Study on Water Quality in Selected area from Rivers in Kelantan

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DECLARATION

I declare that this thesis entitled "Study on River Water, Water Quality in Selected area from Kelantan River" is the results of my own research expect as cited in the reference.

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STUDY ON RIVER WATER, WATER QUALITY IN SELECTED AREA FROM KELANTAN RIVER

ABSTRACT

Water is a fundamental resource essential for sustaining life on Earth. Its quality plays a pivotal role in ensuring the health and well-being of both humans and ecosystems. Water quality refers to the physical, chemical, and biological characteristics of water that determine its suitability for various purposes, including drinking, agriculture, industry, and aquatic habitat support. Understanding water quality is crucial for effective management and conservation efforts to safeguard this vital resource.Iron (Fe), manganese (Mn), cadmium (Cd), lead (Pb), aluminium (Al), and copper (Cu) are among the elements found in trash generated by domestic human activities, agriculture, and mining. Aside from that, it affects the inherent qualities of river water constituents. The purpose of this study is to assess the physical parameters (turbidity, pH, TSS, TDS) as well as the concentration of heavy metals (Fe, Mn, Cd, Pb, Al, and Cu) Next, assess the level of contamination in the research areas. Heavy metal pollution is a significant environmental risk. These contaminants are long-lasting and do not degrade naturally. As a result, statistics are critical for determining the level of contamination. Turbidity and pH were measured in-situ using the YSI multiparameter, whereas TSS, TDS, COD. In addition, for heavy metal analysis, the effluent samples were destroyed with concentrated HNO_3 . The elements' concentrations were evaluated by Inductively Coupled Plasma - Optical Emission Spectrometry with the use of a Sigma-Aldrich multielement standard using a diluted solution of 0.1 ppm, 0.25 ppm, 0.50 ppm, 0.75 ppm, 1.00 ppm, and 2 ppm in lab GREAT at Universiti Malaysia Kelantan. The study's findings show that all of the test data compared to the National Water Quality Standard's allowable values. Maintaining high water quality is essential for sustaining ecosystems, protecting human health, and supporting socioeconomic activities. Effective management strategies, informed by comprehensive understanding and monitoring of water quality, are necessary to address current challenges and ensure the availability of clean and safe water for present and future generations.

Keywords: Kelantan River, water quality assessment, river basin, pollution sources, environmental management

KAJIAN AIR SUNGAI, KUALITI AIR DI KAWASAN TERPILIH DARI SUNGAI SUNGAI DI KELANTAN

ABSTRAK

Air adalah sumber asas yang penting untuk mengekalkan kehidupan di Bumi. Kualitinya memainkan peranan penting dalam memastikan kesihatan dan kesejahteraan manusia dan ekosistem. Kualiti air merujuk kepada ciri fizikal, kimia dan biologi air yang menentukan kesesuaiannya untuk pelbagai tujuan, termasuk minuman, pertanian, industri dan sokongan habitat akuatik. Memahami kualiti air adalah penting untuk usaha pengurusan dan pemuliharaan yang berkesan untuk melindungi sumber penting ini. Besi (Fe), mangan (Mn), kadmium (Cd), plumbum (Pb), aluminium (Al), dan kuprum (Cu) adalah antara unsur yang terdapat dalam sampah yang dihasilkan oleh aktiviti domestik manusia, pertanian dan perlombongan. Selain itu, ia menjejaskan kualiti yang wujud dalam juzuk air sungai. Tujuan kajian ini adalah untuk menilai parameter fizikal (kekeruhan, pH, TSS, TDS) serta kepekatan logam berat (Fe, Mn, Cd, Pb, Al, dan Cu) Seterusnya menilai tahap pencemaran dalam kawasan penyelidikan. Pencemaran logam berat adalah risiko alam sekitar yang ketara. Bahan cemar ini tahan lama dan tidak merosot secara semula jadi. Akibatnya, statistik adalah penting untuk menentukan tahap pencemaran. Kekeruhan dan pH diukur secara in-situ menggunakan multiparameter YSI, manakala TSS, TDS, COD. Di samping itu, untuk analisis logam berat, sampel efluen telah dimusnahkan dengan pekat . Kepekatan unsur-unsur telah dinilai oleh Plasma Berganding Induktif - Spektrometri Pelepasan Optik dengan penggunaan piawaian berbilang unsur Sigma-Aldrich menggunakan larutan cair 0.1 ppm, 0.25 ppm, 0.50 ppm, 0.75 ppm, 1.00 ppm, dan 2 ppm dalam makmal HEBAT di Universiti Malaysia Kelantan. Dapatan kajian menunjukkan bahawa semua data ujian berbanding dengan nilai Piawaian Kualiti Air Kebangsaan yang dibenarkan. Mengekalkan kualiti air yang tinggi adalah penting untuk mengekalkan ekosistem, melindungi kesihatan manusia, dan menyokong aktiviti sosioekonomi. Strategi pengurusan yang berkesan, dimaklumkan melalui pemahaman dan pemantauan menyeluruh terhadap kualiti air, adalah perlu untuk menangani cabaran semasa dan memastikan ketersediaan air bersih dan selamat untuk generasi sekarang dan akan datang.

