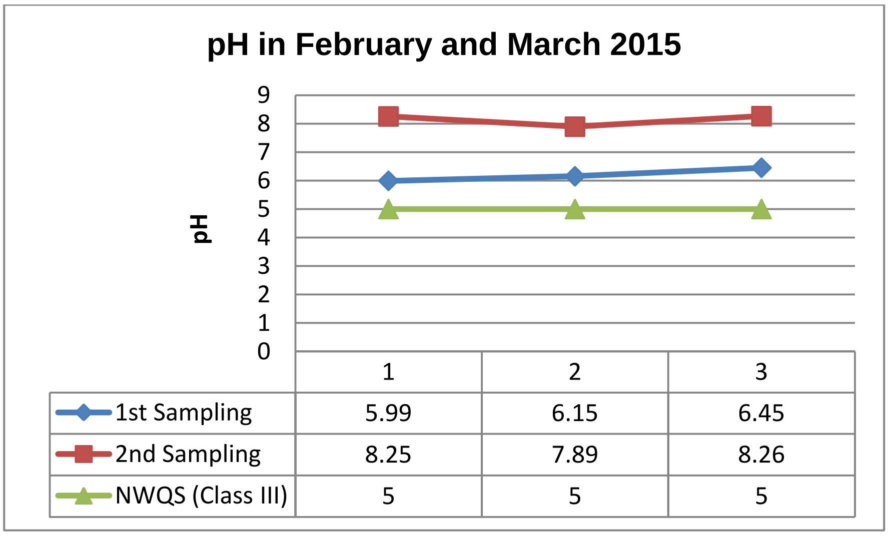


Figure 4.5: The average Concentration Ammoniacal Nitrogen value at for 3 sampling stations

Figure 4.5 showed the average concentration of Ammoniacal Nitrogen for three stations along the Tunggak River. The value showed that 1st sampling was higher compare to the concentration of 2nd sampling. Station 1 and 2 was recorded as 3.50 mg/L and 4.95 mg/L respectively. This values are exceed with the Class IV of INWQS occurred at Station 1 and 2 of Tunggak river due to its located near with industrial and human activities. On 2nd sampling, all three stations was recorded decreasing in ammoniacal nitrogen which the value 2.75 mg/L for station 1, 1.95 mg/L for station 2 and station 3 recorded with 0.00 mg/L.

One of the factors that influence the concentration of ammoniacal nitrogen in the river was due to industrial and human activities. Stations that vicinity the wooden industry and residential area like station 1 and station 2 was received most of their effluents. This is due to the production of the wasted from factory and production of household cleaners lead to ammoniacal nitrogen processes. The increasing the ammoniacal nitrogen may harm the aquatic life because fish may suffer a loss of equilibrium, increase activity and oxygen uptake and increased heart rate.

4.2.6 pH



	1	2	3
1st Sampling	5.99	6.15	6.45
2nd Sampling	8.25	7.89	8.26
NWQS (Class III)	5	5	5

Figure 4.6: The Average Value of pH at 3 stations

The range of pH of all stations shown increasing between 1st sampling and 2nd sampling. From the graph, average value results for station 1 on 1st sampling was indicates much acidic with 5.99 because this might be due to its located exactly after the wooden industry, whereby the direct discharged of wastewater to the Tunggak river has affected the pH value.

The average for station 2 and station 3 on 1st sampling was recorded 6.15 and 6.45 respectively, nearly neutral but less than 7 and this station also indicates the water in acidic condition. Meanwhile, all station on 2nd sampling was recorded 8.25, 7.89 and 8.26 for station 1,2 and 3 respectively. All values are in range of standard Class III which in 5-9 pH and also indicates as alkaline.

