GIS-BASED APPROACH FOR MAPPING OF OIL-BASED POLLUTANT CONCENTRATION ALONG THE SG. GALING, KUANTAN

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Diploma in Civil Engineering

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GIS-based approach for mapping of oil-based pollutant concentration along Sg Galing, Kuantan

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Thesis submitted in fulfillment of the requirements
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ABSTRAK

Kadar perindustrian dan pembandaran yang semakin meningkat di sekitar Sg Galing boleh mencemarkan sungai dan menjejaskan sumber semula jadi air tawar untuk aktiviti manusia. Selain itu, kurangnya penguatkuasaan keselamatan air menyebabkan sungai semakin tercemar dan aktiviti haram tidak terkawal. Hidupan akuatik dan alam sekitar mungkin terjejas oleh sebab-sebab ini. Kaedah konvensional untuk memantau kualiti air tidak berkesan kerana kekangan kos dan masa akan menjadi cabarannya. Oleh itu, teknologi GIS adalah alternatif untuk menyelesaikan isu dan menawarkan pemantauan berulang pada pandangan helikopter yang membolehkan liputan seluruh Sg. Galing. Air adalah keperluan asas kehidupan manusia. Air bersih adalah penting untuk pelbagai aktiviti rutin dan proses alam sekitar. Bahan pencemar air termasuk pencemaran akibat sisa domestik, racun serangga dan racun rumpai, sisa pemprosesan makanan, bahan pencemar daripada operasi ternakan dan banyak sumber lain. Menggunakan alat teknologi spatial iaitu pendekatan GIS, kajian ini memfokuskan kepada pemetaan bahan pencemar air di Sg. Galing, Kuantan. Untuk menentukan kawasan mana yang tercemar teruk, kepekatan pencemar tinggi, sederhana dan rendah akan diinterpolasi secara spatial di sepanjang sungai. Sistem pemprosesan GIS akan digunakan untuk menentukan sumber pencemaran yang paling banyak menyumbang kepada corak peta. Salah satu punca utama pencemaran air sungai ialah pencemaran minyak. Industri pembuatan, aktiviti buatan manusia, dan kemalangan di mana minyak dibuang atau tertumpah ke dalam sungai, mencemarkan air, semuanya boleh dipersalahkan untuk ini. Ini berpotensi berbahaya kepada manusia, hidupan akuatik dan alam sekitar Peta dan analisis yang dihasilkan daripada kajian ini dapat membantu pembuat keputusan dan pihak berkuasa tempatan untuk menyediakan tindakan mitigasi segera bagi mengelakkan pencemaran selanjutnya ke dalam sistem air Sg. Galing, sejajar dengan SDG 11: Bandar dan komuniti mampan; dan SDG 14: Kehidupan di bawah air.

ABSTRACT

The increasing rate of industrialization and urbanization around Sg Galing can pollute the river and affect the natural source of fresh water for human activities. Other than that, lack of enforcing water security causes the river to be more polluted and illegal activities are uncontrolled. Aquatic life and the environment may be harmed by these causes. Conventional method to monitor the water quality is not effectively as the cost and time constraint would be its challenges. Thus, GIS technology is an alternative to solve the issue and offers repetitive monitoring at helicopter view which enable coverage of the whole Sg. Galing. Water is a basic need of human life. Clean water is essential for various routine activities and environmental processes. Water pollutants include contamination because of domestic wastes, pesticide and chemical substance, food processing waste, pollutants from livestock operations and many other sources. Using a spatial technological tool, namely GIS approach, this study focuses on mapping water pollutants in Sg. Galing, Kuantan. To determine which areas are severely polluted, high, medium, and low pollutant concentrations would be spatially interpolated along the river. A GIS processing system would be used to determine which sources of pollution contributed the most to the map's pattern. One of the most common causes of river water pollution is oil pollution. Manufacturing industries, man-made activities, and accidents in which oil is dumped or spilled into a river, polluting the water, can all be blamed for this. These are potentially hazardous to humans, aquatic life, and the environment. The map and analysis generated from this study could help decision makers and local authorities to provide immediate mitigation action to prevent further pollution into the water system of Sg. Galing, aligned with SDG 11: Sustainable cities and communities; and SDG 14: Life below water.

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^{o}C = Temperature

LIST OF ABBREVIATIONS

GIS	Geographical Information System
RS	Remote Sensing
SDG	Sustainability Development Goals
GEP	Google Earth Pro
FCET	Faculty of Civil Engineering Technology
UMP	University Malaysia Pahang
DO	Dissolved Oxygen
BOD	Biochemical Oxygen Demand
COD	Chemical Oxygen Demand
TSS	Total Suspended Solid
WQI	Water Quality Index
UNESCO	United Nations Education, Scientific and Cultural Organization
GAB	General Aerobic Bacteria
DOE	Department of Environment
SRB	Sulfate Reducing Bacteria

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CHAPTER 1

INTRODUCTION

1.1 Background of study

Sg Galing is in the rapidly urbanized area of the city of Kuantan, Pahang. It has a span of 7.7 kilometres and an area of 22.65 kilometres square. The river's catchment area, with the Semambu industrial area located upstream and the Kuantan city central downstream. Numerous water pollutants have been generated as a result of industrial waste and other sources. Meanwhile, the mid-stream area of the river is a mixed development area such as economic growth centres and residential areas.

Nevertheless, Sg Galing is considered one of the main drainage systems for the eastern area of Kuantan city. Another main drainage systems that enter this river system include the catchment area of Sg Galing Kechil (113 hectares) which includes the areas around Medan Tok Sira drainage and Medan Kubang Buaya from the development part of the area on Jalan Beserah comprising Bukit Restali as well as the catchment area around Bukit Sekilau with Jalan Lim Hoe Lek.

Water is a basic need of human life. Clean water is essential for various routine activities and environmental processes. Water pollutants defined as the contamination due to domestic wastes, pesticides and chemical substances, food processing waste, pollutants from livestock operations and several other sources. Using a spatial technological tool, namely GIS approach, this study focuses on mapping water pollutants in Sg. Galing, Kuantan. To determine which areas are severely polluted, high, medium, and low pollutant concentrations would be spatially interpolated along the river.

1.2 Problem Statement

Rapid development in the catchment area has exposed Sg Galing to various pressures that have resulted in incidents such as floods, pollution, decline of water quality lack of water resources, bank and riverbed erosion, squatter problems and laws to manage the river. The water condition of Sg. Galing is founded to be not stable, and highly exposed to pollution. This is due to pollutants such as oil, sediments and chemicals are disposed into the river caused by manmade activities to bring income for their industry. These water pollutants have effects and are dangerous to humans, the environment and other species of animals including aquatic lives.

Illegal activities such as unlawful disposal of toxic and chemical waste has contaminate the environment and the habitat of aquatic life in the river. This prove that the laws to protect the liveliness of the river is not enforced or the enforcement is at minimal. These pollution sources can be from waste oil from vehicle workshops, wet markets or restaurants and food premises and encroachment of river reserve with various return activities. The continuation of this issues can result in the river water to be more polluted thus become poisonous for daily uses and authorities should act against this matter to prevent further pollution of the river.

Water quality monitoring is costly, time inefficiency and need a huge number of manpower to conduct. Non-updated geodatabase creates cascade effect to mitigate water pollution issues in Kuantan. A GIS processing system would be used to determine which sources of pollution contributed the most to the map's pattern. One of the most frequent causes of river water pollution is oil pollution. Manufacturing industries, man-made activities, and accidents in which oil is dumped or spilled into a river, polluting the water, can all be blamed for this. These are potentially harmful to humans, aquatic life, and the ecosystem. The dry season climate is ideal for this research because it is a controlled variable that prevents dilution of the water due to deposition or rainwater. The map and analysis generated from this study could help decision makers and local authorities to provide immediate mitigation action to prevent further pollution into the water system of

Sg. Galing, aligned with SDG 11: Sustainable cities and communities; and SDG 14: Life below water.

1.3 Objectives

The objectives of this study are:

1. To identify water pollutants from oil-based pollutants in Sg Galing using water quality devices and laboratory experiment.

2. To map the concentration of oil-based pollutants and to generate database of water quality in Sg Galing using GIS.

1.4 Scope of study

Figure 1.1:Sampling point along Sg Galing

This study focuses only for Sg Galing as the study area because of the fast pace of industrialization alongside of this river since a decade ago. Sg Galing 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 economic growth centres and residential areas, is in the Galing River's intermediate area.

The instruments involved in this research are the handheld multi-parameter, water depth meter, PH meter along with the use of a cold storage room to store the river water samples provided by FCET, UMP. This research analyse at all three water quality parameters: physical, chemical, and biological. For this study, 8 parameters have been selected. Temperature, pH, conductivity, dissolved oxygen (DO), biochemical oxygen demand (BOD), chemical oxygen demand (COD), ammonia nitrogen, total suspended solid (TSS), and heavy metals are all involved.

