METAL POLLUTION ASSESSMENT OF SEDIMENT AND WATER RESOURCES CONSUMPTION TO BATEK TRIBE IN MERAPOH, PAHANG

By

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THESIS DECLARATION

I hereby declare that the work embodied in this Report is the result of the original research and has not been submitted for a higher degree to any universities or institutions.

………………………………………..

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Date : 27 December 2020

I certify that the Report of this final year project entitled Metal Pollution Assessment of Sediment and Water Resources Consumption to Batek Tribe in Merapoh, Pahang by Nurazrin Bt Mohamed Ghani, matric number E17A0101 has been examined and all corrections recommended by examiners have been done for the degree of Bachelor Applied Science (Sustainable Science) with Honours Faculty of Earth Science, University Malaysia of Kelantan.

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Metal Pollution Assessment of Sediment and Water Resources Consumption to Batek Tribe in Merapoh, Pahang

ABSTRACT

This study aims to evaluate the distributions of metal elements in water and sediments sampled from Merapoh, Pahang. There were 6 sampling stations were selected at two sampling areas and three replication measurements were conducted for the collected samples each sampling stations. The concentrations of heavy metal in those samples were determined using the Atomic Absorption Spectroscopy (AAS) with acid digestion method which has been verified with a certified reference material which is the sy-4 Diorite Gneiss. The result revealed that the metal variability in the water body and sediment mostly originated from human activities around the sampling sites, in addition to natural variations. In general, the results indicate that the total metal level is ordered as: sediment > water based on metal concentrations found. Sediments are suitable for monitoring long-term metal deposition in the aquatic system due to its capability to concentrate heavy metal and generally concentration of heavy metal in sediment is less variable than in the water body. The result obtained from comparison with Sediment Quality Guidelines (SQGs) and Geoaccumulation Index indices, revealed that the metal variability in the water body and sediment samples in this study shows there were within the permissible limit. Metal pollution mostly occurs due to human activities near the sampling sites.

Penilaian Pencemaran Logam Penggunaan Sedimen dan Sumber Air kepada Suku Batek di Merapoh, Pahang

ABSTRAK

Kajian ini bertujuan untuk menilai taburan unsur logam di dalam air dan sedimen yang diambil dari Merapoh, Pahang. Terdapat 6 stesen persampelan yang dipilih di dua kawasan persampelan dan tiga pengukuran replikasi dilakukan untuk sampel yang dikumpulkan setiap stesen persampelan. Kepekatan logam dalam sampel tersebut ditentukan menggunakan Spektroskopi Penyerapan Atom dengan kaedah pencernaan asid yang telah disahkan dengan bahan rujukan yang diperakui iaitu sy-4 Diorite Gneiss. Hasil kajian menunjukkan bahawa kebolehubahan logam di badan air dan sedimen kebanyakannya berasal dari aktiviti manusia di sekitar lokasi pengambilan sampel, selain variasi semula jadi. Secara umum, hasil menunjukkan bahawa tahap logam keseluruhan disusun sebagai: sediment > air berdasarkan kepekatan logam yang dijumpai. Sedimen sesuai untuk memantau pemendapan logam jangka panjang dalam sistem perairan kerana keupayaannya untuk memusatkan logam dan secara amnya kepekatan logam dalam sedimen kurang berubah daripada di badan air. Hasil yang diperoleh dari perbandingan dengan Indeks Kualiti Sedimen (SQGs) dan indeks Geoakumulasi, menunjukkan bahawa kebolehubahan logam dalam badan air dan sampel sedimen dalam kajian ini menunjukkan terdapat dalam had yang dibenarkan. Pencemaran logam kebanyakannya berlaku disebabkan oleh aktiviti manusia berhampiran tempat persampelan.

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LIST OF ABBREVIATIONS

DO	Dissolved Oxygen
TDS	Total Dissolved Solids
Igeo	Geoaccumulation Index
WHO	World Health Organization
SGQs	Sediment Quality Guidelined
NTU	Nephelometric Turbidity Units
NWQS	National Water Quality Standard
USEPA	United States Environment Protection Agency

LIST OF SYMBOLS

%	Percentage
℃	Degree Celcius
n	Number of Sample

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Water pollution is any contamination of harmful or dangerous substances in any form of water bodies as for example which are river and ocean that eventually leads to degradation of water quality. There are several types of pollution which are groundwater pollution, surface water pollution and also ocean water pollution. All these pollution happens due to various types of sources which are categorised in the point source pollution or diffuse point sources. Point source pollution is a direct source of pollution detection whereas diffuse point source pollution is a non-direct pollution and very difficult to detect the source of pollution. Rivers and stream plays an important role in Orang Asli since they can obtain water and food resources from the river. They mostly depend on the river for the water and food sources to survive (Ahmad et al., 2009).

The Original People is also commonly known as Orang Asli by the Malaysian community. Orang Asli are the indigenous minority part of the Peninsular Malaysia. Orang Asli is still recognised under the category of indigenous people internationally due to their unacceptance and high resistance on cultural assimilation and integral policies.

Besides, they are still left further behind on the current mainstream interpretation of laws and affect their rights, and their marginalized position is a result of their subjugation and discrimination by a dominant group (Nicholas et al., 2010).They are the descendants of the early inhabitants of Peninsular Malaysia. There are several types of Orang Asli category in Malaysia which are Negerito, Senoi, and Aboriginal Malay. This study focuses on Batek tribe of the Orang Asli sub-group community since they are still living as the way they are in the past which are depending on the hunting as for survival. As for water resources, it is obtainable from the river near them. Furthermore, living in the new technological era which is increasing in the percentage of pollution in various medium of the ecosystem, the health of the Orang Asli community might be affected (Singh et al., 2017).

1.2 Problem Statement

Metal pollution in river system will be drastically increase in concern since river system is one of the most crucial form of water bodies that provides sources of consumption for the Batek tribe (Ahmad et al., 2009). Heavy metal are the necessities as micronutrients to the river system but in excessive presence of the heavy metal in the medium will lead to toxicity of the water bodies affected and also threaten the uptake of heavy metal into the food web (Hsu et al., 2016). Moreover, there is high possibility that the river with condition of enriched heavy metal content can resulting unsuitable for drinking purposes.

Therefore, it is important to assess the water quality consumed by the Batek tribe. In addition, it is also important to undertake monitoring to ensure the water usage of Batek tribe and their quality stay within the acceptable limits. Rivers and streams play a crucial role in Batek tribe daily life due to their dependency as a water and food source for survival. Hence, it is vital to investigate the levels of heavy metal elements in the river system and sediment in the area of the Batek tribe settlement (Xiong et al., 2019).