4.2.7 Turbidity (NTU)

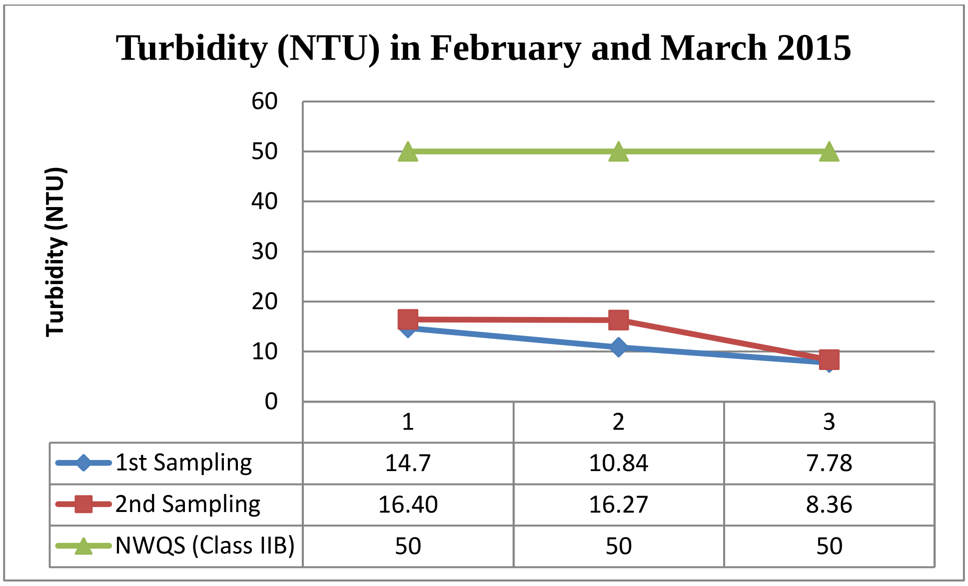
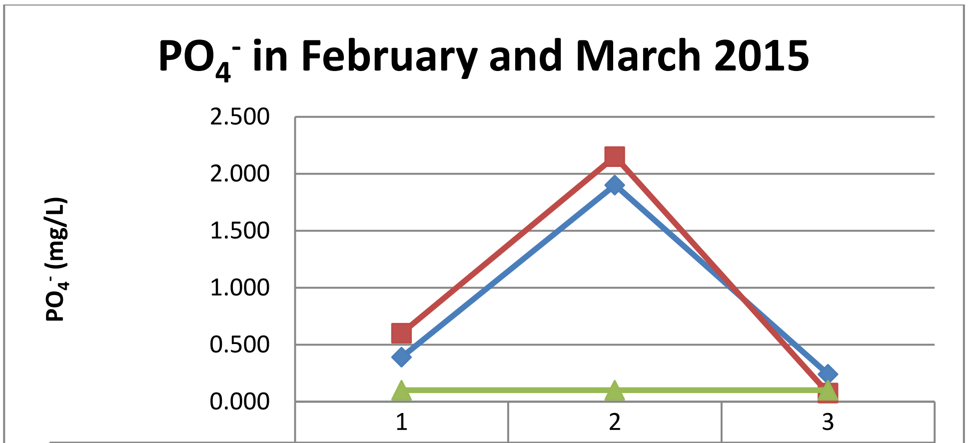


Figure 4.7: The Average Value of Turbidity at 3 sampling stations

From the graph, average value of turbidity for all station on 2nd sampling was higher than average value for all station on 1st sampling. Station 1 was recorded increasing in the value of turbidity from 14.70 NTU to 16.40 NTU on 2nd sampling. Station 2 and station 3 also shown increasing in the average value of turbidity which from 10.84 NTU to 16.27 NTU and from 7.78 NTU to 8.36 NTU respectively. The values for all station are in below range of standard IIB which in 50 NTU.

Turbidity has correlation with total suspended solids. The higher the value of turbidity, the higher the value of total suspended solids. This correlation related because turbidity is caused particles suspended or dissolved in water that scatter light making the water appear cloudy. Industrial and household discharge is one of the caused that lead to particles suspended.

4.2.8 Phosphate (PO_4^{3-})



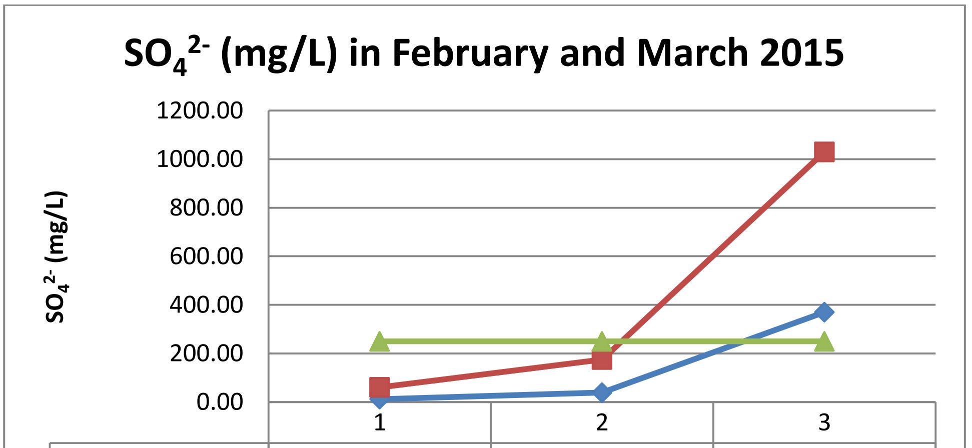
	1	2	3
1st Sampling	0.390	1.900	0.240
2nd Sampling	0.600	2.150	0.075
NWQS (Class III)	0.1	0.1	0.1

Figure 4.8: The Average Concentration of Phosphate at 3 stations

From the figure 4.8, station 2 on both sampling shown the higher concentration of phosphate compare to among 2 others station with 1.9 mg/L for 1st sampling and 2.15 mg/L for 2nd sampling. Meanwhile for station 1 was recorded with 0.39 mg/L on 1st sampling the concentration increased to 0.6 mg/L on 2nd sampling. Station 3 recorded as the lowest value of phosphate with 0.24 mg/L and this concentration decreased to 0.075 mg/L on 2nd sampling. The concentration of phosphate for 1st sampling are exceed the standard Class III of INWQS and for 2nd sampling, only station 3 was not exceed the standard.

