GIS-BASED APPROACH FOR MAPPING OF CHEMICAL-BASED POLLUTANT CONCENTRATION ALONG THE GALING RIVER, KUANTAN

ZAINUDIN BIN AHMAD ZABIDI

Diploma in Civil Engineering

UNIVERSITI MALAYSIA PAHANG

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ZAINUDIN BIN AHMAD ZABIDI

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ABSTRAK

Air adalah sumber terpenting dalam kitaran hidup manusia, mikroorganisma dan mahluk hidupan lain. Penyelidikan berkaitan dengan bahan yang mencemarkan sumber air perlulah dilakukan supaya dapat membendung dan mengelakkan sumber tersebut menjadi sumber yang terhad, dimana ia sukar untuk didapati. Bahan pencemar air ini terdiri daripada sedimen, minyak, dan bahan pencemar berasaskan kimia. Bahan pencemar tersebut telah memberikan kesan yang besar terhadap air, hidupan akuatik dan manusia. Antaranya, warna air akan berubah menjadi gelap dari warna asalnya. Selain itu, hidupan akuatik yang berada di dalam air juga akan terkesan akibat daripada pencemaran tersebut. Seterusnya, manusia akan kekurangan sumber makanan laut akibat daripada pencemaran terssebut atau makanan laut menjadi terhad. Ini telah menunjukkan bahawa jika air di dirawat, ia akan memberi impak yang besar terhadap beberapa pihak. Ini dapat dilihat seperti yang berlaku di Sungai Galing, ia telah dicemari oleh pelbagai jenis bahan pencemar yang telah mengubah tingkah laku air dari segi warna, tahap pH, kekeruhan dan faktor lain. Secara kesimpulan, air perlulah dirawat dan dijaga supaya sumber tersebut tidak menjadi berkurangan dan terhad.

ABSTRACT

Water is the primary source of life for humans, microbes, and other living things. Water pollution research should be done in order to avoid and curbed the source from becoming a rare resource that is difficult to obtain. Sediment, oil, and chemical-based pollutants are among the water contaminants. Pollutants have had a significant influence on the environment, including the air, water, and humans. Among them, the water's color will darken from its initial hue. Furthermore, the pollution will have an impact on aquatic life in the water. As a result of the pollution, people will run out of seafood resources, or seafood will become limited. This has demonstrated that treating the water will have a substantial influence on multiple parties. This may be seen in Sungai Galing, which has been contaminated by many sorts of pollutants, causing the water's behaviour to vary in terms of colour, pH level, dryness, and other aspects. Finally, water must be handled and cared for so that the resource is not depleted and limited.

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CHAPTER 1

INTRODUCTION

1.1 Background of Study

Galing is the river at Kuantan, Pahang, where Kuantan is the state capital of Pahang on the east coast. It has an area of 22.65 km (about 14.07 mi) and a span of 7.7 km. It is also a river with a high density of development in its catchment area, with the Semambu industrial area located upstream and the Kuantan city center located downstream. Meanwhile, the middle area is a combination of development, including housing and economic growth centers. It also serves as the primary drainage system for Kuantan's eastern region.

Figure 1.1 Illustration of Galing river, Kuantan, Pahang

Sources (Sungai Galing Kembali “Bernafas” - Majlis Bandaraya Kuantan, 2022)

Pollutants such as chemicals, sediment, oil, and microorganisms have polluted every river, ocean, and sea on the planet. This type of situation has aggressively attacked India, which was dealing with pollution issues, particularly those related to water. Figure

2 shows the contamination in India which is have been exposed to variety types of pollutants and rubbish that has changed the colorations of water from blue to dark green. This change has effect to humans' life in India such as they are easily exposed to toxicity of contaminated water.

Figure 1.2 Illustration of Water Contamination in India

Sources: (*Water Contamination and Pollution - a Growing Challenge for Health and Biodiversity | India Water Portal*, 2021)

Figure 1.2 illustrate the water contamination in India, this water contamination has led to waterborne diseases spreading through contaminated drinking water with pathogenic microorganisms such as protozoa, viruses, bacteria, and intestinal parasites. Most waterborne diseases cause diarrhea, which can lead to dehydration and, in severe cases, death. This contamination happens due to poor personal hygiene practices, such as preparing, eating, or handling food and water without thoroughly washing hands after defecation, can result in contamination from faecal matter containing disease-causing microorganisms.

Other than that, contamination in India also occur at the source or while transporting water through pipes near sewage lines. This has resulted in sewage contaminating drinking water with disease-causing microorganisms. Other factors that can contribute to contamination include insufficient water supply, poor sanitary conditions, uncovered sources of drinking water, open defecation near sources of drinking water, inadequate human waste disposal systems, and a lack of awareness among populations.

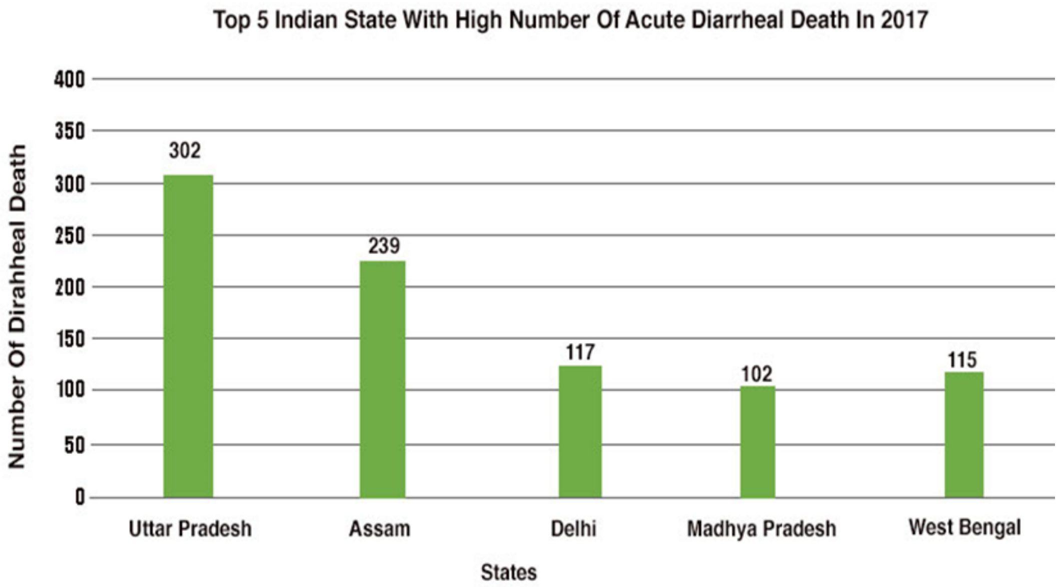

Figure 1.3 Statistic of diarrheal death in 2017 in India State

Source: (Doctorfresh, 2021)

Figure 1.3 shows the statistic of diarrheal death in India states in 2017. This has shown that waterborne diseases are a serious public health problem because they can spread quickly, affecting large segments of the population, resulting in an extremely high disease burden, and having a significant economic impact in countries such as India, where water pollution and open defecation, combined with poor sanitation and hygiene practices, lead to a high incidence of waterborne diseases.

Since the technology has advanced in recent years, we no longer need to use traditional methods to determine the level of contamination and the types of pollutants that contribute to water pollution, so technology that always involved in these types of research called GIS (Graphical Information System) that was introduced by Roger

Tomlinson who conceived and developed the first GIS for use by the Canada Land Inventory in the early 1960s. This technology has help generate a map through the data that was collected at a specific site.

1.2 Problem Statement

The Galing river is at Kuantan, which is the state capital, so the development of industry is extensive, especially along the river. The study focuses on chemical pollutants that contribute to water pollution. There is significant industrial development. This has led to chemical pollution in the water due to chemical waste from factories near the Galing River. Chemical pollution has a severe impact on the availability of clean water, which can affect human health and lead to a lack of seafood sources due to chemical waste that has polluted the water.

Figure 1.4 Photo of Galing river in 2016, Kuantan, Pahang

Figure 1.4 shows the contamination of water at Sg. Galing in 2016. As we can see, it was in bad condition, and there was no treatment taken by any association parties that were responsible for this river pollution. This condition could be the result of an industrial rate increase that dumped chemical waste into water. The development of the Galing River catchment area has exposed it to various pressures, resulting in the occurrence of events such as flooding, contamination or deterioration of water quality, lack of water resources, and erosion in the catchment area. The major issue and problem are the developments in the catchment area that do not care about environmental protection, chemical waste from industry, sewage that has not been properly treated, workshop oil waste, and wet market or restaurant and food premises waste.

Aside from that, the eutrophication process will eventually manifest itself on the water's surface, where plants may cause low light penetration and oxygen in the water column, ultimately killing aquatic life. Furthermore, this research assists us in determining and classifying pollutant types so that we can identify pollutant types that contribute to river pollution. Using GIS (Geographic Information System), a huge area is effectively covered, allowing for repetitive monitoring and investigation. Through GIS, decision-making would be more efficient to strengthen law enforcement and water policy for water security and the richness of aquatic biodiversity.

1.3 Objectives of Study

The objectives of this research are;

1. To identify and generate a map used data collection by using GIS-based approach

2. To determine types of pollutant involved in contribution of Sg. Galing river by using GIS-based approach.

1.4 Scope of Study

This study focused on the Galing river in Kuantan, Pahang. Data on pollution concentrations will be collected along the Sg. Galing River. This study area was at three stations along the Galing River, upstream, downstream, and intermediate area. The Galing River flows upstream through the industrial area of Semambu and downstream through the city of Kuantan which is surrounded by densely populated areas. Meanwhile, a mixed development area, including housing and an economic. Location view of Galing river shows in Figure 5 which is this research study area.

Figure 1.5 Galing river study area

Sources: (*Sungai Galing Kembali "Bernafas" - Majlis Bandaraya Kuantan*, 2022)

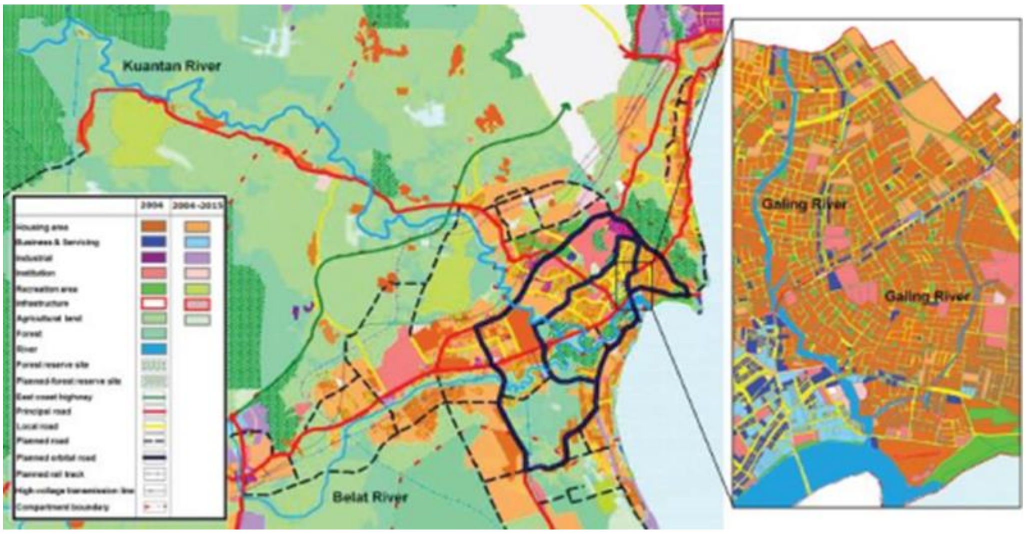

Figure 1.6 Land Use Map for Kuantan

Source: (*Figure 2. Land Use Map for Kuantan. Note: This Figure Was Constructed...*, 2016)

This study focuses on mapping water pollutants in Sg. Galing, Kuantan, using spatial technology, specifically Geographical Information System (GIS) tools. In this study, determination of which areas are severely polluted, pollutant concentrations at high, medium, and low levels would be spatially interpolated along the river. A GIS processing system could be used to determine which sources of pollution contributed the most to the map's pattern.

