POTENTIAL IMPACT OF BAUXITE MINING ACTIVITY ON WATER QUALITY AT SUNGAI PENGORAK, KUANTAN CATCHMENT AREA

AZZA NURSHAFIRA BINTI ZUL'AZMAN

B. ENG (HONS.) OF CIVIL ENGINEERING

UNIVERSITI MALAYSIA PAHANG

UNIVERSITI MALAYSIA PAHANG

DECLARATION OF THESIS / UNDERGRADUATE PROJECT PAPER AND COPYRIGHT

Author's full name : **AZZA NURSHAFIRA BINTI ZUL' AZMAN**
Date of birth : **5th APRIL 1994**
Title : **POTENTIAL IMPACT OF BAUXITE MINING ACTIVITY ON WATER QUALITY AT SUNGAI PENGORAK, KUANTAN CATCHMENT AREA**
Academic Session : **2016/2017**

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.

Certified by:

______________________	______________________
SIGNATURE	**SIGNATURE OF SUPERVISOR**
(940405-13-6206)	**(DR. MIR SUJAUL ISLAM)**
Date: 12th January 2017	Date: 12th JANUARY 2017

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

POTENTIAL IMPACT OF BAUXITE MINING ACTIVITY ON WATER QUALITY AT SUNGAI PENGORAK, KUANTAN CATCHMENT AREA

AZZA NURSHAFIRA BINTI ZUL' AZMAN

Thesis submitted in fulfillment of the requirements for the award of the degree of

Bachelor (Hons.) of Civil Engineering

Faculty of Civil Engineering and Earth Resources

UNIVERSITI MALAYSIA PAHANG

JANUARY 2017

SUPERVISOR'S DECLARATION

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

Signature :

Name of Supervisor : DR MIR SUJAUL ISLAM

Position : SENIOR LECTURER

Date : 12th JANUARY 2017

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 the degree.

Signature :

Name : AZZA NURSHAFIRA BINTI ZUL' AZMAN

ID Number : AA13074

Date : 12th JANUARY 2017

I dedicated this thesis to my parents,

Zul ' Azman Bin Yaakub and Zaleha Binti Jani

as they always believed in me and give full encouragement whilst producing this thesis.

ACKNOWLEDGEMENTS

I am grateful and would like to express my sincere gratitude to my supervisor, Dr. Mir Sujaul Islam for his invaluable guidance, continuous encouragement and constant support in making the research possible.

My sincere thanks go to all of my labmates and members of the Civil Engineering Department, UMP who helped me in many ways and made my stay at UMP pleasant and unforgetable.

Deepest gratitude also goes to my close friends and family for the constant support and understanding that were inevitable to make this work possible. I cannot find the appropriate words that could properly describe my appreciation for their devotion and faith in my ability to attain my goals.

ABSTRACT

Bauxite mining has become a serious matter to ponder in Malaysia. In 2013, a total of 236 mine sites are identified to produce and transport bauxite but only 36 are legal.This irresponsible act gives serious impact to the local Kuantan community such as air pollution, water pollution, ecosystem degradation and bring discomfort to people. Sungai Pengorak (Pengorak river), Kuantan is one of the affected area due to bauxite mining. The purpose of this study is to evaluate the spatial variation of bauxite affected river water quality in Sungai Pengorak Kuantan, to classify the river water by assessing the water quality according to the Normal Water Quality Standard (NWQS) and to make recommendations and suggestions for sustainable bauxite management of the river system. In-situ parameters and ex–situ tests were conducted to obtained the results. The river water sample was taken from three (3) different point source, as much as three (3) times to conduct the water quality analysis. HORIBA meter was used to record the in – situ parameters data. Ten (10) paramenters were chosen to be analysed which were pH, turbidity, temperature, electrical conductivity (E.C), dissolved oxygen (DO), biochemical oxygen demand (BOD), chemical oxygen demand (COD), total suspended solid (TSS), hardness and heavy metals. The results of parameters obtained were classified according to NWQS. pH value recorded as high as 7.42 at Station 1 and as low as 6.14 at Station 3 and it is within NWQS standard. Next, the highest temperature recorded among the stations was 27.9 °C while the lowest was 27.6 °C. The turbidity recorded exceeded the 5mg/l standard range with 57 mg/l at Station 1 while the lowest was 43 mg/l at Station 3. As for total suspended solids, the highest value obtained was 48 mg/l at Station 3 and 16 mg/l at Station 1 and the standard range was 25 mg/l. High concentration of turbidity and total suspended solids was due to the discharge of unregulated mine waste from nearby mine site. Hardness was the highest at Station 1 with 5.69 mg/l while the lowest with 1.51 mg/l at Station 2. Sungai Pengorak is considered soft water because the values recorded does not exceeded the NWQS standard which is 250 mg/l. As for dissolved oxygen concentrations, the highest was 4.17 mg/l at Station 3 while the lowest was 3.75 mg/l at Station 1. The highest biochemical oxygen demand value (8.86 mg/l) was recorded at Station 1 while the lowest value (6.53 mg/l) recorded at Station 2. The highest chemical oxygen demand value (47 mg/l) was recorded at Station 3 while the lowest value (30 mg/l) recorded at Station 2. The values of all concentrations were highly exceeded the NWQS standard. It is due to the bauxite mining activity conducted at nearby area. In addition, the electrical conductivity was recorded the highest of 1200 µS/cm at Station 3 while the lowest of 854 µS/cm at Station2. High electrical conductivity indicates high ions concentrations in the water and vice versa. Analysed heavy metals concentration towards the water found that chromium was the highest in concentration which is 0.45 mg/l, followed by iron 0.3 mg/l, copper 0.05 mg/l and cadmium 0.09 mg/l. All of the heavy metals exceeded the NWQS standard of 0.05 mg/l each. In a nutshell, the river is classified overall to its water classes as Class IV at Station 1 and Station 3 while Class III at Station 2. For future use of water, precautions measures should be implemented. Water quality laws should be reinforced, environmental education should be implemented and ‘polluters pay principle’ should be practiced so that the community is aware of the problem and the problem can be reduced even if it takes time.

ABSTRAK

Perlombongan bauksit telah menjadi satu perkara yang serius di Malaysia. Pada tahun 2013, sebanyak 236 tapak perlombongan telah dikenalpasti tetapi hanya 36 yang sah berdaftar. Sungai Pengorak, Kuantan adalah salah satu kawasan yang terjejas kerana perlombongan bauksit. Tujuan kajian ini adalah untuk menilai variasi spatial kualiti air sungai terjejas bauksit di Sungai Pengorak Kuantan, untuk mengklasifikasikan air sungai dengan menilai kualiti air mengikut Standard Kualiti Air Normal dan untuk mengemukakan cadangan untuk menguruskan sistem sungai yang terjejas oleh bauksit Parameter in – situ dan ujian makmal dijalankan untuk mendapat keputusan. Sampel air sungai diambil dari tiga (3) stesen yang berbeza, sebanyak tiga (3) kali untuk menjalankan analisis kualiti air. HORIBA meter telah digunakan untuk merekodkan data parameter in- situ. Sepuluh (10) paramenter yang telah dipilih untuk dianalisis adalah pH, kekeruhan, suhu, kekonduksian elektrik (SPR), *dissolved oxygen* (DO), *biochemical oxygen demand* BOD), *chemical oxygen demand* (COD), jumlah pepejal terampai, kekerasan dan logam berat. Keputusan parameter yang diperolehi dikelaskan mengikut piawaian *NWQS*. Nilai pH yang tertinggi adalah 7.42 di Stesen 1 manakala yang terendah adalah 6.14 di Stesen 3 dan masih berada dalam piawaian *NWQS*. Seterusnya, suhu tertinggi dicatatkan di kalangan stesen adalah 27.9 ° C manakala yang terendah adalah 27.6 ° C. Kekeruhan direkodkan melebihi 5mg/l piawaian dengan catatan rekod 57 mg/l di Stesen 1 manakala adalah 43 mg/l di Stesen 3. Bagi jumlah pepejal terampai, nilai yang paling tinggi diperolehi ialah 48 mg/l yang paling rendah di Stesen 3 dan 16 mg/l di Stesen 1 manakala piawaian *NWQS* adalah 25 mg/l. Kekeruhan dan jumlah pepejal terampai yang tinggi adalah disebabkan oleh pelepasan sisa lombong yang tidak terkawal dari tapak lombong berdekatan. Kekerasan adalah yang tertinggi di Stesen 1 dengan 5.69 mg/l manakala yang terendah dengan 1.51 mg/ l di Stesen 2. Sungai Pengorak dianggap air lembut kerana nilai-nilai yang dicatatkan tidak melebihi piawaian NWQS iaitu 250 mg/l. Bagi *dissolved oxygen* tertinggi adalah 4.17 mg/l di Stesen 3 manakala yang terendah adalah 3.75 mg/l di Stesen 1. Nilai *biochemical oxygen demand* yang tertinggi (8.86 mg/l) di Stesen 1 dan terendah (6.53 mg/l) di Stesen 2. Nilai *chemical oxygen demand* yang tertinggi (47 mg/l) di Stesen 3 manakala terendah (30 mg/l) di Stesen 2. Ia adalah disebabkan oleh aktiviti perlombongan bauksit dijalankan di kawasan berhampiran. Di samping itu, kekonduksian elektrik dicatatkan tertinggi 1200 μS / cm di Stesen 3 manakala yang terendah daripada 854 μS / cm pada Station2. Kekonduksian elektrik yang tinggi menunjukkan kepekatan ion yang tinggi di dalam air dan sebaliknya. Bagi kepekatan logam, kromium adalah yang tertinggi iaitu 0.45 mg / l, diikuti oleh besi 0.3 mg / l, tembaga 0.05 mg / l dan kadmium 0.09 mg / l. Semua logam berat melebihi piawaian NWQS iaitu 0.05 mg / l setiap satu. Secara ringkas, sungai diklasifikasikan Kelas IV di Stesen 1 dan Stesen 3 manakala Kelas III di Stesen 2. Untuk kegunaan masa depan langkah berjaga-jaga perlu dilaksanakan. Undang-undang kualiti air perlu diperkukuhkan, pendidikan alam sekitar perlu dilaksanakan dan 'pencemar membayar prinsip' perlu diamalkan.

TABLE OF CONTENTS

CHAPTER 2 LITERATURE REVIEW

List of Tables

LIST OF FIGURES

LIST OF SYMBOLS

°C	Celcius
g cm^{-3}	Gram per centimeter cube
km	Kilometer
L	Litre
m	Meter
mg/l	Miligram per litre
mg/d	Milligram per day
mg/week	Milligram per week
mL	Milliliter
mm	Millimeter
NTU	Nephelometric Turbidity Unit
µm	Micrometer
µS/cm	Microsiemens per centimeter

LIST OF ABBREVIATIONS

AMD	Acid mine drainage
BOD	Biochemical Oxygen Demand
Cd	Cadmium
$CaCo_3$	Calcium Carbonate
COD	Chemical Oxygen Demand
Cr	Chromium
Cu	Copper
DO	Dissolved Oxygen
EC	Electrical Conductivity
Fe	Iron
NWQS	National Water Quality Standard
TSS	Total Suspended Solids
WHO	World Health Organization

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

Bauxite mining has become a contentious issue in Kuantan, Pahang. Since Indonesia stopped producing and exporting bauxite ores to China, Malaysian miners take over the labor and later become the world's top producer beating China itself for nearly half of its ore supply. In 2013, around 100,000 tonnes of bauxite are exported and it increased to approximately 2.5 million tonnes in a year. The exports of bauxites hit a high mark of 20 million tonnes in 2015. Bauxite is a mixture of hydrous aluminium oxides, aluminium hydroxides, clay minerals and insoluble materials such as quartz, magnetite, hematite, siderite and goethite. It is the world's main source of aluminium and commonly found near the surface.

Open-cast bauxite mining affect the Pahang province for months. The most famous excavation area is Felda Bukit Goh , Gebeng Kuantan. Unregulated mining of bauxite gives crucial impact to the serving community. Out of 236 active mine sites, only 36 are legal. This means that, for one legal site excavated, another six are being dug up. Red cuts in the hills are seen behind the east coast town of Kuantan. Tonnes of bauxite are transported from mine sites to Kuantan port daily, resulting the country roads to be clogged by large lorries, damaged by potholes and covered by red residues from ores. In addition, nearby rivers and sea are also stained red with pollution if there is heavy rain.

1.2 PROBLEM STATEMENT

Many of the environmental impacts of mining are related with the release of harmful elements from mine waste. If uncontrolled disposal of mine waste occurs, turbidity in receiving waters will increased or with the release of significant amount of potentially harmful elements, acidity or radioactivity. These contaminants may spread to the pedosphere, biosphere, atmosphere and hydrosphere and cause environmental effects (Lottermoser, 2007). The drawbacks from excessive mining are air pollution, water pollution, ecosystem degradation and brought discomfort to population.

Felda Bukit Goh is known for its active bauxite mining activities for the past three (3) years. Most of it is illegal mining. For months, certain area in the district have suffered serious air pollution problems from the red bauxite debris and residue that are largely released to the surrounding by the processing plants or leaked during transported to the Kuantan Port. The nearby community experience health deterioration such as asthma and eye irritation.

Figure 1.1 : Air Pollution (Sources: Malaysia Kini)

Besides, water pollution also occurred. If mine waters are released into local water bodies, the environmental imprint depends on the quality of the effluent. Bauxite wastes are dumped on the ground. Its toxic chemicals will be diffuse to the underground water table along with rainwater. Precipitation of dissolved constituents may results in abundant mineral coatings. Hence, the receiving waterways will eventually increase in acidity and contaminated the main water source.

Figure 1.2 : Water Pollution (Source: New Straits Time)

Next, ecosystem degradation. Malaysian Society of Marine Sciences chairman Dr Harinder Rai Singh stated that the bauxite contaminated red sea off the Pahang coastal area is bound to be a ‘dead sea’ for up to three (3) years. The aquatic life would be severely affected as sedimentation of bauxite can clog the gills of fish and the breathing system of the clams. A study is done towards the fishes back in August 2015 at the affected area , and it contained 100 time more from the permissible level designated in 1985, which is only 11.85 mg/L .

Figure 1.3 : Ecosystem Degradation (Source: The Straits Time)

In a nutshell, bauxite mining in Gebeng brings discomfort to its living community. Such irresponsible practices affects the health and daily activities of the people who live near the effected area. The aquatic ecosystems also shows great depletion of life as toxic constituents that enters the waterways poisoned the aquatic organisms. Hence, guidelines and rules should be strictly implemented to save the environment.

1.3 RESEARCH OBJECTIVES

I. To evaluate the spatial variation of bauxite affected river water quality in the Sungai Pengorak, Kuantan.
II. To classify the river water by assessing the water quality standard for sustainable management of ther river system.