1.3 Objective

The objectives of this research are to identify and assess the quality of water consumption to Batek tribe in Merapoh, Pahang. Thus can be achieved in the following manners:

a) Determine the metal (Pb, Cd, Cu, As, Zn, and Ni) distribution in water and sediments at Sungai Yu and Sungai Kalung, Merapoh, Pahang, Malaysia.
b) Identify the correlation of sediment metal pollution and the possible effect towards the daily life of Batek tribe community in Kg. Teluk Gunung, Merapoh, Pahang, Malaysia.

1.4 Scope of Study

Ex-situ analysis on the water and sediment sources of Sungai Yu and Sungai Kalung, Merapoh, Pahang, Malaysia will be conducted with replication of thrice. The research will be focused more on the sediment quality due to sediment has a longer term effect on the pollution affecting the river which is the sources for Batek population in the mentioned area. The sample collection of sediment for this research will be conducted at Merapoh, Pahang whereas the analysis of the sample will be conducted at UMK Jeli Campus.

In this study, metal concentrations in sediment samples will be compared with numerical sediment quality guidelines (SQGs). The SQGs are recognized as a perfect threshold to assess the adverse effects of metal contamination in sediment for aquatic life and human health as well. There is also another method to analyse the risk assessment of metal pollution in sediment and water sources which is the Geoaccumulation Index (Igeo). Igeo is a quantitative measurement method of detection and identification metal pollution. The application of this method is by calculation of a specific algorithm formula that will include the total measured concentration of the metal elements over its background concentration values (Abdullah et al., 2015).

1.5 Significance of the Study

Information on the quality of aquatic environment by knowing their physical, chemical and biological characteristics are very useful for water use. So that the determination of metal pollution in Sungai Yu and Sungai Kalung will be able providing information on the sources of pollution which affecting the quality of the water resources. Rivers and streams play an important role in Batek life, where can provide water, fish, a place to bath and natural territorial boundaries. Therefore, monitoring the total concentrations of heavy metal in water and sediment are important to ensure the potential health risk to Batek tribe due to metal pollution is low.

CHAPTER 2

LITERATURE REVIEW

2.1 Water Resources

Water is an essential role in survival of living organism which is the flora and fauna. Water resources are required to sustain the life cycle of livings on Earth. Water is a permanent source since there is continuous water cycle. Once the water is out of source, then the water cycle will be terminated automatically which is likely to be impossible. Environmental resources for human usage which are water the major component will be polluted due to human activities itself (Wan et al., 2013). Water pollution has always been one of the main issues in the environmental crises correlated to rapid economic development, increasing in anthropogenic activities and population growth (Singh et al., 2017).

There are many form of water body presence which is rivers, lakes, dams, groundwater, and waterfalls. Rivers as a source of water body is a crucial component to human as their daily requirements in order to survive (Ashraf et al., 2010). It is very much essential for a country especially for supply valuable drinking water sources to humans, irrigation of water to farmlands and provide habitat to many aquatic plants and living organism. River has always been the most important freshwater resources for survival, as ancient civilizations have flourished along them, and most developmental activities are still dependent on them. In this current situation, most rivers in Malaysia are polluted due to human activities such as mining, uncontrollable waste disposal and agricultural residues (Bhuiyan et al., 2015).

Rapid industrialization and consequent urbanization has mostly contributed to several issues in water quality management. Many cities in developing countries have been developed without adequate and proper planning. This has driven indiscriminate actions including dumping waste into water sources and also fishing as well as bathing in open surface of water bodies. The roles portrayed from human itself as mentioned above leads to degradation of environment (Bhuyan et al., 2019).

Most cases, the effluents discrete from various industries are not treated before disposal into the water bodies due to high treatment cost and other various causes. As a result in the disposal of waste without treatment will lead to highly polluted of water bodies affected with different kinds of harmful contaminants. In addition, rivers have the ability to recover or withstand a certain amount of contaminants or pollutants, but if there is too much or excessive contaminants and pollutants the river is unable to withstand that situation. By means, humans have to undergo treatment for safe water supply (Xiong et al., 2019).

2.2 Water Quality

Water quality can be described as the chemical, physical and biological characteristics of water. It is the assessment of determination on the water condition that uses the concept on using the National Water Quality Standards (NWQS) as a reference of the water quality (Ashraf et al., 2010). The need to undergo monitoring of water quality is due to the extreme drastic increase of water pollution that leads to degradation of water quality (Chigor et al., 2012). Human development activities have led to the degradation and deterioration of the environment due to increment of human population and increase in waste generation and disposal. The disposal of municipal and industrial wastes in the water sources is causing major problems regarding the environment and making it a lot more fragile. When there is presence of water pollution, the polluted water source will then not be suitable for drinking purposes.

The food sources from the polluted water sources will also be not suitable for consumption since will affect human health (Badaii et al., 2013). The river water quality is truly a sensitive issue nowadays due to its impact affecting human health and the aquatic ecosystem as well. The discharge of untreated or partially treated industrial wastewater which contains heavy metal in the water bodies especially river, prevail in aquatic bodies and get bioaccumulated along the food chain. Biomagnification of these heavy metal in the food chain occurred leading to various health hazards to both humans and other living organism (Rafiquel et al., 2016).

The contamination of river water by heavy metal is a seriously ecological problem as some of them as the mercury and lead are toxic even at low concentrations, non-biodegradable and able to bio-accumulate through the food chain. From the environmental, economical and social point of view, it is important to identify the sources and the contribution of pollutions to the total contaminated of an area. Factors affecting pollutions of river basins are in various sources which include urbanization. The possibility of higher degradation of water quality at developing countries or areas is higher than the undeveloped countries or areas (Xiong et al., 2019).

In order to preserve the water from degrading, water quality monitoring and water quality management must play its essential role in determining the river water quality and water grade classification through time as it is able to provide information and recommendations of further action to decrease deterioration of water quality or preserve the water quality if required. Beside carrying different kinds of waste materials, rivers also carry many particulates, nutrients, and minerals which play a major role in maintaining the productivity of the water bodies (Ray et al., 2013).

2.2.1 Physical Parameters

a) Turbidity

Turbidity is the measure and observation on water transparency which dependent on the light source penetration into the water source (Offem, 2011). This parameter is highly related to the quantity of suspended solids and dissolved solids in water bodies which will results in the water transparency levels but turbidity does not involve in suspended solids and dissolved solids measurements. Turbidity is only function due to the scattering and penetration of light into the water source (Badaii et al., 2013).