Among causes of phosphates enters to the river is from human waste, laundry, cleaning and industrial effluents. Too high in concentration of phosphate can give bad impact to environment where this condition which eutrophication will occur and the rapid growth of aquatic vegetation eventually dies and as it decays it uses up oxygen. This process in turn causes the death of aquatic life because of the lowering of DO levels.

4.2.9 Sulphate (SO_4^{2-})



	1	2	3
1st Sampling	12.00	38.50	370.00
2nd Sampling	60.33	175.00	1030.00
NWQS (IIB)	250	250	250

Figure 4.9: The Average Concentration of Sulphate at 3 stations

Based on the graph, it shown the average value of sulphate increased between 1st sampling and 2nd sampling. Station 3 was recorded with highest value with 370 mg/L on 1st sampling and 1030 mg/L for 2nd sampling also the sulphate value for this station are exceed with the standard Class IIB of INWQS . Meanwhile, the lowest value was recorded at station 1 with 12 mg/L on 1st sampling and 60.33 mg/L on 2nd sampling and sulphate value at station 2 was 38.50 mg/L and it increased to 175 mg/L on 2nd sampling. These stations are not exceeding the standard Class IIB.

According to previous research, station that located near sea and this station received sea water lead to the higher level of SO_4. Since stations 3 located at near the South China Sea so that the reason why the station 3 was recorded with higher level of SO_4. Some of the major sources of sulphate in rivers are rock weathering, volcanoes and human activities such as mining, waste discharge, and fossil fuel combustion process (Fawaz Al-Badaii; *2013*).

4.3 HEAVY METALS CONCENTRATION IN WATER OF THE TUNGGAK RIVER

Table 4.1: The Average Concentration of Selected Heavy Metals

Station	Statistical Tools	Copper	Iron	Lead	Cadmium	Zinc
				ppm		
1	Average	0.0180	0.6903	0.1365	0.0293	0.0703
2	Average	0.0198	0.7403	0.1645	0.0438	0.054
3	Average	0.0503	0.7013	0.1100	0.1513	0.0768

The result of average concentrations of 5 heavy metals (Cu, Fe, Pb, Cd and Zn) in station 1, 2 and 3 along the Tunggak River on 1st sampling and 2nd sampling are reported in Table 4.1. The highest average copper concentration of 0.0503 ppm was recorded at station 3, followed by station 2 at 0.0198 ppm and lowest at station 1 with concentration of 0.0180 ppm. Meanwhile, the other heavy metals such as Fe and Pb concentrations in water samples of station 2 were the highest compared to station 1 and station 3 with 0.7403 ppm and 0.1645 ppm for each heavy metal. Station 1 was recorded with the lowest concentrations among the station 2 and station 3 with 0.0293 ppm in cadmium and station 2 was recorded with the lowest concentrations with 0.054 ppm in zinc.

In this study, the average values of copper on 1st sampling points of the Tunggak river were not within the INWQS for Class IIB except station 3 as shown in figure 4.9 with the value concentration of station 1, 2 and 3 was 0.0195 ppm, 0.0130 ppm and 0.0245 ppm respectively. Meanwhile, the amount of Cu on 2nd sampling changing decreased at station 1 to 0.0165 ppm while station 2 shown increasing to 0.0265 ppm and station 3 with highest value 0.076 ppm.