The method used to determine and classify types of pollutant is by extracting the river water samples and taken to the lab to undergo laboratory testing. The testing that we were conducted to classify its pollutants are the oil and grease test, total suspended solid test, biochemical oxygen demand test and chemical oxygen demand test. The further use of QGIS software is to generate a mapping of the concentration of pollutants and by using IDW interpolator we can interpolate and predict the concentration of oil-based, chemical-based and sediment-based pollutants along the whole river.

1.5 Significant of study

The significant of this study is the obtained data of the water quality of Sg Galing can be compared to Malaysia's Water Quality Index (WQI) and the National Water Quality Standard (NWQS). Water quality index is distributed into five main classes, Class I water is in its natural state and does not require treatment, Class II water is suitable for recreation and requires standard treatment before use, and Class III water requires standard treatment before use. Then there's Class III water, which requires extensive treatment before it can be used. Only Class IV River water can be used for irrigation, whereas Class V River water is too polluted to be used. By classifying its water quality classes, we can evaluate the availability of the river water for daily uses based on the conditions.

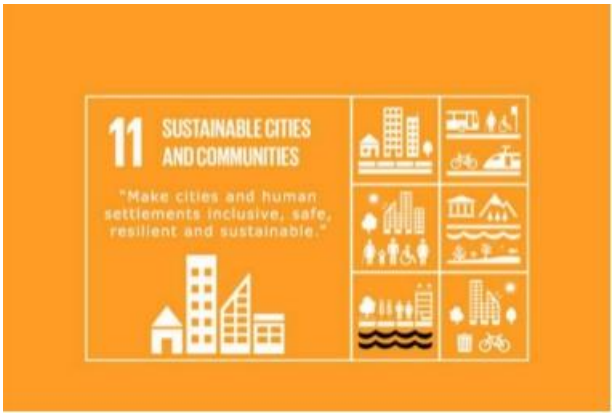

Figure 1.2: SDG 11 Sustainable cities and communities

Other than that, we can control pollution by constructing sustainable structures that can decrease pollution along Sg Galing. This can be aligned with SDG 11 (Sustainable cities and communities) goal because we are able to control pollution by constructing sustainable structures that can decrease pollution along the Sg Galing. This goal is important in order to build a more sustainable city or an urbanized area where less pollution can be created thus preventing the river to be more polluted.

Figure 1.3:SDG 6 Clean water and Sanitation

Apart from that, the significant of our study is that we are able to classify the pollution level, predict and provide solutions to overcome the water pollution at Sg Galing. This aligns with SDG 6 (Clean water and sanitation). By taking early measures, we are able to prevent further disasters and health threats towards the environment and

the communities this includes avoid humans and animals from river water poisoning and the safety uses of the water.

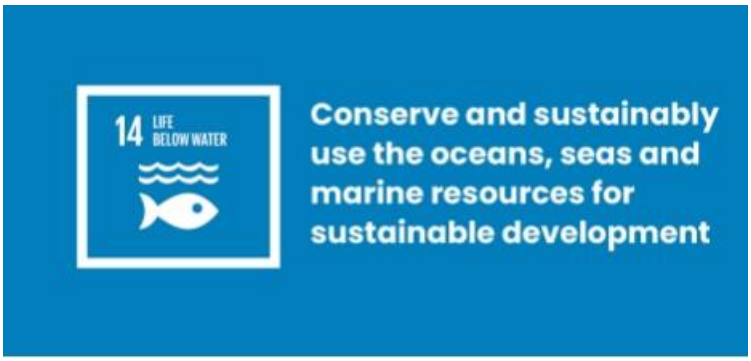

Figure 1.4:SDG 14 Life below water

Lastly, the significant of this study is to preserve the habitat of the river and the aquatic life in the Galing river from pollution. This aligned with SDG 14 (Life below water). As we all know there are aquatic life living in the river, if the river water is polluted due to human activities this aquatic life would be threaten and would harm it's habitat environment. We as an intelligent species should preserve and coexist with these aquatic creatures and we must preserve its natural habitat to prevent any extinction of any aquatic species.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter clarifies about water pollution and its impact on a global scale, Asia and especially in Malaysia. There are data and statistics presented on how water pollutant has affected the environment, humans and animal's life. Moreover, this chapter also explains the types of pollutant such as sedimentation, oil and chemicals on its impact towards oceans, rivers and water sources. This include how these natural and man-made pollutants were formed and its process in polluting natural water sources. This chapter also contains a deeper explanation of how oil can cause big impacts towards water sources in the world and in Malaysia. In this chapter, the usage and application of modern technology software to analyse and collect data on how pollute the water source have been highlighted. From the existing document and situation, monitoring activity and a mapping of the river pollutant, we are able predict the impacts and effects of this situation towards the environment and the community if it was no resolved at an earlier phase.

2.2 Water pollution to river, lakes and oceans

Figure 2.1:The illustration of water pollution in a lake

Water pollution can mainly be defined as the contamination of a river, ocean, a stream, lake or any other stretch of water. The degrading water quality and rendering it lethal to environment and humans. A practical description of water pollution is the addition of substances that directly or indirectly modify the nature of the water body in such a manner that adversely affects its legitimate uses. There are two types of water pollution that is organic pollution which is due to microorganism such as bacteria and viruses present in the water generated by animal, vegetable waste and excrement. Another type of water pollution is chemical pollution generated by nitrates and phosphates of insecticides, household products, hydrocarbons used in industries, heavy metals and acids. This widespread problem of water pollution can jeopardize the human health, the environment and other species of animals.

Statistically, there are more people that die each year due to unsafe or unclean water than from war combined with all other types of violence combined. For the time being, the amount of freshwater that is available to us is estimated to be less than 1% of the total earth's freshwater reserve that are reachable and accessible by us. It is predicted that by the year 2050, the world's requirement for freshwater is to be one-third higher than what we currently demanded. This issue is only going to become more appalling when early precautions or solutions is not implemented.

Only about 3% of the Earth's water is freshwater. Hence, only about 1.2 % can be used as for consumption. The rest is locked up in ice caps, glaciers and permafrost or even buried deep in the ground. Some 80% of the world's wastewater are mostly untreated and were dumped back into the environment as a result polluting lakes, rivers and oceans. For the meantime, our drinkable water sources are finite. If precaution was not taken at an early stage, these challenges will only increase by the year 2050, when the global requirement for freshwater is expected to be one-third greater than what is demanded now.

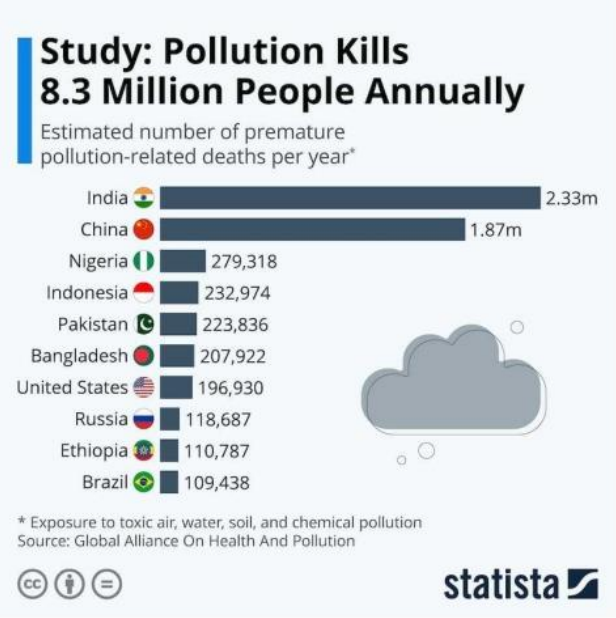

Figure 2.2:Total death due to water pollution around the world according to Statista.

In a fact, according to UNESCO (United Nations Education, Scientific and Cultural Organization) untreated sewage in many developing countries is often disposed and pollutes rivers, oceans and lakes. At the same time, oil spills such as the Deepwater Horizon oil spill of 2010 cause a lot of damage to our water and especially to the aquatic life that inhabits under water. Figure 2.2 shows the illustration number of deaths due to pollution all the around the world.

The toxic chemicals can alter the colour of water and raise the amount of minerals also known as eutrophication which has a bad impact on life in water. Thermal pollution is defined by a rise in temperature of water bodies, this would further contribute to global warming and causes serious risk to aquatic life.

2.2.1 The impact of water pollution in Asia

The impact of water pollution in Asia is also quite worrisome. Its rapid development and lack of sustainable infrastructure in rural areas cause water quality in those regions to be in a state of worsening. As a fact, Asia's rivers are three times more polluted by bacteria from human waste. In the Country of India alone, at least 40 million litters of wastewater polluted the waters in India each day. Thus, this has made 70% of surface water in India unsuitable for consumption. While in China, according to the government surveys, they found that 70% of China's waters are unsuitable for human consumption because of the overuse of insecticides and fertilizers. Lastly, in Vietnam 90% of urban wastewater is disposed back into the environment in untreated condition. The impacts are being felt by both humans and nature. There are 42% of the deaths related with unsafe or inadequate sanitation of water, water supplies and hygiene occur in Asia. Asian countries should take crucial efforts to deal with these problems, but the pace and scale of this policy response must also be addressed in an urgent matter for the sake of the people's heath.