Low turbidity necessary for light to reach submerged aquatic vegetation and promote growth. High turbidity resulting from suspended solids in the water body which includes silts, clays, industrial wastes, sewage and planktons. Turbidity is measured in Nephelometric Turbidity Units (NTU) which measures the extent to which a focused light beam scatters in the medium (Kumar et al., 2015).

b) Total Dissolved Solids(TDS)

Total dissolved solid consist of dissolved minerals and indicates the presence of dissolved materials that unable to be removed by conventional filtration. The presence of synthetic organic chemicals such as fuels, detergents, paints and solvent imparts objectionable and offensive tastes, odours and colours to fish and aquatic plants even when they are present in low concentrations (Islam et al., 2015).

Natural occurrence and anthropogenic action are the main factor contribution towards the formation of dissolved solids in water bodies which is mainly composed of inorganic matter and minor organic matter constituents. Total Dissolved Solids parameter is the measurement of dissolved solids presence. High levels of Total Dissolve Solids leads to toxicity which effects from increase of salinity (Ashraf et al., 2010).

2.2.2 Chemical Parameters

a) pH

pH is one of the chemical parameters that measures and identifies the acidity and alkalinity of water bodies (Ashraf et al., 2010). pH reading and measurement is dependent on the concentration of hydrogen ion of the water source. The increasing and decreasing of the pH values affects the ecosystem. The water bodies will be in hazardous, corrosive and unbalanced state either very acidic or very alkaline. A tiny changing variation of the pH value will not affect the aquatic life but if the changing variation is excessive, which is excessively high pH or excessively low pH, the impact on aquatic life and human consumption in endangered (Ray et al., 2013).

Low pH causes the toxic elements and compounds to become available for the uptake by aquatic plants and animals. Besides, pH is a crucial parameter in wastewater treatment and water purification process since those processes depends on the pH values for evaluation and classification of water quality (Fauziah et al., 2014). In addition, pH of a water body is very important in the determination of water quality since it affects other chemicals reactions such as solubility and metal toxicity.

b) Dissolved Oxygen (DO)

Dissolved oxygen is one of the most important parameter in water quality assessment which measures the amount of oxygen freely available in water body and it is commonly expressed as a concentration in terms of milligram per litre (mg/L). Dissolved oxygen concentrations are influenced by several factors which includes the water temperature, rate of photosynthesis, the degree of light penetration, the degree of water turbulence or wave action, and the amount of oxygen used by respiration and decay of aquatic organism and matter (Kumar et al., 2015).

Good water quality includes sufficient dissolved oxygen levels for aquatic life to survive (Ashraf et al., 2010). Dissolved oxygen in water bodies which can be observed when the microscopic bubbles of oxygen gases are mixed in the water body is the definition on dissolved oxygen parameter (Othman et al., 2012). Function of this parameter is to measure the content of oxygen availability for Biochemical activity in water source. The relationship of dissolved oxygen and oxygen content in the water bodies are when the temperature decreases, the oxygen content available increases (Naubi et al., 2015).

Low dissolved oxygen level in any water body makes the aquatic species migrate, weaken or even die due to the intolerance towards the low dissolved oxygen content. Decrease in dissolved oxygen levels also tend to promote availability of inorganic reducing agent such as ammonia, nitrite, ferrous iron and certain oxidizable substances (Chigor et al., 2012).

c) **Salinity**

According to the United States Environmental Protection Agencies (USEPA), salinity is the measures of all the salts dissolved in water. Change in salinity can affect biota in freshwater directly or indirectly. Toxic effects as a consequence of increasing salinity causes physiological changes resulting in a loss or gain of species. Indirect changes may occur where there is presence of increase in salinity modifies community structures and function by removing or adding taxa that provides refuge, food or modify predation pressures. Other factors such as water logging or loss of habitat may interact with salinity or have more immediate impact on species richness (Nielsen et al., 2003).

2.3 Metal Distribution in the Environment

2.3.1 Heavy Metal in Water

Contaminants are known as foreign substances or particles that are dissolved in water bodies and disrupt the natural system either by pollution or disturbing any elements of the ecosystem. Contaminants are not all of its presence in the form of toxic that lead to toxicity to the ecosystem but pollutants will. In order to identify the contaminants in water source, tests on physiochemical parameters are essential for contaminations or pollutions occurrence (Abdullah et al., 2015). Pollutions have two main sources which are point source pollution and non-point source pollution. Point source defines that the discharged pollutants are at a direct source through an inlet in the bodies of water whereas the non-point source criteria is a bit difficult to detect the whereabouts of the discharged pollutants (Ashraf et al., 2010).

Contaminants can originate from non-point source pollution and also point source pollution along the river settlement. Non-point sources of contamination include the domestic and wild animal defecation, malfunctioning sewage and septic systems, storms water drainage and urban runoff. As for point sources of contamination includes industrial effluents and municipal wastewater treatment plants (Rafiquel et al., 2016). The waste released into the river may contain harmful substances or chemicals such as heavy metal, oils, suspended solids, nutrients and ammonia.

These pollutants have various effects on the organism in the receiving water body. Contaminants in environment vary from organic and inorganic matters which can cause bad effects to the ecosystem and human health through food chain. Heavy metal is one of the most concern contaminants in the environment. The source of heavy metal contaminations is categorised as anthropogenic activities which cause by human activities and lithogenic activities. The anthropogenic activities that may cause heavy metal contamination are wasstewater discharges and industrial discharges (Maanan et al., 2014).

2.3.2 Heavy Metal in Sediment

The percentage potential of having an accumulation of heavy metal in sediments of rivers is quite high since it is able to happen in various methods such as disposal of liquid effluents, terrestrial runoff, traffic emissions, and leachates carrying chemicals originating from numerous urban, industrial and agricultural activities as well as atmospheric deposition (Salomons & Stigliani, 1995). More than 90 % of the total heavy metal loads in aquatic ecosystem is bound to the suspended particulate matter and sediments. Since heavy metal elements can be easily accumulated in sediments for a short period of time and able to sustain the accumulation of metal elements in sediment for a longer term, it is much efficient to detect the source of pollution by analysing the sediment rather than the water source itself (Ahmad et al., 2010).

In addition, a little small amount from the accumulation of heavy metal deposited at the bottom of the water body will re-enter the water body and will be uptaken by the aquatic biodiversity such as fishes (Idera et al., 2014). On the other hand, water body has a high potential in receiving sediments from various sources that will lead to deposition at the bottom of water body. Biomagnification is a process by which the water body acts as both the carrier and potential source of metal accumulation in aquatic food chain. Finally, the human health is adversely affected by uptaking of metal elements by the food and water sources from the aquatic food chain system (Abdullah et al., 2015). Therefore, it is necessary to investigate the current status of heavy metal in sediments of the river Kalung and Yu at Merapoh, Pahang.