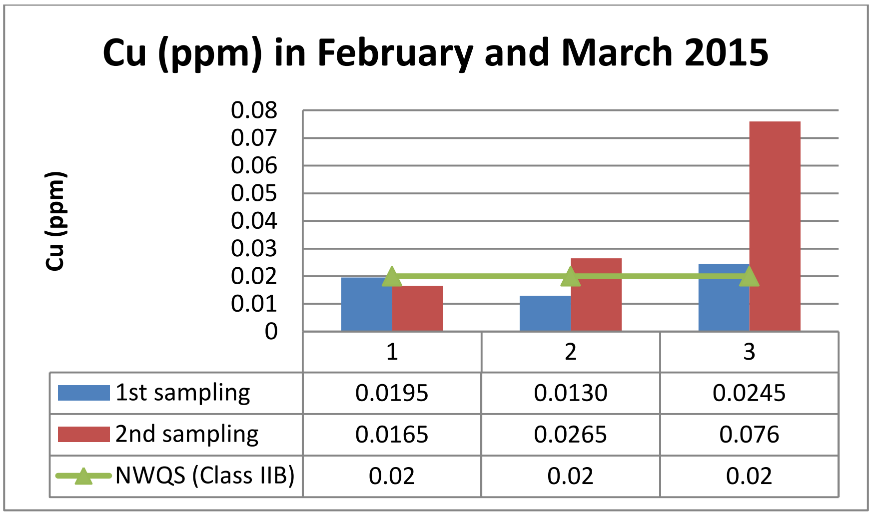
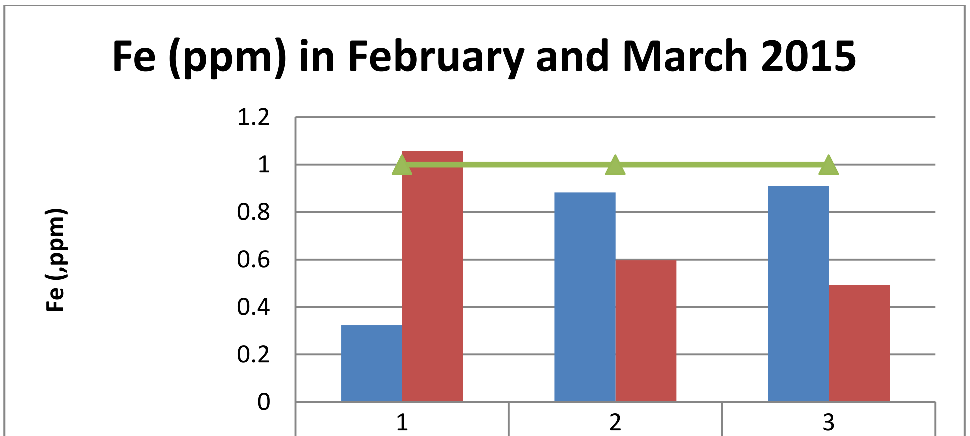


Figure 4.10: The average Concentration of Copper at 3 stations

In this study, presence of iron in the Tunggak River for station 1, 2 and 3 were detected at each station in a month each of the sampling duration as shown in figure 4.10. Station 1 showed increasing in concentration of iron from 0.3225 ppm to 1.058 ppm. Meanwhile, concentration for station 2 and station 3 was recorded decreasing from 0.883 ppm to 0.5975 ppm and 0.909 ppm to 0.4935 ppm respectively. The average of iron concentration for all stations in both sampling were not within the INWQS for Class III except for station 1 on 2nd sampling. The discharged from industries and household into the Tunggak river accelerate the concentration of iron (Mohammad Zakarul Islam; 2010).



	1	2	3
1st sampling	0.3225	0.883	0.909
2nd sampling	1.058	0.5975	0.4935
NWQS (Class III)	1	1	1

Figure 4.11: The average Concentration of Iron at 3 stations

Figure 4.11 shown, the presence of zinc in water samples of the Tunggak River for station 1, 2 and 3 were detected on 1st and 2nd sampling taken. Generally, zinc concentration in all station between 1st sampling and 2nd sampling are increased. Station 1 was recorded 0.0665 ppm and increased to 0.074 ppm on 2nd sampling. Station 2 and station 3 shown same increasing with 0.019 ppm to 0.089 ppm and 0.049 ppm to 0.1045 ppm respectively. the average concentration for three stations on both sampling were not within the INWQS for Class III. From this figure, it can be conducted that the

Tunggak River is safe for water supply to consumer and industrial uses after proper treatment.

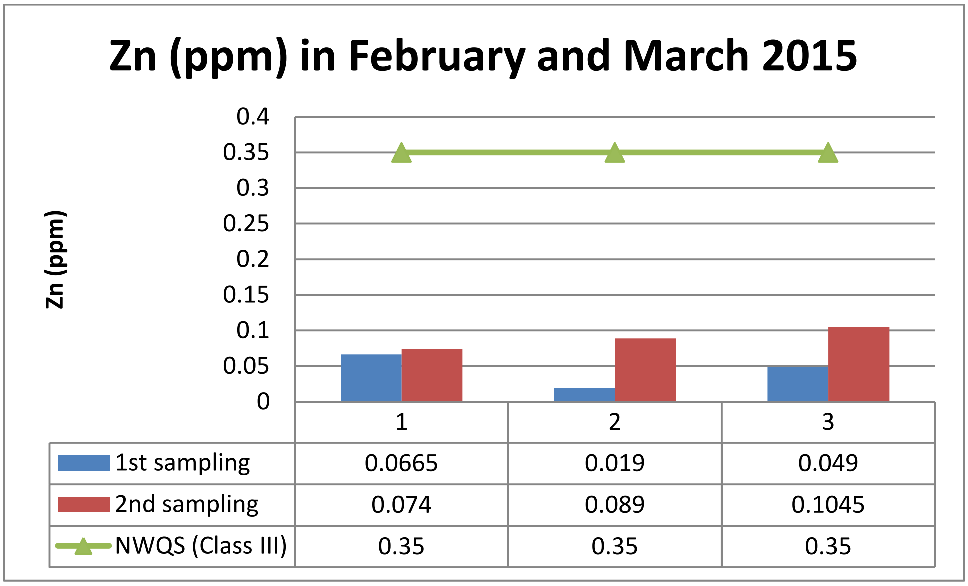


Figure 4.12: The average Concentration of Zinc at 3 stations

In this study, presence of Cd in the Tunggak River for station 1, 2 and 3 on 1st samping and 2nd sampling were detected at concentration as shown in figure 4.12. Based on INWQS for Class III which is 0.01 ppm, the average values of Cd for station 1, 2 and 3 of the Tunggak River are exceeded the Class III for INWQS. The high levels of Cd concentration in the Tunggak River can be toxicity to human otherwise a proper treatment to the Tunggak River to less considered for human exposure.