One of the identified pollutants is chemical. This type of pollutant appears in the water due to human activity such as the manufacturing industry, which produces the most chemical waste, as they made it easy for their work by throwing the chemicals into the river. This activity can cause harm as it can be hazardous to humans, aquatic life, and the environment. The dry season climate is ideal for this study because it is a controlled variable that prevents water dilution caused by deposition or rainwater

1.5 Significant of Study

This research will benefit humans by reducing water pollution in Sg. Galing. We can determine the types of pollutant that contribute to water pollution using GIS-based approach technology, and then take action to overcome the pollution, such as imposing a fine on the factory that dumps their chemical waste in Sg. Galing as we know that Sg. Galing, which is a mixed development area. This research also updates the current database of WQI and mapping of Sg. Galing using GIS technology. The current update will help humans to monitor the water pollution of Sg. Galing. Other than that, through this research we can classify pollution level, predict, and provide solutions to overcome water pollution at Sg. Galing.

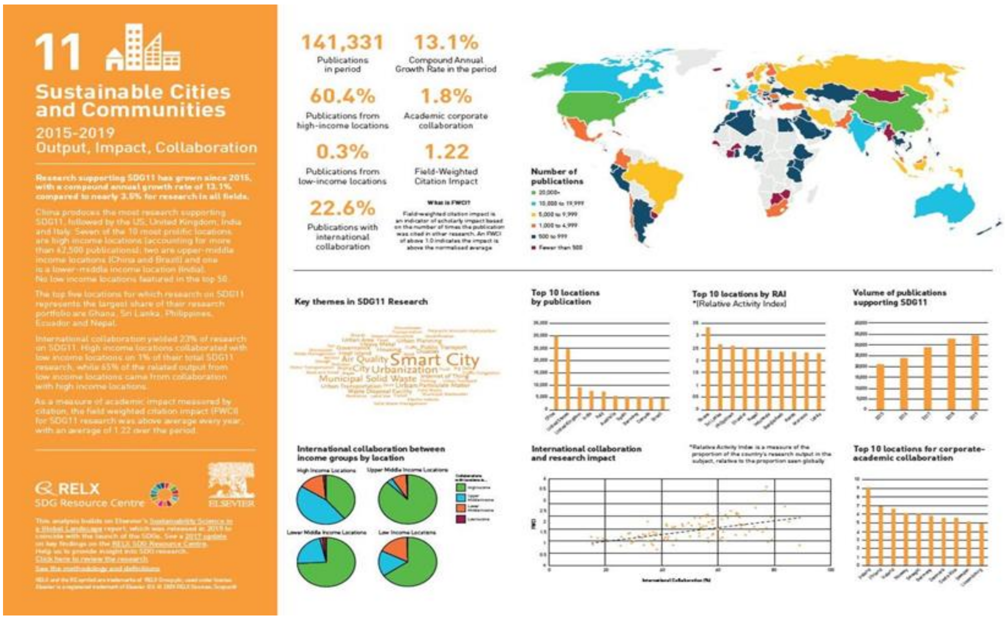

Figure 1.7 SDG 11 data and requirement for entire world

Source: (*SDG 11 Graphic*, 2020)

Figure 7 depicts data from around the world that is aligned with SDG 11 achievement. Aside from that, this research is aligned with SDG 11 (Sustainable Cities and Communities), as the purpose of this SDG is to improve urban planning, management, and development, resulting in more accessible, safe, resilient, and sustainable urban spaces around the world. This research will aid in the achievement of the SDG 11 goals due to the action that will be taken against those who contribute pollutant to the Galing River, as data collection will aid in determining where the source of pollutant originates.

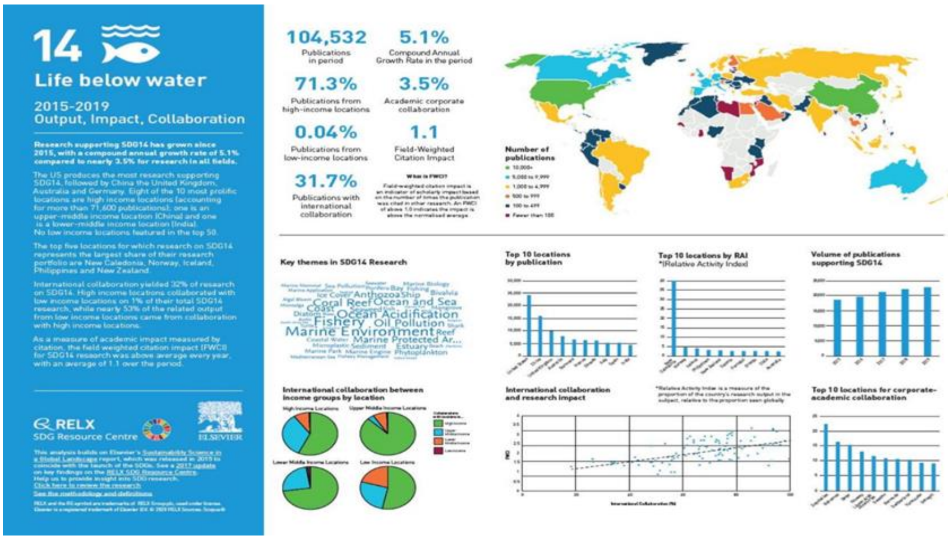

Figure 1.8 SDG 14 data and requirement for entire world

Source: (*SDG 14 Graphic*, 2020)

Aside from that, this research will be aligned with SDG 14 (life under water), which is related to this study, which is to determine the types of pollutants that contribute to the contamination of the Galing river. Pollutants may originate in urban areas, as the Galing River runs through the heart of Kuantan, a city undergoing rapid development. Furthermore, the Galing River flows through an industrial area, which is likely to pollute it due to chemical waste from nearby industries. Since the Galing River contains aquatic life, this pollutant may have an impact on this habitat. To prevent this action from becoming more far-reaching or detrimental, SDG 14 was created, which outlines how to prevent water pollution.

1.6 Summary of Chapter 1

In summary, this chapter has described the background of study that and problem statement of the study. Otherwise, this chapter also states the study's objective that should be achieved at the end of this research and scope of the study which is at Galing river in Kuantan. This chapter also describes the technology used in this research, such as GIS, which is critical to the study's success. Other than that, this research also contributes to achievement of SDG 11 and SDG 14 which is protecting environment from pollution and make the environment suitable for people to living.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In general, this chapter focused on water pollution, the effect of pollutant to the environment, human and aquatic life and the types of pollutant that cause water pollution such as sediment, oil and chemical. This chapter explain in details about chemical pollutant that led to water pollution, the effect of chemical pollutant to water and type of diseases it contributes to both the environment and human. Furthermore, this chapter also elucidate on spatial science technology as the main tool to derive this study, including (i) Geographic Information System (GIS); and (ii) Remote Sensing (RS). In fact, this chapter explicates the application of GIS and RS in overcoming the threat of various water pollutants along the Sg. Galing. The advantages and disadvantages of conventional against the geospatial technological based of related previous studies also have been analyzed at the end part of this chapter.

2.2 Types of Water Pollution

Water pollution is defined as groundwater contamination of a stream, river, lake, ocean, or other body of water that reduces water quality and makes it toxic to the environment, humans, and aquatic life. Water pollution is classified into two types which is point source pollution and non-point source pollution.

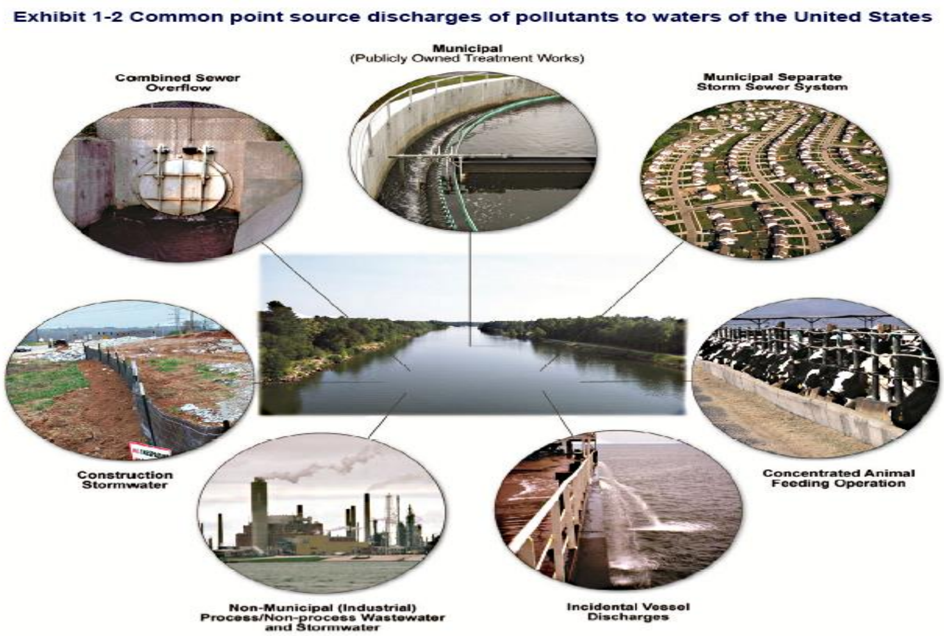

Figure 2.1 Types of point source and non-point source

Source: (Wikipedia Contributors, 2021)

Figure 2.1 shows various point source pollution, which is originated from a single pollutant source place such as factory discharges and wastewater treatment plants and it can be detected, while non-point source pollution is pollution that cannot be detected back to a particular source or property. As a result, non-point source pollution is riskier because no action can be taken since the source of the pollutant is unknown, whereas point source pollution can be remedied because the source of the pollutant is known.

A variety of pollutants, including chemical, sediment, and oil-based pollutants, contribute to water pollution. These substances may contribute to contamination, specifically on land, air, and water. This pollutant can cause harm if it is not controlled by associated parties. Furthermore, all types of pollution have a negative impact on human health and well-being, as well as the environment and wildlife (Jerry A. Nathanson,2022).

Other than that, the concentration of pollutant is led to the indication of water pollution level. Thus, GIS-based approach is effective to determine the concentration of the pollutant that contaminate the water, as GIS comes to play a big part in keeping track of these water conditions. Through the data acquired, the level of pollutant concentration of high, medium, and low could be classified and it can be classes into several types of water quality classes.

Quality class	*Quality index range*	*Description and treatment process*
Class I	100 – 95	Excellent water quality No necessary treatment
Class II	94 – 90	Very good water quality Requires a standard physical treatment process: rapid filtration and disinfection
Class III	89 – 80	Good water quality Requires a conventional physical and chemical treatment process: prechlorination, coagulation-flocculation, sedimentation, filtration, disinfection (final chlorination)
Class IV	79 – 65	Medium water quality Requires an advanced treatment process: pre-oxidation, coagulation- flocculation, sedimentation, filtration, adsorption (activated carbon), disinfection (ozone, final chlorination)
Class V	65 – 45	Polluted water Used for drinking purposes only in exceptional conditions, after a suitable advanced treatment process
Class VI	44 - 0	Very polluted water Not usable for drinking purposes

Figure 2.2 Classification of Water Quality

Source: (*Table 5. Classification of Quality Indexes in Water Quality Classes*, 2017)

Figure 2.2 depicts water pollution classes based on pollutant concentration ranges, as there are six types of classes ranging from excellent water quality that is not polluted by any type of pollutant to very polluted due to pollutants that may be contributed by manufactured sources such as chemical release from industrial areas. As these classes were created to categorize river quality through the calculation of the Water Quality Index by using the data collection from fieldwork. As a result, the classes include a description of each class as well as what treatments can be used to resolve river pollution as a recommendation for treatment action.