1.4 SCOPE OF STUDY

The research is carried out in Sungai Pengorak , Kuantan Pahang. Its length is 3.84 m. Three (3) stations are selected along the river to collect the water sample. The duration for the collection is from September until November. The paramaters tested are of physical and chemical characteristics in determining water quality. In–situ test is practiced towards the water sample to obtained data for pH, dissolved oxygen, electrical conductivity, turbidity and temperature while ex–situ or laboratory analysis are for total suspended solid, biochemical oxygen demand, chemical oxygen demand, hardness and heavy metals. The acquired result is used as a guide to classify the river water according to the National Water Quality Standard (NWQS).

1.5 SIGNIFICANCE OF STUDY

The importance of doing water quality analysis towards Sungai Pengorak is to promote science – based policies as a guide in future which includes access to safe drinking water by applying the knowledge and information obtained at the decision making levels and technical approaches by the policy makers to address this problem. Next, to help manage the amount of pollution in time. Water quality control needs to be implemented frequently, be it in polluted river or non – polluted river. It is better to keep track of the parameters and standards laid out so that the environment is in controlled manner. In addition, water quality analysis information is important for future plan. This is because, the water usefulness change in time. If water is badly polluted, it cannot serve fishery activities anymore but can function as irrigation. So, the measures taken can be used to help protect the river.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

Literature review focused on the findings of the researcher throughout the study. This chapter is the key to help determine the water quality of the study area, which is Sungai Pengorak, Kuantan. General overview of bauxite mining is talked about and its impact to environment are discussed. Water quality parameters (physically and chemically) of the study area are narrowed down to a few in each aspect to be analyzed and the related heavy metals are examined as well to obtained acquired results.

2.2 WATER

Water is the only substance that exist naturally on earth in all three (3) physical states of matter; gas, liquid and solid. It covers approximately 70% of the Earth's surface and is essential for life. Pure water is colourless, odourless and tasteless (Shakashiri, 2011).

Nowadays, natural water around the world has been exploited, mistreated and contaminated. The marine population decline, euthropication in rivers occur, stench and smell comes out as a result of putrefaction in water. Over 780 million of people in the world lack access to clean and improved water source. It is approximately 1:9 people in ratio and it covers 18% of urban population while the rest are of rural population.

Malaysia uses an average of 250 litre water per person daily despite the water crisis. Only 30% are for actual consumption while the rest is for utility use. The water consumption is high compared to neighbouring countries such as Thailand (160 litre to 170 litre per capita), Singapore (130 litre to 150 litre per capita) and Indonesia (140 litre to 160 litre per capita) (New Straits Time, 2016). Water and Energy Consumers Association of Malaysia (WECAM) secretary – general Foon Weng Lian stated that, consumers should learn to save water for the future.

2.3 BAUXITE MINING

Mining is the first step to exploitation of mineral. It is defined as the removal of material from the ground to discover one or more piece of the mined materials. There are three principal activities of the mining industry - mining, mineral processing and metallurgical extraction. Parallel to the process, mine waste is produced. Mine waste can be in the form of solid, liquid or gaseous by-product of mineral processing and mettallurgical extraction (Lottermoser, 2007). Numerous mine wastes, particularly in the metal mining industry contains metal and/or metalloid at different height.

Bauxite is constitute of one or more aluminium hydroxide minerals and diverse combination of titania, silica, aluminosilicate, iron oxide and small amount of trace elements. It is mostly made up of boehmite γ - AlO (OH), diaspore α - AlO (OH) and gibbisite $Al(OH)_3$. Bauxite is then further classified according to its functions; mainly in cement, abrasive, chemical, obstinate and metallurgical. Aluminium is produced by crushing bauxite and further purified using Bayer Process. Bayer process needs high energy, thus it is produced in area where the energy cost is low. Elizah Leigh (2010) stated that, of all the earth's natural elements, aluminium happens to be the third most abundant resource on pur planet in its raw form.

For many bauxite residues, trace metals can be of concern and may exceed regulatory levels in certain circumstances (Lottermoser, 2007). The oceans and rivers surrounding port Kuantan reddens and polluted by heavy metals due to poor control by the authorities.

2.4 BAUXITE IN SURFACE WATER QUALITY

Water quality is a term used to describe the chemical, biological and physical characteristics of water. These traits affect the water suitability for human consumption and ecosystem health. Migliaccio (2008) stated, by that time only 8 percent of worldwide water use is for household purposes, 22 percent for industrial uses and 70 percent for crops irrigation.

Normally, the major pollutants associated with coal mining are suspended solids, dissolved salts (especially chlorides), acidity and iron compounds (Lottermoser, 2007). When suspended solids enter the waterways, it makes the water to become turbid and may deposit a sediment at the bottom of the stream (Fondriest, 2014).

The worst example of mine water quality is acid mine drainage (AMD) water, which originates from the oxidation of sulfide minerals. Acid mine drainage (AMD) water is the most severe for the first decade after sulfide oxidation begins. Since large masses of sulfide is oxidised during the mining and milling processes, the surrounding environment often cannot attenuate the resulting low pH conditions High acidity in water can destroy living organisms and corrodes metal equipments in contact with the acids waters thus making it unavailable to be use for drinking or recreational activities (Lottermoser, 2007)

2.5 WATER QUALITY PARAMETERS

Water is tested chemically, biologically and physically to identify its water quality status. Two (2) major parameters that is taken into account are physical parameters; total suspended solids, turbidity and temperature and chemical parameters; pH, dissolved oxygen, electrical conductivity, total dissolved solids, chemical oxygen demand, biological oxygen demand and total hardness. Heavy metals are also examined. For instance, chromium, copper, cadmium and iron.

2.6 PHYSICAL PARAMETERS

Physical parameters of water are decided by senses of touch, sight, smell and taste. Three (3) physical parameters are tested which are temperature and total suspended solids and turbidity.

2.6.1 Temperature

Chemical and biological reaction rates rise with increasing temperature. It affects the dissolved oxygen level in the water, metabolic rates of aquatic organisms and photosynthesis of aquatic plants. Thermal pollution usually occurs near power plants, due to urban runoff, decrease of shades in the environment, high solar radiation reaching the water's surface and removal of vegetation that further caused soil erosion and sedimentation in the stream. The sediments absorbs heat from sunlight and it heats the water. Low dissolved oxygen weakends the aquatic organisms (Migliaccio, 2011).

2.6.2 Total Suspended Solids

Total suspended solids (TSS) are solids in water that are larger than 2 microns found can be trapped by a filter. It include materials such as silt, decaying plant and animal matter, industrial wastes and sewage. High level of total suspended solids can block light from penetrating the water from reaching submnerged vegetation.As the amount of light recieved is low, photosynthesis also slows down. Hence resulting in small amount of dissolved oxygen (Murphy, 2007). As levels of total suspended solid (TSS) increase, water began to lose its ability to support the aquatic life.

According to the National Water Quality Standard (NWQS) the allowable range for the presence of total suspended solids (TSS) in rivers are from 25 mg/L to 50 mg/L. Aquatic organisms can live in the ecosystem up to Class III which are approximately 150 mg/L. Thus, control measures should be applied to decrease the suspended solids in streams, lakes and rivers.

2.6.3 Turbidity

Turbidity is an optical property that causes light to be scattered and absorbed rather than transmitted in straight line through sample causes cloudiness and haziness in water. It is commonly measured in Nephelometric Turbidity Units (NTU) using a turbidimeter. Turbidity is caused by silt, mud, bacteria and germs and chemical precipitates and tend to increase during runoff events.

Primary Standard for turbidity is range generally 5 NTU to 5.0 NTU at any time. According to the international standard, permissible level of turbidity for domestic use ranges from 5.0 NTU to 25 NTU (Mark J Hammer, 1981). While Malaysian Ministry of Health has set a standard of low level turbidity which is 1000 NTU.

The suspended particles are all small in size and difficult to settle down by gravity. Some of the suspended solids contribute to turbidity as it limits the light to penetrate the water thus, refraining the aquatic organisms to respirate and do photosynthesis.

2.7 CHEMICAL PARAMETERS

Chemical parameters refer to the ability of water to act as solvent. Amongst the parameters tested are electrical conductivity, dissloved oxygen, chemical oxygen demand, biochemical oxygen demand, total hardness and pH.

2.7.1 Electrical Conductivity

Conductivity is a measure of the ability of a water sample to transmit electric current and it depends on the ionic strength of the water. Most of the inorganic acids, bases and salts such as hydrochloric acid (HCl), Sodium Carbonate (Na_2CO_3) and sodium chloride (NaCl) are very good conductor.

The electrical conductivity of the water depends on the water temperature. As the temperature increase, so does the electrical conductivity. Conductivity will vary with water source. It's unit is mho/cm or 1 siemen and measured using a probe. Most streams range between 50 to 1500 µS/cm. Freshwater streams ideally should have an adequate value of 150 µS/cm to 500 µS/cm to support the aquatic life.

2.7.2 Dissolved Oxygen (DO)

Dissolved oxygen (DO) is oxygen gas molecules (O_2) that present in the water and expressed as a concentration. A concentraton is the amount of weight in a particular substance per given volume of liquid. Oxygen enter streams from the surrounding air as product of photosynthesis from aquatic plants. High level of dissolved oxygen will lead to healthy ecosystem. Dissolved oxygen (DO) reaches it peaks during the day and slows down duing night as photosynthesis stopped.

Dissolved oxygen (DO) is related closely to temperature, salinity and pressure. It increases when the temperature is low, decreasing salinity and high surrounding pressure and vice versa. Clear surface water contains more dissolved oxygen (DO) than stagnant surface water. If there is no respiration in water by aquatic organisms , bacteria will consume oxygen as organis matter. Hence, results in euthropication.

Dissolved oxygen (DO) is measured in milligram per litre, mg/L. The suitable range for aquatic organisms to live is from 4 mg/L to 11 mg/L where the most critical range is from 0 mg/L to 4 mg/L. According to Department of Environment (DOE) the dissolved oxygen (DO) for Malaysia's river is from 3 mg/L to 5 mg/L.

2.7.3 Chemical Oxygen Demand (COD)

Chemical oxygen demand (COD) is a measure of the oxygen in the organic matter content of a sample that is open to oxidation by a strong chemical oxidant. Potassium dichromate (K2Cr2O7) and sulphuric acid H2SO4 is used in the test to oxidesed the organic matter and the sum of the oxygen used for oxidizing process also be determined (Murphy, 2007).

National Water Quality Standards (NWQS) has declared that the chemical oxygen demand (COD) of Malaysian surface water was set to 50.00 mg/L. Both the value of biochemical oxygen demand (BOD) and chemical oxygen demand (COD) rise due to increase in pollution (Islam Mir Sujaul, 2012).

2.7.4 Biochemical Oxygen Demand (BOD)

Biochemical oxygen demand (BOD) is the amount of oxygen that would be consumed if all the organics in one litre of water were oxidized by bacteria and protozoa (Murphy, 2007). Organic matter in the water is decomposed by microoragnisms such as bacteria. Hence, much of the available dissolved oxygen is consumed by aerobic bacteria so that tey can survive.

If there is large quantity of waste in the water, abundant bacteria will be working to decompose the waste. In this case, the demand for oxygen will be high so, the biochemical oxygen demand (BOD) is also high. It correlates perfectly with dissolved oxygen (DO) whereby , when biochemical oxygen demand (BOD) increased , dissolved oxygen (DO) decreased as bacteria needs oxygen to oxidise the organic waste.

Table 2.1 : BOD Level (ppm)

(Sources: Pharmaceutical Guidelines)

BOD Level in mg/liter	Water Quality
1 - 2	**Very Good:** There will not be much organic matter present in the water supply.
3 - 5	**Fair:** Moderately Clean
6 - 9	**Poor:** Somewhat Polluted - Usually indicates that organic matter present and microorganisms are decomposing that waste.
100 or more	**Very Poor:** Very Polluted - Contains organic matter.

2.7.5 Hardness

When water passes through or deposit such as limestone, the levels of ca^{2+} , Mg^{2+} and HCO_3^- ions present in the water can greatly increase and caused the water to become hard. Total hardness is the sum of of calcium and magnesium hardness in mg/L $CaCO_3$. American Water Works Association indicates that water quality should not contain more than 80 mg/L of total hardness as $CaCO_3$. High level of total hardness would not cause harm to health instead calcium is an important component of cell walls in acquatic plants and magnesium provide nutrients for plants.

Table 2.2 : Hardness

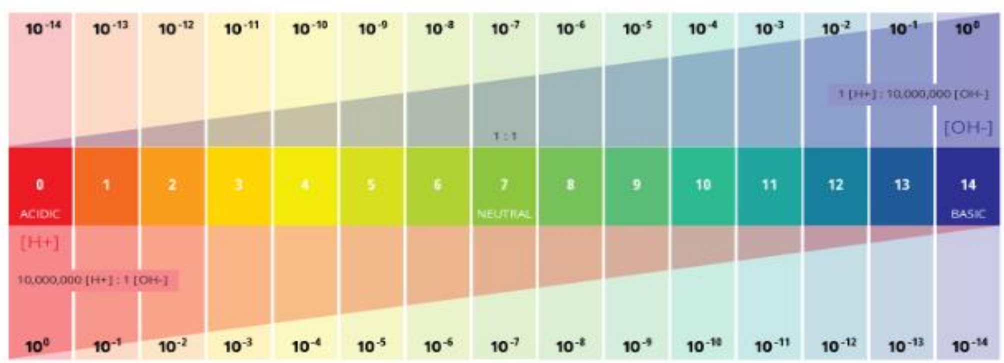
(Sources: Science Probeware)

Total Hardness (mg/L as $CaCO_3$)	
• Soft:	0-30
• Moderately soft:	30-60
• Moderately hard:	60-120
• Hard:	120-180
• Very hard:	>180

Typical seawater contains calcium hardness of 1000 mg/L , magnesium of 5630 mg/L and total hardness of 6630 mg/L as $CaCO_3$ while freshwater's calcium hardness range from 10 to 250 mg/L , magnesium range from 5 to 125 mg/L and the total hardness are is 15 to 375 mg/L as $CaCO_3$.

2.7.6 pH

pH is a determine value based on scale. Acidic water range form 0 to 6 in the scale 7 is neutral while basic water is from 8 to 14 in the scale. pH stands for ' power of hydrogen' [3] . The value of pH is determined by the molar concentrations of hydrogen ions (H^+) in the water.



The logarithmic scale of pH means that as pH increases, the H+ concentration will decrease by a power of 10. Thus at a pH of 0, H+ has a concentration of 1 M. At a pH of 7, this decreases to 0.0000001 M. At a pH of 14, there is only 0.00000000000001 M H+.

Figure 2.1 : pH Scale

(Sources:Fundementals Of Environmental Measurements)

In water, organisms will die of the pH water is too low or even too high. pH can affect the solubility of toxicity of chemicals and heavy metals in the water. Most of the aquatic life lives in a pH range of 6.5 to 9.0. Some can live outside the stated range too.