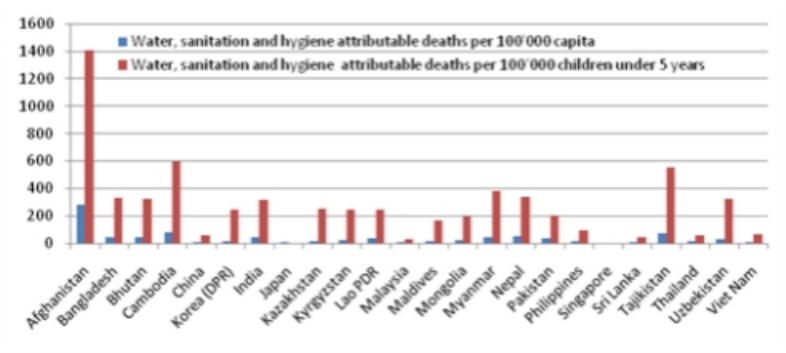

Figure 2.3:Water, sanitation, and hygiene related deaths in Asia. Source: WHO (2008)

2.2.2 The impact of water pollution in Malaysia

The rapid development and growth of the population has led to both the ever-rising demand for water consumption and in tandem of the levels of water pollution in Malaysia. This rapid development has generated a great number of human wastes, including industrial, commercial, household and transportation wastes which unavoidably ends up polluting in river, ponds and lakes. Numerous rivers are so polluted that in some regions, the effects are to the extent that the rivers cannot be treated or rehabilitate again. Based on the figure 2.4, the data provided from the Department of Environment (DOE) Malaysia in 2012 shows about nine rivers within Klang River Basin under River of Life Project were included to the national river water quality monitoring programme. Out of 473 rivers in Malaysia was monitored, about 59% of the river were found to be clean, 34% are slightly polluted, and about 7% are polluted.

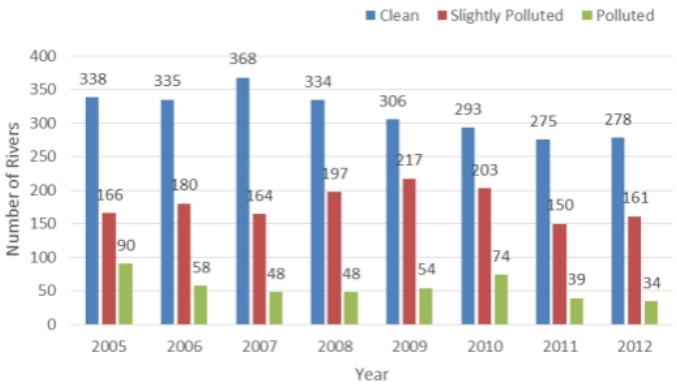

Figure 2.4:River water quality trend for 2005-2012

River water pollution control and quality need to be tackled urgently since 98% of the total water use originates from rivers. 70% of the water resources in the country are for the agricultural industry. As river water pollution increases, the concentrations of the current pollutants would also increase. Therefore, it also affects the increasing demand for safe water reserve thus affecting the water available for use decreases. As a result, in an cooperate way of going water treatment costs would increase significantly due to the occurrence of new pollutants. Furthermore, the ecological health of the water bodies and the surrounding environments would become worsen, this would further impact the aquatic lives in the river and daily recreational activities.

2.3 Factors of water pollution in rivers

Figure 2.5:River water pollution in India

As a fact, human activities is the primary responsible for water pollution in rivers, even if it's a natural phenomenon such as floods and landslides which can also cause to the downfall of water quality. As an example, to these issues is deforestation and rapid urbanization. This can cause a lot of indirect impacts towards water pollution such as cutting down trees and concreting over large areas generates an increase of rate of flows this would cause the water insufficient time to penetrate and be distilled by the ground. Chemical waste products from industrial processes are often unintentionally disposed into rivers. These properties enter the river water bodies in high concentration that aquatic life and other animals that consume the water to die immediately. Manufacturing factories mainly uses water from rivers to cool down or power their machineries. Thus, this affect result in the contaminated water containing chemicals is disposed into the river. By raising the temperature of the water reduces the level of dissolved oxygen and can interrupt the balance of life in the water. Humans itself are one of the main factors of pollution in river as they often irresponsibly throw waste directly into rivers.

2.3.1 Types of Pollutants in rivers, lakes and oceans

Water pollutants can be classified as inorganic and organic pollutants, pathogens, suspended solids, , radioactive, nutrients and agriculture pollutants, thermal and other

pollutants. Organic and inorganic pollutants are mainly emitted from industrial emissions and sewage into the river water bodies. Contamination result in environmental pollution or become public health concerns when they reach a intensity high enough to have significant bad impacts.

2.3.2 Sediment Pollutant

Figure 2.6:Shows the image of sediments pollutant.

Sediments are one of the usual forms of water pollution in any lake steam or ocean. Sediments are tiny portions of rocks or other solid fragments of soil that are washed or driven from land into the water. They aggravate flooding by clogging storm water sewers then settling in lakes and streams causing them to become shallower thus limiting sunlight penetration and photosynthesis for aquatic lives in river. As a result, this causes lack of nutrients for aquatic life and fishes by blocking their gills and covering their eggs. Sediments can come from a variety of manmade activities location such as farming activities, construction sites, logging activities and mining activities.

2.3.2 Chemical Pollutant

Figure 2.7:Shows the chemical pollutants dumped into a river.

Another common form of water pollutant is chemicals. Chemical waste is considered lethal and hazardous as it is explosive, poisonous, explosive, carcinogenic, mutagenic. Sources of lethal chemicals consist of inappropriately disposed of wastewater from industrial plants and chemical process facilities such as mercury, lead and chromium. Apart from that, sources such as surface runoff or spills carrying insecticides used on agricultural regions and suburban grasslands can also be the cause of water pollution and soil pollution. Solvents and metals from industrial work can pollute rivers and lakes or even the ocean thus intoxicating their waters. These are extremely poisonous to many forms of aquatic life and may drag their development, causes them to be infertile or even result in death and their extinction.

2.3.3 Oil Pollutant

Figure 2.8:Shows the river is polluted by oil pollutants.

Petroleum is a different form of chemical pollutant that commonly pollutes water through oil spills when a ship ruptures. Oil spills frequently have only a localized effect on wildlife but can spread for miles anywhere when in a large region of water such as an ocean. The oil can affect the death of many fish due to poisonousness and stick to the feathers of seabirds causing them to lose the ability to fly thus making them exposed to predators or even making them immobilized. Petroleum or oil pollution happens when oil from roads and parking lots is carried in surface runoff into water bodies. Thus, oil slicks eventually move towards the shore harming maritime life and aquatic life further damaging recreation areas. Purely land-based oil spills are different from maritime oil spills in that oil on land does not spread as quickly as in water and the impacts is remain as regional.

Figure 2.9:Oil spill from a ship polluting the ocean.

Generally, oil spills can impact animals and plants in two ways that is directly from the oil and further from the response or clean-up process. There is no clear relation between the amount of oil in the aquatic environment and the likely impact on biodiversity but a minor spill at the wrong time or the wrong season in a dedicated environment may demonstrate much more destruction than a bigger spill at another time of the year in the same location.

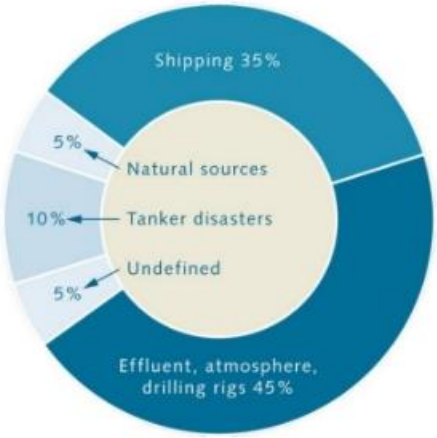

Figure 2.10:Shows the statistics of causes of oil pollution in oceans and rivers.

2.3.4 Types of oil pollutant

Oil-consuming bacteria can be classified into three types. That is sulphate-reducing bacteria (SRB) and acid-producing bacteria. While, generally for aerobic bacteria (GAB) are aerobic and acid-producing bacteria are anaerobic. These bacteria happen spontaneously and will act to remove oil from an ecosystem, and their biomass will tend to replace other populations in the food chain. The chemicals from oil which disintegrate in water are hence accessible to bacteria. There are those also in the related portion of the oil. The chemicals in crude oil are mostly hydrocarbons that contains toxic chemicals, as an example is poly-aromatic hydrocarbon, benzenes, toluene, and oxygenized polycyclic aromatic hydrocarbons. These kind of chemicals can create adverse health effects when being inhaled into human body. In addition, these chemicals can be oxidized by oxidants in the atmosphere to form fine particulate matter after they evaporate into the atmosphere .