2.2.1 Sediment-based Pollutant

Figure 2.3 Sediment-based pollutant river contamination

Source: (Tracy Haun Owens, 2021)

Figure 2.3 illustrate impact of sediment pollutant to water, roughly seen in the figure that the change of color of water since the sediment is a substance that is formed by the erosion of rocks and soil such as sand, clay, silt, and soil fragments that become loose due to water movement caused by human action or weather events. Sediment pollution occurs when water carries sediment downstream in runoff in large scale. These particles are carried by streams, rivers, and eventually the ocean.

2.2.2 Oil-based Pollutant

Figure 2.4 Oil-based pollutant ocean contamination

Source: (*Oil, Sewage, Heavy Metals: The Pollution Plaguing Latin America's Water*, 2020)

Figure 2.4 depicts oil spilt on the water surface from a boat or any other mode of transportation that used water as their track, as oil is an ancient energy source that is still beneficial to us today, such as it can be used as an electricity generator, power a large sector of our economy, and is commonly used to keep our homes warm. Since oil is insoluble in water when it appears on the water surface, it can affect the water surface and the marine life that lives beneath the water. As a result, oil spills can harm marine life and make seafood unsafe to eat.

2.3 Effect of River Water Pollution

Figure 2.5 Galing river contamination

Figure 2.5 depicts the contamination that occurred at the Galing River during the site visit. Pollutants in water are harmful to the environment, humans, and marine life. Pollutants such as sediment, chemical, and oil-based pollutants have changed the color and quality of water. This may also influence aquatic life that lives beneath the water, as pollutant that can harm them, such as chemicals and oil, may be affected. This type of pollutant may contribute to human well-being because the source of seafood is dwindling due to genetic defects or a small amount of fish in the water. This also has an impact on seafood availability, which may raise the cost of purchasing seafood, affecting the country's economy.

2.3.1 Effect of Sediment-based Pollutant to River

Figure 2.6 Sediment-based pollutant contamination

Figure 2.6 depicts the effect of sediment-based pollutant contamination at Galing river which located at urban areas, as when land is cleared for urban development, earthworks are required to establish roads and building sites. The exposed soils are prone to erosion and can cause massive quantities of sediment to be washed into nearby waterways through surface runoff, especially after heavy rain (Sediment and urbanization, March 08, 202) as it occurs at Galing river.

Aside from that, the effect of sediment pollutant on water is that it reduces light penetration into the water due to suspended sediment that appears on the water surface, which can endanger aquatic life and lead to reduced aquatic life survival. Furthermore, sediment in stream beds disrupts the natural food chain by destroying the habitat of the smallest stream organisms and causing massive fish population declines. Thus, sediment raises the cost of drinking water treatment and can cause odor and taste issues.

Furthermore, high concentrations of suspended sediment will irritate aquatic habitats and can cause death. It also dislodges plants, invertebrates, and insects from the stream bed, affecting fish food sources and potentially resulting in smaller and fewer fish. Finally, sediment can erode the protective mucous that covers the eyes and scales of fish, making them more susceptible to infection and disease. Since sediment particles absorb heat from the sun, the temperature of the water rises. As a result, some fish species may be stressed.

2.3.2 Effect of Oil-based Pollutant to River

When oil spreads over the surface of the water, it can cause severe damage in the oceans because the tide can carry the oil to beaches and intertidal zones, which are particularly vulnerable to oil pollution. Since oil is a less dense substance than water, it can spread across the water's surface when it spills, and lighter oils, such as gasoline, spread faster than heavier crude oils. Currents, wind, and warm temperatures are some of the factors that could influence or lead to the spread of oil.

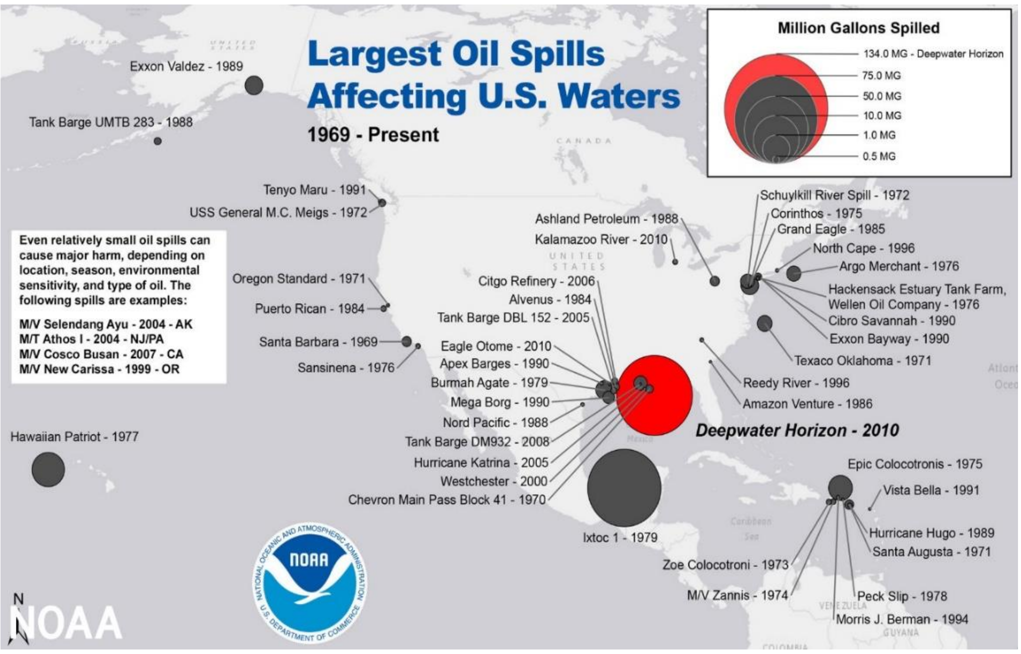

Figure 2.7 Data of Oil spill in U.S

Source: (Christiansen, 2013)

Figure 2.7 depicts the data collection that was done by NOAA which known as National Oceanic and Atmospheric Administration, as the NOAA's National Weather

Service (NWS) provides weather, water, and climate forecasts and warnings for the United States, its territories, adjacent waters, and ocean areas. In performing this critical mission, NWS provides for the protection of life and property and the enhancement of the national economy. The data that was collected by NOAA explicit about oil spills that affecting U.S. water, as it was cause by drilled, transported, or used. Thus, when oil spills in the ocean, in the Great Lakes, on the shore, or in rivers that flow into these coastal waters, NOAA experts may get involved, as The Office of Response and Restoration's mission is to develop scientific solutions to keep the coasts clean from threats of oil, chemicals, and marine debris.

The obvious effect of oil pollutant is it would give a bad impact to marine life, as an oiled seabird was found dead on the beach following the Kuroshima oil spill near Dutch Harbor, Alaska, (NOAA, November 1997). Other than that, on January 7, 1994, a ship, Morris J. Berman with 1.5 million gallons of fuel oil is broke away from its tow line which caused by collision with a coral reef around near San Juan, Puerto Rico, (John Iliff, N.A). The natural resources, including surface waters, sediments, seagrasses, reefs, rocky shorelines, beach, invertebrates, fish and birds are affected by oil spill.

2.4 Chemical-Based Pollutant

Chemical is a substance that is created as a result of a natural disaster, such as a volcano, which releases chemical pollutants. Chemical pollution is defined as an increase or overall presence of a potentially harmful chemical that does not occur naturally in an area or exists in low concentrations. The majority of chemical pollution is caused by man-made manufacturing or other human activities that emit CO_2, organic volatiles (VOCs), nitrogen oxides (NO_x), and heavy metal particles. Chemicals released into water can contribute to water pollution because they are a hazardous substance that can harm the environment and humans.

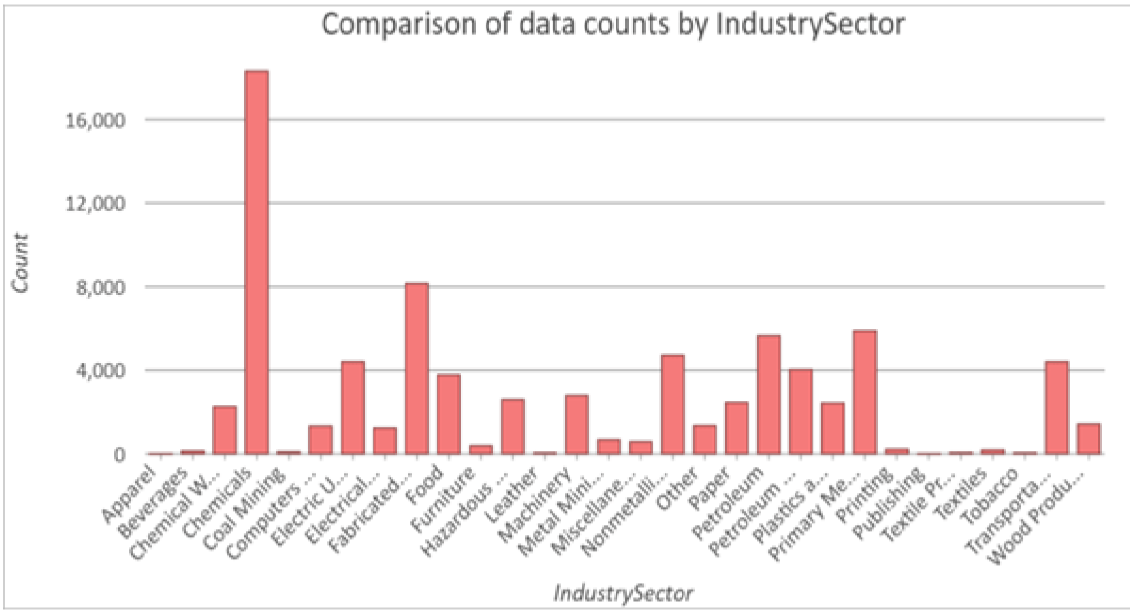

Figure 2.8 Data of Industry Sector that contribute to Water Pollution

Source: (Defratti, 2020)

Figure 2.8 depicts the comparison data counts by industry sector, shown that the highest amount of chemical was produced by chemical industry, followed by fabricated, petroleum and others. Besides that, many chemicals found in commonplace products, such as cosmetics, pesticides, and plastic packaging, are toxic. Toxins in plastics, for example, increase long-term health risks, such as cancer and respiratory problems, and have a negative impact on reproductive systems.

2.4.1 Effect of Chemical Pollutant to River

The effect of chemical pollutant to water is demolishing a whole aquatic food chain. Chemicals that are improperly disposed of pollute marine life and kill sea mammals, corals, and fish. Sea birds are also affected because they eat the fish. Any organism that digests affected marine life can have negative consequences.

Aside from that, naturally occurring toxic geologic agents such as heavy metals, agricultural and industrial chemicals, hydrocarbon fuels, mining wastes, nuclear waste, garbage, septic tank and landfill leakage, sewage, pharmaceutical drugs, and bacterial, parasitic, and viral pathogens, as well as human contact with polluted water through drinking, skin contact, or even consumption of food grown or prepared using polluted water, are common sources of chemical pollution. Since chemical pollutants in water can cause disease or act as poisons.

Hazardous chemicals from agriculture, industries, and residential areas that pollute water sources can result in acute toxicity and death, as well as chronic toxicity complicated by neurological problems and cancers. As a result, infectious pathogens contaminating water via sewage can cause gastrointestinal diseases, which are a major cause of morbidity and mortality worldwide.