2.7.7 Heavy Metals

The term "heavy metals" is used because there are alternative , scientifically rigorous definition. Heavy metals can occur in various forms in Acid Mine Drainage (Amd) waters. It can either be dissolved as ion or molecule , even exist as solid mass. Acid mine drainage is the discharge of acidic water from metal mine or coal mine (Lottermoser, 2003)

Acid Mine Drainage (AMD) is currently the main pollutant of surface water. AMD is caused when water flows through sulfur – bearing materials forming solutions of net acidity. AMD comes mainly from the mining activity or abandoned coal mines through runoff, resulting the water to be more acidic. Mine drainage can contaminate the waters, disrupted the growth of aquatic life and plant and corrodes structure such as bridge due to high acidity in water. The heavy metals tested are iron (Fe), cadmium (Cd), chromium (Cr) and copper (Cu).

2.7.7.1 Iron (Fe)

Iron has an atomic number 26, atomic weight 55.84, density 7.87 gcm^{-3}, melting point 1538 ^{0}C and 2862 ^{0}C. It is the fourth most common element in the Earth's crust. Elemental iron occurs in meteoroids and other low oxygen environments. It is reactive to oxygen and water. Fresh iron surfaces appear silver-gray, but oxidize in normal air to give hydrated iron oxides (rust).

The precipitation of dissolved Fe^{3+} provides significant acidity to the solution by the release of hydrogen ions in water. This reaction lowers the pH and allows more Fe^{3+} to stay in solution. Such a precipitate is observed as the familiar reddish – yellow to yellowish – brown stain, coating, slimy sludge, gelatinous flocculant and precipitate in acid mine drainage affected streams.

2.7.7.2 Cadmium (Cd)

Cadmium is an element with atomic number 48, atomic weight 112.4, density 6.65 gcm^{-3}, melting point 320.9^0C and boiling point 765^0C. Along with mercury and lead, cadmium is one of the three heavy metal poisons. It is a silvery – white metal, soft and ductile and has a relatively high pressure. Cadmium is a rare element and normally distributed in the Earth's crust, where it is generally estimated to be present between 0.15 and 0.2 mg kg^{-1}.

Industrial and municipal waste are the main source of cadmium pollution. Dissolution of sediment – bound cadmium may increase the acidity in water. The concentration of cadmium in umpolluted fresh water is less than 0.001 mg/L whereas the concentration of cadmium in seawater is about 0.00015 mg/L. Cadmium is very hazardous to life due to its acute toxicity. Cadmium tends to accumulate in the body with 33% in the kidney and 14% in the liver. The World Health Organization (WHO) has recommended the permissible cadmium intake should not exceed 0.4-0.5 mg per week or 0.057 – 0.071 mg/d.

2.7.7.3 Chromium (Cr)

Chromium has an atomic number of 24, atomic mass 52, density 7.19 gcm^{-3}, melting point 1875^0C and boiling point 2665^0C. Chromium is mined as a primary ore product in the form of mineral chromite $FeCr_2O_4$. Chromium concentration in natural waters are very limited by the low solubility of Cr (III) oxides.It is recognized to be a hazardous element as it contain severe toxic effects. Hexavalent chromium is considered to be lethal if adult consume more than 3 g. The first symptoms are vomiting and diarrhea. Convulsions occur during the final stage of the illness. Nevertheless , severe toxic effects on plant at Cr (IV) concentrations of approximately 0.5 mg/L.

2.7.7.4 Copper (Cu)

Copper is a metal with atomic number 29,atomic weight 63.5,density 8.96 gcm^{-3}, melting point 1083^0C and boiling point 2595^0C. Copper is the most used metal in the world. Copper is an essential micronutrient required in the growth of both plants and animals. Copper is indeed essential, but in high doses it can cause many health problem such as anaemia, liver and kidney damage. It normally exist in Cu pipes, as well as additives to control algal growth. Research shows that most introduced into the environment, rapidly becomes stable and the result does not pose risk to the environment.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 INTRODUCTION

This chapter discusses about the technique and processes that is going to be apply throughout the research. All the methods involved in the research is presented and explained further to give detail understanding for each task. Information and data collection can be obtained by identifying methods of testing for a particular parameter. Thus, the methods and procedures associated will be further discussed in order to reach the objectives of the research.

3.2 STUDY AREA

The study area will take place at Sungai Pengorak. Sungai Pengorak is a stream located 55.7 km away from Kuantan, Pahang. Sungai Pengorak became contaminated due to the discharge of mine waste, majorly bauxite. Non-point source pollutions occur in this matter as urban runoff is discharge from the mine site to the nearby water source. Hence, the stream will be slowly contaminated and flowed to other locations. Since the river is contaminated due to uncontrolled bauxite mining, responsible agencies are asked to ensure a sustainable environment and public health.

3.3 FLOWCHART FOR RESEARCH METHODOLOGY

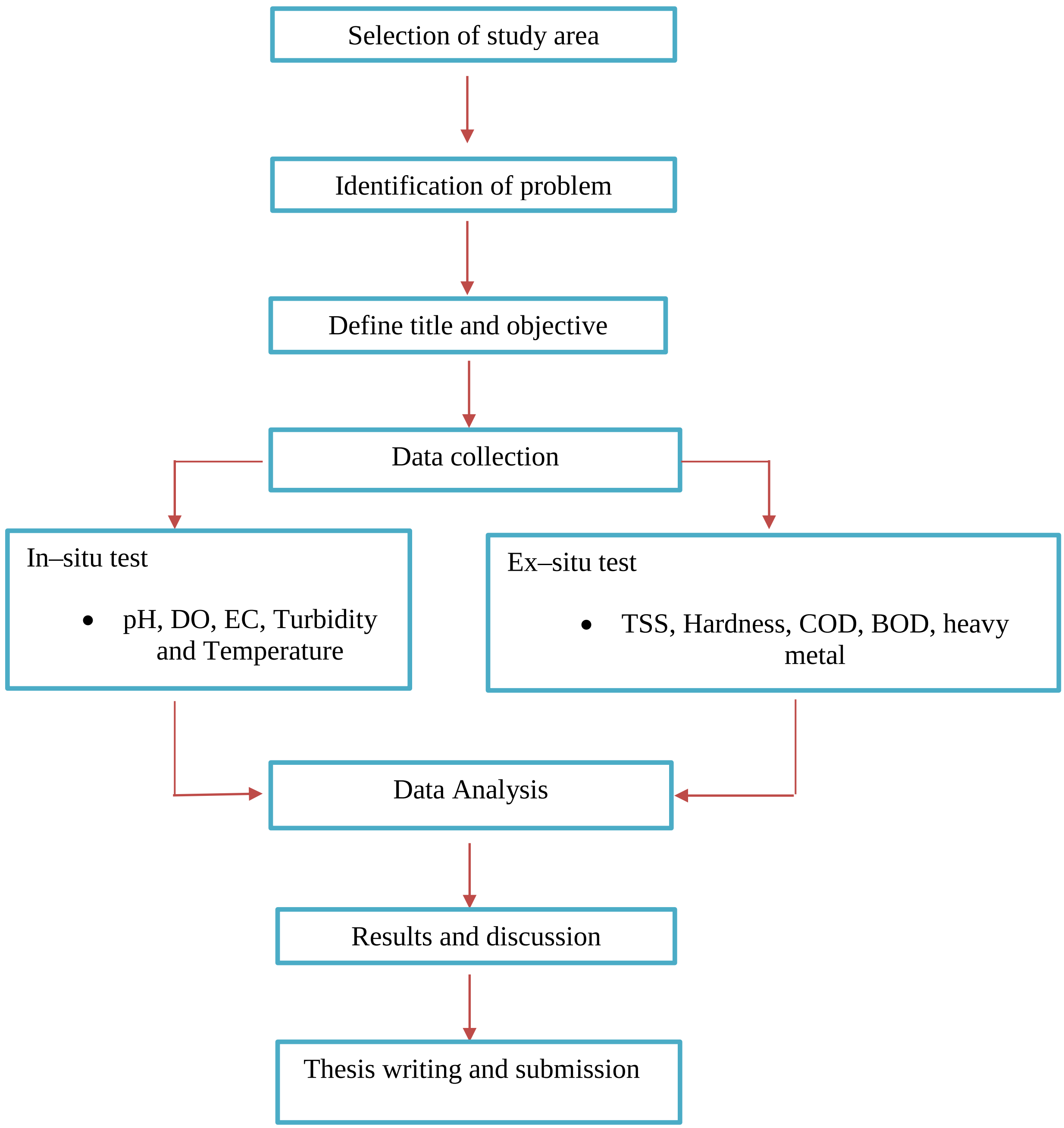


Figure 3.1 : Flowchart of study

3.4 SAMPLE COLLECTION

Sampling is done to collect water samples and handling it a proper way so that no change in composition occur in the water before the test is carried out. Water sample are collected at three station for 3 times at a depth of 15 cm to 30 cm in water by using grab method. Grab method shows performance only at the point in time that the sample was collected. The sample is collected manually at a specific location, depth and time interval.

3.5 WATER SAMPLE PRESERVATIONS TECNHIQUE

Proper methods of sampling and preservations is taken into account to keep the composition of water sample intact. All sample must be preserved in a maintained chilled environment or a temperature of approximately 4º C in the ice box or refrigerator. If ice boxes are used, it must be clean and if possible reserved exclusively for water analysis of rivers, pools and other artificial resevoirs. Essential apparatus and materials is prepared for testing the water samples so that the result can be further classified according to the standards.

3.6 SAMPLE ANALYSIS

Sample analysis is implemented mainly for observing puposes. It is to check whether the water quality is parallel to the standards, hence suitable or not for the designated use. In addition, it is also used to track the competence of a methodology that works for water quality maintenance. Water quality analysis should be implemented to public health sectors and industrial use sector to avoid poor water crisis especially for drinking use.

In–situ analysis is done at the study area to measure the parameters given . For instance, pH, dissolved oxygen (DO), electric conductivity (EC), turbidity and temperature is tested when the apparatus is upon contact to the water. Reading from the digital instrument is recorded as current data of the experiment.

While for ex–situ , parameter such as biochemical oxygen demand (BOD), chemical oxygen demand (COD), heavy metals, total suspended solids and total hardness are tested by using appropriate apparatus, materials and particular method to obtain its distinctive results.

3.7 METHODS OF TESTING

The methods and apparatus used for the test related to the paramters aro shown in Table 3.1.

Table 3.1 : Methods and apparatus used for test

PARAMETERS		METHODS	APPARATUS
Physical	Temperature	The multimeter is placed in the slected points in the river water and the temperature reading is recorded.	Horiba Multi Parameter
	Turbidity	The multimeter is placed in the slected points in the river water and the turbidity reading is recorded.	Horiba Multi Parameter
	Total Suspended Solids	Filter paper is placed on the filter apparatus and vaccum is applied.Then, the sample water is fitered through the filter paper.The filter paper containing suspended solids is then heated in the oven for more than 1 hour. Te filter paper is cooled, dessicated and weighted to obtain the value of	Glass microfiber filter disc (5.5m, Whatman type GF/C (0.7µm)), disposable aluminium dishes, suction flask 1L, 47mm glass microanalysis filter holder (funnel, clamp and base), drying oven for operation (103º-105º), desiccator, analytical balance and

		suspended solids,	distilled water
Chemical	Biochemical Oxygen Demand	Dilution water is prepared in glass container by bubbling compressed air in distilled water for about 30 minutes. Then , 1 mL of each phosphate buffer, magnesium sulphate, calcium chloride and ferric chloride is added to each litre of dilution water and mixed well.The sampe is neutralized around Ph 7 by using 1 N NaOH or $H_2SO_{4..}$ Samples of dilution water in filled in the BOD bottles and kept in the incubator of 30º. The DO content is measured using oxygen meter.	BOD bottles, BOD incubator (Temperature 20º)
	Chemical Oxygen Demand	A vial is set at 45º angle.A pipette is used to add 2 mL of sample to the vial and is inverted gently several times.The vial is placed in the COD Reactor for two hours. The room temperature vials is inserted to spectrophometer cell holder to obtain the reading.	DR 2500 Spectrophometer, COD reactor, 2 mL volumetric pipette.

	pH	The pH reading is taken directly at the study area. The multimeter is inserted in the river at each sampling point and the reading taken.	Horiba Multi Parameter
	Total Hardness	The sample is diluted to the ratio 1:10000 by using distilled water. 1mL of of calcium and magnesium indicator solution is added to the 100 mL of diluted sample and inverted for several times. 1. mL of alkali solution is added then further inverted.The sample is separated into three square sample cells. One drop of 1M EDTA solution is added for blank sample, one drop of EGTA solution added for magnesium and the third one is calcium. It is the placed in the spectrophometer for readings to be taken.	DR 2500 Spectrophometer
	Dissolved Oxygen	The dissolved oxygen reading is taken directly at the study area. The multimeter is inserted in the river at each sampling point and the reading taken.	Horiba Multi Parameter

	Electrical Conductivity	The electrical conductivity reading is taken directly at the study area. The multimeter is inserted in the river at each sampling point and the reading taken.	Horiba Multi Parameter
	Heavy Metals (Iron, copper,cadmium and chromium)	The sample water was aspirated into the flame to be atomized. A beam of light is focused through the flame to measure the quantity of light that has been absorbed by the atoms inside the flame. The heavy metal concentration of the sample is recorded for the digital display.	Atomic Absorbtion Spectrometer

3.8 WATER QUALITY STANDARD

The analyzed parameters are further classified into its own water classes and uses according to NWQS for Malaysia. Water quality standards are provisions of state, territorial, authorized tribal or federal law approved by EPA that describe the desired condition of a waterbody or the level of protection or instructions how the desired condition will be expressed or established for such waters in the future.