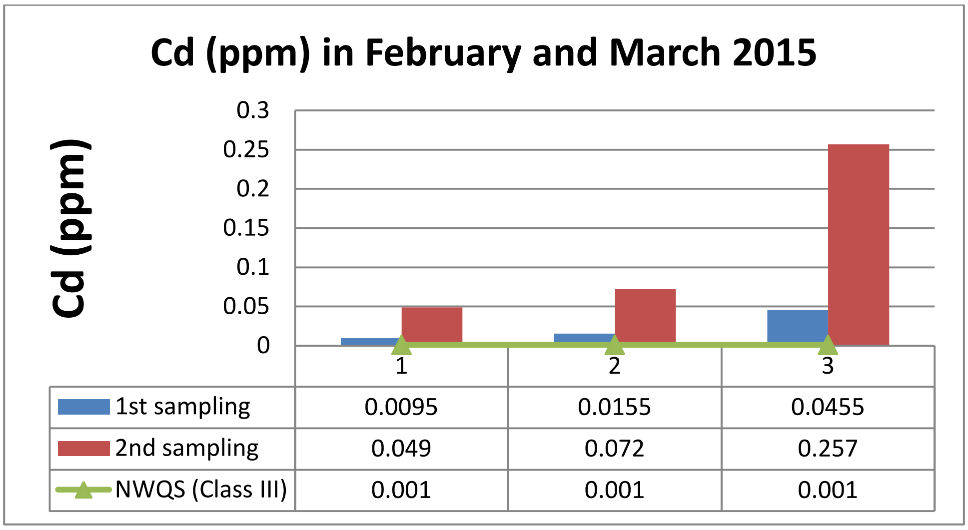


Figure 4.13: The average Concentration of Cd at 3 stations

Figure 4.13 shown, the presence of Pb in water samples of the Tunggak River for station 1, 2 and 3 on 1st and 2nd sampling. Station 1 was recorded decreased in concentration of lead which are from 0.1595 ppm to 0.1135 ppm. Meanwhile, station 2 was recorded increased in Pb concentration with 0.13 ppm to 0.199 ppm. Otherwise for station 3 that shown decreased same as station 1 from 0.1435 ppm to 0.0765 ppm. The average concentration of lead for all station on both sampling were within the INWQS for Class IIB with 0.05 ppm.

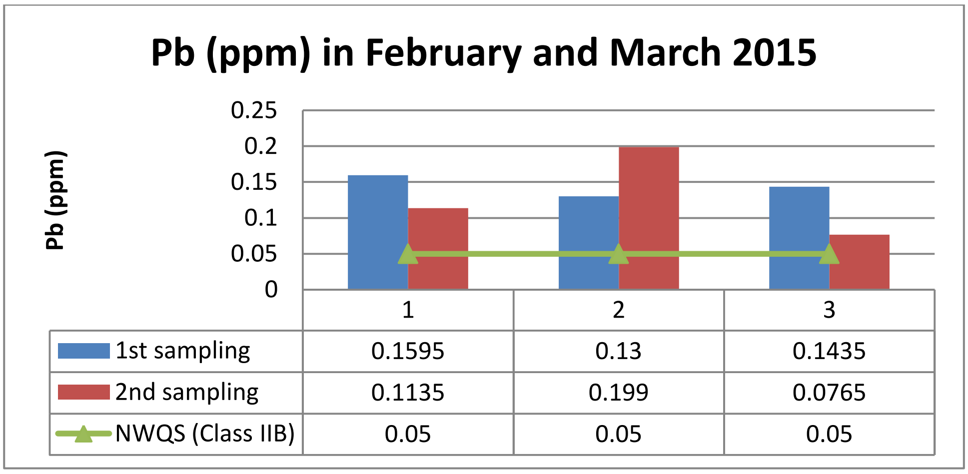


Figure 4.14: The average concentration of Pb at 3 stations

4.4 WATER QUALITY CLASSIFICATION IN THE TUNGGAK RIVER BASED ON DOE-WQI

Table 4.2: Water Quality Status on WQI and Sub Index for the Tunggak River

Station	SIDO	SIBOD	SICOD	SIAN	SITSS	SIpH	Total Score	CLASS	STATUS
1	0	53	67	10	96	99	49.53	IV	Highly Polluted
2	0	60	58	3	96	99	48.37	IV	Highly Polluted
3	0	76	73	0	93	98	52.76	III	Polluted

The value of the water quality index (WQI) for each station is determined by first obtaining the sub index value for each parameter. The WQI is good indicator of any improvement of river water body. Based on table 4.2, it shows the sub index for WQI in station 1, 2 and 3 of the Tunggak River. Sub index for DO are been converted from mg/L to percent and according the percent all three stations got zero value.