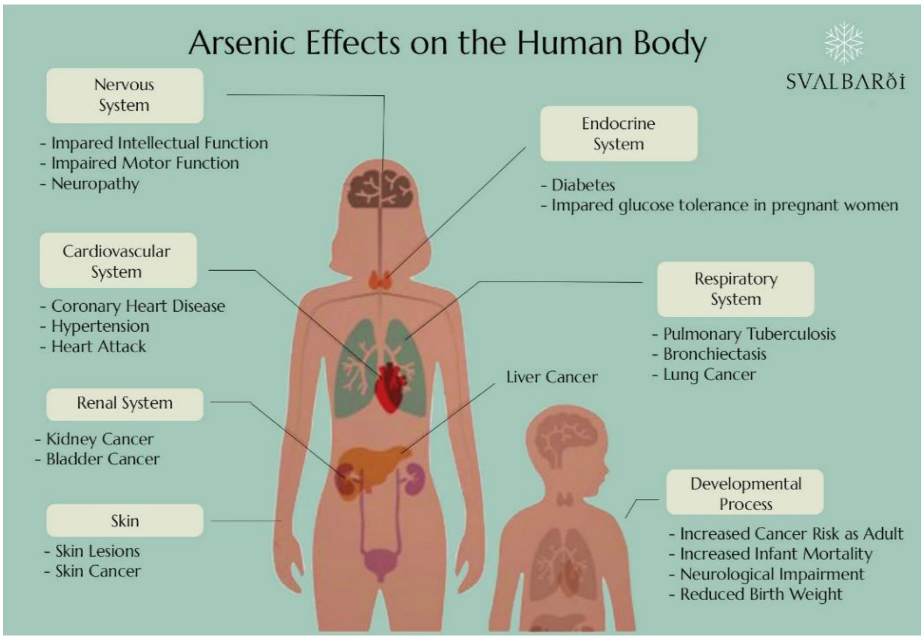

Figure 2.9 Arsenic's effects on human body

Source: (*Fig. 1: Arsenic's Effects on Human Body. Source: Human Rights Watch...*, 2016)

Figure 2.9 depicts arsenic, a chemical pollutant that affects human health through drinking water. This chemical has affected approximately 140 million people worldwide through drinking water, where arsenic levels in drinking water exceed the World Health Organization's (WHO) provisional guideline of 10 µg/L. These chemical pollutants occur naturally in water, but industrial and agricultural pollutants can contaminate the water, causing arsenic levels to rise above 10 µg/L. Arsenic has been linked to lung, bladder, skin, and kidney cancer by the International Agency for Research on Cancer. Arsenic exposure has been linked to chronic cough, decreased lung function, diabetes, developmental effects in children, decreased cognitive functioning, ischemic heart disease, and chronic renal disease, according to the National Institute of Environmental Health Sciences in the United States.

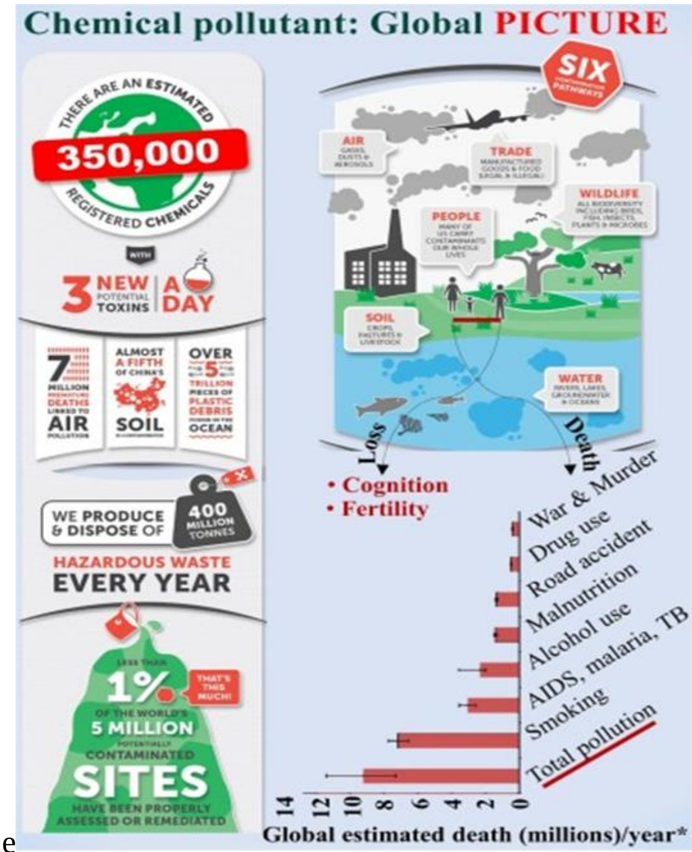

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Figure 2.10 Overview of Global Source and Pathways of Chemical Pollutant

Source: (*Fig. 1. An Overview of Global Sources and Pathways of Chemical...*, 2020)

Figure 2.10 depicts the global sources and paths of chemical pollution, as well as their potential effects on the environment and human health. As shown in the image, six significant chemical pollutant pathways including soil, air, water, wildlife, humans, and trade have been identified. Environmental pollution is responsible for more "silent" deaths than any other commonly recognized risk factor. The graphical component of the schematic in figure represents estimated deaths reported for 2015 (Landrigan et al. 2018) and may differ from year to year.

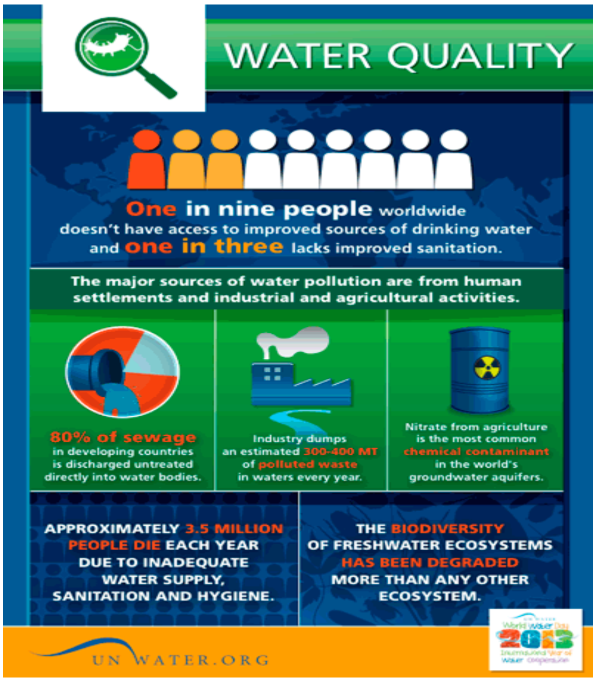


Figure 2.11 Source of Chemical Pollutant that decrease the Water Quality

Source: (*Water Quality | International Decade for Action "Water for Life" 2005-2015*, 2015)

Figure 2.11 depicts global water quality. Based on the figure, it is stated that there is a lack of access to improved water drinking sources and a lack of sanitation in water drinking. As previously stated, human activities such as settlements, industry, and agriculture contribute significantly to water pollution. Approximately 80% of sewage in development areas is discharged untreated directly into the water. In addition, industry dumps and, finally, nitrate, which was commonly used in agriculture, has contaminated the world's groundwater aquifers. Furthermore, approximately 3.5 million people die as a result of inadequate water supply, sanitation, and hygiene.

2.5 Technology in combating water Pollutant / Technological based approach

There are two technology that commonly used in combating water pollutant which is GIS and RS. The application of this technology could be effectively used in monitoring water quality parameter such as suspended matter, phytoplankton, turbidity, and dissolved organic matter. In fact, the capability of this technology offers great tools of how the water quality monitoring and managing can be operationalized in this country.

2.5.1 Geographic Information System (GIS) Application for Water Pollution

Figure 2.12 The use of GIS

Source: (GISGeography, 2014)

Geographic Information Systems (GIS) have a significant impact on health care, infectious disease surveillance, mapping, and monitoring of infectious vector distributions over time and space (Shaw, 2012). GIS technology is a useful tool for forecasting illness trends and determining parasite ecology connections. GIS combines complex algorithms, geographical analysis, geostatistics, and modelling (Higgs, 2004; Guo et al. 2005; García-Rangel and Pettorelli, 2013) GIS combines complex algorithms, geographical analysis, geostatistics, and modelling (Higgs, 2004; Guo et al. 2005; García-Rangel and Pettorelli, 2013). Given the range of GIS tools, ideas, and applications in public health, a succinct summary of the current state of the topic is required.

Furthermore, the focus of this paper's review of effective GIS applications in public health is parasitic illnesses such as this study is focused on pollutants that contribute to contamination at Galing river. GIS is useful to mapping the concentration of pollutants based on the data that was key in, into the software. Through that map, the concentration of pollutants can be classified into several class of WQI classification of water pollution that contained 6 level of classification. As the pollutants that contribute to contamination to Galing river, it has spreading the several disease that may harm the life around the Galing river.

2.5.2 Remote Sensing (R.S) Application for water pollution

There are two types of remote sensing in general active remote sensing and passive remote sensing. Active remote sensing is a type of active sensor that measures light reflection from the Earth's surface. While passive remote sensing is a passive sensor that detects solar radiation reflected by an active sensor from the Earth's surface. Passive sensors have the advantage of not requiring their own energy source because they rely on the Sun's light to illuminate the target, making them less complicated in general.

Aside from that, remote sensing is used in land mapping, weather forecasting, environmental research, natural disaster research, and resource exploration. Essentially, this study requires the use of land mapping and environmental studies to investigate various types of pollutants such as chemical, oil, and sediment-based pollutant. This software is also extremely useful because it can map the concentration of pollutant around the study area with minimal effort. Through this software, user can save time and complete this study more quickly and efficiently.

2.6 Advantages & Disadvantages of Technological-Based Approach for River Pollution Mapping

Remote Sensing (RS) is a technology that was created by human, as the technology was created by human itself is not perfect at all. There some advantages and disadvantages the remote sensing contribute to human and environment. Firstly, the advantage of remote sensing is it can measure light reflection from surface through the sensor that was install on aircraft, drone or satellite. The sensor's location enables them to cover a large area in a short period of time. By surveying from the air, remote sensors can scan and map inaccessible locations. Other than that, the data can be analyze for numerous purposes by key in the data into remote sensing technology system. Furthermore, the amount of effort required in the field is reduced because data is examined in a lab using software. This also reduces employee costs because surveys and post-scan analysis can be conducted in small groups.

Unfortunately, no technology, including remote sensing, is without weaknesses. While the advantages of remote sensing outweigh the disadvantages, it is a good idea to consider the following drawbacks before investing in this survey method. The disadvantage of remote sensing is that the equipment must be calibrated; otherwise, human error will occur. This will affect the time because it takes around 10 - 15 minutes for the equipment to calibrate, which can waste some time before beginning the survey. In addition, High-resolution remote sensing data may be difficult to store because if a project data that has been collected may be a lot and it will take large of software store. This will result lagging while using the software.

CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter describes the method used to collect data for this study in detail, with an emphasis on meeting the objectives of this proposal. This chapter will explain how to use machine learning to generate a map of Sg. Galing pollutant concentrations using satellite images. Figure 3.1 depicts a study flowchart, and Figure depicts a Gantt chart with a study flow. This chapter also discusses data verification for accuracy assessment by entering data into GIS.

3.2 Flowchart of chemical-based concentration mapping of Galing river

The study's flowchart is depicted below in Figure 3.2. The preparation of apparatus and equipment, such as a handheld multiparameter, a water depth meter, a pH meter, and other tools, is the first step before beginning fieldwork. The extraction of the water sample and the survey of the area around Sg. Galing were then carried out after the apparatus and equipment were ready. The sample that was collected is pertinent to the study of chemical-based pollutants, and a laboratory test was used to determine the pollutant's source. The processing of satellite images using a machine learning method then began after the sample collection was complete. The steps taken to measure the Sg. Galing water quality index (WQI). In order to verify the accuracy of the data, the data collection is keyed into GIS software. The database and mapping of water pollution along Sg. Galing are the process's final results.