Table 3.2: NWQS for Malaysia

(Source : WEPA Policy Laws Malaysia)

PARAMETER	UNIT	CLASS				
		I	IIA/IIB	III#	IV	V
Al	mg/l		-	(0.06)	0.5	
As	mg/l		0.05	0.4 (0.05)	0.1	
Ba	mg/l		1	-	-	
Cd	mg/l		0.01	0.01* (0.001)	0.01	
Cr (IV)	mg/l		0.05	1.4 (0.05)	0.1	
Cr (III)	mg/l		-	2.5	-	
Cu	mg/l		0.02	-	-	
Hardness	mg/l		250	-	-	
Ca	mg/l		-	-	-	
Mg	mg/l		-	-	-	
Na	mg/l		-	-	3 SAR	
K	mg/l		-	-	-	
Fe	mg/l		1	1	1 (Leaf) 5 (Others)	
Pd	mg/l		0.05	0.02* (0.01)	5	

Table 3.3 : NWQS for Malaysia

(Source : WEPA Policy Laws 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	-	-	-
Electrical Conductivity*	μS/cm	1000	1000	-	-	6000	-
Floatables	-	N	N	N	-	-	-
Odour	-	N	N	N	-	-	-
Salinity	%	0.5	1	-	-	2	-
Taste	-	N	N	N	-	-	-
Total Dissolved Solid	mg/l	500	1000	-	-	4000	-
Total Suspended Solid	mg/l	25	50	50	150	300	300
Temperature	°C	-	Normal + 2 °C	-	Normal + 2 °C	-	-
Turbidity	NTU	5	50	50	-	-	-
Faecal Coliform**	count/100 ml	10	100	400	5000 (20000)a	5000 (20000)a	-
Total Coliform	count/100 ml	100	5000	5000	50000	50000	> 50000

Table 3.4 : Water Classes and Uses

(Source: WEPA Policy Laws Malaysia)

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

3.9 CONCLUSION

In a nutshell, the water sample is collected at three (3) selected stationa at Sungai Pengorak, Kuantan. Samples are taken from September to November, once a month to observe the parameters in detail. Specific methods and apparatus is used to study the water quality status of Sungai Pengorak according to the parameters stated. The test is conducted both in-situ and ex-situ way. The data collected is analyzed, interpreted and later compared to standards for further classification of water.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 INTRODUCTION

This chapter discussed the results and analysis obtained through in–situ and ex–situ tests within time range and later, the values are to be used to determine the water quality of Sungai Pengorak, Kuantan. The parameters discussed for in–situ tests are pH, turbidity, electrical conductivity (EC), dissolved oxygen (DO) and temperature while for ex–situ tests, total suspended solids (TSS), biochemical oxygen demand (BOD), chemical oxygen demand (COD), total hardness and heavy metals.

The aim of these experiments is to classify the river water into its own classes by assessing the river water quality. Three (3) sets of sampling are taken from three (3) different points to determine the accurate water quality of Sungai Pengorak, Kuantan due to bauxite effect. Time gap are implemented while collecting samples so that the acquirement would have difference in results and analysis obtained.Thus, the classification of river water would be more reliable.

The samples are collected for three different months starting from 20th September 2016 , 19th October 2016 and 9th November 2016. The in–situ tests are conducted using HORIBA while the samples for ex–situ tests are placed in a plastic bottle and stored in the chiller to minimize any biological and chemical reaction of sample.

4.2 PHYSICAL PARAMETERS

4.2.1 Temperature

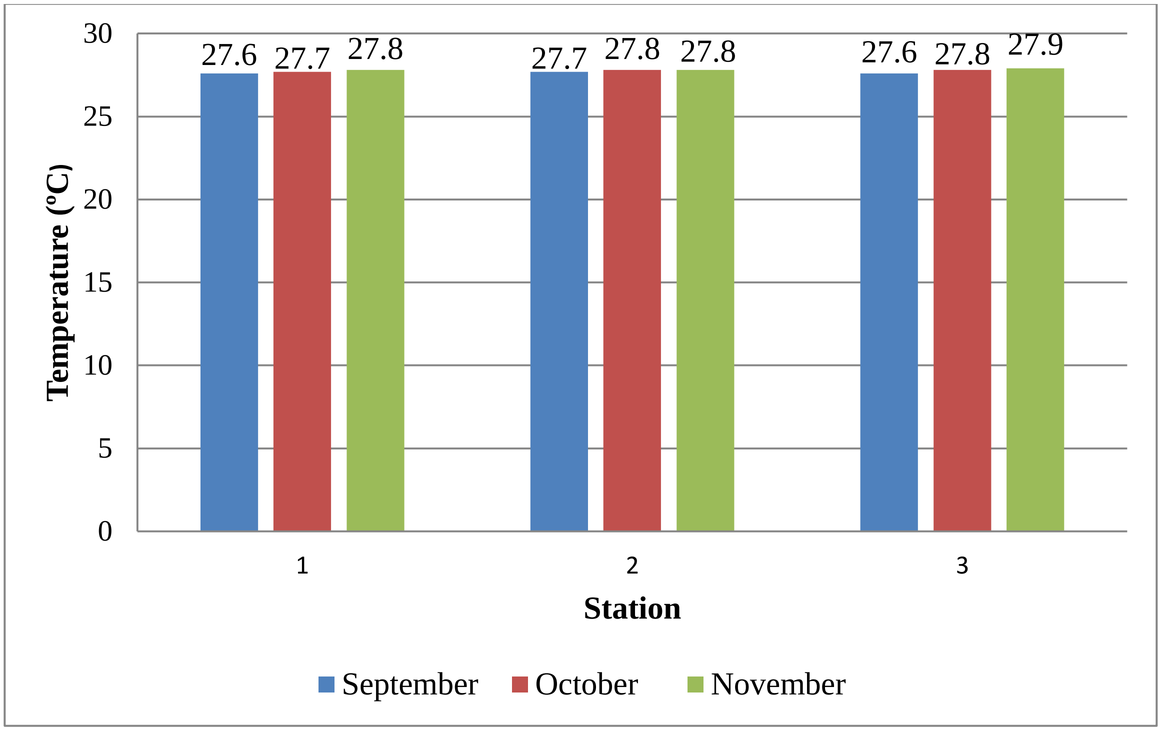


Figure 4.1 : Temperatures at Different Stations

Figure 4.1 shows the variation of temperature readings throughout three (3) times of samplings.. All samples range from as low as 27.6 °C to as high as 27.9 °C. The average of each station is 27.73 °C, 27.80 °C and 27.83 °C. The highest temperature read would be of Station 3 which value 27.9 °C in November while the lowest is 27.6 °C at Station 1 in September. According to NWQS, the river water temperature is Class IIA which is normal as it increase within the range of Normal +2

4.2.2 Temperature During Dry and Wet Season

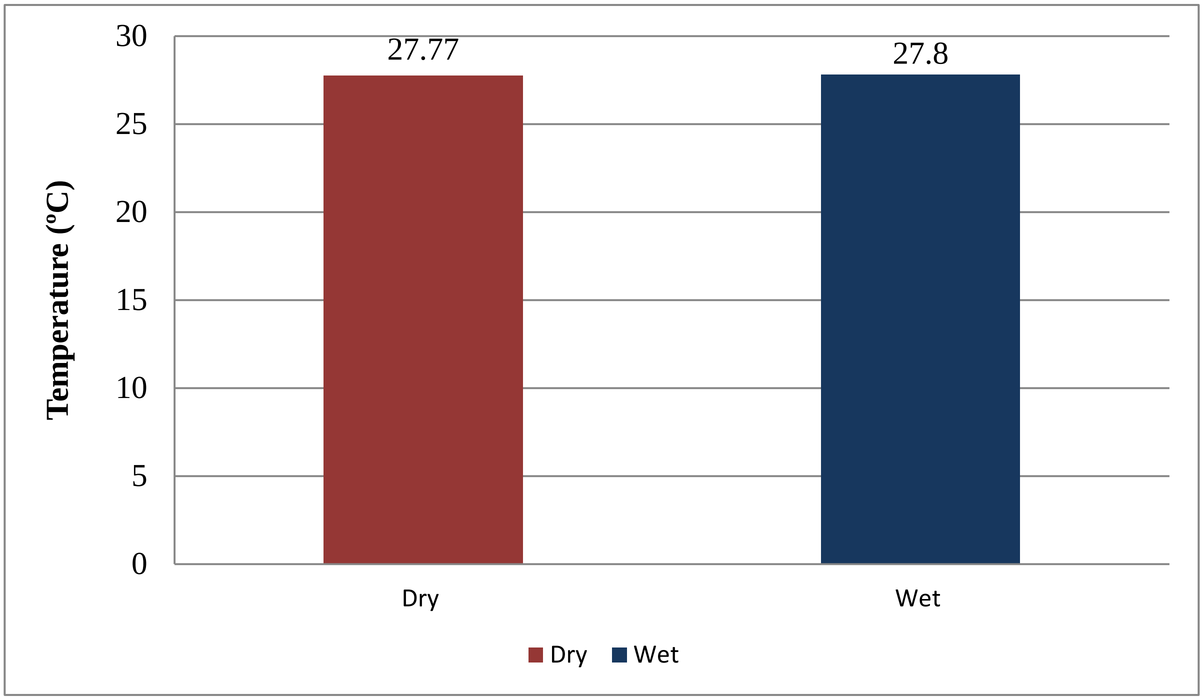


Figure 4.2 : Temperatures at Different Seasons

Water temperature fluctuates every day (diurnal temperature changes) and over longer time periods. It varies along the length of a river with altitude and elevation but can also vary between small sections, depending on local conditions. Figure 4.2 shows values of samples taken in two (2) different seasons. Samplings 1 are taken during dry season and its average temperature is 27.77 °C while samplings 2 and samplings 3 are taken during wet season and the average temperature is 27.8 °C. Supposed, the temperature during dry season should be higher than wet season but due to runoff of nearby human activities which is mining, the heated industrial effluents affects the water by slightly increasing the temperature.

4.2.3 Turbidity

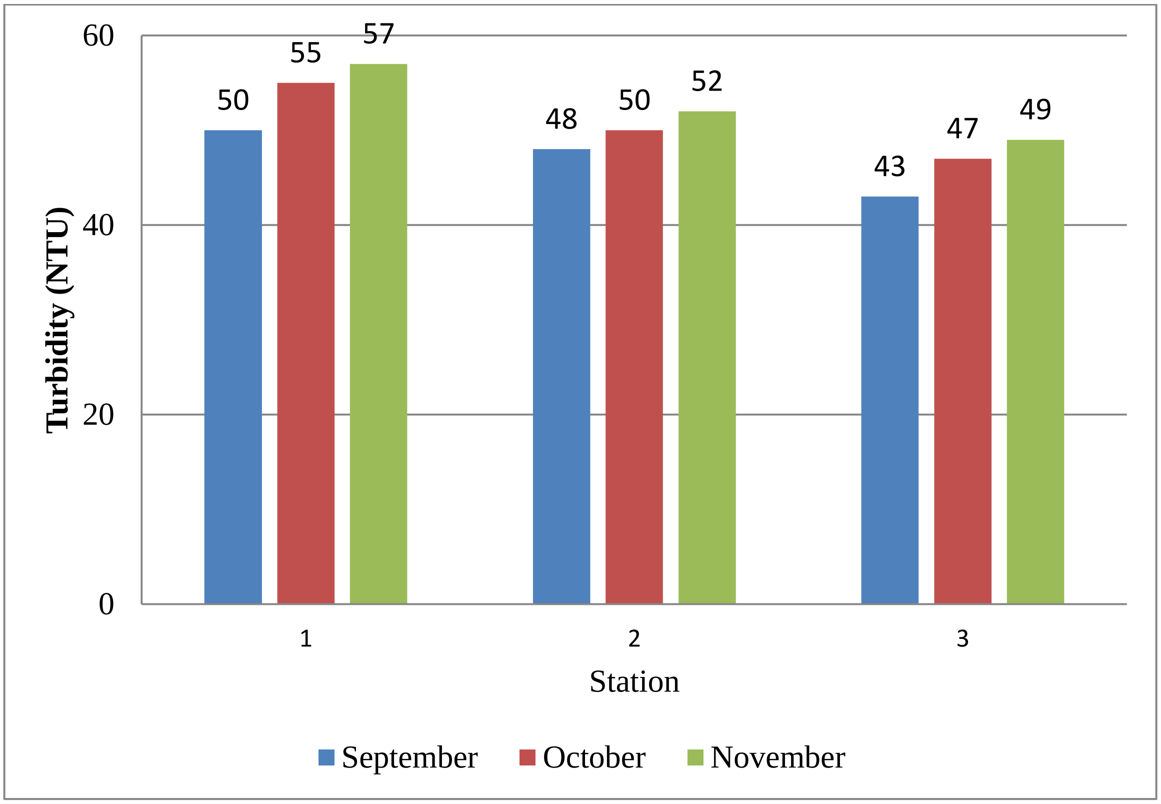


Figure 4.3 : Turbidity at Different Stations

Figure 4.3 shows the variation of turbidity readings throughout three (3) times of samplings. Turbidity is caused by particles suspended or dissolved in water that scatter light making the water appear cloudy or murky. The turbidity in Sungai Pengorak ranges from 43 NTU to 57 NTU. The average values of each stations are 54.00 NTU, 50.00 NTU 46.33 NTU. The highest turbidty obtained is during Sampling 3 (Station 1) which is 57 NTU while the lowest turbidity is during Sampling 1 (Station 3) at 43 NTU. According to NWQS, all stations are Class IIA turbidity.

4.2.4 Turbidity During Dry and Wet Season

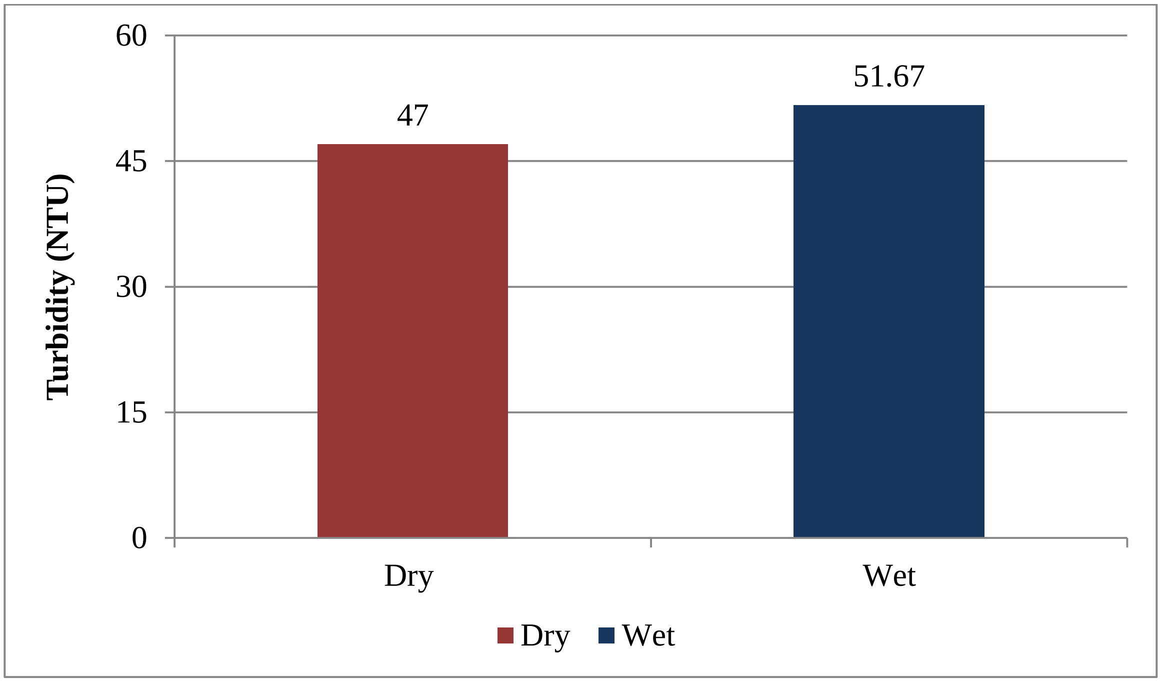


Figure 4.4 : Turbidity at Different Seasons

Sediment oftens tops the list of substances or pollutants causing turbidity. However, any waterways has multiple sources of the pollutants or physical features that can affect its clarity. It can be divided into a natural of background and human caused sources. Natural sources can include erosion from upland and stream banks while human activities can accelerate erosion. Figure 4.4 shows the turbidity of Sungai Pengorak during the day season and wet season. Samplings 1 are taken during dry season and its average turbidity is 47 NTU while samplings 2 and samplings 3 are taken during wet season and the average turbidity is 51.67 NTU. Wet season possessed more turbid water because the effluent deposited by runoff is concentrated where the sediments may be moved to creek when it rains.