2.4 The introduction of (Geographic information system) GIS

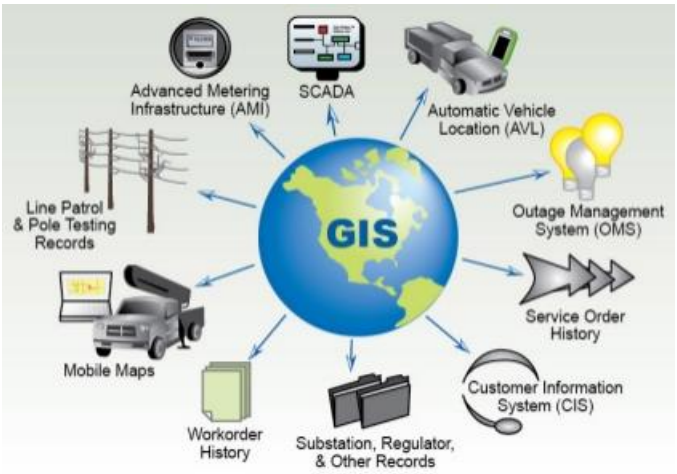

Figure 2.11:Shows the usage of GIS.

The geographic information system (GIS) is a system that generates, manage, analyses, and maps all types of data. GIS connects data to a map, integrating location data with all sorts of descriptive information. This further provides a foundation for generating a mapping and analysis that is used in science in an almost every industry. GIS helps

users to understand patterns, relation and geographic context in the most convenient way. The software's advantages involve of enhanced communication and efficiency as well as better supervision and decision making.

2.4.1 The application of GIS for water pollution and mapping analysis

GIS technology widely provide geographic scientist with tools for knowledge and cooperation to monitor streams or water movement along a continent or ocean. It assists people reach a common goal that is to gain actionable information from all types of data. Data such as GIS maps are easily allocated and embedded in apps and software in a matter of fact it is also accessible by virtually everyone and everywhere. GIS also combine various kinds of data layers using spatial location. Most data have a geographic component while GIS data includes descriptions of illustration, features and base maps linked to spreadsheets and tables. GIS also comes in a spatial analysis feature for you to assess suitability and capability, predicting and estimating, clarify and understand. Thus, this technology provides new perspectives to the awareness and decision making in this case. v

2.4.2 The introduction of (Remote Sensing) RS

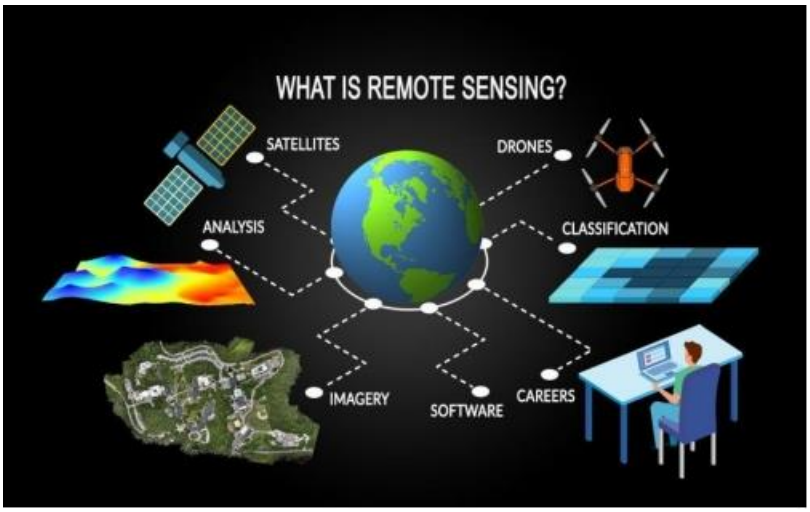

Figure 2.12:Show the usage and links of remote sensing.

Remote sensing is the process of detecting as well as monitoring the physical characteristics of an area by determining its reflected and emitted radiation at a distance typically from an aircraft or a satellite. Unique cameras are installed to collect remotely sensed images, which help researchers and analyst to observe objects around the Earth. An examples of remote sensing are cameras installed on satellites and airplanes that can catch images of large areas on the Earth's surface. This allows us to see much more than we can see when we are standing on the ground. Sonar systems on ships can also be used to generate images of the ocean floor without needing to travel to the bottom of the ocean. Cameras on satellites can be used to make descriptions to monitor changes of temperature in the oceans, lakes and rivers.

2.4.3 Usage of remote sensing for water pollution and mapping analysis

There are a few specific uses of remotely sensing images of the earth. Those includes of large forest fires can be mapped from space, this can help rangers to see a much larger view of the area than from the ground. Next, one of its uses is to help weather report by tracking clouds to assist predict the weather or monitoring erupting volcanoes and dust storms. The following is tracing the growth of a city and charges in farmland or forest over several years or even decades in the future. Lastly, is discovering and mapping of the rugged geography of the ocean surface such as deep canyons, huge mountain ranges and the magnetic stripping on the ocean surface.

2.4.4 Comparison of the advantages and disadvantages of GIS and RS for water pollution mapping

Table 1: Comparison the between the advantages and disadvantages of GIS and Remote Sending

Advantages of GIS	Disadvantages of GIS

• It allows users to organize and visualize the variety layers of data by generating maps and scenes. • It can clearly visualize various types of data where user is able to uncover patterns, trends and monitor changes as well as respond to events thus improve in decision making. • Reduce cost and increase efficiency in terms of maintenance schedule, fleet movements and scheduling timetables. • Easy to record keeping, the geographical changes are convenient to be recorded by GIS for those who are responsible in monitoring and recording changes of data.	• The period to learning curve on GIS software can take a longer time and the software shows spatial relationships but it does not supply with absolute solutions.
Advantages of RS	**Disadvantages of RS**

• Used for a wide area of coverage analysis and recurring coverage analysis such as agriculture and water. • Data attainment at different resolutions and scales can be performed easily which can be processed swiftly using a computer in the lab. • Detects natural catastrophe such as floods or forest fires so that immediate rescue operations and planning can be conducted.	• The repetitive aerial photographs are required for analysis of dynamics features such as using drones, helicopters, airplanes and satellites thus this would overall increase the cost to the system. • The choice of sensors, mounting of sensors and collection of data as well as its timings are conducted by human workers which may lead to errors if it is taken lightly.
These software advantages mostly outweigh its disadvantages and with the help of these software we can be able to collect data and analyse our research more deeply.	

2.5 Summary of Chapter

This chapter introduce and explains the major issue of water pollution is affecting global and the coming problems that both mankind and natural life will face if the issue is not taken care of at an early stage. Our part as the intelligent species of this planet should find ways to overcome and create an alternate solution so that this issue would not threat our health in the coming future. Human technologies and authority have a major

role in preventing any water pollutant related problems thus enhance the goal of achieving sustainable development in order to have been a more earth friendly species on this planet.

CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter outlines the methodology of the study to achieve the objectives of obtaining the turbidity, conductivity, PH levels, temperature, BOD level of the water in Sg Galing, Kuantan. The following data would be tested and evaluate to differentiate the type of pollutant in the river. We then use processing of satellite images by machine learning method to generate the mapping of Sg Galing. The following extracted sample would be analysed and classify its pollutant type thus it cause to the river in a long term. Thus, this chapter also explain the data verification for accuracy assessment by keying in the data in GIS. The end of the chapter would be explaining the outcome of water pollution mapping of Sg Galing and its database.

3.2 Flowchart of oil-based concentration mapping of Sg Galing

The mapping and classification of the water quality index of Sg Galing river is starting by preparation of apparatus and equipment needed for the fieldwork. The preparation of apparatus and equipment is needed to extract the water sample thus analyse the water quality index in terms of the turbidity, temperature, PH levels and conductivity of the river water to determine its risk of pollution to the river. The next process of the research is to survey the parameters of Sg Galing and pinpoint the affected location in google Earth Pro for sample to be taken. The following locations are focused on heavy presence of industries area the river for better evaluation of the affected parts of the river. We start pinpoint from the upstream to the downstream of the river. We then pinpoint the affected location in Google Earth Pro for sample to be taken. There will be a number of water sample extracted from the river that are related with oil pollutants and identify its sources. The following samples are then stored in a cold storage room provided by the FCET, UMP until further testing is conducted to determine its composition. The result would then be key into the QGIS software according to the survey and pinpointed location. It would be processed in satellite images by machine learning method and using spatial interpolation we would generate the mapping of the whole river with colour contract indicating the level of oil pollutant concentration.