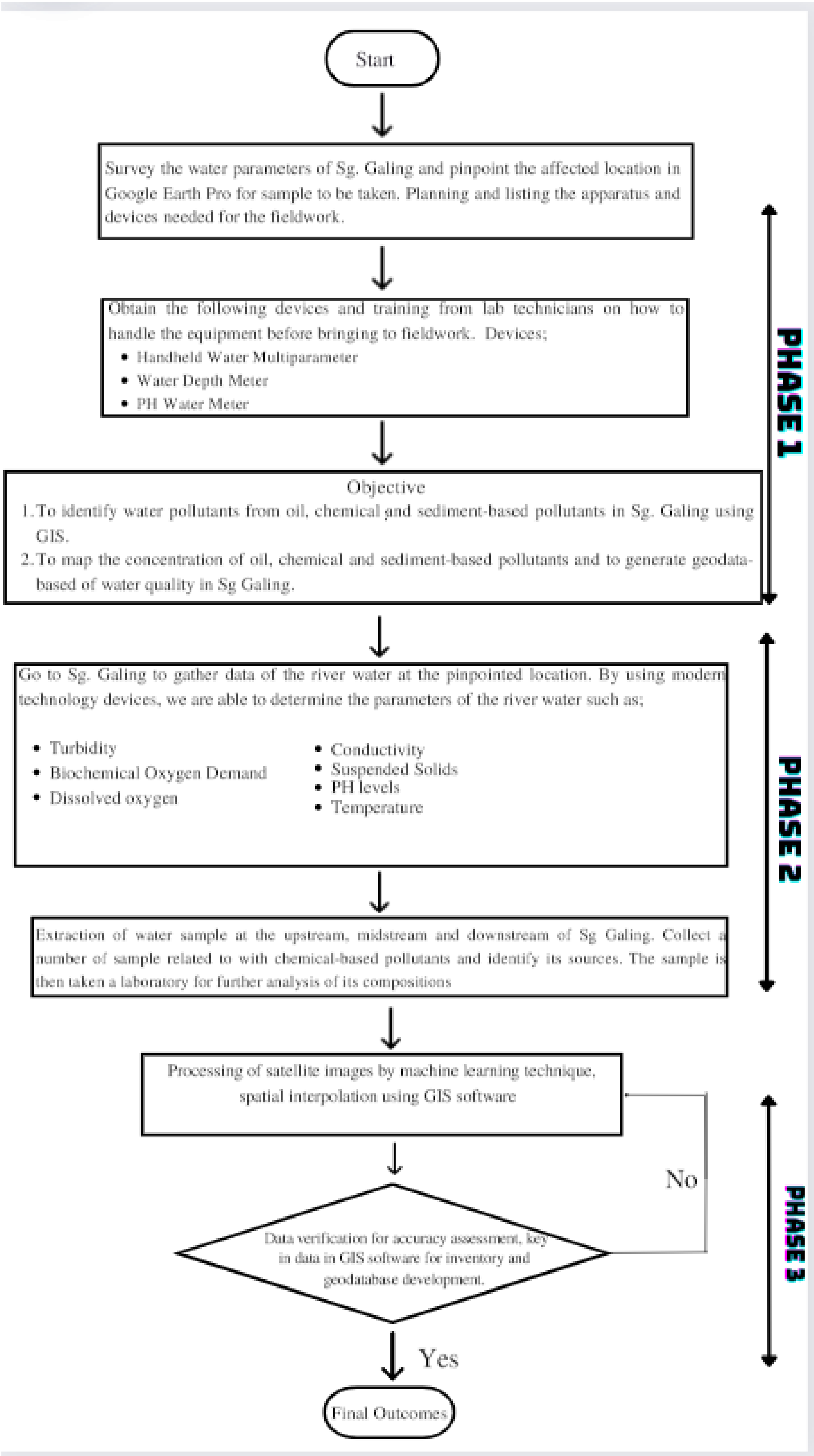

Start
Survey the water parameters of Sg. Galing and pinpoint the affected location in Google Earth Pro for sample to be taken. Planning and listing the apparatus and devices needed for the fieldwork.
Obtain the following devices and training from lab technicians on how to handle the equipment before bringing to fieldwork. Devices;
Handheld Water Multiparameter
Water Depth Meter
PH Water Meter
Objective
1. To identify water pollutants from oil, chemical and sediment-based pollutants in Sg. Galing using GIS.
2. To map the concentration of oil, chemical and sediment-based pollutants and to generate geodata-based of water quality in Sg Galing.
PHASE 1
Go to Sg. Galing to gather data of the river water at the pinpointed location. By using modern technology devices, we are able to determine the parameters of the river water such as;
Turbidity
Biochemical Oxygen Demand
Dissolved oxygen
Conductivity
Suspended Solids
PH levels
Temperature
Extraction of water sample at the upstream, midstream and downstream of Sg Galing. Collect a number of sample related to with chemical-based pollutants and identify its sources. The sample is then taken a laboratory for further analysis of its compositions
PHASE 2
Processing of satellite images by machine learning technique, spatial interpolation using GIS software
No
Data verification for accuracy assessment, key in data in GIS software for inventory and geodatabase development.
Yes
Final Outcomes
PHASE 3

Figure 3.1 Study Flowchart of Methodology

3.3 Field data collection

The fieldwork is carried out at Sg. Galing, Kuantan, using the in-situ method of water quality sampling with handheld multiparameter, water depth meter, and pH meter as the main tools to detect the water quality parameters such as turbidity, toxicity, pH level, and then temperature, conductivity. The range of water quality from each location along the river that was chosen during the site visit can be categorized and further examined using these parameter values. Figure 3.3, which depicts Sg. Galing's perspective during the research's fieldwork, is shown below.

Figure 3.2 Sg. Galing, Kuantan

Water quality instruments are used in this study because fieldwork relating to water is done in Sg. Galing, Kuantan. The FTKA 1000-PB103(M)-170800040001 pH meter, FTKA 1000-PB103(M)-1305000100001 Handheld Multiparameter, and the water depth meter will be the main tools used to measure the water quality parameter. The monitor will display data for the water quality parameters including temperature, pH level, conductivity, biochemical oxygen demand (BOD), and toxicity as the water quality instruments sensors are dipped into the water river. The turbidity of the water is analyzed using a laboratory test, which involves collecting a water sample in a bottle, having the test done in the lab, and then calculating the turbidity value of the water using scientific methods.

Handheld Multiparameter

Water Depth Meter

pH meter

Figure 3.3 Tools used in fieldwork.

Figure 3.3 represents the tools used in this study. Tools such as the Handheld Multiparameter, water depth metre, and pH metre are essential for obtaining data on water parameters such as conductivity, pH level, dissolved oxygen, turbidity, and temperature. A typical reading could be the result of abnormal conditions in a body of water, but it could also be the result of equipment problems or failure. If the readings appear abnormal, firstly is to look for problems with the equipment, such as a broken electrical cable or insulation, a fouled sensor or faulty probe, depleted batteries, and so on. Take additional measurements to confirm that the results are correct and check the calibration if the equipment appears to be in good working order. Thus, the data that was obtained from the tool was recorded for laboratory test and after the laboratory test results is produce, the result was used for the interpolation mapping by using GIS software to detect level of the concentration area along the Galing river in overall.

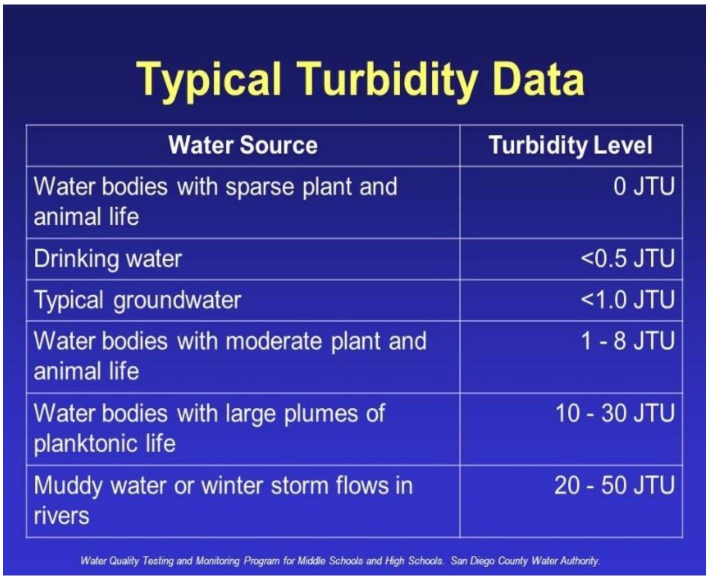
3.4 Physical Parameter of Water Quality

The physical parameter of water quality that most important to be recorded through the tool that was used in this study is turbidity, dissolved oxygen, pH level, conductivity, and temperature. All of the parameter is required to be recorded to proceed the laboratory test to determine the level of the concentration of each pollutants involved in this study and the data also used for the interpolation mapping of the concentration along the Galing river using GIS software.

3.4.1 Turbidity

The murkiness of the water is known as turbidity. It is a measurement of light's ability to flow through water as a result of suspended material in the water created by runoff from streams or ponds, such as clay, silt, organic matter, plankton, and other particle elements. This can cause water turbidity to rise and become darker than its normal hue, affecting the microorganisms that reside under the surface.

The effect it may have on marine life as it disinfects the marine life's armour. As a result, suspended debris can clog or injure fish gills, impair disease resistance, slow development, impact egg and larval maturation, and reduce the efficacy of fish catchment systems.



Typical Turbidity Data

Water Source	Turbidity Level
Water bodies with sparse plant and animal life	0 JTU
Drinking water	<0.5 JTU
Typical groundwater	<1.0 JTU
Water bodies with moderate plant and animal life	1 - 8 JTU
Water bodies with large plumes of planktonic life	10 - 30 JTU
Muddy water or winter storm flows in rivers	20 - 50 JTU

Water Quality Testing and Monitoring Program for Middle Schools and High Schools. San Diego County Water Authority.

Figure 3.4 Turbidity Classification

Source: (Carr, 2017)

Figure 3.4 shows the turbidity level and the water source of each level. As shown in Figure 3.4 0 JTU represents the water source come from the water bodies with sparse plant and animal life. Next, below 0.5 JTU it represents the drinking water that used for human to drink, if its more than that turbidity level which below 1.0 but above 0.5, it is not suitable for human drinking because it is typical groundwater, since an aquifer is a body of porous rock or sediment saturated with groundwater. While the rest of the level is not representing the highest level of turbidity that may contained a lot of suspended material, as shown in Figure 3.4 the maximum level of turbidity is 50 JTU, which is the limit of the turbidity level.

3.4.2 Dissolved Oxygen

Dissolved oxygen (DO) is a measure of how much oxygen is dissolved in the water and the amount of oxygen available to living aquatic organisms. The amount of dissolved oxygen in a stream or lake can describe a lot about its water quality.