The major concern of heavy metal are arsenic (As), cadmium (Cd), plumbum (Pb), chromium (Cr), cuprum (Cu), mercury (Hg) and nickel (Ni) (Hseu et al., 2002). Heavy metal extremely affect the human health if consume intentionally or accidentally because of their toxicity. The heavy metal can inhibit the biological reactions within human body and might cause chronic disease even death. Heavy metal can cause cancer and severe disease such as Minamata disease that affects the Minamata residents in Japan due to high toxicity of mercury in the seafood. Heavy metal contamination of river water and surface sediments becomes the major quality problems in rapid urbanization cities since water and sediment quality maintenance and hygiene structure do not grow along with population and urbanization (Chigor et al., 2012). On the other hand, metal contamination in aquatic ecosystem has potential natural occurrence.

2.4 Effect of Metal Pollution towards Human Health

Heavy metal toxicity can have several health effects in the body. Heavy metal can damage and alter the functioning of organs such as the brain, kidney, lungs, liver, and blood (Singh et al., 2011). Heavy metal toxicity can either be acute or chronic effects. Long-term exposure of the body to heavy metal can progressively lead to muscular, physical and neurological degenerative processes (Maanan et al., 2015). Also, chronic long-term exposure of some heavy metal may cause cancer (Kusin et al., 2017). The exposure of heavy metal to humans involve various diverse forms through food and water consumption, inhalation of polluted air, skin contact and most important by occupational exposure at workplace (Islam et al., 2015). Though some heavy metal such as iron and manganese are essential for certain biochemical and physiological activities in the body, elevated level in the body can have delirious health effects (Chigor et al., 2012).

Most of the other heavy metal are generally toxic to the body at very low level (Singh et al., 2011). The main mechanism of heavy metal toxicity include the generation of free radicals to cause oxidative stress, damage of biological molecules such as enzymes, proteins, lipids, and nucleic acids, damage of DNA which is key to carcinogenesis as well as neurotoxicity (Fauziah et al., 2014). Some of the heavy metal toxicity could be acute while others could be chronic after long-term exposure which may lead to the damage of several organs in the body such as the brain, lungs, liver, and kidney causing diseases in the body.

2.5 Risk Assessment

Numerical Sediment Quality Guideline (SQGs) can be described as one of the best method to analyse overall water pollution by determining the concentration of contaminants in the sediment that able to cause adverse ecological effects to human and also other biodiversity involved in the ecosystem (Gharibreza et al., 2013). Generally there are two types of SGQ which are theoretical and empirical SQG that are in use in common nowadays. Both types of SGQ are used for determination and early detection on the presence of adverse ecological effects. The adverse ecological effects commonly happen due to the accumulation of excessive heavy metal contents in the sediment and water sources (Islam et al., 2015).

In addition, SQG purpose is also to protect any potential harm towards the aquatic ecosystem due to mainly from the accumulation of heavy metal in the sediment of the river system (Praveena et al., 2008). Furthermore, benthic organisms are known to be living on the surface of the sediment or in the sediment in the rivers and streams. Benthic organism is a physical indicator for a toxic environment since benthic organism serves as an important food source in the food web (Naji et al., 2010).

CHAPTER 3

MATERIALS AND METHOD

3.1 Research Methodology Flow Chart

In this chapter, the methodology used in this research is discussed. Figure 3.1 summarized the methodology has been used. Two locations were selected as the sampling sites for the collection of water and sediment samples. Standard Reference Materials (SRM) has been used to validate the method. The analysis was carried out using Atomic Absorption Spectroscopy (AAS). For the risk and safety assessment, the samples of water and sediment were analysed using respective indices; Sediment Quality Guidelines (SQGs) and Geoaccumulation Index (Igeo).