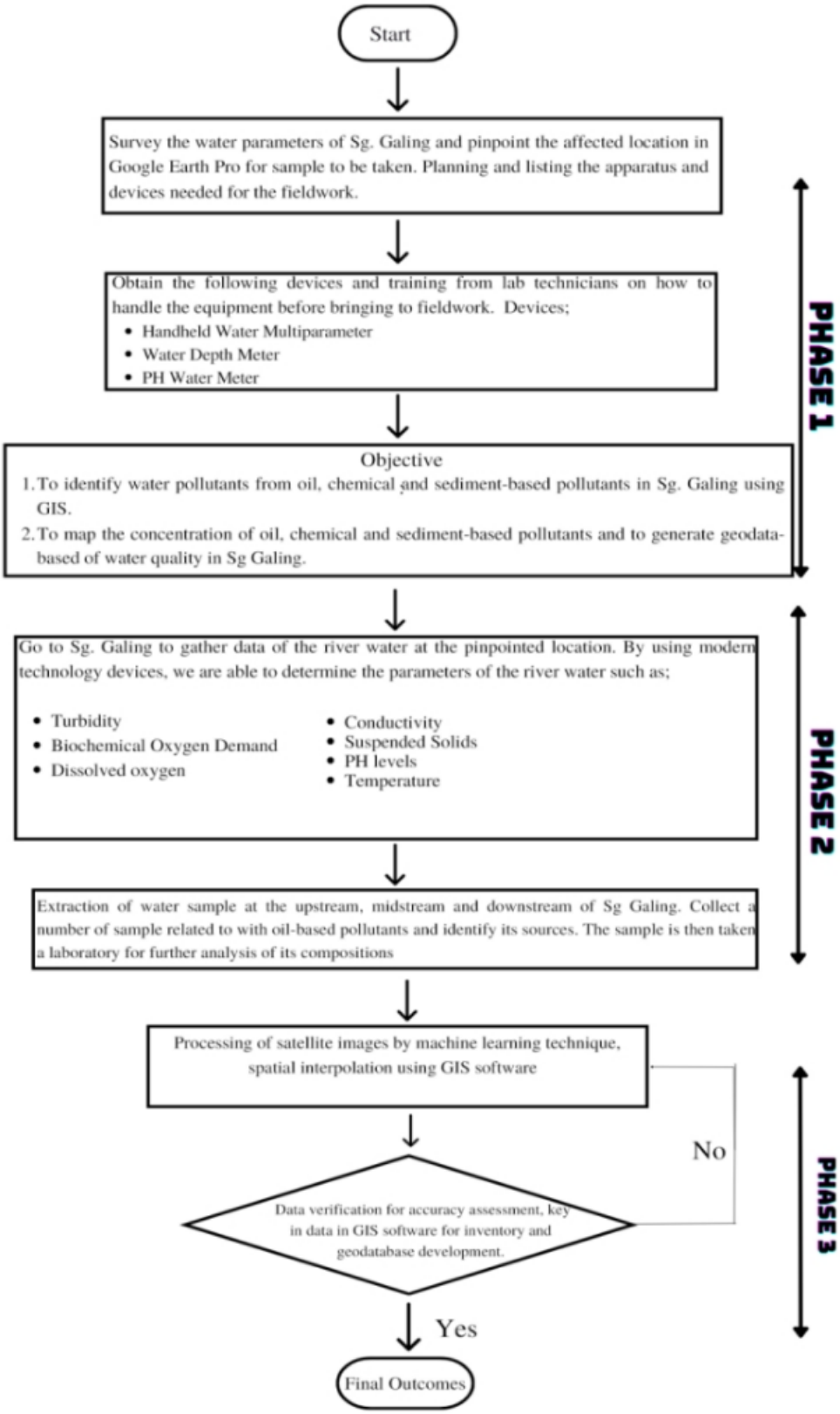

Figure 3.1:Flowchart of the study

3.3 Field data collection

Figure 3.2:Sg Galing

The fieldwork is conducted at Sg Galing, Kuantan using the method of water quality sampling in situ with water quality instruments. With the help of tools to detect water quality, we can classify and further analyse the ranges of water quality from each location of the river.

Water quality instruments that we are going to use is the FTKA 1000-PB103(M) -170800040001 PH meter, FTKA 1000-PB103(M)- 1305000100001 Handheld Multiparameter and a water dept meter. The instrument's sensors are dipped into the river water and the monitor will shows the data for the following water qualities such as the temperature, PH levels, conductivity and Biochemical Oxygen Demand (BOD). The turbidity can be determined when several water samples is extracted and by using scientific calculation.

Table 2: Shows the devices used to conduct water quality test at Sg Galing

 Handheld Multi-parameter	 Water dept meter
 PH meter	

Table 2 shows the devices that is being used to conduct water quality test at Sg Galing. A typical reading of the device may be caused by irregular conditions in a body of water, but they could also be a sign of equipment problems or failure. This shows average dissolved oxygen, electrical conductivity, and pH readings in potable, fresh, and marine water. If the readings appear abnormal, the first step is to check for the equipment issues such as a broken electrical cable, insulation, a fouled sensor or faulty probe, depleted batteries, and so on. If the equipment seems to be in good working order, take further measurements to confirm that the results are correct and check the calibration.

Table 1:Shows the typical ranges for dissolved oxygen, conductivity and pH from different water types.

Parameter	Potable water	Fresh water	Marine water
Dissolved oxygen (DO)		Typical concentrations under ambient conditions 6–10mg/L. Values may be higher if algal blooms are present, or lower if anoxic conditions are present.	
Electrical conductivity (EC)	50–500µS/cm	<1500µS/cm	~52 000µS/cm
pH		6–8.5. These may be lower if acid rock drainage or acid sulfate soils/sediments are present. The total range of pH values is generally 0–14.	

3.4 Physical parameter of water quality

Colour, taste, odour, temperature, turbidity, solids, and electrical conductivity are the examples of the physical properties. Though, chemical parameters can also include dissolved oxygen, biological oxygen demand, pH, acidity, alkalinity, chlorine, hardness, and other suchlike factors. Because different applications may have distinct needs, water quality criteria are important. For instance, one of the most crucial factors in determining the water quality of a river is the amount of dissolved oxygen. The degree of pollution in a water sample depends on the amount of dissolved oxygen present. Low levels of dissolved oxygen point to a highly polluted body of water where organic contaminants are robbing it of its oxygen-carrying capacity.

3.4.1 Turbidity

Turbidity is described as the cloudiness of water. It is a measurement of the capacity of lights to pass through water. It is usually cause by suspended material in water such as silt, organic matter clay, plankton, and other particulate materials. Turbidity in consumption water is undesirable because it makes the water appear unappealing. The impact of turbidity can raise the cost of water treatment for a variety of purposes. In the matter of fact, particulates act as a haven for harmful microorganisms, sheltering them from the disinfection process. Suspended materials in the other hand can clog or damage

fish gills, , reducing growth rates, reducing disease resistance affecting their eggs and larval maturation.

Turbidity is measured using a nephelometric turbidimeter device, which determines the turbidity in terms of NTU or TU. A TU corresponds to 1 mg/L of silica in suspension. Turbidity that are greater than 5 NTU can be seen by the average person, but turbidity in muddy water that exceeds 100 NTU cannot. Due to the natural filtration that occurs as water penetrates the soil, groundwater typically has very low turbidity.

Table 2:Shows the turbidity level based on NTU.

No	Turbidity level	TSM (NTU)
1	Fairly turbid	15 – 25
2	Rather turbid	25 – 35
3	Turbid	35 – 50
4	Very turbid	> 50

3.4.2 Temperature

Water temperature influences odour, chemical reactions, solubility, habitability, and viscosity, among other aspects of water quality. As a result, biological oxygen demand, chlorination and sedimentation are all affected by water temperature. Generally, water temperatures are meant to stay in the range between 50- and 60-degrees Fahrenheit.

3.4.3 Conductivity

Another important physical parameter to be aware of is electrical conductivity. It measures how well a sample of water, or a solution conduct electrical currents. As the number of ions in the water increases, so will the conductivity levels. Because of the this, water contamination levels can be detected when measuring water conductivity. This is also one of the most important parameters when measuring water quality. High conductivity implies that the water contains a high concentration of contaminants. Ultra-

pure water and potable are practically unable to conduct any electrical current. Electrical conductivity is commonly measured in micromhos/cm and milli Siemens/m, of which is latter be abbreviated as mS/m.

3.4.4 PH Level

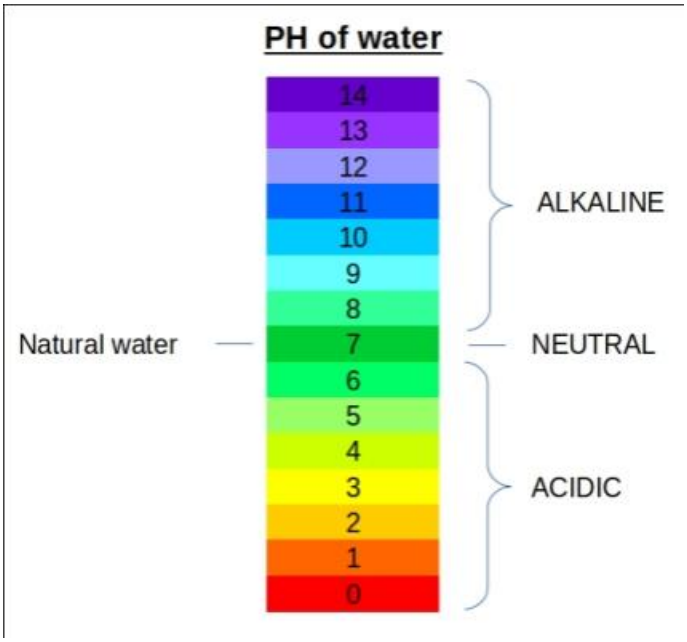

Figure 3.3:Shows the PH of water.