4.2.5 Total Suspended Solid (TSS)

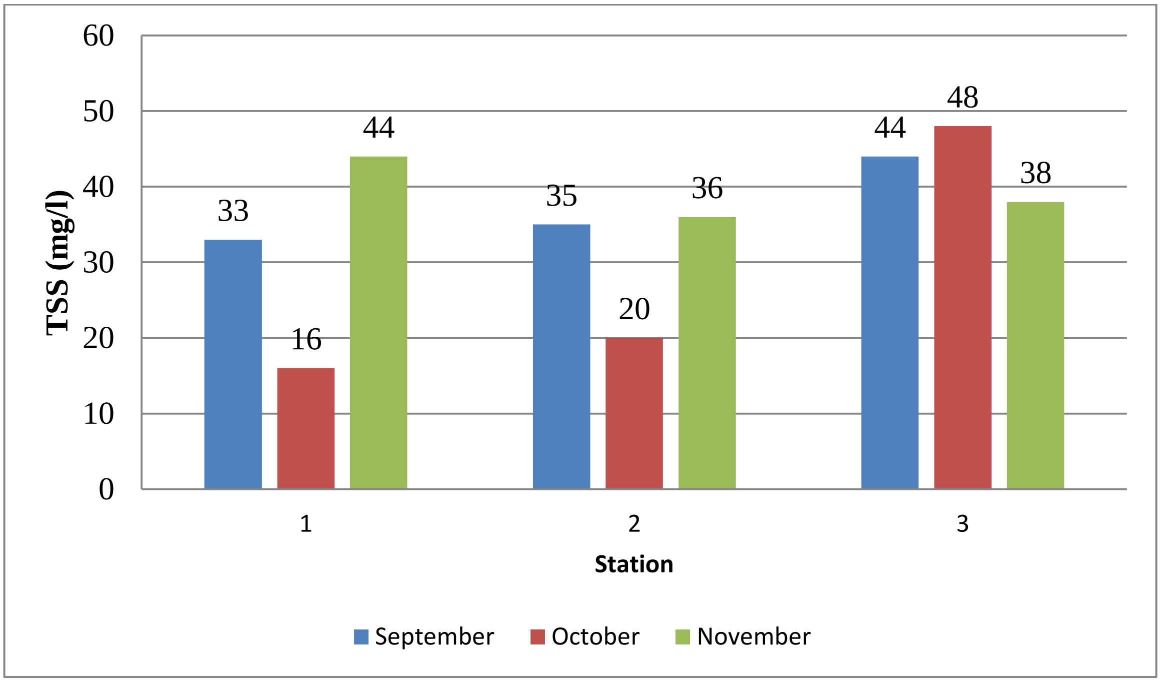


Figure 4.5 : Total Suspended Solid at Different Stations

Figure 4.5 shows the variation of TSS readings throughout three (3) times of samplings. TSS are particles that are larger than 2 microns found in the water column. In this case, heavy metals deposition by nearby bauxite mining site causes metals colloids to aggregate into larger particles (flocculation) and occur as suspended particles in the water (Schemal et al. 2000, Zanker et al. 2002). The TSS in Sungai Pengorak ranges from 16 mg/l to 48 mg/l. The average values of each stations are 31.00 NTU, 30.33 NTU and 43.33 NTU. The highest TSS obtained is during Sampling 2 (Station 3) which is 48 NTU while the lowest TSS is during Sampling 2 (Station 1) at 16 NTU. According to NWQS, Station 1 and Station 2 are Class 11A while Station 3 is Class I.

4.2.6 Total Suspended Solids During Dry and Wet Season

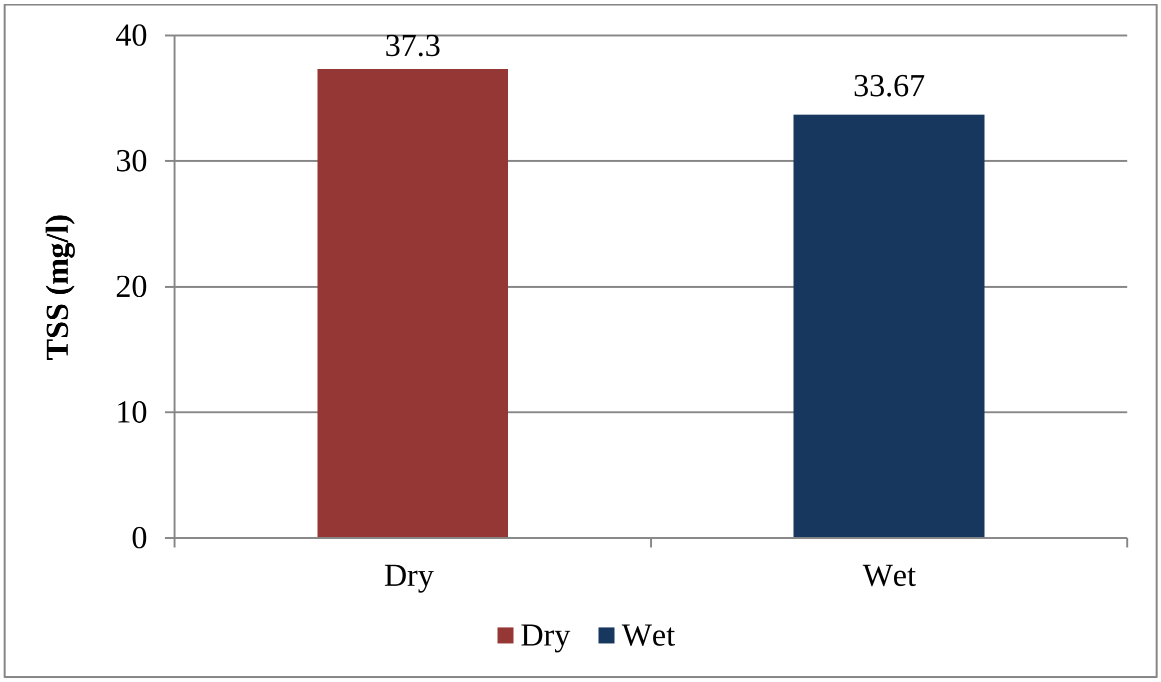


Figure 4.6 : Total Suspended Solids at Different Seasons

High TSS can block sunlight from reaching submerged vegetation. This reduces the rate of photosynthesis for aquatic plants. The decrease in water clarity caused by TSS can affect the ability of fish to see and catch foods. Figure 4.6 shows the turbidity of Sungai Pengorak during the day season and wet season. Samplings 1 are taken during dry season and its average turbidity is 37.3 mg/l while samplings 2 and samplings 3 are taken during wet season and the average turbidity is 33.67mg/l. Dry season has higher concentration of TSS in it water bodies due to waste discharge into river and while wet season's TSS is more diluted and the TSS may be flow to other areas.

4.3 CHEMICAL PARAMETERS

4.3.1 pH

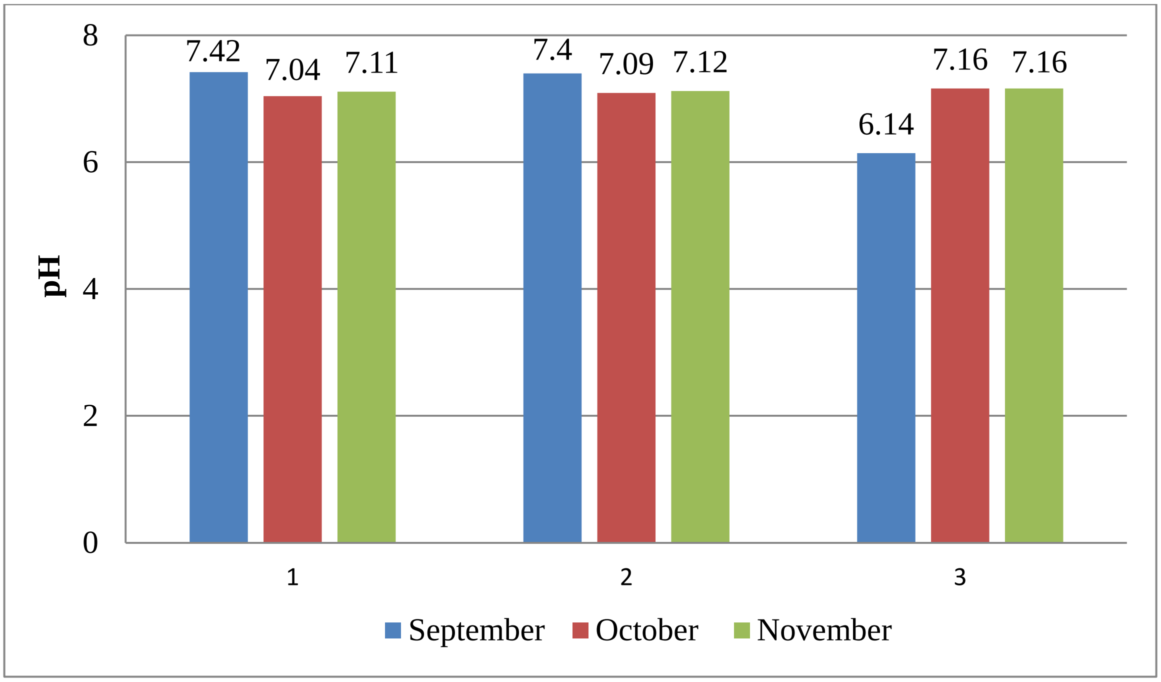


Figure 4.7 : pH at Different Stations

Figure 4.7 shows the variation of pH readings throughout three (3) times of samplings. While neutralization of AMD causes the removal of most metals, neutral to alkaline mine waters are known to contain elevated metals and metalloid concentrations. The elements can be carried for long distances downstream of their source and may adversely impact on the quality of receiving water bodies. The pH in Sungai Pengorak ranges from 6.14 to 7.42. The average values of each stations are 7.19, 7.20 and 6.82. The highest pH obtained is during Sampling 1 (Station 1) which is 7.42 while the lowest pH is during Sampling 1 (Station 3) at 16.4. According to NWQS, all stations are Class I pH which ranges from 6.5 to 8.5.

4.3.2 pH During Dry and Wet Season

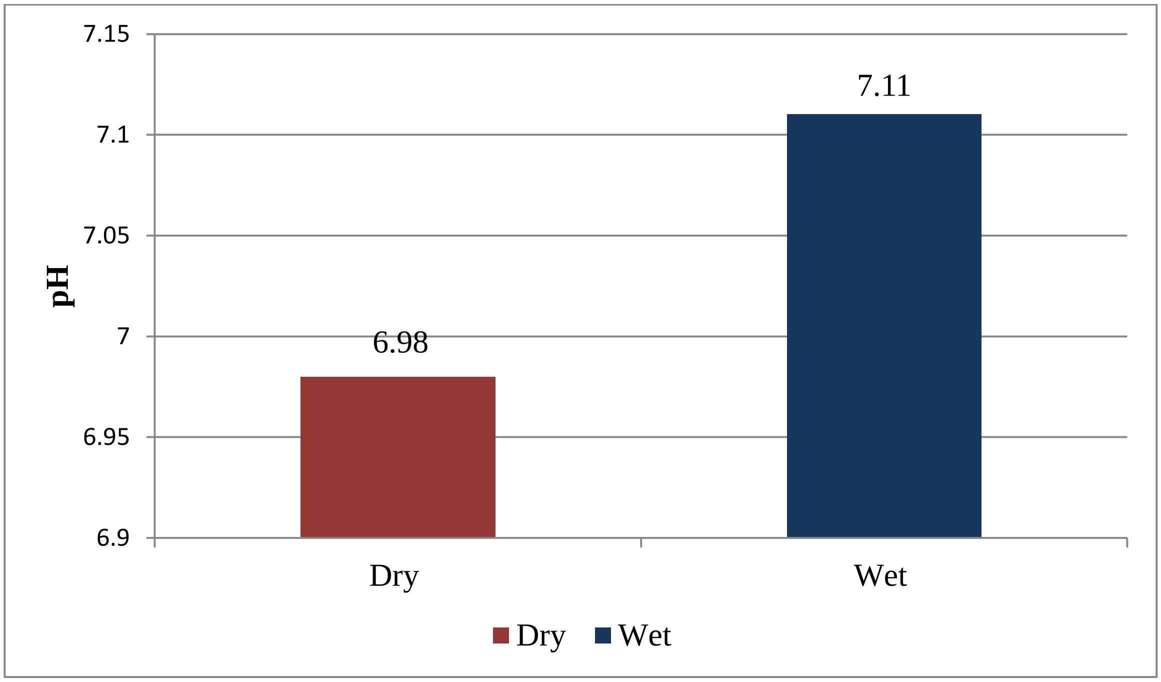


Figure 4.8 : pH at Different Seasons

pH is a numeric scale used to specify the acidity or basicity of an aqueous solution. Solutions with a pH less than 7 are acidic and solutions with a pH greater than 7 are basic. Figure 4.8 shows the pH of Sungai Pengorak during the dry season and wet season. Samplings 1 are taken during dry season and its average turbidity is 6.98 while samplings 2 and samplings 3 are taken during wet season and the average turbidity is7.11. The seasonality in the pH of Sungai Pengorak may be due to discharge of acid mine drainage in the area as well as the imbalance level of H^+ ions input from surface runoff's during rains.