Among the three stations, the highest WQI was recorded at station 3 with 52.76. This is mainly due to its location that surrounding with lowest human activity from nearest residential area and the location itself as a fishing area. Despite the highest in WQI, station 3 was classified as Class III with polluted status. From that, household discharged may contribute to the polluted status for this station.

Meanwhile the remaining stations such as station 1 was recorded with 49.53, classified as Class IV with highly polluted status. The lowest in total score of WQI recorded as station 2 with 48.37 and also classified same as station 1 with highly polluted status. This may due to its location that station 1 was surrounded with industrial area such as wood industry and station 2 surrounded with residential, industrial area such as wood factory and other land use. Based on the result of WQI, industrial and residential discharged may contribute to the highly polluted to station 1 and station 2.

4.5 SOURCES OF POLLUTION IN THE STUDY AREA

Based on observations and seeing at the each stations of the Tunggak River, it is clear that a few sources of pollution that contributed to bad effect on water quality of this river. Among the sources are industrial and human activities, solids waste dumpling and poor waste water management that been practise by some of industries.

4.5.1 Industrial Activities

Industrial and human activities are examples of point sources of river pollution. Figure 4.14 shown wood industrial that located besides station 1 of the Tunggak River. station 1 was recorded in within the highly polluted according to the WQI because based on observations this industry were discharged their waste to the Tunggak River and based on water quality parameters also shown decreased in DO, highly in BOD and COD and value of TSS also increased.

Figure 4.15: Wooden Industry near to station 1

4.5.2 Solids Waste Dumping

Solids waste dumping also example of point sources pollution. Solids wastes like trash, plastic, household waste, detergent and so on are directly came from human and residential area and this give effects on river water quality. This is because solids waste dumping as shown in figure 4.15 has equally increased the concentration of organic and inorganic constituents (Nkwocha, E. E.; *2011*) of the Tunggak River.

Figure 4.16: Solids Dumping at Station 2

4.5.3 Poor Waste Water Management

Some of industries do not have proper waste water management system installed in their factory. Huge amount of waste from industries which contain toxic and pollutants are directly discharged the waste into the Tunggak River without treat the waste first. Industrial wasted usually contain this toxic chemicals such as copper, lead and many other harmful chemicals can damage the river with increased amount of minerals also known as Eutrophication and give hazard to aquatic life.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 CONCLUSION

This research showed that adverse effect of poor waste water management practises has given effect to the Tunggak River water quality. The objectives of the research were achieved based on water quality parameters that been conducted and the analysis according to the standard of INWQS.

The Water Quality Index (WQI) based on DOE-WQI was good indicator in determined the quality of the river whether it is polluted or not and suitable or not for uses as water supply for consumer. Based on the formula of WQI, the water samples of the Tunggak River were found that is 49.53 for station 1 with classified as Class IV and station 2 also classified as Class IV with 48.37 total score. Meanwhile only station 3 classified as Class III with total score 52.76. The average score for the Tunggak River are 50.22, classified as Class IV with status high polluted.

The sources of pollution of this study area also revealed which are industrial and human activities as point sources are one of the cause river pollution that give bad effect to the Tunggak River. Besides that, solids waste dumping that occured on the stations also contributed to effect of water quality of the river. Moreover, poor waste water management that been practises by some industry lead to decreased in water quality. This is because the untreated waste discharged directly to the river and it contained a lot of harmful pollution and toxic chemical that may not just harm to aquatic life in the river but also to human.

5.2 RECOMMENDATIONS

There are few recommendations that suggested to improve the water quality of the Tunggak River are:

i. The local authority is needed to make sure to do the proper treatment for the Tunggak River before it be supply to the consumer. Proper treatment can reduce organic and inorganic constituents that been contain in the Tunggak River and that constituents can harm human.

ii. The Malaysian Government should enforce the law strictly to industry who fail to install or practising the poor waste water management in their factory. Strictly punishment such as prison or pay the penalty can make the industrials obey to do the treatment to the wasted before it discharged.

iii. The society should play a important role in contribute to protect the Tunggak River by arrange the ‘gotong-royong’ activities to clean up the river so that it can reduce the solids waste dumping. Plus, awareness campaign about ‘love your river’ should be conducted to give knowledge to society on how important to protect the river so that it can reduce the river contamination.