PH is one of the first factors to consider when determining the level of water quality. The PH of water usually determined by using a simple PH sensor device or a test kit, which would tell the result whether the water is acidic or alkaline. Acidic water would contain more hydrogen ions. While alkaline would contain more hydroxyl ions.

The PH level ranges between 0 and 14. When the reading of 7.0, it indicates the water is neutral. Any readings less than 7.0 are acidic, while any readings more than 7.0 are alkaline. The pH of pure water is on considered neutral. Rainfall are statistically slightly more acidic, with a pH of 5.6 on average. If the water is considered safe to consume if it has a pH range of 6.5-8.5. The many impacts that altering the pH levels on plants and animals. Generally, aquatic plants and animals can live in water with a specific

pH, which means that minor changes can ruin the quality of life. Thus, slightly acidic water can damage membranes, irritate fish gills and reduce the number of hatched fish eggs. Lastly, water with exceptionally high or particularly low pH is lethal to aquatic plants and animals and even some cases for humans as well.

3.5 Laboratory testing

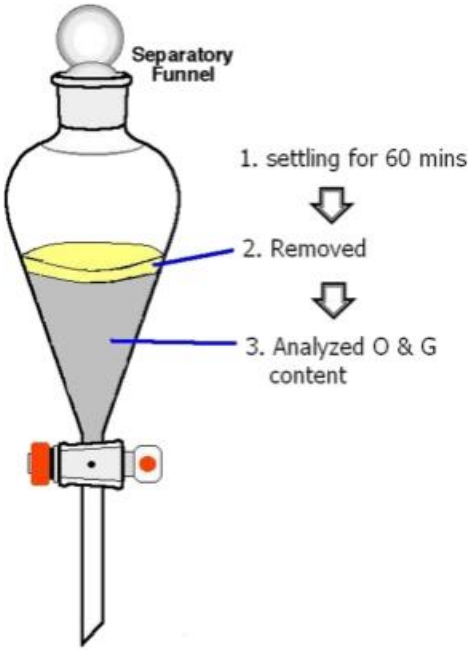

Figure 3.4:Shows the apparatus used for oil and grease laboratory testing.

Next, the following samples area then stored in the environment lab for testing. The oil and grease test. The oil and grease test provides a measure of the uses of hexane extractable non-volatile oils and greases which can be either natural origin or petrogenic. Meanwhile, mineral oil and grease determines only non-volatile, non-polar oils and greases. The uses of hexane is to extract material (ideally just oil and grease) from an acidified aliquot of the sample stream. The hexane should be evaporated, thus the entire quantity of the remaining residue left behind is defined as oil and grease.

The glass bottle used to collect samples for the oil and grease method must not have been pre-rinsed with sample. Oil and grease compounds are hydrophobic, meaning

they prefer to attach themselves to glass containers over the water in the sample collection. In the event that sample analysis is postponed, hydrochloric (HCl) or sulfuric acid must be used to preserve the sample to a pH of 2. (H2SO4). Following collection, every sample needs to be kept cold (6°C). A smaller volume is appropriate if it is anticipated or known that the sample will contain a significant amount of extractable material (>500 mg/L). Grab samples were used for all samples gathered for this research. The laboratory can perform a composite if additional volume in different containers is required.

3.6 Application of QGIS software

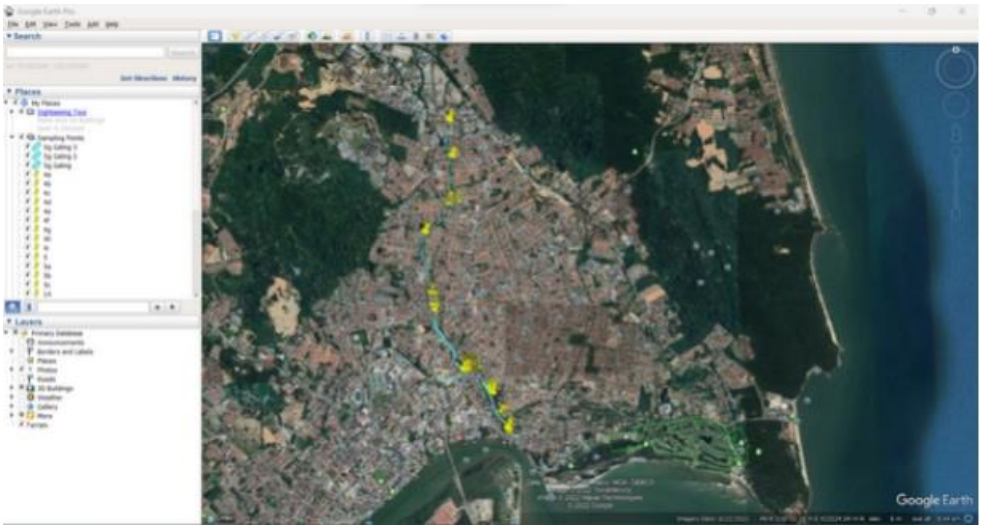

Figure 3.5:Shows the application of Google Earth Pro to mapping Sg Galing with the location of sampling points.

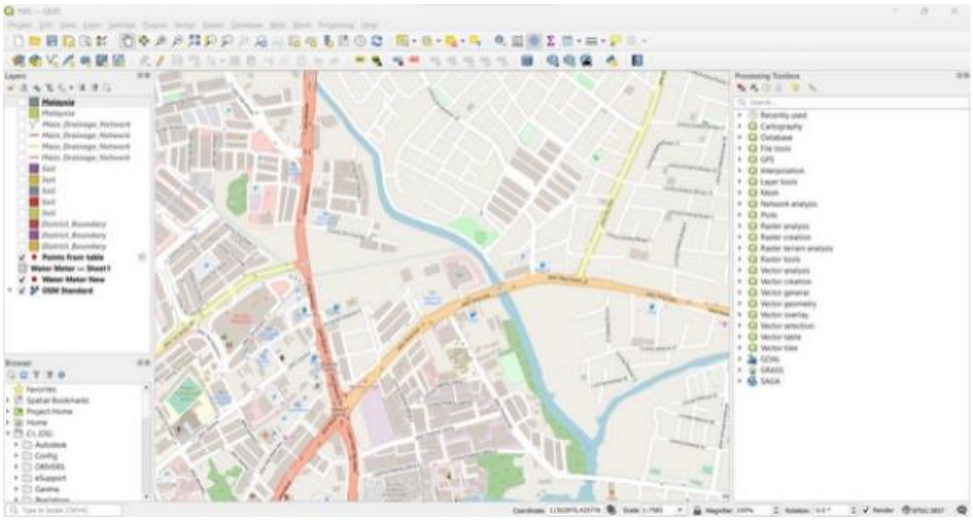

Figure 3.6:Shows the application of QGIS to generate the mapping of oil pollutant at Sg Galing

After we gathered the results of the test. We then tabulate it in Microsoft excel which is then process it into QGIS software. The function of the QGIS software is to do spatial interpolation which helps us predict the concentration of the whole river due to some of the river streams are no prohibited to be access or unable to access. This software would also help us to generate a mapping of the whole river overlaying with a contrast of colour which indicates the concentration of each pollutant along the whole river.

3.7 Cost Analysis

Table 3:Shows the cost analysis of the study.

NO	ITEMS	QUANTITY	PRICE PER UNIT	PRICE
1	ROPES 	10 METERS	RM 10 PER METER	RM 10
2	JERRY CAN 	7	RM 5	RM 35
3	RUBBER GLOVES 	1	RM 5	RM 5
4	WATER PLASTIC PAIL 	1	RM 4	RM 4
6	PHUA CHU KANG SAFETY SHOES 	3	RM10	RM30
7	LABORATORY TEST 	6	RM 140	RM840
8	COLD STORAGE FOR WATER SAMPLE	1	FREE	PROVIDED BY FCET,UMP
TOTAL COST				RM 924

The total amount of cost for the study is roughly around RM924 with equipment's to collect water sample such as water plastic pale and jerry can with some other tools example is ropes, rubber gloves, safety shoes and a Cold storage where the water sample is kept.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Introduction

This chapter presents the evaluation and final product of generating the mapping of different types of pollutant concentration. The mapping shows an updated database of oil, sediment and chemical concentration along the whole river stream overlay with a contrast of colours to indicates it level of concentration. Other than that, a discussion and findings are made to conclude our project study where the objectives of this study are fulfilled.

4.2 Result and discussion for river water sampling

Table 5: Water parameters for each sampling point.