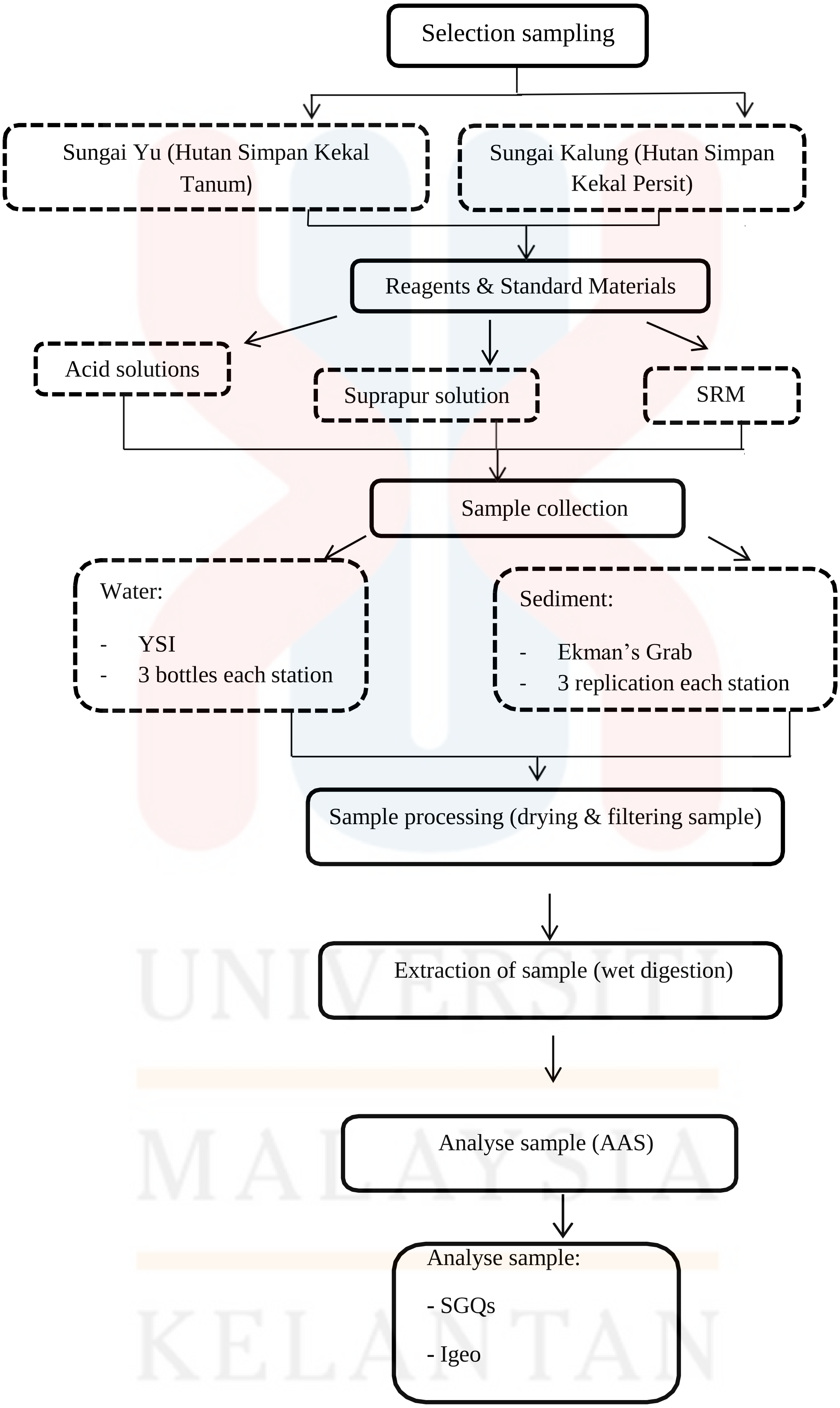

Figure 3.1: Research methodology flowchart

3.2 Sampling Sites

Briefly, Sungai Yu and Sungai Kalung were located in Merapoh, Pahang, Malaysia. Pahang was the largest state in the Peninsular Malaysia. Merapoh on the other hand was a small town in Lipis District. It is located next to the Pahang- Kelantan border. Merapoh is located in Central Forest Spine-Primary Linkage interconecting National Park and Titiwangsa range. This area supports four forest types which were lowland, hill, upper hill and mountain forest. The assessment has been carried out at two different locations which are Sungai Yu and Sungai Kalung. Both of this river are located in the Malaysian Reserved Forest.

Both these rivers were located in the state of Pahang. The coordinate of Sungai Yu is 4.6185 latitude and 101.9810 longitudes whereas the coordinate of Sungai Kalung is 4.6271 latitude and 101.9909 longitudes were tabulated in Table3.1. Both these rivers were located in the rural area which the majority Batek community can be found. On the other hand, Sungai Yu was located in the area of Tanum Forest Reserve whereas Sungai Kalung was located in the area of Persit Forest Reserve in the district of Lipis, Meraoph, Pahang, Malaysia.

The forest reserve in this study area were the production forest and have been subjected to selective logging in the past resulting in logged forests that have been identified as suitable home range for Asian elephants. Both of the sampling site were chosen due to the Batek community that depends on both of the rivers for their survival which includes water resources for daily activities and food consumptions. The Batek community depends on the food source and water source from both of the mentioned rivers. Figure 3.2 shows the study area in the state of Pahang.

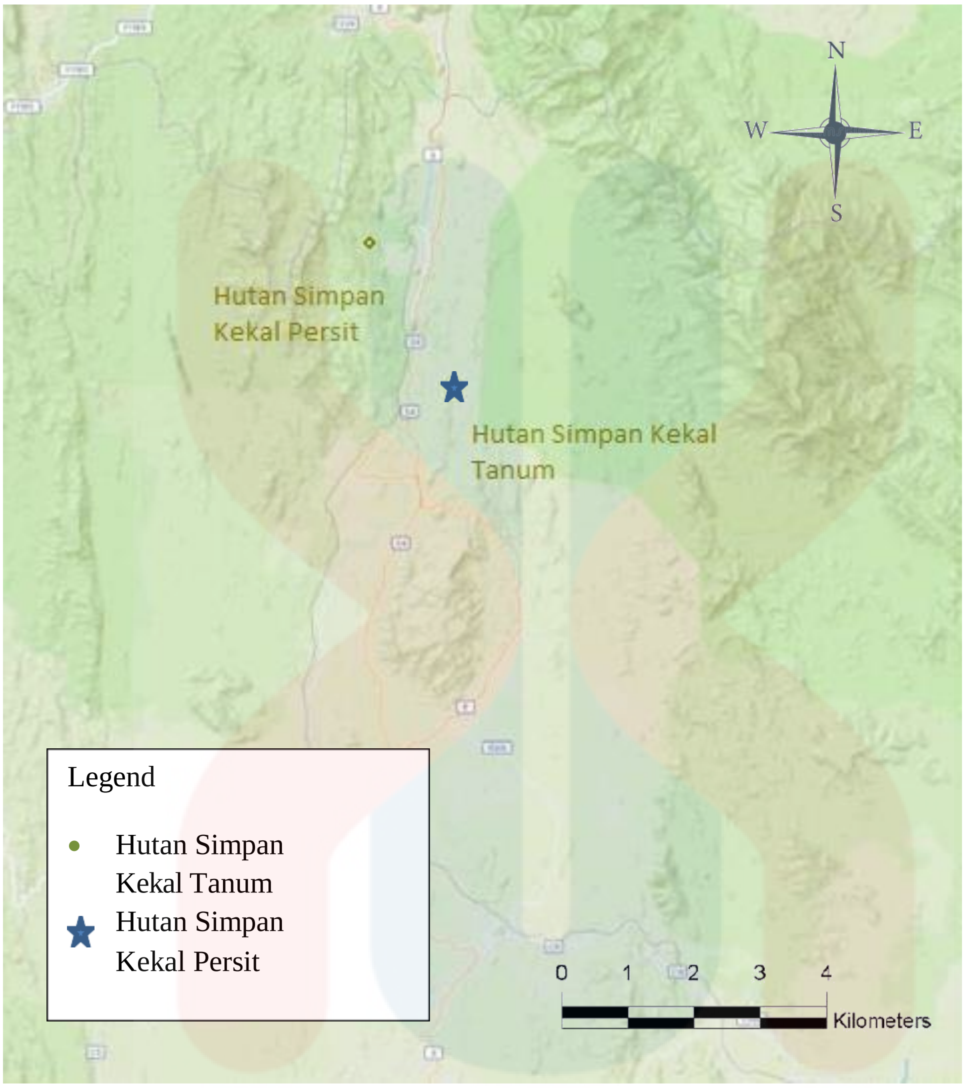

Figure 3.2: The map based on the sampling site in Persit and Tanum Forest Reserve at Merapoh, Pahang

(**Source** : Google Map, 2020)

Table 3.1: The coordinate of both the sampling sites

River	Latitude	Longitude
Sungai Yu	4.6185	101.9810
Sungai Kalung	4.6271	101.9909

3.3 Reagents and Standard materials

Nitric acid (HNO_3), Hydrogen Peroxide (H_2O_2), and solutions of Suprapur® quality were used. Standard Reference Material (SRM) for trace heavy metal has been used to demonstrate the validity of methods used. They were Diorite Gneiss Reference Materials Certified Values (SY-4).