5.3 RECOMMENDATIONS FOR FURTHER STUDY

i. It is recommended to have continuous research for more particular of pollution risk of atmospheric, soil and water environment in Gebeng area.

ii. Further investigations should be conducted on the effect of water quality in especially those in industrial and residential area.

REFERENCES

A.H.M.J. Alobaidy, Bahram K. Maulood and Abass J. Kadhem. 2010. Evaluating Raw and Treated Water Quality of Tigris River within Baghdad by Index Analysis. *Journal Water Resources and Protection.* (2): 629-635.

Bashir, H. and Kawo, A.H. 2004. Environmental Pollution: A case study of wastewater Effluent parameters of some Industries in Kano, Nigeria. *Biological and Environmental Sciences Journal for the tropics 1*(1): 133-139

Bolawa O.E. and Gbenle G.O.,. 2012. Analysis of industrial impact on physiochemical parameters and heavy metal concentrations in waters of river Majidun, Molatori and Ibeshe around Ikorodu in Lagos, Nigeria. *Journal of Environmental Science and Water Resources*. **Volume 1**(2): 34–38

Bulbul Ahmed, H.M. Rasel and Md. Shafi Uddin Miah. 2013. Investigate The River Water Quality Parameters : A Case Study. *American Journal of Civil Engineering.* **Volume 2013**: 84-90.

B.Y. Kamaruzzaman, N.T. Shuhada, B. Akbar, S. Shahbudin, K.C.A. Jalal, M.C. Ong, S.M. Al-Barwani and J.S. Goddard (2011). Spatial Concentrations of Lead and Copper in Bottom Sediments of Langkawi Coastal Area, Malaysia. *Research Journal of Environmental Sciences.***Volume 5**: 179-186.

Department of Environment. 2010. Malaysia Environmental Quality Report 2010. Malaysia. Ministry of Natural Resources and Environment Malaysia.

Department of Statistics. 2011. Compedium of Environment Statistics. Malaysia. The Source of Malaysia Official Statistics.

Engku Azman Tuan Mat, Jamil Shaari and Voon Kok How. (undated). Wastewater Production, Treatment, and Use in Malaysia. (Online). http://www.ais.unwater.org/ais/pluginfile.php/501/mod_page/content/87/report_malaysia.pdf.(25 Actover 2014).

Fawaz Al Badaii, Muhammad Shuhaimi Othman and Muhd Barzani Gasim. 2013. Water Quality Assesment of the Semenyih River, Selangor, Malaysia. *Journal of Chemistry*. **2013**: 1-11.

Holdsworth, R. (1991). New Health Consideration in Water Treatment, Avebury Technical, Aldershot. IRDC, Rural Water Supply in China. *Journal Int. Research. Dert. Center (IRDC),* pp 1-11.

Johns, M.W. and Lawrence, C.R. (1973). Nitrate-rich Groundwater in Australia: A Possible Cause of Methaemoglobinaemia in Infants. *The Medical Journal of Australia.* **Vol 2**:925-975.

Liza Evianti Tanjung. (2013). *Assessment of Heavy Metal in Surface Water and Sediment in Balok and Tunggak River, Kuantan.* Master. Thesis. Universiti Malaysia Pahang, Malaysian.

Murray, K., Du Preez, M. and Van Ginkel, C. (2000). National Eutrophication Monitoring Programme Implementation Manual Draft. Water Research Commission, Pretoria.

Nasly M.A, M.A. Hossain and Mir Sujaul Islam. 2013. Water Quality Index of Sungai Tunggak : An Analytical Study. *3rd International Conference On Chemical, Biological and Environment Sciences (ICCEBS'2013,*pp 40-44.

Nkwocha, E. E., Pat-Mbano, E.C. and Nnaji, A. (2011). Effect of Solid Waste Dump on River Water Quality : A Paradigm In A Nigeran Tropical Environment. *International Journal Of Science And Nature.* **Volume 2**(3) : 501-507.

Ogwo,P.A and Ogu, O. G.2014. Impact of Industrial Effluents Discharge on The Quality of Nwiyi River Enugu South Eastern Nigeria. *Journal of Environmental Science, Toxicology & Food Technology*. **Volume 8**: 22-27.

P. Das, S. Samantaray and G.R. Rout. (1998). Studies On Cadmium Toxicity In Plants: A Review. *Environ. Pollution*. **Volume 98** (1): 29-36.

Pentas Flora. (undated). Water Pollution Problems. (online). http://www.pentasflora.com/pollution-problems/. (24 October 2014).

R.K. Kushwah, Avinash Bajpal and Suman Malik. 2011. Wastewater Quality Studies of Influent and Effluent Water at Municipal Wastewater Treatment Plant, Bhopal (India). *International Journal of Chemical, Environment and Pharmaceutical Research.* **Vol 2**: 131-134.

Ruth F.Weiner, Robin A. Matthews. 2003. *Environmental Engineering*. United States of America. Elsevier Science.