4.3.3 Dissolved Oxygen (DO)

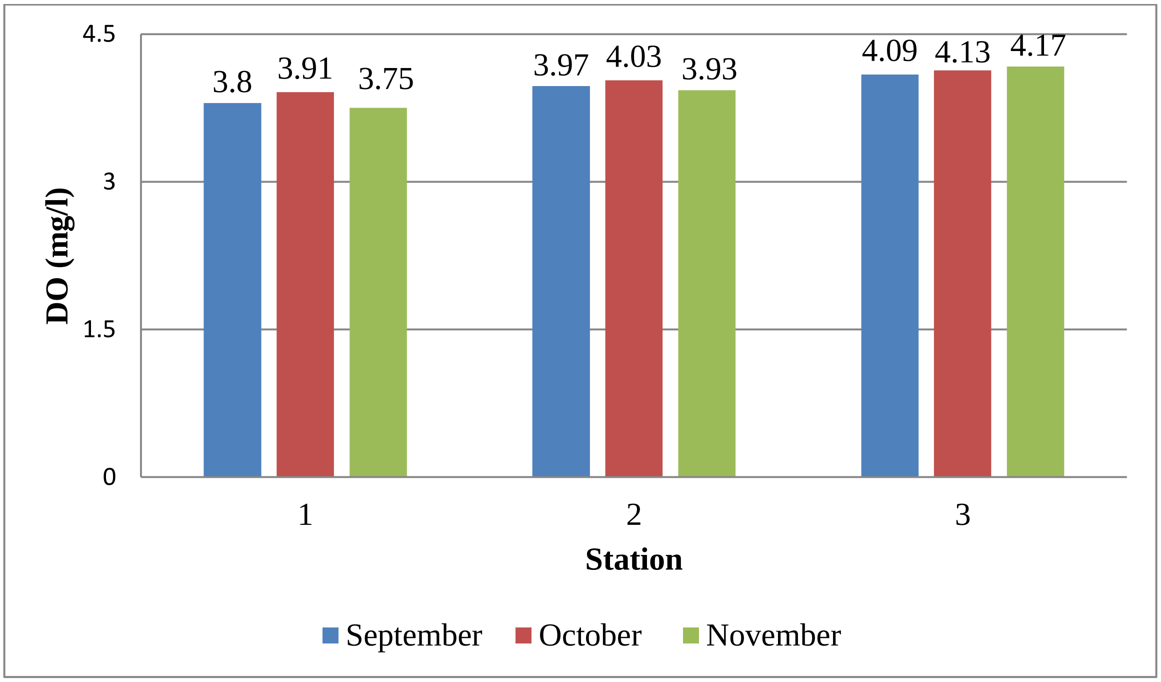


Figure 4.9 : Dissolved Oxygen at Different Stations

Figure 4.9 shows the variation of pH readings throughout three (3) times of samplings. The amount of DO that dissolves in water varies in daily and seasonal patterns and decreases with higher temperature, salinity and elevation. The DO in Sungai Pengorak ranges from 3.75 mg/l to 4.17 mg/l. The average values of each stations are 3.82 mg/l, 3.98 mg/l and 4.13 mg/l. The highest DO obtained is during Sampling 3 (Station 3) which is 4.17 mg/l while the lowest pH is during Sampling 3 (Station 1) at 3.75 mg/l. According to NWQS, all stations are Class III DO which ranges from 3 mg/l to 5 mg/l.

4.3.4 Dissolved Oxygen (DO) During Dry and Wet Season

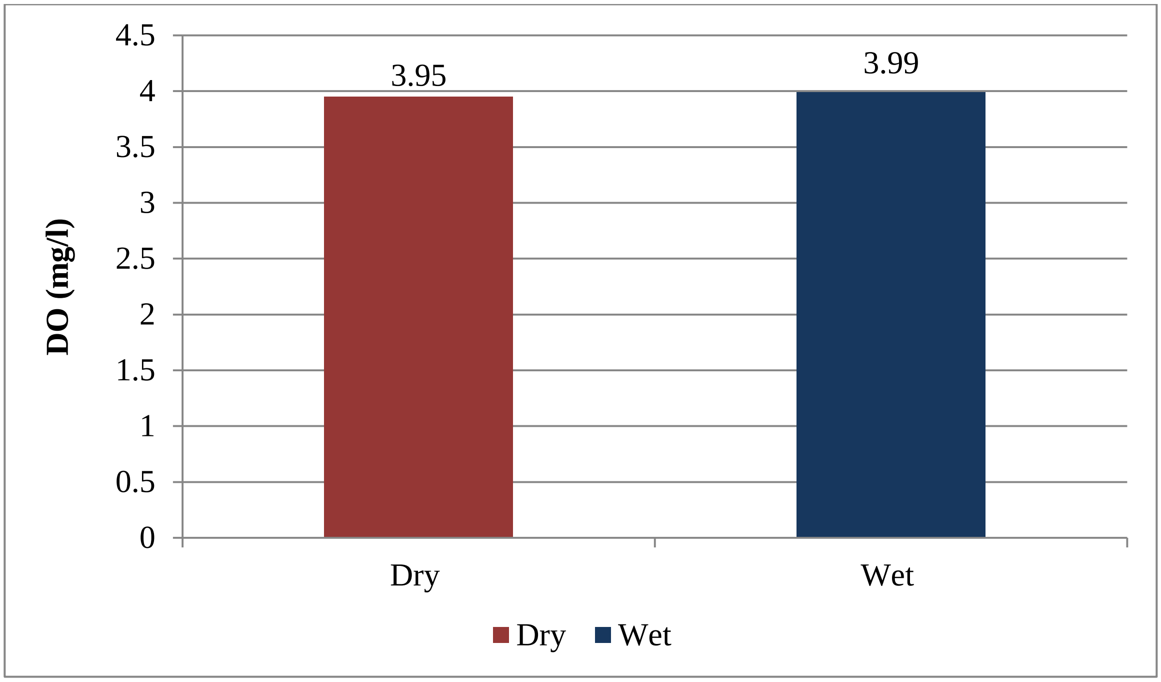


Figure 4.10 : Dissolved Oxygen at Different Seasons

Surface water, near the water – atmosphere interface is generally saturated with oxygen. Deeper water receives oxygen through mixing by wind, currents and inflows. Figure 4.10 shows the DO of Sungai Pengorak during the dry season and wet season. Samplings 1 are taken during dry season and its average turbidity is 3.95 mg/l while samplings 2 and samplings 3 are taken during wet season and the average turbidity is 3.99 mg/l. The DO increases as it moves downstream and it values varies significantly. This coul be attributed to nutrient regeneration from bottom sediments, decomposition and mineralization of microbes downstream (Wan Mohd Afiq Wan Mohd Khalik, 2012).

4.3.5 Biochemical Oxygen Demand (BOD)

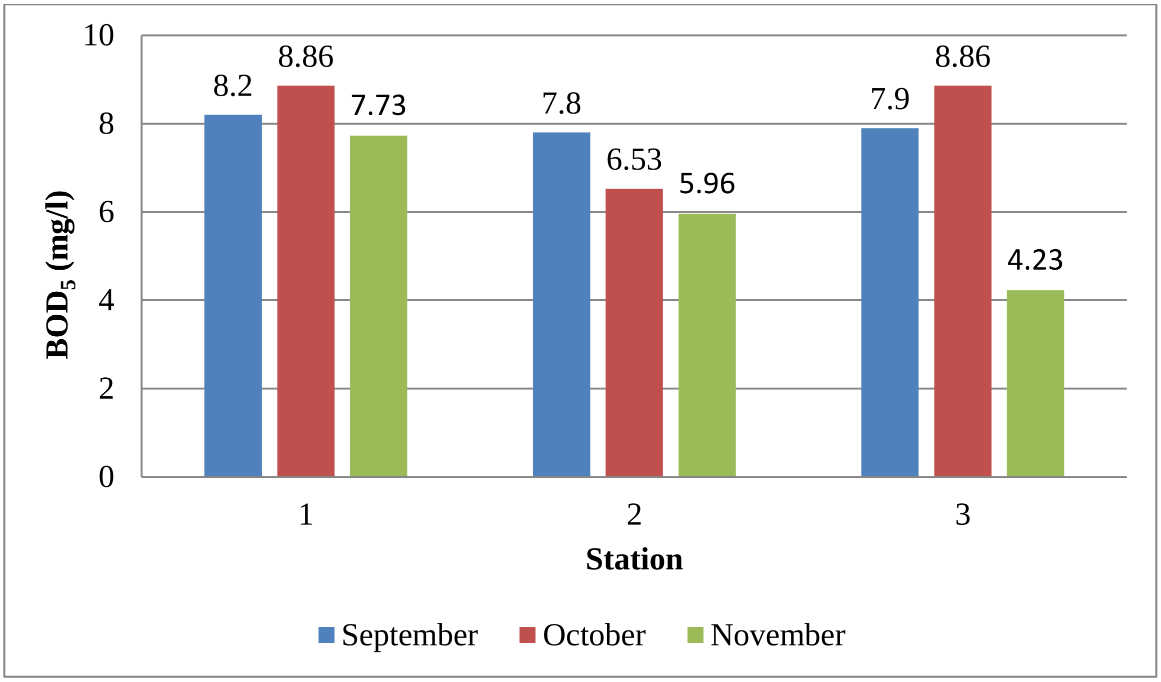


Figure 4.11 : Biochemical Oxygen Demand at Different Stations

Figure 4.11 shows the variation of BOD_5 readings throughout three (3) times of samplings. BOD_5 is the amount of dissolved oxygen needed by aerobic biological organisms to break down organic material present in a water sample. The BOD_5 in Sungai Pengorak ranges from 4.23 mg/l to 8.86 mg/l. The average values of each stations are 8.26 mg/l, 7.21 mg/l and 7.94 mg/l. The highest BOD obtained is during Sampling 2 (Station 1 and Station 3) which is 8.86 mg/l while the lowest BOD is during Sampling 3 (Station 3) at 4.23 mg/l. According to NWQS, all stations are Class IV BOD which ranges from 6 mg/l to 12 mg/l.

4.3.6 Biochemical Oxygen Demand (BOD) During Dry and Wet Season

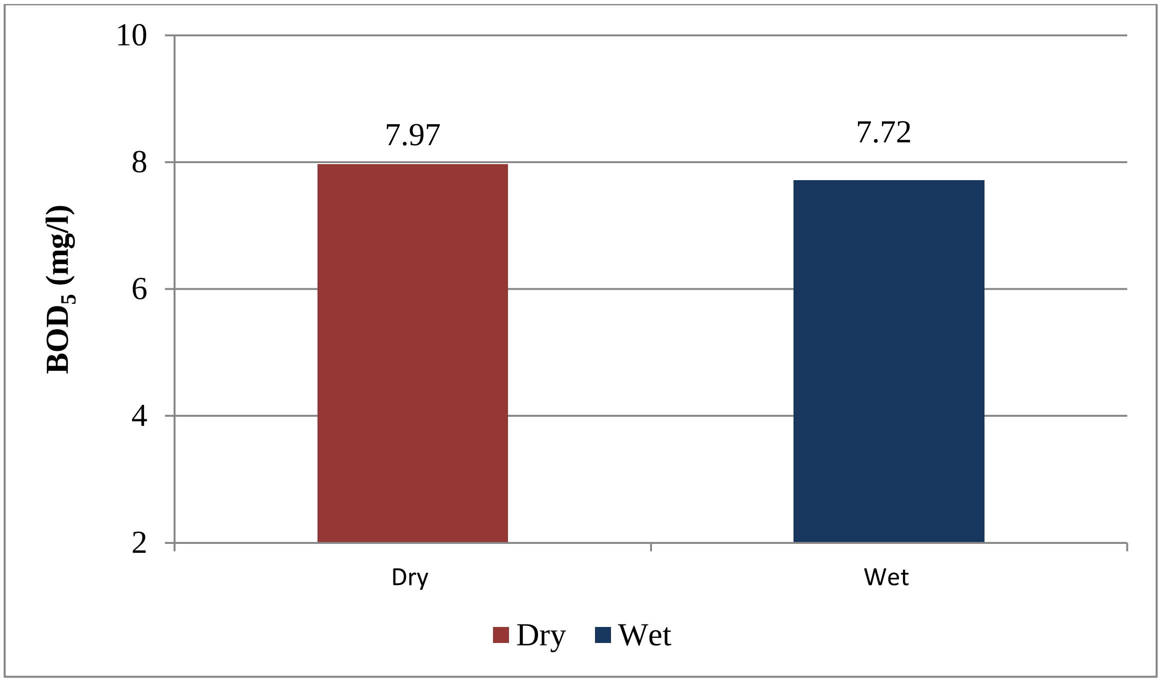


Figure 4.12 : Biochemical Oxygen Demand at Different Seasons

Figure 4.12 shows the BOD_5 of Sungai Pengorak during the dry season and wet season. Samplings 1 are taken during dry season and its average BOD_5 is 7.97 mg/l while samplings 2 and samplings 3 are taken during wet season and the average BOD_5 is 7.72 mg/l. Availability of oxygen to living organism decreases with increasing BOD_5 value, high BOD_5 value indicate maximum oxygen consumption. Slight difference of BOD_5 between the seasons is possibly due to changes of current that increases or decreases the speed of water overflow (Wan Mohd Afiq Wan Mohd Khalik, 2012).

4.3.7 Chemical Oxygen Demand (COD)

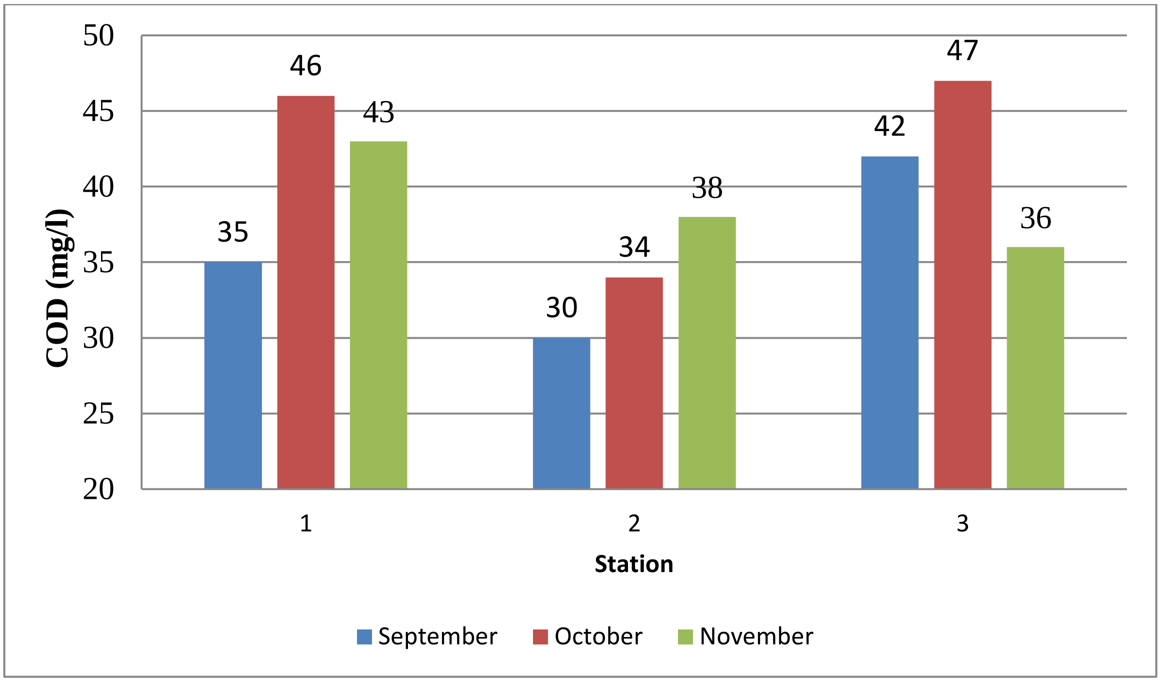


Figure 4.13 : Chemical Oxygen Demand at Different Stations

Figure 4.13 shows the variation of BOD_5 readings throughout three (3) times of samplings. COD test is used to indirectly measure the amount of organic compounds in water. High COD indicates contaminated water. The COD values in Sungai Pengorak ranges from 30.00 mg/l to 47.00 mg/l. The average values of each stations are 41.3 mg/l, 34.00 mg/l and 41.67 mg/l. The highest COD obtained is during Sampling 2 (Station 3) which is 47 mg/l while the lowest COD is during Sampling 1 (Station 2) at 30 mg/l. According to NWQS, all stations are Class III COD which ranges from 25 mg/l to 50 mg/l.