3.4 Cleaning Glassware

In order to avoid cross-contamination and reduce any possible decontamination, all apparatus were cleaned and soaked overnight in dilute 10% HNO_3. Then they was rinsed thoroughly with the distilled water and dried before use (Bhuyan et al., 2019).

3.5 Sample Collection and Preparation

3.5.1 Sampling of Water

Water sample storage in enclosed glass bottles was prewashed with acid to avoid early contamination (Badaii et al., 2009). For water sampling, the bottles sampling was rinsed twice with the water sample before collection on surface water. The closed-sampler was submersed and the bottle has been opened to fill-in the sample and recapped sub-surface (EPA, 1996).The samples were stored less than 8ºC for further elemental analysis. Sample collection technique for this water sampling was by grabbing technique below the surface water for 20 cm in depth. The enclosed glass bottles were submerged fully below the surface of water bodies until filled with water samples fully and then recapped the bottles underneath the water surface. The sample bottles were removed from the water bodies in fully capped condition to avoid air bubbles in the sample bottles.

3.5.2 Sampling of Sediment

Surficial sediment samples has been collected from the bottom of the river using Ekman's Grab Sampler which were comprised of the upstream, middle stream and downstream of the river analysis. Bulk samples have been placed into polyethylene sampling bag, labelled and returned to the laboratory and has been stored under -20℃.

3.6 Sample Processing

All foreign matters (stones, detritus) have been removed from the sample before dried in the oven at the temperature of 60℃ or less (Wang et al., 2018). The dried samples have been grinded and then passed through a 45-mesh sieve. The homogenized samples have then been kept in amber jars under desiccator for further analysis (EPA, 1996).

3.7 Extraction of Sediment Samples

The wet digestion method has been used based on the analytical methods for atomic absorption spectrometer. Approximately, 1-2 g of dried samples (sediment) has been placed in 250 ml beaker with 15 ml of HNO_3 and the beaker then has been placed on a hot plate and heated at 100 ºC for 1 hour. After cooled to room temperature, the samples have then been added with 5 ml of H_2O_2 and reheated slowly 100 ºC until the sample remains 10 ml. After digestion, the samples have been cooled down filtered into 100 ml of volumetric flask and volume made up to the mark with deionized water.

3.8 Method for Heavy Metal Analysis

Atomic absorption spectrometry (AAS) detects elements in either liquid or solid samples through the application of characteristic wavelengths of electromagnetic radiation from a light source. Individual elements will absorb wavelengths differently, and these absorbance are measured against standards (Bhuyan et al., 2019). In effect, AAS takes advantage of the different radiation wavelengths that are absorbed by different atoms. In AAS, analytes are first atomized so that their characteristic wavelengths are emitted and recorded. Then during excitation, electrons move up one energy level in their respective atoms when those atoms absorb a specific energy (Rafiquel et al., 2016). As electrons return to their original energy state, they emit energy in the form of light. This light has a wavelength that is characteristic of the element. Depending on the light wavelength and its intensity, specific elements can be detected and their concentrations measured.

3.9 Risk Characterisation

Background values play an important role in the interpretation and analysis of geochemical data. Previous studies used average shale values or average crustal abundance data as a reference baseline (Islam et al., 2015). In this work, sediment contamination of the study area has been assessed and evaluated by two different indices which were Sediment Quality Guidelines (SQGs) and Geoaccumulation index

3.9.1 Sediment Quality Guideline (SGQs)

Standard Quality Guidelines was one of the methods that compared the concentration of heavy metal elements with standard levels of each metal element. SQG was able to analyse and assessed the overall pollution presence of the area and was also managed to provide future solutions in solving the water pollution issues (Indera et al., 2014).

3.9.2 Geoaccumulation Index (Igeo)

Geoaccumulation Index was one of the method that has be used to detect metal pollution content in the sediment by comparing analysed concentrations of heavy metal elements with background value of each individual metal elements as follows (Bhuiyan et al., 2015):

$$I_{geo} = log_2[\frac{C_n}{1.5B_n}] \quad (3.1)$$

Where B_n was the background value of given metal element, 1.5 was the background matrix correction factor owing to lithogenic effects and C_n was given metal levels

(Gharibreza et al., 2013). According to the crustal abundance data of the previous studies (Kabata-Pendias & Mukhkerjee, 2007), the reference samples were As : 1.8, Cd : 0.2, Cu : 55, Ni : 75, Pb : 13 and Zn : 70 mg/kg.

3.10 Statistical Analysis

All calculations and statistical analysis has been performed with SPSS version 20 and Microsoft Excel 2010. One way ANOVA has been used to determine and analysed the difference of variance between the sampling points (Idrus et al., 2014). The most reliable method for ascertaining the water and sediment quality was through statistical analyses of data. The specific analyses performed that has been decided upon during the design and planning phase of the monitoring program. Statistical analysis also has been used by the previous case study in water and sediment quality assessment.

For this metal pollution assessment on sediment sample, a paired sample t- test were used. In this test, two samples were required which were from the upstream and downstream along the sampling sites. It was considered a paired sample test due to the null hypothesis was phrased to determine if the mean values of the samples were equal without regard for the direction of a potential differences. As for example of the situation when this test might be applied would be a pre-treatment analysis of two sites to demonstrate that no difference exists between those two. Future post- treatment differences that might be detected between the two sites would therefore be attributable to the anthropogenic activity.

CHAPTER 4

RESULT AND DISCUSSION

4.1 Acid Digestion Method Verification

The analytical performance of the acid digestion method for water and sediment samples were checked with respective standard reference materials (SRM) Diorite Gneiss Reference Material SY-4. Table 4.1 shows excellent agreements between the AAS measurements and the certified values.

Table 4.1: Analysis of SY-4 Sediment Sample standard reference material

SY-4			
Metal elements	Certified (µg g^{-1})	Found (µg g^{-1})	Recovery (%)
As	0.1 -2	0.1613 ± 0.07	5-100
Cd	0.1 - 2	1.7 ± 0.2	50-100
Cu	7 ± 1	9.9 ± 0.1	83
Ni	9 ± 1	18.8 ± 0.8	93.5
Pb	10 ±1	19.6 ± 1	97.5
Zn	93 ± 2	88.9 ± 2	47.54

Mean and standard deviations ± 2 (*n* =3)

Throughout all scenarios, recovery was reported to be within the range of 50% to 100% within the universally agreed results for the certified values that determine the outcomes of the present analysis, and thus can be assumed to be acceptable with respect to the true concentrations in the samples (Enamorado-Baez et al., 2013).