Wellner, Joseph P.,Jr.,Dinger and James S. 1989. Dissolved Oxygen Profiles at Major Wastewater Discharges and Hydroelectric Dams on The Ohio River. *Ohio Journal of Science.***Volume 89**. (5): 164-171

W.X. Wang, R.C.H. Dei. (2001). Effectsof Major Nutrient Additions on Metal Uptake In Phytoplankton. *Environ. Pollution*. **Volume 111**: 233-240.

APPENDICES A

National Water Quality Standards for Malaysia

PARAMETER	UNIT	CLASS					
		I	IIA	IIB	III	IV	V
Ammoniacal Nitrogen	mg/l	0.1	0.3	0.3	0.9	2.7	> 2.7
Biochemical Oxygen Demand	mg/l	1	3	3	6	12	> 12
Chemical Oxygen Demand	mg/l	10	25	25	50	100	> 100
Dissolved Oxygen	mg/l	7	5 - 7	5 - 7	3 - 5	< 3	< 1
pH	-	6.5 - 8.5	6 - 9	6 - 9	5 - 9	5 - 9	-
Colour	TCU	15	150	150	-	-	-
Odour	-	N	N	N	-	-	-
Salinity	%	0.5	1	-	-	2	-
Taste	-	N	N	N	-	-	-
Total Dissolved Solid	mg/l	500	1000	-	-	4000	-
Total Suspended Solid	mg/l	25	50	50	150	300	300
Temperature	°C	-	Normal + 2 °C	-	Normal + 2 °C	-	-
Turbidity	NTU	5	50	50	-	-	-

(DOE, 2010)

APPENDICES B

Water Classes and Uses

CLASS	USES
Class I	Conservation of natural environment. Water Supply I - Practically no treatment necessary. Fishery I - Very sensitive aquatic species.
Class II	Water Supply II - Conventional treatment. Fishery II - Sensitive aquatic species.
Class II	Recreational use body contact.
Class III	Water Supply III - Extensive treatment required. Fishery III – Common of economic value and tolerant species, livestock drinking.
Class IV	Irrigation
Class V	None of the above.

(DOE, 2010)

APPENDICES C

In- situ Parameters (1st Sampling)

Station	Parameter	Sample 1	Sample 2	Average
1	Temperature (°)	25.2	25.2	25.2
	pH	6.02	5.95	5.99
	Turbidity	6	13	9.5
	EC	0.17	0.172	0.171
	DO	2.16	2.3	2.23

Station	Parameter	Sample 1	Sample 2	Average
2	Temperature (°)	27.8	27.9	27.9
	pH	6.14	6.16	6.15
	Turbidity	26	32	29
	EC	0.82	0.76	0.79
	DO	1.86	1.98	1.92

Station	Parameter	Sample 1	Sample 2	Average
3	Temperature (°)	27.2	27.1	27.2
	pH	6.3	6.6	6.45
	Turbidity	20	23	21.5
	EC	15.4	11	13.2
	DO	4.84	5.07	4.96

APPENDICES D

In- situ Parameters (2nd Sampling)

Station	Parameter	Sample 1	Sample 2	Average
1	Temperature (°)	28.9	28.9	28.9
	pH	7.98	8.52	8.25
	Turbidity	31	28	29.33
	EC	3,61	3.95	3.78
	DO	4.75	4.80	4.78

Station	Parameter	Sample 1	Sample 2	Average
2	Temperature (°)	28.2	28.7	28.45
	pH	8.69	7.09	7.89
	Turbidity	36.67	20	28.34
	EC	14.6	39.05	26.83
	DO	7.18	7.00	7.09

Station	Parameter	Sample 1	Sample 2	Average
3	Temperature (°)	29.5	29.5	29.5
	pH	8.77	7.74	8.26
	Turbidity	13.67	10.67	12.17
	EC	49.15	49.2	49.18
	DO	7.84	7.06	7.45

APPENDICES E

Average and Standard Deviation of Water Quality Parameters of Tunggak River

Station	Statistical Tools	DO%	BOD (mg/L)	COD (mg/L)	Turbidity (NTU)	TSS (mg/L)	pH	PO_4 (mg/L)	SO_4 (mg/L)	AN (mg/L)
1	Average	43.49	12.56	26.65	15.55	17	7.12	0.50	36.17	3.13
	ST Deviation	20.76	6.26	0.21	1.22	12.73	1.60	0.15	34.17	0.53
2	Average	95.71	10.42	35.34	13.56	15	7.02	2.03	106.75	3.45
	ST Deviation	7.81	11.53	8.96	3.84	12.02	1.23	0.18	96.52	2.12
3	Average	79.07	6.19	19.50	8.07	7.50	7.36	0.16	700	0.55
	ST Deviation	20.46	7.58	0.71	0.41	6.36	1.28	0.12	466.69	0.78

APPENDICES F

Figure 5.1: BOD instruments

Figure 5.2: COD Parameter