Point	Latitude	Longitude	Temperature (°C)	Dissolved Oxygen (mg/L)	Total Suspended Solid (mg/L)	PH	Conductivity (us/cm)
1	314909	424217	27.3	3.39	96.2	5.69	154.6
1A	314902	424180	27.7	2.83	111.15	5.43	180.1
2	315024	424213	26.7	8.96	67.6	4.65	106.7
3	314619	423809	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	314902	425259	27.2	5.36	66.3	0	106.9
6a	314898	425285	27	4.58	68.9	3.28	110.5

Table 6: Concentration of oil pollutants at each sampling points.

Sampling Points	Latitude	Longitude	Oil (mg/L)
1	314909	424217	0.23
2	314902	424180	0.35
3	315024	424213	0.12
4	314619	423809	0.57
5	315310.39	422134.92	1.34
6	315293.51	422143.5	1.49
7	315294.88	422125.74	1.53
8	315260.56	422115.7	1.42
9	315280.84	422129.11	1.42
10	315218.78	422108.91	0.98
11	315175.69	422101.06	0.67
12	315206	422161	1.20

13	315137.06	422187.57	1.09
14	315132.95	422094.28	1.06
15	314726.8	422959.68	0.48
16	314744.77	422896.14	1.39
17	314763.08	422814.36	1.46
18	314710.79	423041.25	1.66
19	314706.23	423074.4	1.22
20	314902	425259	0.10
21	314898	425285	0.11
22	315470	421874	0.31
23	315488	421845	0.11
24	315496	421811	0.13
25	315616	421578	1.59
26	315639	421556	1.44
27	315702	421409	1.56
28	315709	421382	1.32
29	315693	421375	1.14
30	315702	421353	1.23

31	314942	424788	1.15

The table 5 below shows the result of the water parameters for each sampling location along the Galing river. The following parameters that were recorded was the temperature(°C), dissolved oxygen(mg/L), total suspended solid(mg/L), PH level and Conductivity (us/cm). The obtained the result of these parameters with a device called the Handheld water multi-parameter and a portable PH meter. By using these parameters, we are able to run laboratory test to obtain the concentration of oil, sediment and chemical pollutants. From the table, the highest concentration of dissolved oxygen is at point 2 which is about 8.96 mg/L while for total suspended solid the highest concentration is point 5c which is about 5597 mg/L. In the table 6, the highest conductivity among the sampling is 6118 us/cm which is located at point sampling 5c. Other than that, the based on the laboratory test result the highest concentration of oil pollutants is 1.66 mg/L while the lowest concentration is 0.10 mg/L.

4.3 Result and discussion with the application QGIS software

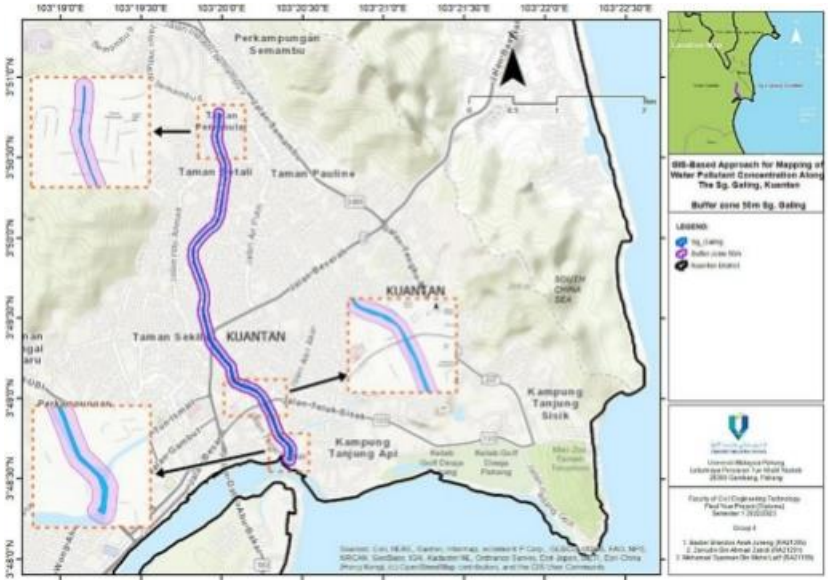

Figure 4.1:Map of Sg Galing using GIS software.

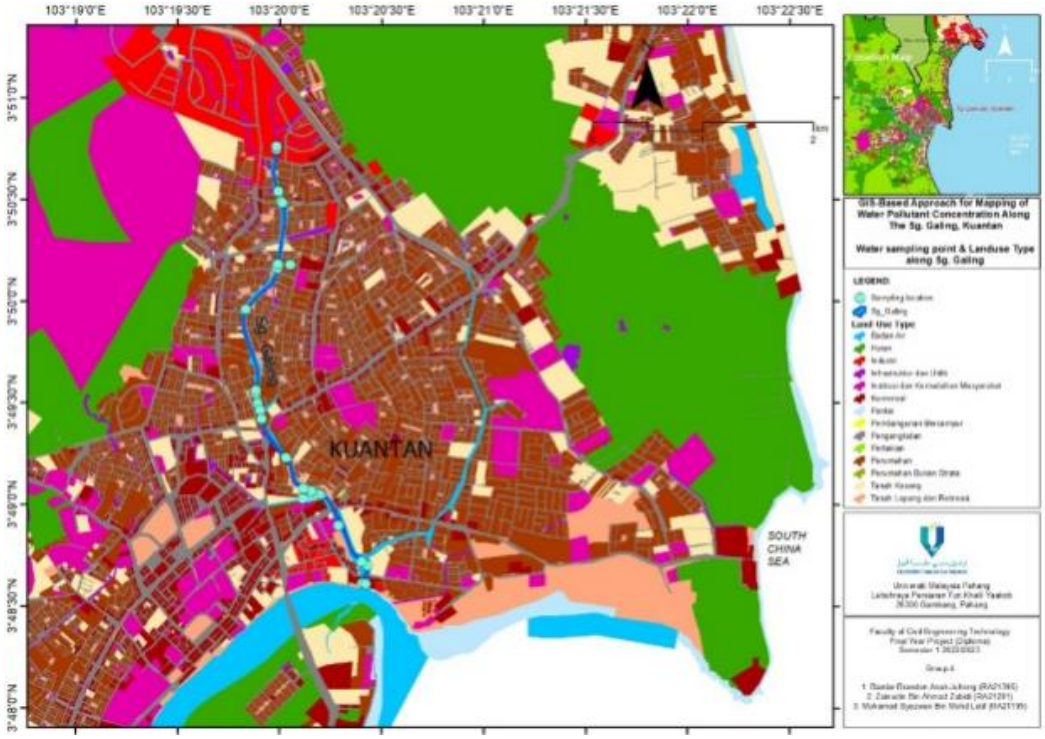

Figure 4.2:Shows the map of human-made infrastructures along the whole river.

4.4 Result of mapping and discussion after spatial Interpolation

The following figure 4.3, figure 4.4 shows the outcome of the process of spatial interpolation using QGIS. Spatial interpolation is the process of altering spatial data to obtain new knowledge and significance from the original data is known as spatial analysis. Usually, a Geographic Information System is used for spatial analysis (GIS). A GIS generally offers tools for spatial analysis for generating feature statistics and executing geo-processing tasks like data interpolation such the mapping shown below.