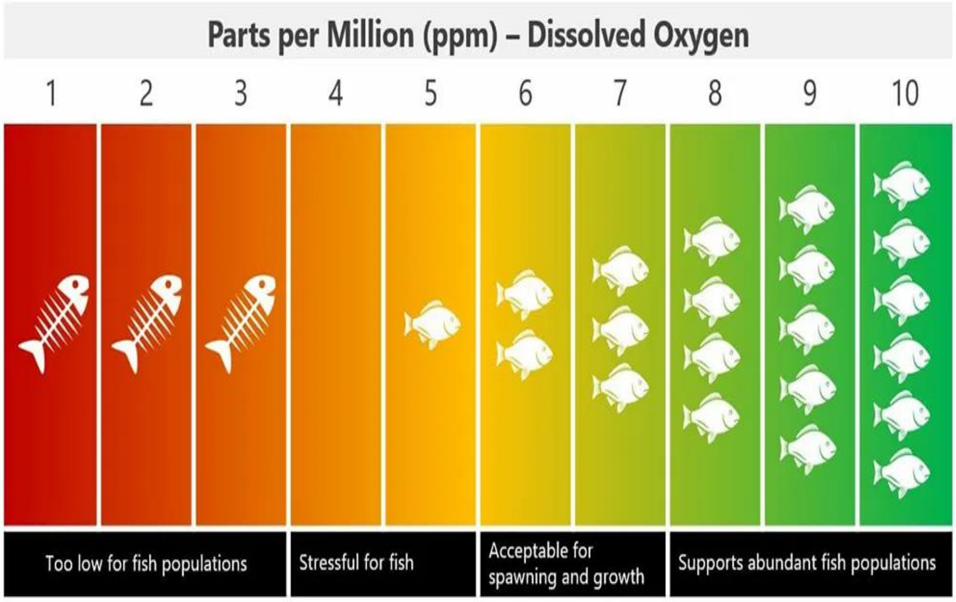


Figure 3.5 level of dissolved oxygen in ppm

Source: (*Water Quality Knowledge*, 2021)

Figure 3.5 shows the level of dissolved oxygen, as shown that at the level of 1-3 the population of fish is too low due to unavailable oxygen in living aquatic, and it has cause the water pressure become very high and it may affect the fish as it has been stressful. While the level of 4-5 is shown that the population of fish also low but still contained certain types of fish that can survive the stressful, this may impact the size of the fish as it will be smaller, while the larger fish will be dead due to high pressure. In addition, at level 6-10, the fish may survive to spawn and growth in a large scale of population.

3.4.3 pH level

pH is a short term of potential hydrogen and it also a measure of how acidic and alkaline the water, this measurement has been done by using pH meter as shown in Figure 3.3. The determination of pH level of water is important to classified either the water quality is in acid, neutral or alkali.

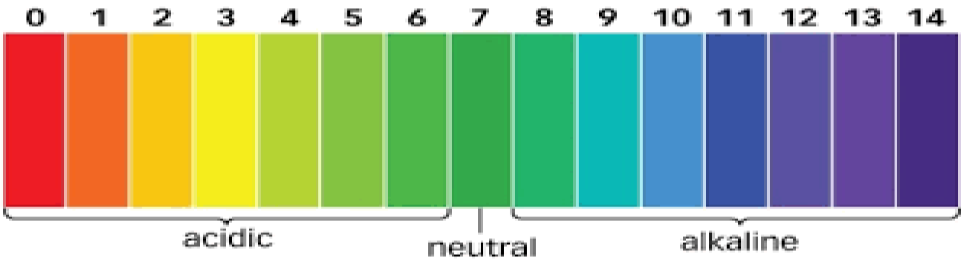


Figure 3.6 pH level diagram

Source: (*PH Monitoring Is the Key to Cell Culture - Scientific Bioprocessing*, 2018)

Figure 3.6 depicts a pH level diagram. As illustrated in the figure, 0-6 corresponds to acidity, 7 corresponds to neutrality, and 8-14 corresponds to alkalinity. It is critical to understand the pH level in water because it influences the availability of nutrients, biological processes, microbial activity, and the behaviour of chemicals that will react with the water. This pH level must be assessed in order to avoid harming the environment. If the acidity level exceeds the optimal level, it may have an impact on human and marine life health by weakening antibodies, which can lead to disease infection.

3.4.4 Conductivity

Other key physical metric to be informed of is electrical conductivity, which evaluates how well a sample of water or comparable solution can transmit or conduct electrical currents. The conductivity values grow as the number of ions in the water increases.

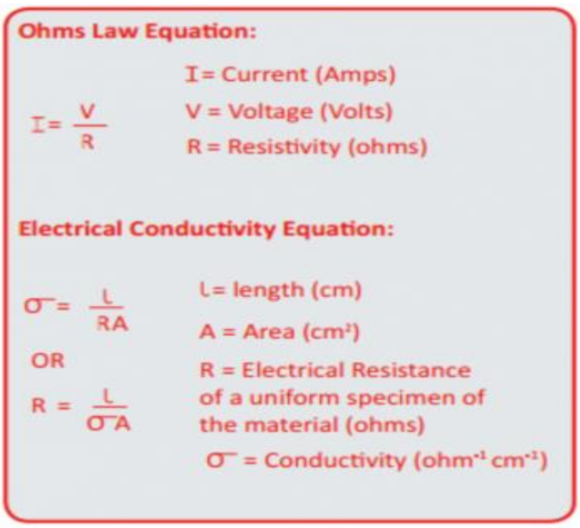


Figure 3.7 Equation of Electrical Conductivity

Source: (*Introduction to Conductivity*, 2021)

Figure 3.7 shows the equation need to be calculation to get the the value of conductivity, but this value has been determined by the Handheld Multiparameter as shown in This is one of the most essential characteristics for analysing water quality because of the ease with which water pollution levels may be determined when monitoring water conductivity. High conductivity implies a high concentration of pollutants in the water. In contrast, potable and ultra-pure water are almost incapable of transmitting an electrical current. Electrical conductivity is generally measured in micromhos/cm and milliSiemens/m, prefixed as mS/m.

3.4.5 Temperature

The temperature of the water is important to be consider because it may influence the odours, chemical reactions, solubility, palatability, and viscosity of the water quality. As the normal temperature of the water should be between 50 - 60 degrees Fahrenheit, and if it is exceeded than the temperature of the ideal water temperature, it will affect the biological oxygen demand, sedimentation, and chlorination.

3.5 Cost Analysis

This study has cost a significant amount of money because of the instruments that needed to be used for fieldwork and the laboratory tests that were done to collect the results of pollutants concentration for mapping of pollutants concentration along the Galing river using GIS software.

Table 3.8 Table of the cost analysis

NO	ITEMS	QUANTITY	PRICE (RM)

1	Ropes	10 m	10
2	Jerry Can	7	35
3	Rubber Gloves	1	5
4	Water Plastic Pail	1	4
5	Phua Chu Kang Safety Shoes	3	30
6	Laboratory Test	6	840
7	Cold Storage for Water Sample	1	FREE
TOTAL COST			924

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Introduction

This chapter is an overall analysis of the results that will be discussed, and the data output will be interpreted using Geographic Information System (GIS) software, which was used in this study to map the concentration of pollutants along the Galing River. The fieldwork data was tabulated into several types of pollutant and will be entered into GIS software for the mapping of sediment, oil, and chemical-based pollutant. This chapter will discuss the chemical-based pollutant in detail in order to provide a better understanding of the contamination, as stated in objective is to map the concentration of chemical-based, sediment-based, and oil-based pollutants in Galing River using GIS technology and to identify water pollutants from oil, chemical and sediment-based pollutants in Sg. Galing using GIS.

4.2 Objective

This result corresponds with the study's goal of identifying water pollutants in Galing River from oil, chemical, and sediment-based pollutants using GIS and mapping the concentration of chemical-based, sediment-based, and oil-based pollutants in Galing River using GIS technology. The data collected during fieldwork has revealed the types of pollutants that have been identified as sediment, oil, and chemical-based pollutant, indicating that the first objective of this study has been met. A map of the concentration of chemical-based pollutant concentrations along the Galing River is also shown in this chapter as a result of GIS software mapping. Then, the second goal of the study has been met since the map of chemical-based pollutant concentrations was completed.

4.3 Data and Result Based on Chemical Pollutant

The Galing river, which is located in the heart of Kuantan, has a lot of development such as urban areas, manufacturers, agricultures, and others that may contribute to water contamination at the Galing river, because the it is located around the development area. This has resulted in significant pollution in the middle of the Galing river, as the color of the water changes to dark green, the water exposes an unpleasant odor, and dirt from sewage that is linked from the urban area and the development that located around the Galing river.

The chemical pollutant data output is obtained using the Handheld Multiparameter, which is the tool used in this study to determine the water quality parameter that will be used in subsequent action. While data was collected, the coordinates of each point of sample collection, as well as the longitude and latitude of each water sample, were recorded. Following data collection on the field, a sample of water is collected for laboratory testing. This test was performed to obtain the results of BOD and COD of the water, which are useful for mapping of water pollutant concentrations. The data from the laboratory tests was tabulated in Excel and entered into GIS software for mapping the concentration of chemical-based pollutants along the Galing River.

Point	Latitude	Longitude	Temperature (°C)	Dissolved Oxygen (mg/L)	Total Suspended Solid (mg/L)	PH	Conductivity (us/cm)
1	3.836364	103.3332382	27.3	3.39	96.2	5.69	154.6
1A	3.836407	103.3332	27.7	2.83	111.15	5.43	180.1
2	3.8362974	103.3341231	26.7	8.96	67.6	4.65	106.7
3	3.8402336	103.3337023	27.1	8.21	89.2	4.32	112.2
4	315310.39	422134.92	26.9	3.43	1306.5	3.38	2388
4a	315293.51	422143.5	29.3	3.67	1722.5	1.78	2870
4b	315294.88	422125.74	29.2	2.06	1891.5	2.05	3147
4c	315260.56	422115.7	29.3	2.82	1722.6	1.78	2865
4d	315280.84	422129.11	29.4	2.43	1722.5	1.78	2867
4e	315218.78	422108.91	30.3	5.29	884	1.74	1496
4f	315175.69	422101.06	30.3	2.89	864.5	2.18	1465
4g	315206	422161	29.6	4.33	708.5	5.58	1182
4h	315137.06	422187.57	29.8	2.76	995.5	4.36	1669
4i	315132.95	422094.28	29.7	5.47	890.5	1.76	1495
5	314726.8	422959.68	29.8	4.62	95.55	0.5	160.4
5a	314744.77	422896.14	30.1	4.41	2704	1.67	5639
5b	314763.08	422814.36	29.7	1.75	3516.5	1.76	5915
5c	314710.79	423041.25	29.9	0.75	5597	1.76	6118
5d	314706.23	423074.4	30.1	0.41	669.5	3.56	1130
6	3.849999	103.3326	27.2	5.36	66.3	0	106.9
6a	3.832776	103.3659	27	4.58	68.9	3.28	110.5

Figure 4.1 Water Quality Parameter

Figure 4.1 depicts the water quality parameter extracted from the Handheld Multiparameter tool. Temperature, dissolved oxygen, total suspended solid, pH, and conductivity data were collected, and the longitude and latitude of each point were recorded to determine the coordinates of each point along the Galing River. The data will be used to determine chemical-based pollutant concentrations in dissolved oxygen, as the water sample was collected for laboratory testing to determine the BOD and COD of the water for chemical pollutants concentration.

4.3.1 Result at Each Point Based on Chemical-Based Pollutant

Table 4.2 Result of the concentration of Galing river

No	Latitude	Longitude	Chemical-based pollutant concentration
1	314909	424217	97.50
2	314902	424180	95.50
3	315024	424213	42.30
4	314619	423809	43.12
5	315310.39	422134.92	42.50
6	315293.51	422143.5	42.65
7	315294.88	422125.74	41.97
8	315260.56	422115.7	42.42
9	315280.84	422129.11	44.68
10	315218.78	422108.91	46.50
11	315175.69	422101.06	46.80
12	315206	422161	94.89
13	315137.06	422187.57	95.12

14	315132.95	422094.28	97.89
15	314726.8	422959.68	98.88
16	314744.77	422896.14	98.91
17	314763.08	422814.36	98.95
18	314710.79	423041.25	99.01
19	314706.23	423074.4	99.32
20	314902	425259	99.17
21	314898	425285	42.5
22	315470	421874	43.3
23	315488	421845	41.12
24	315496	421811	42.78
25	315616	421578	44.8
26	315639	421556	43.9
27	315702	421409	43.1
28	315709	421382	42.17
29	315693	421375	44.5

Figure 4.2 shows the results of chemical-based concentrations along the Galing River at various water sampling points. As shown in Figure 4.2, the upstream of the river is highly polluted by chemicals, with concentrations ranging from 95 to 99 mg/L. This concentration level has increased as a result of an industrialized area located within 40 meters of the Galing River. This industrialization area has a lot of manufacturing development, such as agricultural, construction industry, textile industry, steel industry, food industry, and cleaning service, all of which may use chemicals as their main substance in their factories. Since a decade ago, this has contributed a significant amount of chemical pollution to the rivers upstream.