4.3.8 Chemical Oxygen Demand (COD) During Dry and Wet Season

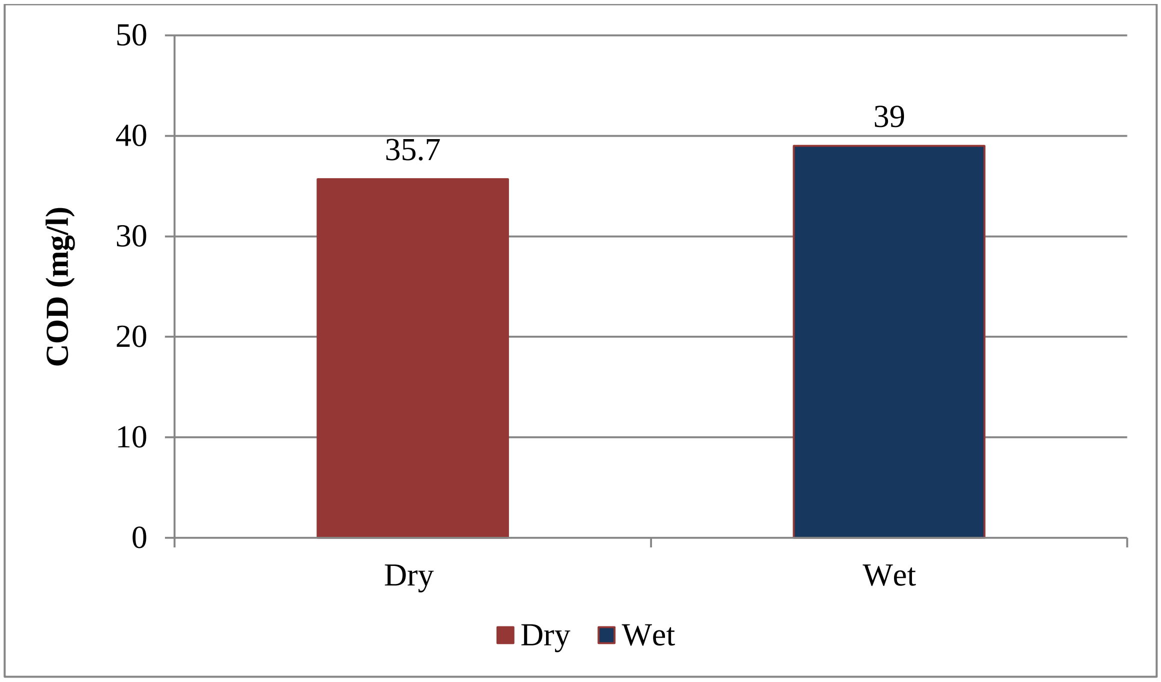


Figure 4.14 : Chemical Oxygen Demand at Different Seasons

Figure 4.14 shows the COD of Sungai Pengorak during the dry season and wet season. Samplings 1 are taken during dry season and its average COD is 35.7 mg/l while samplings 2 and samplings 3 are taken during wet season and the average COD is 39.00 mg/l. High amount of chemicals are oxidized by oxygen during wet seasons. It is mostly due to the movement of current that enables oxygen to diffused deep into the water and intrigued the process.

4.3.9 Electrical Conductivity (EC)

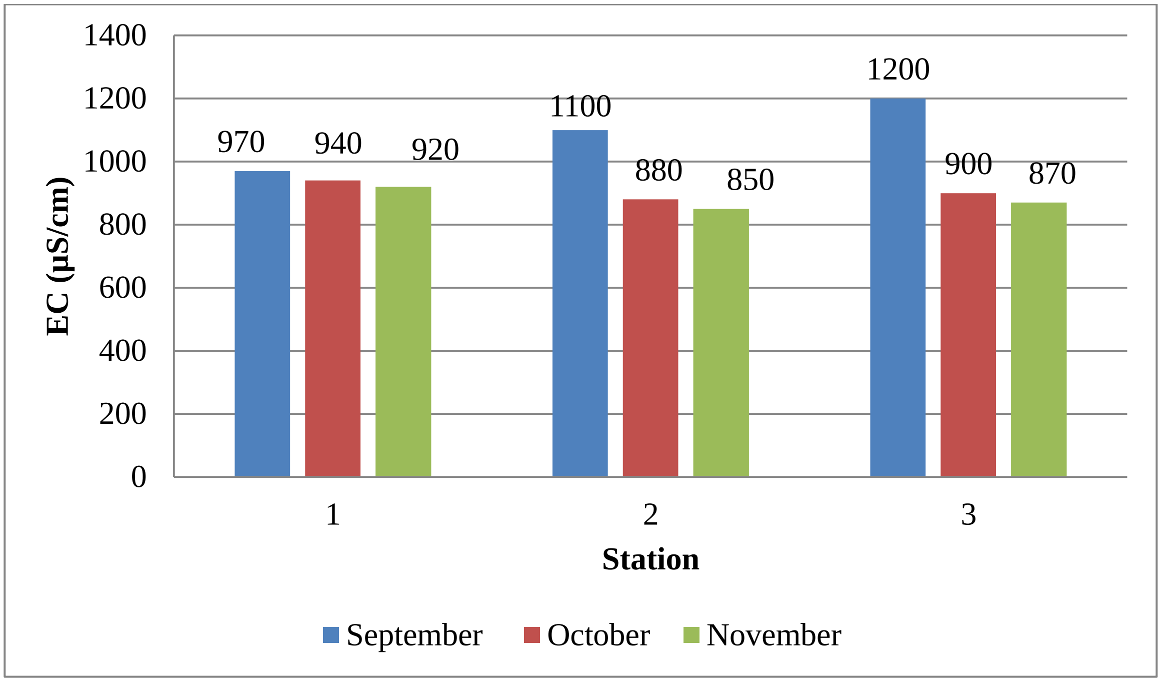


Figure 4.15 : Electrical Conductivity at Different Stations

Figure 4.15 shows the variation of EC readings throughout three (3) times of samplings. The electrical conductivity of water is directly related to the concentrations of dissolved solids in the water. Ions from the dissolved solids in water influence the ability of that water to conduct electrical current. The EC values in Sungai Pengorak ranges from 850 S/cm to 1200 S/cm. The average values of each stations are 947 S/m, 946 S/cm and 992 S/cm. The highest EC obtained is during Sampling 1 (Station 3) which is 1200 S/cm while the lowest EC is during Sampling 3 (Station 2) at 850 S/cm. According to NWQS, all stations are Class I EC which ranges from 0 S/cm to 1000 S/cm.

4.3.10 Electrical Conductivity (EC) During Dry and Wet Season

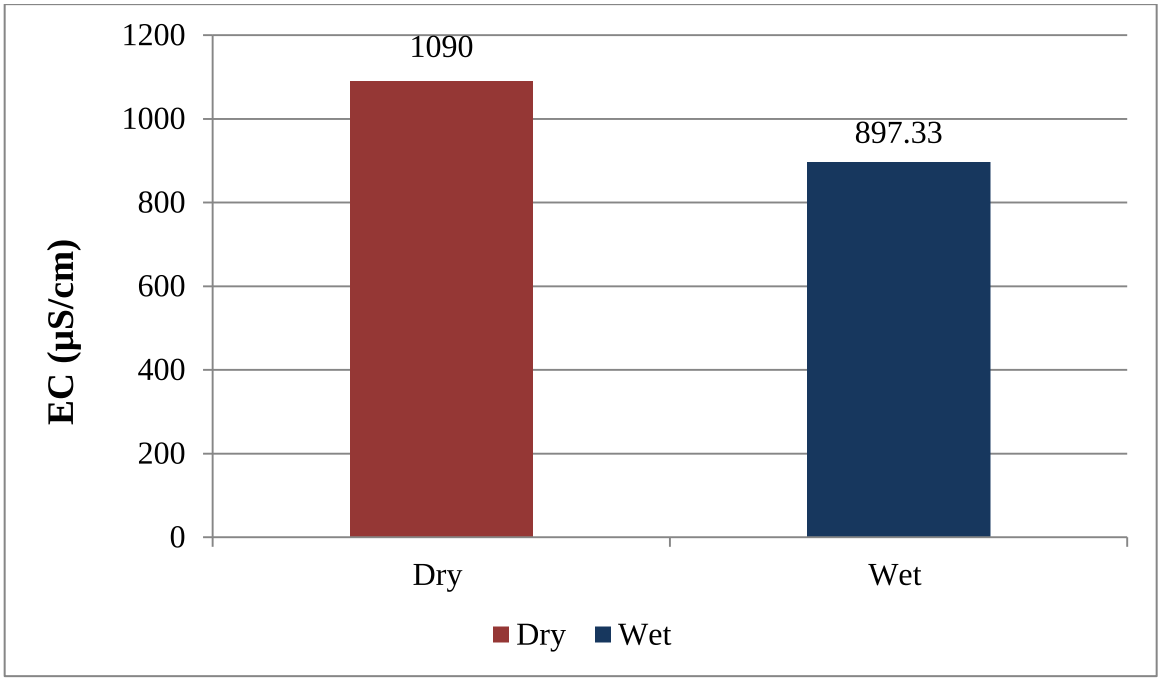


Figure 4.16 : Electrical Conductivity at Different Seasons

Figure 4.16 shows the EC of Sungai Pengorak during the dry season and wet season. Samplings 1 are taken during dry season and its average EC is 1090 S/cm while samplings 2 and samplings 3 are taken during wet season and the average EC is 897.33 S/cm. Conductivity in streams is affected primarily by the geology of the area through which the water flows. It is caused by the presence of inorganic dissolved solids such as chloride, nitrate, sulfate ad phosphates ions. Dry season has higher electrical conductivity due to its high concentration of ions compared to wet seasons where the dissolved solids may be diluted and changes current.

4.3.11 Hardness

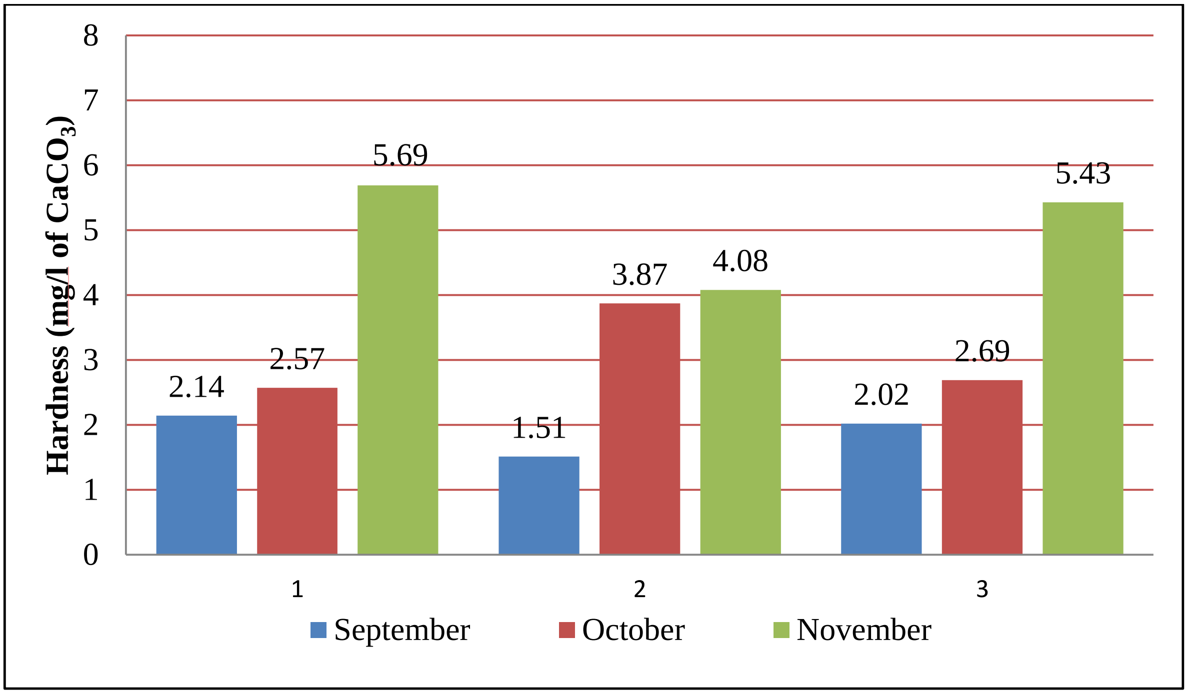


Figure 4.17 : Hardness at Different Sations

Figure 4.17 shows the variation of hardness readings throughout three (3) times of samplings. Hard water is formed when water passes through or over limestone or chalk areas and calcium and magnesium ions dissolve into the water. The concentrations values in Sungai Pengorak ranges from 1.51 mg/l to 5.69 mg/l. The average values of each stations are 3.47 mg/l, 3.15 mg/l and 3.38 mg/l. The highest concentration obtained is during Sampling 3 (Station 1) which is 5.69 mg/l while the lowest concentration is during Sampling 1 (Station 2) at 1.51 mg/l. According to NWQS, all stations are Class I hardness which ranges from 0 mg/l to 250 mg/l.