4.2 Metal Concentration in Surface Water

The concentration of 6 heavy metals in water samples are summarised in Table 4.2. The mean metal concentrations in water shows variations which can be related to the human activities surrounding them.

Table 4.2 : Mean Metal Concentrations in Surface Water

Metal elements ($\mu g\ g^{-1}$)	Sg. Yu	Sg. Kalung
As	ND	ND
Cd	0.00	0.00
Cu	ND	ND
Ni	0.002	ND
Pb	ND	ND
Zn	0.0023	0.00

Mean ± standard deviation (*n*=18) Note :
ND = not detected

The result shown in Table 4.2 indicate that the mean concentration of the metal elements presence in the study area were well below the benchmarks levels that is classified under category class IIA/IIB of the National Water Quality Standard Malaysia . On the other hand, the highest amount of metal found presence in the water body of Sg.Kalung is the zero values for Cd and Zn while Cu, Ni, Pb values were below the benchmark limit of AAS. As for Sg.Yu, the presence of metal Cd and Zn were detected which is that the values were also under the permissible limit based on table 4.3. According to the literature, metal elements presence in the water bodies varies in concentrations able to relate by the congested development of human activities in the surrounding specific area. The ecosystem and biodiversity that is located near the mining industry might be affected by the pollution causes by the industry itself which will lead to various disadvantages to the environment, flora and fauna ecosystem and also to human itself. Since, the AAS measurement were not able to detect the metal presence in both of the water body so this may be due to the properties of the water itself that does not hold the metal presence in a long term (Singh et al., 2011).

Table 4.3: Water quality criteria and standards

	NWQS (DOE, 2007)	Drinking Water Quality Standards		
Conc of metal (mg/L)	Class IIA/IIB	MOHM (1995)	WHO (2006)	USEPA (2009)
As	0.05	0.01	0.01	0.01
Cd	0.01	0.003	0.003	0.005
Cu	0.02	1.0	2.0	1.3
Ni	0.05	-	0.07	-
Pb	-	0.01	0.01	0.015
Zn	5.0	3.0	3.0	5.0

- : Not reported

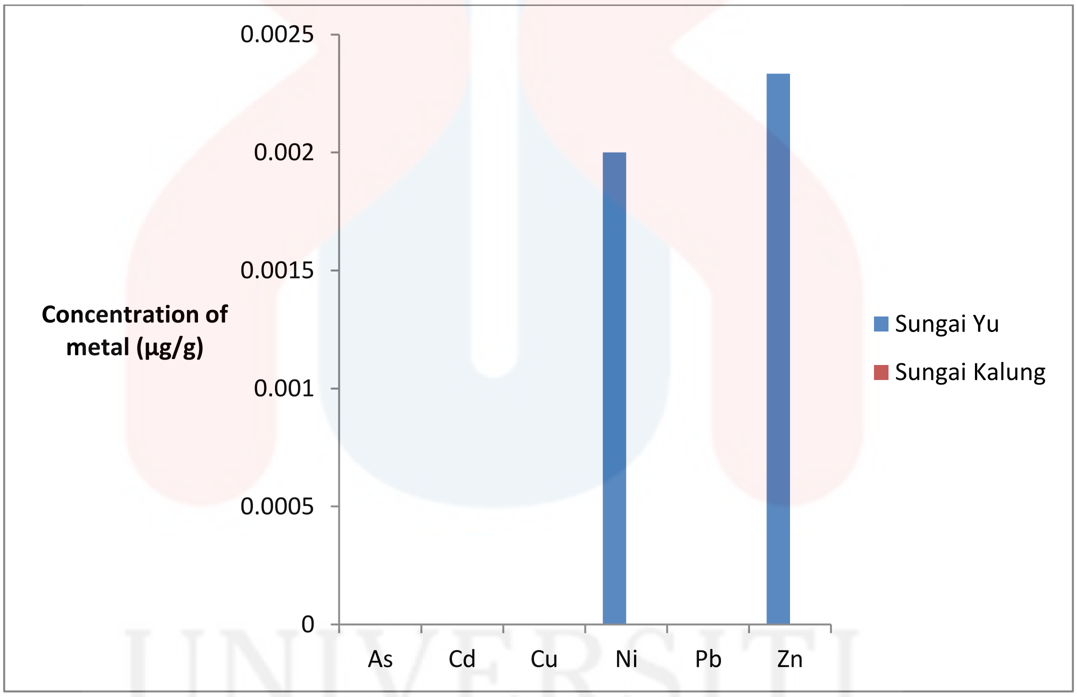

Figure 4.1: Distribution of heavy metal in surface water sample

4.3 Metal concentrations in the sediment

4.3.1 Variations in the Metal Concentrations

The sediment samples collected from Sg. Yu and Sg. Kalung, Merapoh, Pahang. The sites were analysed for elements As, Cd, Cu, Ni, Pb and Zn. Table 4.4 shows the mean concentrations according to the dry weight of sediment samples and the mean concentrations varied significantly across the sampling site ($p < 0.001$ except for Zn and Cd $p > 0.05$).

Elemental differences in sediment samples are primarily due to variations in the ratio of their organic and inorganic fractions. Part of the differences was derived from the parent rocks and the remaining deviations may be due to the human activities of the surroundings (Ashraf et al., 2014). Consistency of the aquatic environment can be reflected to a certain degree based on the metal elements associated with the surface sediment fragments. This is due to those metal elements able to remobilized and redistributed between the sediment and water body under favourable conditions (Botha et al., 2005).

Table 4.4: Metal concentrations in sediment sample

Conc. Of heavy metal (µg/g)	Sampling location		Sediment Quality Guidelines (SQGs)	
	Sg. Yu	Sg. Kalung	TEC	PEC
As	8.58 ± 1	6.66 ± 4	9.79	33
Cd	0.75 ± 0.3	0.75 ± 0.3	0.99	4.98
Cu	94.74 ± 40	17.47 ± 3	31.6	149
Ni	14.75 ± 4	8.46 ± 3	22.7	48.6
Pb	33.91 ± 5	19.14 ± 4	35.8	128
Zn	86.99 ± 9	87.89 ± 10	121	459

Mean ± standard deviation (*n*=54)

However, from Table 4.4, increasing trend pattern is seen for certain elements where a slightly high level of Zn was recorded in the sediments of Sg.Kalung instead of Sg.Yu. To conclude, the dominant mean concentration value throughout all of the analysed heavy metal, Cu has the highest mean value compared to the rest of the analysed heavy metal followed by Zn, Pb, Ni, As and lastly Cd (Figure 4.2). High levels of Cu may get into the environment through mining, farming, manufacturing operations, and municipal or industrial wastewater releases into rivers and lakes.