4.4 Interpolation map using Geographic Information System (GIS)

The interpolation map was created using GIS software as the primary software to map the concentrations of each type of pollutant involved in this study, including sediment, oil, and chemical-based pollutant. This interpolation map makes use of each point's longitude and latitude. This chapter's findings will only concern chemical-based pollutants. The concentration level of pollutant at each point will be shown in the map by mapping the concentration using GIS software, from the highest to the lowest concentration level at a certain point.

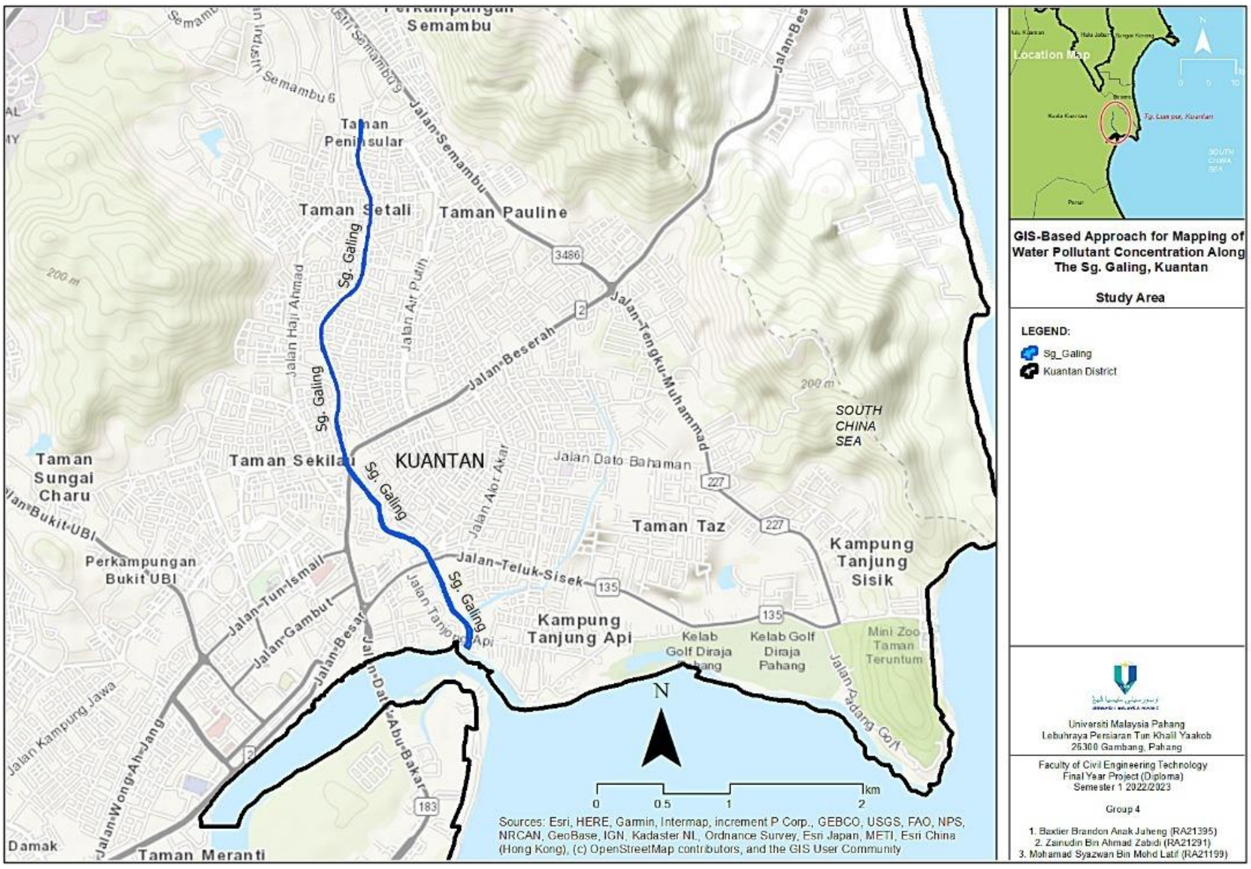


Figure 4.3 Study area

Figure 4.3 depicts the span of Galing river, which is the study area, as the Galing river has about 22.7 km span and 28 m width. Figure 4.3 show the location of Galing river along the Kuantan district, as shown that Galing river is started from Taman Peninsular to Kampung Tanjung Api.

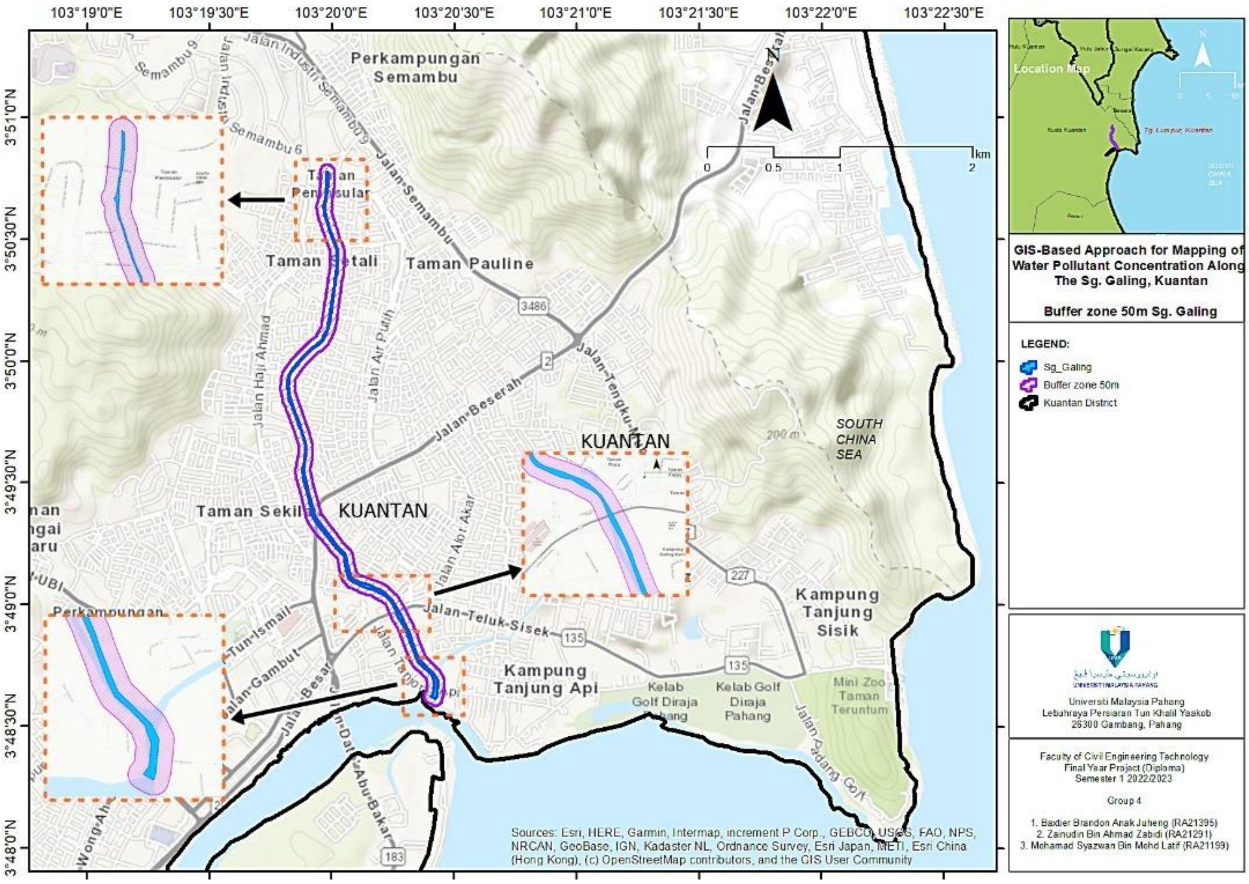


Figure 4.4 Buffer about 50 m along the Galing river

Figure 4.4 depicts the study area, Galing river, as the surrounding of river has been buffer about 50 m.

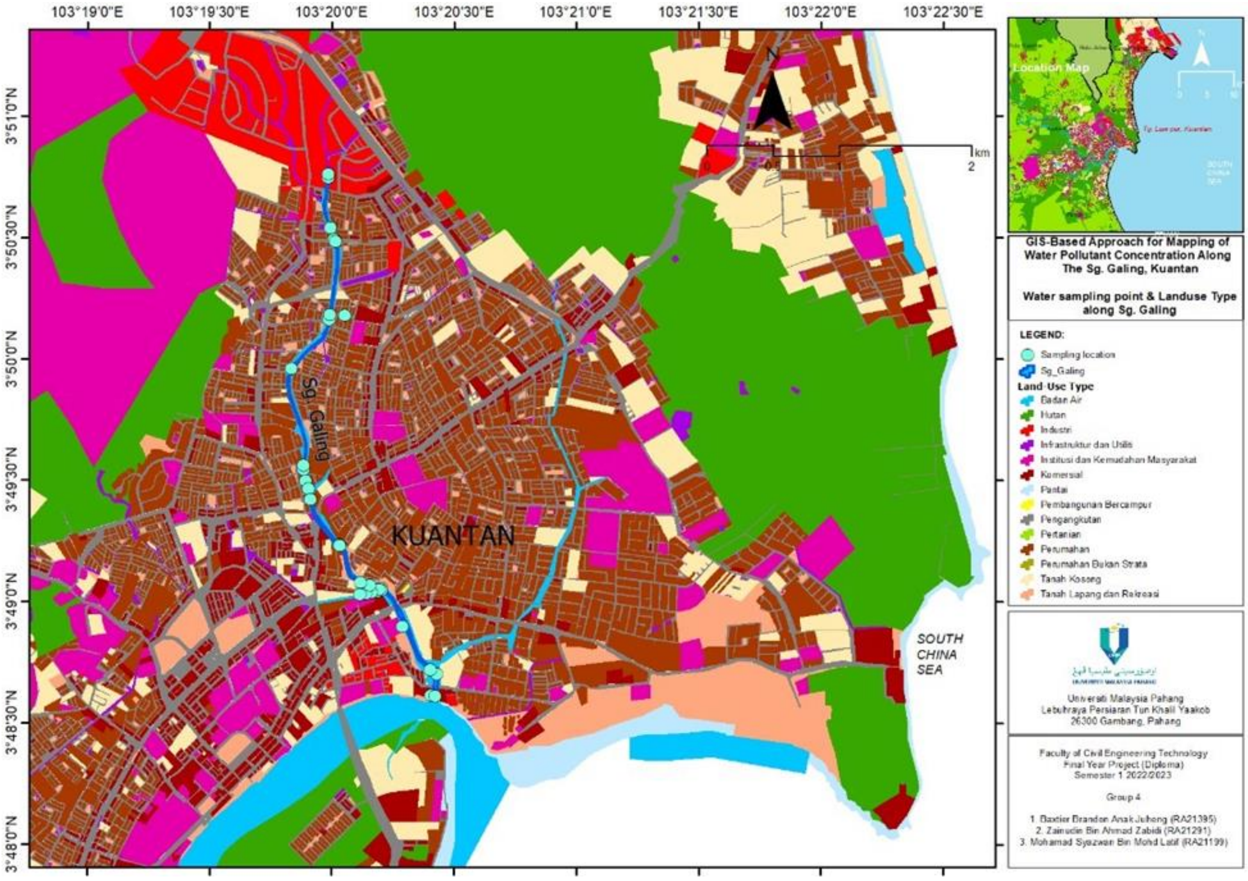


Figure 4.5 GIS based Mapping of Water Pollutant concentration along the Galing river, Kuantan.