4.3.12 Hardness During Day and Wet Seasons

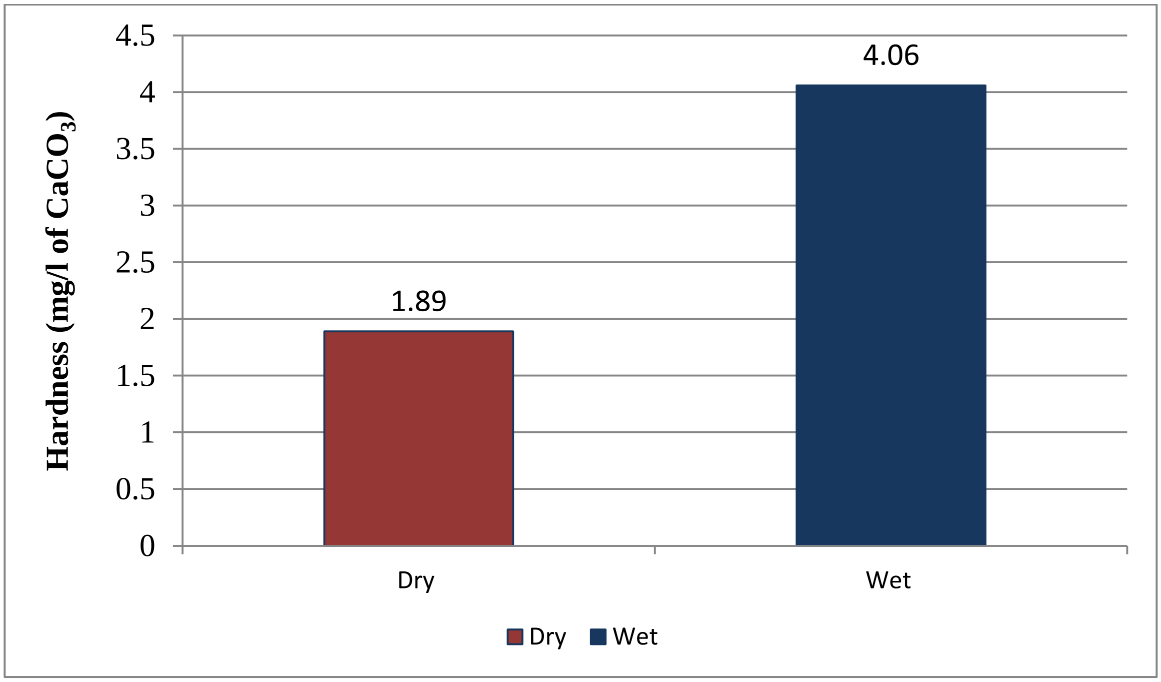


Figure 4.18 : Hardness at Different Seasons

Figure 4.18 shows the hardness concentration of Sungai Pengorak during the dry season and wet season. Samplings 1 are taken during dry season and its average concentration is 1.89 mg/l while samplings 2 and samplings 3 are taken during wet season and the average concentration is 4.06 mg/l. The water in the river has little chance of passing through rocks and to dissolve the minerals that make water hard. Therefore, majority of water is soft.

4.3.13 Heavy Metals

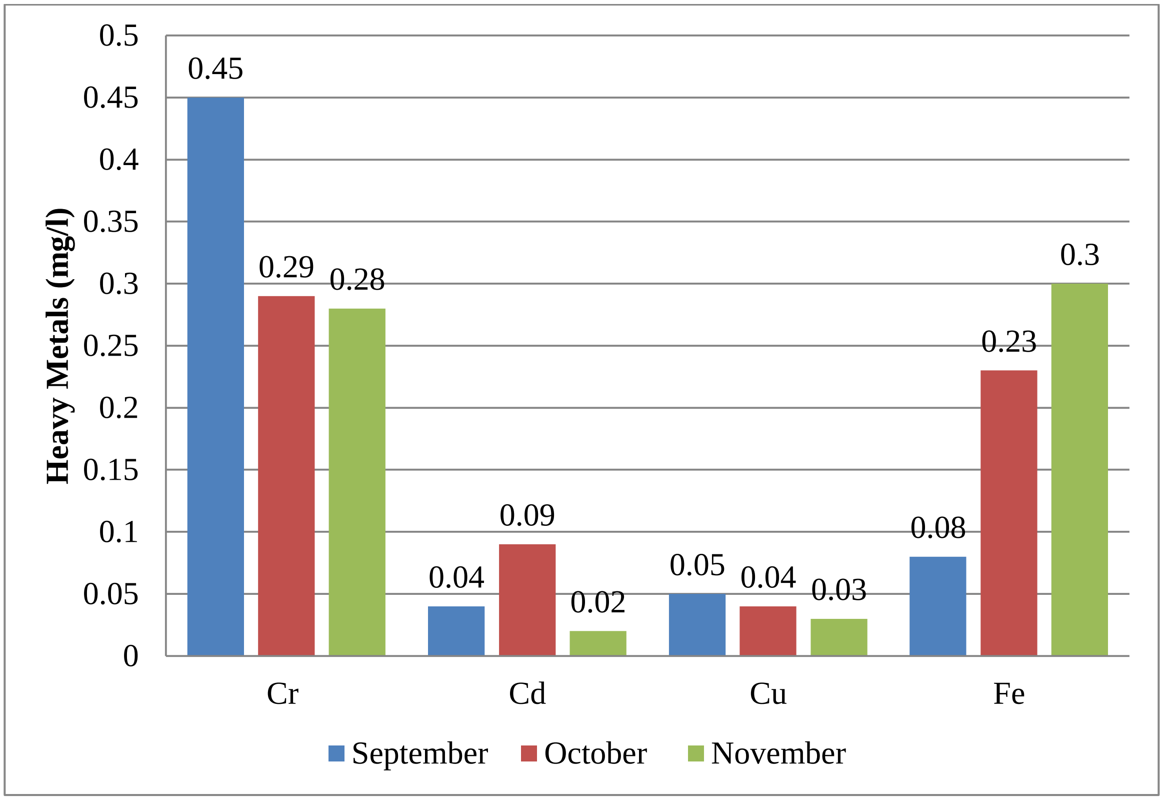


Figure 4.19 : Variation of Heavy Metals at Different Stations

Figure 4.17 shows the variation of heavy metals concentrations throughout three (3) times of samplings. The oxidation of various sulfide minerals releases their major and trace elements including numerous heavy metals. Heavy metals can occur in various AMD waters. The concentration of heavy metals in Sungai Pengorak ranges from 0.02 mg/l to 0.45 mg/l. The average values of each heavy metals are; Cr 0.34 mg/l, Cd 0.05 mg/l, Cu 0.04 mg/l and Fe 0.20 mg/l. The highest concentration obtained is during Sampling 1 (Station 1) which is 0.45 mg/l of Cr while the lowest concentration is during Sampling 3 (Station 3) at 0.02 mg/l of Cd. According to NWQS, all stations for Cr and Cd are Class IV, all stations for Cu are Class II and all stations for Fe are Class I.

4.3.14 Heavy Metals during wet and dry seasons

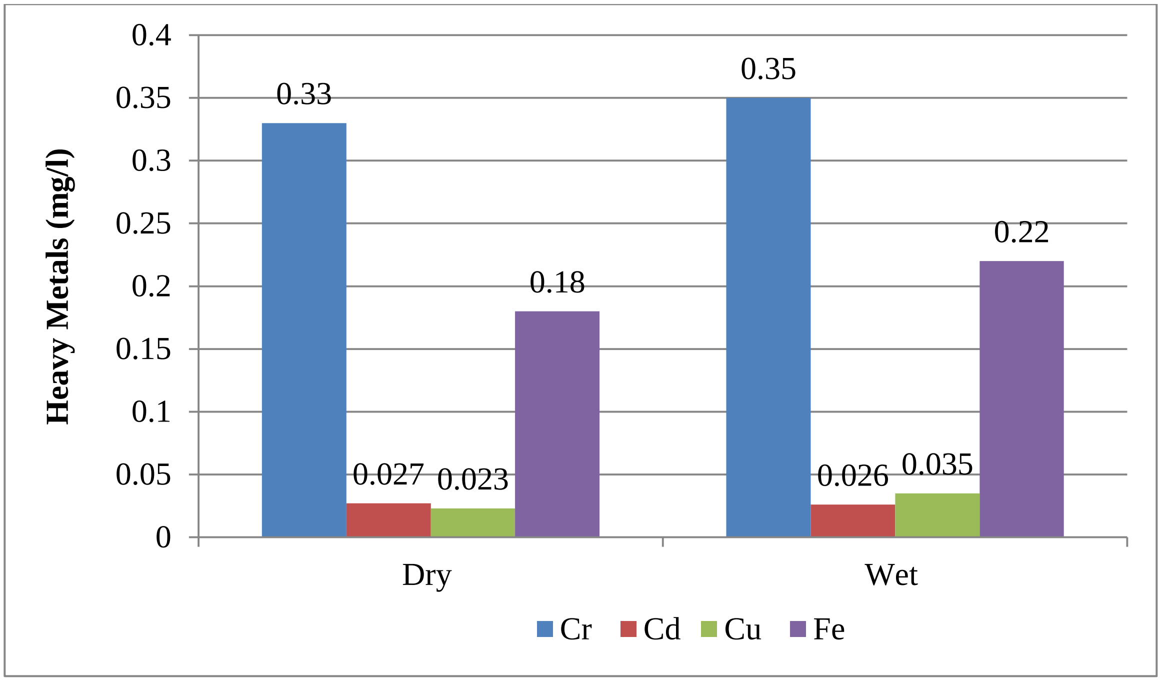


Figure 4.20 : Variation of Heavy Metals at Different Seasons

Figure 4.18 shows the concentration of Sungai Pengorak during the dry season and wet season. Samplings 1 are taken during dry season and its average concentration for each heavy metals are; Cr 0.33 mg/l, Cd 0.027 mg/l, Cu 0.023 mg/l and Fe 0.18 mg/l while samplings 2 and samplings 3 are taken during wet season and the average concentration are; Cr 0.35 mg/l, Cd 0.026 mg/l, Cu 0.035 mg/l and Fe 0.22 mg/l. Dissolved aluminium concentrations are strongly pH dependent, and the formation of colloids controls the aqueous aluminiums concentration (Nordstrom and Alpers, 1999a)

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 CONCLUSION

In a nutshell, the river is classified according to the NWQS after the analysis of parameters are completed. Station 1 and Station 3 of Sungai Pengorak are Class IV river water which serve irrigation purposes while Station 2 is Class III river water. It is further classified as water supply III, where the water is contaminated and requires extensive treatments. In addition, it is suitable for Fishery III activities, whereby it is a common condition for aquatic organisms. Fisheries activity can be practiced to maintain the community's economic value and and its water can be used for livestock drinking. Hence, local authorities and nearby populations should monitor the mining activities at a stern manner so that the production of mine waste are at a controllable stage, resulting a more controlled clean environment for the future.

5.2 RECOMMENDATIONS

Precaution measures should be implemented in future to lessen the impact of pollutions towards surrounding environment and affected communities. There are many aspects where the folks could first take action. The aspects are law reinforcement in monitoring mining activities, environmental education implementation to community and practicing polluters pay principle'.

First, existing laws should be reinforced. Water quality laws must identify the substances qualify as ‘water pollution’ for purposes of further control. This requires defining the classes of materials that qualify as pollutants and the activites that transform a material into a pollutant. Local authorities should monitor the mining activities at a stern manner especially at Felda Bukit Goh. Regulated and legal mining must be implemented in order to reduce the production of mine waste. Hence, discharge of acid mine drainage would also be reduced.

Next, environmental education implementation is just as important in developing industrialized nations. However, reaching out to the people can be very difficult. Community leaders can help ease communication problems and bridge the cultural divide that often stands in the way of outreach efforts. For example, hold awareness campaign on water pollution regularly to educate the community. Besides, classroom education also should be practiced. This will help them foster a sense of responsibility and ‘proactive citizenship’, so that when they become adults they will make choices that help the environment rather than harm it.

Lastly, practicing ‘polluters pay principle’ to miners that break the rules. The principle is enacted to make the party responsible for producing pollution responsible for paying for the damage done to the environment. The pay is then used to covered pollution prevention and control measures.

REFERENCES

Abdullah, N. I. (2016, 1 14). *Malaysia Kini* . Retrieved December 5 , 2016, from Bauxite mining's unhealthy effects on people, environment : http://www.malaysiakini.com/letters/326807

Asrari, E. (2014). *Heavy Metal Contamination of Water and Soil* . Florida : Appl Academic Press .

Aziz, F. (2016, January 8). *New Straits Time* . Retrieved December 7, 2016, from Health Ministry to Increase Monitoring Frequency of Water Quality in Kuantan : http://www.nst.com.my/news/2016/01/121182/health-ministry-increase-monitoring-frequency-water-quality-kuantan

Farrah Naz Karim, A. S. (2016, January 11). *New Straits Time* . Retrieved November 11, 2016, from Bauxite: Illegal Miners Outnumber Legal Ones : http://www.nst.com.my/news/2016/01/121598/bauxite-illegal-miners-outnumber-legal-ones-say-sources

Fondriest. (2014, Jun 13). Retrieved April 6, 2016, from Fundamentals of Environmental Measurements: http://www.fondriest.com/environmental-measurements/parameters/water-quality/turbidity-total-suspended-solids-water-clarity/

Fred G. Bell, L. D. (2006). *Mining and Its Impact on the Environment.* Florida : CRC Press.

Islam Mir Sujaul, M. A. (2013). Effect of Industrial Pollution on the Spatial Variation of Surface Water Quality . *American Journal of Environmental Science* , 10.

Leigh, E. (2010, November 9). *Recycle Nation.* Retrieved April 1, 2016, from What Aluminium Extraction Really Does to the Environmnet : http://recyclenation.com/2010/11/aluminum-extraction-recycling-environment

Lottermoser, B. G. (2007). *Mine Waste* . Cairns, Queensland 4870, Australia : Springer .

Mark J Hammer, K. A. (1981). *Hydrology and Quality of Water Resources* . Michigan : Wiley .

Migliaccio, Y. L. (2011). *Water Quality Concepts, Sampling and Analyses* . Florida : CRC Press .

Murphy, S. (2007, April 23). *City of Boulder* . Retrieved Mac 30, 2016, from General Imformation on Solids : http://bcn.boulder.co.us/basin/data/NEW/info/TSS.html

Nigel Aw, S. A. (2015, 12 30). *Malaysia Kini* . Retrieved December 7, 2016, from How the bauxite rush is taking a toll on Kuantan's future : https://www.malaysiakini.com/news/324788

Shah, A. (2016, January 20). *New Straits Time* . Retrieved October 15, 2016, from All Mines in Bukit Goh Illegal : http://www.nst.com.my/news/2016/01/123096/all-mines-bukit-goh-illegal

Shakhashiri, P. (2011, January). *scifun* . Retrieved March 28 , 2016, from Water .

Tartajada, C. (2013). *Water Quality Policy and Management in Asia* . 2 Park Square, Milton Park, Abingdon, Oxon : Routledge.

Wan Mohd Afiq Wan Mohd Khalik, M. P. (2012). Seasonal Influence on Water Quality Status of Temenggor Lake Perak . *The Malaysian Journal of Analytical Sciences*, 9.

Wu, E. (2016, Feb 17). *Asia One* . Retrieved November 25, 2016, from A red Curse in Pahang: http://news.asiaone.com/news/malaysia/red-curse-pahang