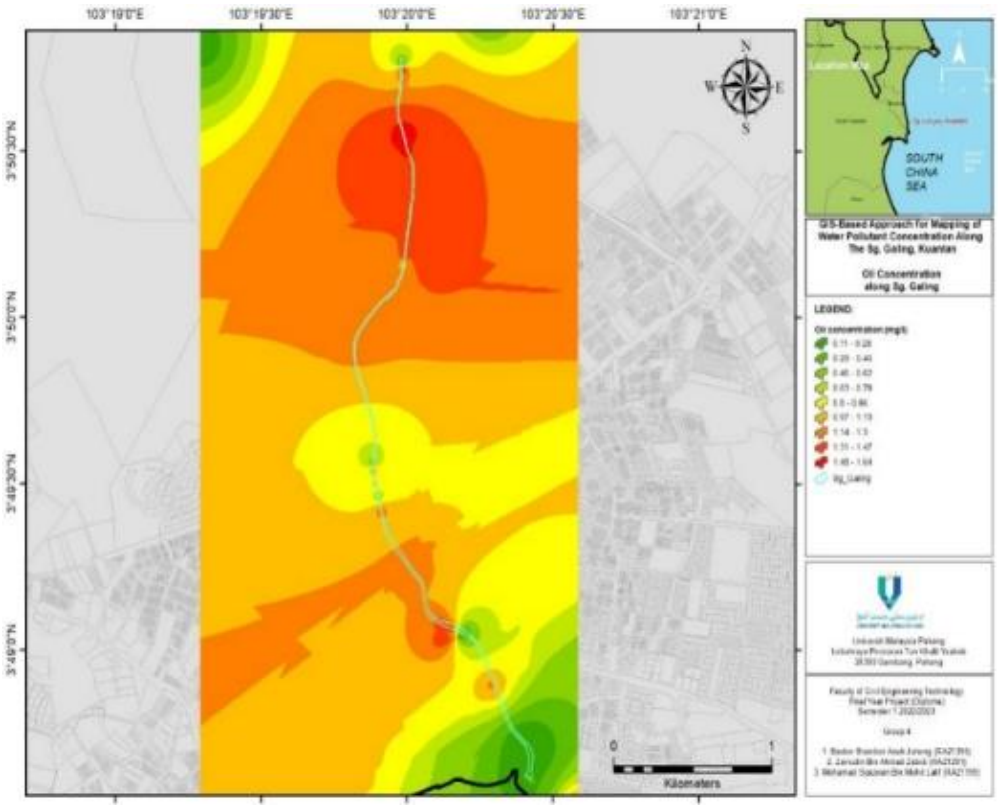

Figure 4.3:Interpolation map before raster clip

Figure 4.4:Interpolation map after raster clip

The findings indicates that high concentration of oil pollutants on the upstream of Sg Galing is due to the high number of industrial factories and car servicing factories at the area. There are about more than 10 industrial companies such as STC Poultry Processing Sdn. Bhd., Semambu Indutri Area, Perodua Service Centre, Hume Industries Berhad etc. These industries which is about 333.73 meter away from the river may contribute some oil-based pollutant due to its need to run generators, machinery and disposal of unfiltered oil. The factories and humans' infrastructure at the upstream of the river is mainly the cause of the highly concentrated presence of oil pollutants. The result of these oil pollution can be further proven in figure 4.5 which shows a the presence of It is It is suspected that the AC Hotel near the river stream may contribute to this pollution

as it is one of the nearest commercial canters at the location. Figure 4.6 also shows proof of oil-based pollutant along the mid-stream of the river.

Figure 4.5:Shows oil pollutant at along Sg Galing near Taman Pinggiran Sungai Galing.

Figure 4.6: Presence of oil pollution at the mid-stream of Sg Galing

CHAPTER 5

CONCLUSION

5.1 Introduction

This study focused on the mapping of types of water pollutant concentration along Sg Galing, Kuantan, Pahang during dry season. The main finding of this study have been accomplished by extracting water samples from the river and conducting laboratory testing to identify the pollutants. The test results is then tabulated into a Microsoft excel file where the data would then be transferred into the QGIS software to generate a mapping of the river with different contrast of colours indicates the level of the pollutant concentration. Thus, the mapping of the oil pollutant concentration is then generated, the discussion states that the river is heavily polluted at the upstream and the downstream of the river. This is generally due to the rapid urbanization and the heavily industrialized area at the upstream of the river.

5.2 Recommendation

From this study, there are some recommendations make this study more accurate and successful. Firstly, is to increase the number sampling location along the whole river. By expanding the area of the sampling point can drastically improve the accuracy of our result and findings due to some locations of the river are not accessible to extract any sample. The number of sampling data could increase the odds of obtaining a more valid result and data compared to having less samples. This can specifically show the concentration level of oil-based pollutants along the whole river. Thus, we can extract more data about its sources and predict its affects to the river soon.

Next, is to have better equipment and tools to extract river water samples. In this study, we manage to extract the river water by scooping the shallow water sample using

a pale tied with a heavy load and for deep water sample the bucket is descended into the bottom of the river then we lifted using a rope. With proper instrument or equipment, the water sample can be extracted more easily and accurately. For instance, riding a boat to extract every catchment area of the river water that can be taken rather than only extracting at water sample at the edge of the river.

REFERENCES

Use a reference manager such as *Mendeley*, *EndNote* or any reference manager software to generate all your list of references here. Once all the references are included then apply *Caption for Reference* style.

Alexandra E. V. Evans, Dr. Munir A. Hanjra, Yunlu Jiang, Dr. Manzoor Qadir & Pay Drechsel (2012 June). Global Water Forum ,*Water pollution in Asia: The urgent need for prevention and monitoring,* https://globalwaterforum.org/2012/06/09/water-pollution-in-asia-the-urgent-need-for-prevention-and-monitoring/

Sourgum Waste,*Water Pollution Statistics,* https://www.sourgum.com/trash-talks-blog/water-pollution-statistics/ , https://www.sourgum.com/trash-talks-blog/water-pollutionstatistics/#:~:text=Every%20day%2C%202%20million%20tons,children%20all%20around%20the%20world.

RSS (2022).What are the Sustainable Development Goals?: Intalcon,https://www.intalcon.com/magazine/the-17-goals-of-sustainable-developmentGavi, *the Vaccine Alliance (2022) Sustainable Development Goals*, https://www.gavi.org/our-alliance/global-health-development/sustainable-development-goals?gclid=CjwKCAjwwL6aBhBlEiwADycBIK4HJ3R42sTikA7T5i7V6ZmYAJY2uKZAq_cDgGsLlBElJr_Kpf4ZDxoCcGgQAvD_BwE

Denchak.M (2023 January). NRDC,*Water Pollution: Everything You Need to* Know,,https://www.nrdc.org/stories/water-pollution-everything-you-need-know#types

Okafor.J , BSC(2022 November).TRVST, *40 Water Pollution Facts & Statistics*, .https://www.trvst.world/environment/water-pollution-facts-statistics/

Wikipedia. (2023 January). Water pollution, https://en.wikipedia.org/wiki/Water_pollution

The Borgen Project. (2019 December). *10 Facts About Water Quality in Asia*, https://borgenproject.org/facts-about-water-quality-in-asia/#:~:text=Some%20common%20issues%20are%20rapid,by%20bacteria%20from%20human%20waste.

Huang. Y.F , Ang. S.Y , Lee. K.M , Lee.T. S (2015 September) *Quality of Water Resources in Malaysia*, IntechOpen, https://www.intechopen.com/chapters/47539

CDP(2021) CDP and SDG's,https://www.cdp.net/en/policy/program-areas/sustainable-development-goals?cid=7855922369&adgpid=85519955207&itemid=&targid=kwd-304400616200&mt=b&loc=9066630&ntwk=g&dev=c&dmod=&adp=&gclid=CjwKCAjwwL6aBhBlEiwADycBIF7eqrkTpmWDz1u_0VcTwVsvT9qOV_ZVMBpaSRz8ns0t4DC4lFLgJBoC9L4QAvD_BwE

Univeristy of Florida, Gainesville(2016) *Sources of Pollution: Sediments - UF Clean Water Campaign*, https://soils.ifas.ufl.edu/campuswaterquality/sources/sediments.shtml#:~:text=Sediments%20are%20the%20most%20common,from%20land%20into%20the%20water.

Water Wells - African Relief Fund - arf.org.uk,https://www.arf.org.uk/campaigns/water-wells

Stop Global Destruction(2020) *How To Stop Water Pollution*, https://www.stopglobaldestruction.org/how-to-stop-water-pollution/?gclid=CjwKCAjwwL6aBhBlEiwADycBIOMggNBCY31Lumryg1uPjBFqfZf1tuQaRsdYV4385_PAz61PovwlfRoC4XsQAvD_BwE

Kailas L. Wasewar, ... Sushil Kumar Kansal, in Inorganic Pollutants in Water, (2020) *Water Pollutant, Water Pollutant - an overview | ScienceDirect Topics*, https://www.sciencedirect.com/topics/earth-and-planetary-sciences/water-pollutant#:~:text=Water%20pollutants%20can%20be%20classified,sewage%20into%20the%20water%20bodies.

Jerry A. Nathanson (2021) Encyclopædia Britannica, water pollution, https://www.britannica.com/science/water-pollution

Water Pollution(2021 December) Chemical Water Pollution, https://www.water-pollution.org.uk/chemical-water-pollution/

National Geographic Society(2020) GIS (Geographic Information System), https://education.nationalgeographic.org/resource/geographic-information-system-gis/

Geographic Information System Mapping Technology(2020) What is GIS?, https://www.esri.com/en-us/what-is-gis/overview

School of Engineering & Technology(2021 July) Remote Sensing and Geographic Information Systems (RS-GIS), https://set.ait.ac.th/programs/information-and-communications-technologies/remote-sensing-and-geographic-information-systems-rs-gis/

What is remote sensing and what is it used for? | U.S. Geological Survey(2022) What is remote sensing and what is it used for?, https://www.usgs.gov/faqs/what-remote-sensing-and-what-it-used#:~:text=Remote%20sensing%20is%20the%20process,sense%22%20things%20about%20the%20Earth.

APPENDICES

Appendix A: Sampling points along Sg. Galing

Picture 1: Sampling point for downstream

Picture 2: Sampling point for midstream

Picture 3: Sampling point for upstream

Appendix B: Fieldwork at Sg Galing

Picture 4: Surveying for sampling points along Sg Galing

Picture 5: Shallow River water sample taking at Sg Galing

Picture 6: Shows the uses of a PH meter and a Handheld water multi-parameter.

Picture 7: Using a Handheld water multi-parameter to calibrate the water parameter at one of the sampling points