4.5 Interpolation Map Before and After Raster Clip Using Geographic Information System (GIS)

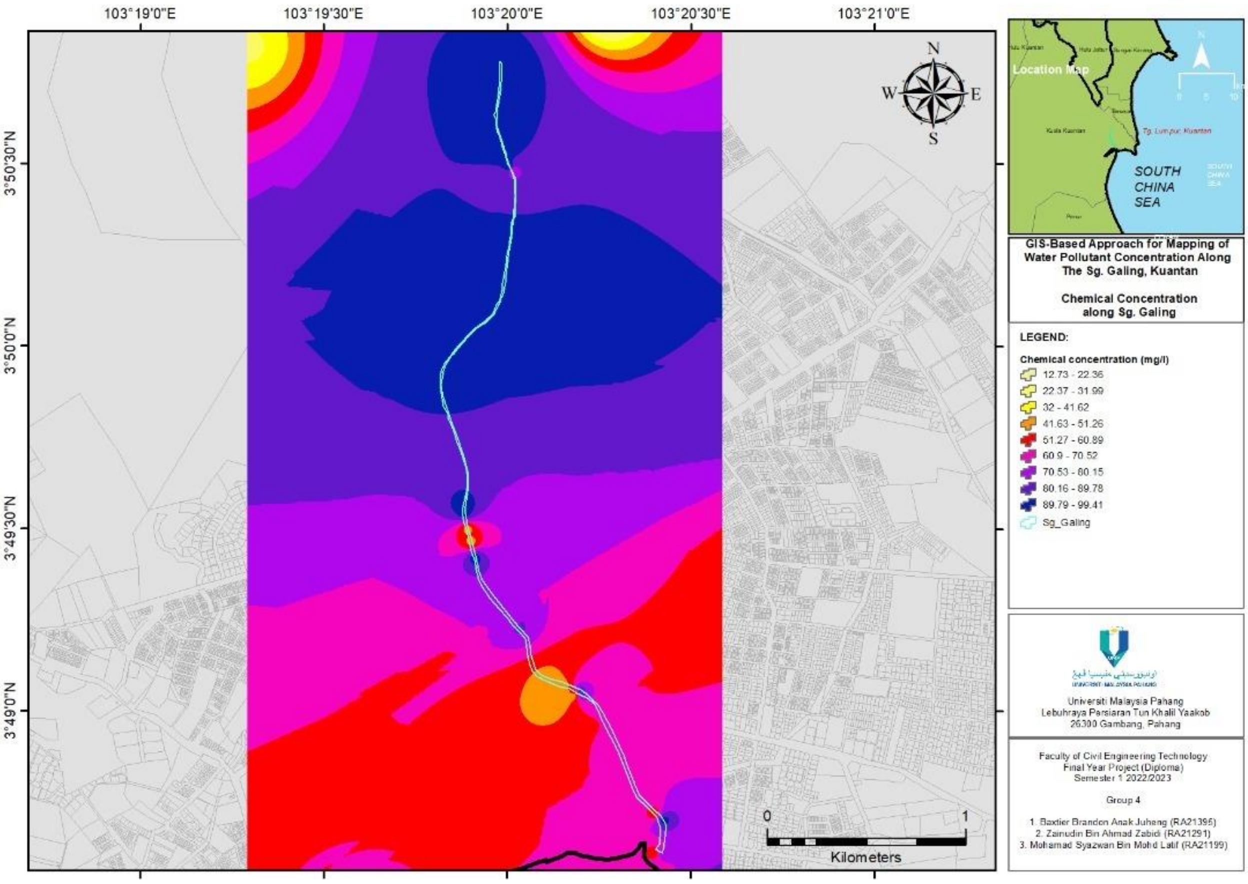


Figure 4.6 Interpolation map before raster clip

Figure 4.6 depicts the interpolation before raster clipping, with different colors appearing along the Galing River to describe the concentration level. Since the dark blue color represents the highest level of concentration and the yellow color represents the lowest level of concentration of the chemical-based pollutant along the Galing river. Figure 4.6 shows the interpolation map before raster clip, which has a large area color that also appears far from the study area, and as this before clip, it does not trim tidy along the study area.

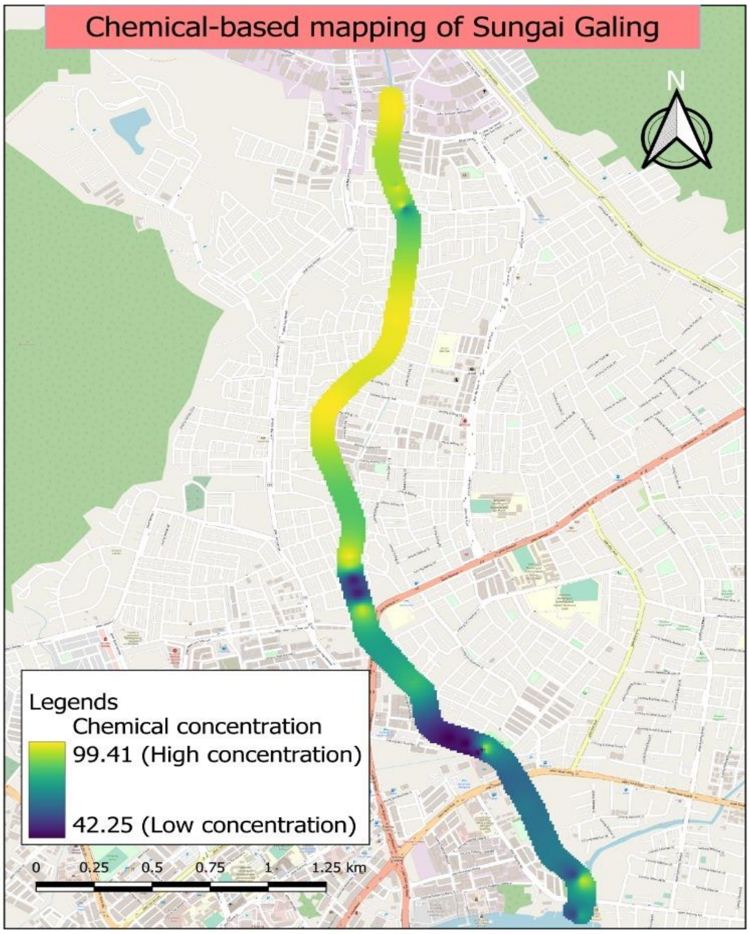


Figure 4.7 Interpolation map after raster clip

Figure 4.7 depicts the interpolation map after using raster clip. Since raster clip allows for the extraction of a portion of a raster dataset based on a template extent, the result depicted in Figure 4.7 is formed. According to Figure 4.7, the upstream of the river is highly concentrated by chemical-pollutant due to the highly industrialized area that was developed in the area, such as agriculture, construction equipment supply, cleaning services, food industry, steel production, and others, which may contribute a large amount of chemical-based pollutant into the Galing river, increasing the concentration of chemical-based pollutant at the Galing river. As shown in Figure 4.7, the high concentration value of chemical concentration is 99.41 mg/L, while the low concentration value is 42.25 mg/L, as the highest concentration of chemical was represented by yellow color and the lowest by purple color.

4.6 Discussion

This chapter presented the results of the chemical-based pollutant concentration mapping. This finding indicated the study's aim, because the kind of pollutants was determined, the study's first objective was met. The pollutant identified is a chemical-based pollutant, as demonstrated by the results. Since the Galing River is located in an industrialised region where many chemical compounds are employed, there is chemical contamination in the surrounding area.

Aside from that, a few steps were completed prior to the creation of the interpolation map. As study was conducted along the Galing River to evaluate which location had the greatest chemical-based pollution in the water based on the development that stood along the river. The concentration of each pollutant, such as sediment, oil, and chemical-based pollution, was then determined using water parameter tools. The concentration of chemical-based pollutant is determined using this tool, which has aided this study since the value of concentration of chemical-based pollutant has been determined. Through GIS, the concentration value of a chemical-based pollution is utilized to make an interpolation map. The region concentration may be classified as greater or lower concentration using this mapping..

The concentration at each point of location along the Galing river, from upstream to downstream, is detected using an interpolation map created with GIS software. The concentration of the chemical is highly concentrated upstream of the river, as shown in Figure 4.7, as represented by yellow color, because the upstream of the river is located in an industrialized area, which may contribute a large amount of chemical-based pollutant into the river. While the downstream of the river has a low concentration of chemical-based pollutant, which is represented by the purple color, this is due to the downstream of the river being located in an urban area, where the chemical substance is not commonly used in daily activities.

CHAPTER 5

CONCLUSION

5.1 Introduction

The final outputs of the study have been determined in the previous Chapter 4. In this chapter, conclusion were stated as the overall summary of the study and to highlighted that the objective have been achieved. Recommendations are offered as possible ways to improve this study.

5.2 Conclusion

The three type of pollutants that involved in this study has been determined, which is from sediment, oil, and chemical-based pollutants. As mentioned that, this type of pollutant has contaminated the Galing river in a large scale due to some factor that lead it to spreading. This is because of the urban area and industrialization area such as food, steel, textile, construction industry that was developed near to the Galing river.

At the end of this study, the interpolation map has been done by using GIS software, the map has shown the concentration of the pollutants along the Galing river from the highest level to lower level of concentration that was classified by colour. The area that have the highest concentration of chemical-based pollutant has been identified, which is occur at the upstream of the river, since the industrialization area is located at upstream of the river. As a conclusion, the objective of the study was able to be achieved.

5.3 Recommendations

This study is primarily concerned with the identification of pollutants such as sediment, oil, and chemical-based pollutants found in the Galing River. Because this study was conducted in 2022 and updated the data from the previous study, it is recommended that another study be conducted in the following year. This is due to the fact that the concentration level of pollutant followed by time is not the same, and it is recommended to update the WQI data that can be used for river classification based on trend.

Aside from that, it is recommended to use an interpolation map in this study because the concentration level of pollutants can be classified and the area with the highest concentration can be determined. This can help with law enforcement in the area with the highest concentration of pollutants to avoid the water being polluted by these pollutants again.

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APPENDICES

Appendix A: fieldwork at Galing river

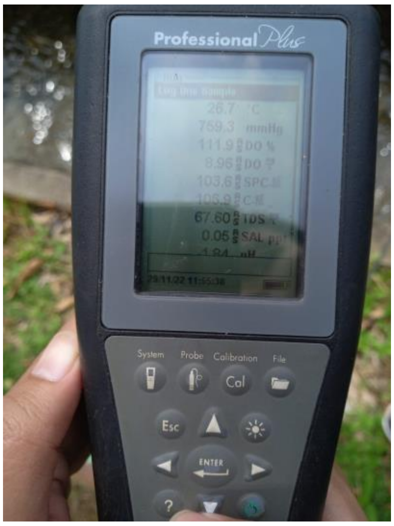
Collection of water sample at industrialization area

collection of water sample at middle river

Collection of water sample at urban area

Collection of data using Handheld Multiparameter

Appendix B: Tools used to collect data of the water parameter



Handheld Multiparameter

pH meter

Water depth meter