But from the geographical and location factor of both these assessed rivers, the reason for level of Cu reaching the TEC level of Sediment Quality Guidelines (SQGs) is likely due to minor mining or farming in the study area (Ghazban et al., 2015). The mean concentration value of As, Cu, Ni, and Pb in Sg. Yu is much higher than the mean concentration of the mentioned heavy metal in Sg. Kalung except for Cd which has the same value which is 0.75 ± 0.0013 µg/g and Zn values that is slightly high than Sg.yu that differ by 0.9 µg/g.

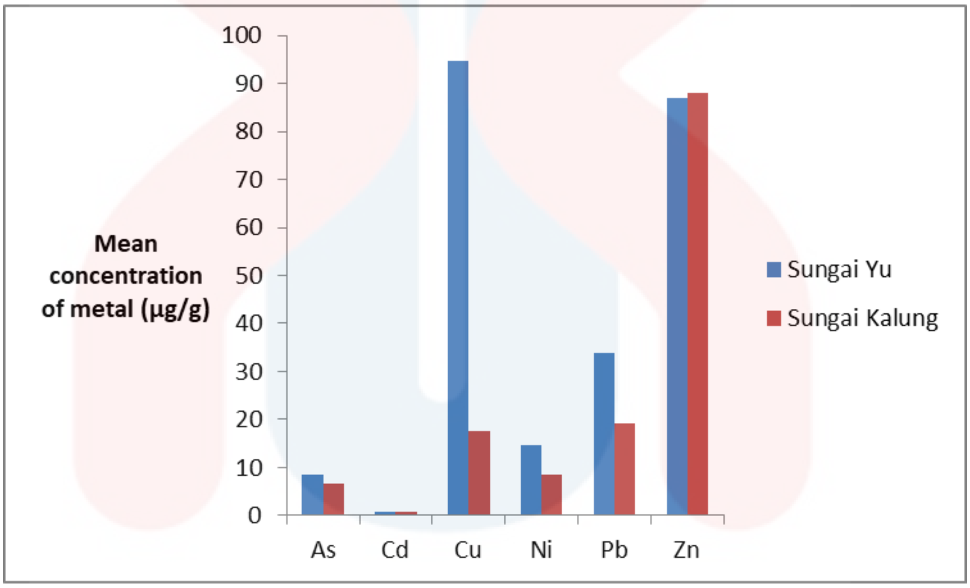

Figure 4.2: Distribution of metal concentration in sediment sample

4.3.2 Assessment of Metal Contamination in Sediment

a) Sediment Quality Guidelines (SQGs)

The metal concentrations in sediment samples of both sampling sites were analysed in this study with numerical sediment quality guidelines (SQGs) that consist of consensus-based TEC (Threshold effect concentration) and PEC (Probable effect concentration) values based as been tabulated in the table 4.3 above. TEC level refers to Threshold effect concentration whereas PEC levels refers to Probable effect concentrations values.

Both TEC and PEC levels are guidelines used to assess possible risk due to metal contamination in sediments. Each metal element has different TEC and PEC level. These guidelines are used to compare and identify the possible risks effects from metal contamination in sediment samples.The SGQs are recognized as perfect threshold to assess the adverse effect of metal contamination in sediment for aquatic life and also human health as well (Gharibreza et al., 2013). Classification of the published SQGs (consensus-based TEC and PEC) has been calculated to identify contaminant concentrations which may give harmful effects on sediment dwelling organism (Ghazban et al., 2015). As for the comparison the concentration values of analysed sediment sample in both of the rivers with the SQGs, none of the metal concentration of analysed sediment sample that exceed the TEC level which means that the water source and food source from both of the river is highly not polluted. Contamination in sediments that exceeds the guidelines may need management plans which include controlling the source of the pollution and removing the polluted sediment.

b) Geoaccumulation Index (Igeo)

By considering the effect of geochemical background concentrations in the assessment of metal contamination in sediment, Igeo provides guidelines of 7 descriptive classes as shown in Table 4.5 below. On the other hand, table 4.6 revealed the result of Igeo values for both rivers analysed and can be concluded that the surface sediment from both locations can be strongly polluted due to high accumulation of arsenic content (Ahamad et al., 2020) compared to other elements presence in the water body of analysed. The main cause for high arsenic content in water body is due to fertilizer usage and also mining activities in nearby area. Mining activities in general have been known to generate environmental impacts at the rivers in Pahang state such as degradation of sediment quality, on water and aquatic life (Kusin et al., 2016).

Table 4.5: Classes of Geoaccumulation Index (Igeo)

Igeo value	Igeo class	Pollution level
≤ 0	0	Unpolluted
0-1	1	Unpolluted to moderately polluted
1-2	2	Moderately polluted
2-3	3	Moderately polluted to strongly polluted
3-4	4	Strongly polluted
4-5	5	Strongly to very strongly polluted
>5	6	Very strongly polluted

Source : (Gharibreza et al., 2013)

Table 4.6: Geoaccumulation Index (Igeo) of heavy metal in sediment samples

	Sampling location			
	Sungai Yu		Sungai Kalung	
Metal elements	Igeo	Class	Igeo	Class
As	3.18	4	3.70	4
Cd	3.28	4	2.50	3
Cu	1.15	2	0.21	1
Ni	0.13	1	0.08	1
Pb	1.74	2	0.98	1
Zn	0.83	1	0.84	1

CHAPTER 5

CONCLUSION

5.1 Conclusion

The study on the variation distribution of metal elements in water and sediment at Sungai Yu and Sungai Kalung, Merapoh, Pahang has been assessed and analysed in this work. The results through various analysis such as Sediment Quality Guidelines (SQGs) and Geoaccumulation Index obtained from the water and sediment samples, the trend pattern of distribution and accumulation of heavy metal in the river of study area observed is able to obtain information and identify the levels of pollutions present in the study area. One of the significant observations from the analysis is that the water was the main depository for Ni and Zn. However, a contrasting trend was observed in the riverine sediments where levels of Zn, Pb and Cu were high. This indicates that the amounts of heavy metal accumulated in sediment fractions were entirely independent of current inputs and therefore would typically exhibit long-term metal accumulation within the river systems ecosystem (Singh et al., 2011).

5.2 Recommendation

Recommendation for the reduction in arsenic contamination is by undergoing water treatment in the removal of arsenic contamination. Arsenic contamination is able to affect human health and also aquatic life in the affected area. The best solution is to limit human consumption with the affected rivers. Awareness need to be spread since the Batek community is mainly depending on the food and water resources from both of the rivers.

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