Kata kunci: Sungai Kelantan, penilaian kualiti air, lembangan sungai, punca pencemaran, pengurusan alam sekitar

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LIST OF ABBREVIATIONS

TSS	Total suspended solid
TDS	Total Dissolved Solid
BOD5	Biological oxygen Demand
COD	Chemical Oxygen Demand
pH	Measure of acidity
Fe	Iron
Al	Aluminum
Mn	Manganese
Cu	Copper
Cd	Cadmium
Pb	Lead
NWQS	National Water Quality Standard
ml	Milliliter
HDPE	High-density polyethylene
DOE	The Department of Environment
WQI	Water Quality Index
USEPA	United States Environmental Protection Agency
ICP-OES	Inductively Coupled Plasma Optical Emission Spectrometry
TS	Total Solid
mg	Milligram
µm	Micrometer
HNO_3	Nitric acid
HCl	Hydrochloric acid

g	Gram
M	Molar
n.d	Not detected

LIST OF SYMBOLS

°C	Degree Celcius
K	Kelvin
µ	micro

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Water quality refers to the chemical, physical, biological, and radiological characteristics of water. It's a key aspect of environmental health and is vital for the well-being of ecosystems and human communities. Monitoring water quality helps assess its suitability for various purposes, such as drinking, agriculture, industry, and recreation.

Factors affecting water quality include pH levels, dissolved oxygen, nutrient content, pollutants (chemical and microbial), temperature, and turbidity. These parameters can vary based on natural conditions, human activities, and geographical location. Ensuring good water quality involves regular testing, pollution prevention and effective water management. Government regulations and international standards often set guidelines for water quality to protect public health and the environment. With growing concerns about water scarcity and pollution, maintaining and improving water quality has become a global priority.

Water is essential for human survival and activities such as manufacturing, agriculture, and others, and it is recognized as one of the ecosystem's most sensitive components (Das and Acharya, 2003). The rising demand for fresh water has come from the past decades' fast industrial development and population growth (Ramakrishnaiah et al., 2009). Surface and groundwater quality are determined by the physical, chemical, and biological qualities of the water (Loukas, 2010).

Heavy metals are a group of metallic elements that exhibit high density and are often toxic at low concentrations. These elements have a density greater than 5 g/cm^3 and include metals like lead, mercury, cadmium, arsenic, and chromium, among others. While some heavy metals are essential for biological functions in trace amounts, elevated levels can have detrimental effects on human health and the environment.

Heavy metals are naturally occurring elements that have a high atomic weight and a density five times that of water (Banfalvi, 2011). Because of their toxicity, heavy metals are a major concern for environmental chemists. Heavy metals are often present in low concentrations in natural streams, although many are harmful even at extremely low doses (Herawati et al., 2000). Heavy metal pollution are also long-lasting and non-biodegradable, posing a significant and broad environmental hazard. Sediments are the last sink for heavy metals in the marine environment, and they play a significant role in the transportation and storage of potentially hazardous metals.

1.2 Probelem Statement

This pervasive contamination poses a critical threat to ecosystems and human well-being. Heavy metals, including lead, mercury, cadmium, and arsenic, persist in air, water, and soil, accumulating in organisms and disrupting ecological balance. The consequences extend to human health, with documented cases of neurological disorders, organ damage, and an increased risk of chronic diseases associated with prolonged exposure. Despite regulatory efforts, the problem persists, highlighting the need for targeted interventions, comprehensive monitoring, and strategic management to mitigate the far-reaching impacts of heavy metal pollution.

As a result, statistics are badly needed to determine the level of contamination in the water in that location for future research or conservation.

1.3 Objective

i. To determine the physicals parameters of river (turbidity, pH, TSS, TDS) from selected rivers in Kelantan.
ii. To determine the concentration of heavy metal from selected rivers in Kelantan.
iii. To evaluate the level of pollution from selected rivers in Kelantan by comparing the result with The National Water Quality Standards for Malaysia.

1.4 Scope of Study

Water samples were taken from selected area in Kelantan for this study. The following are included in the project scope. These are referred to as checkpoints. Following that, the sample was placed in a bottle and subjected to a series of water quality tests as well as heavy metal analysis at the Universiti Malaysia Kelantan laboratory in order to determine the physical properties as well as the concentration of heavy metal. Furthermore, the goal is to identify the amount to which pollution occurs in the region.

1.5 Significance of Study

This study will aid future research by providing data on heavy metal concentration measured in selected rivers from Kelantan. The data collected from the investigation of heavy metal concentrations in river water from various factors will aid academics and industry personnel in comprehending heavy metal distribution. This research's regeneration study of water quality will aid in understanding the contamination caused by heavy metals, hence improving the economic feasibility of the process in the industry sector around the study region. It will also assist researchers in understanding the pattern and action required to control the degree of heavy metal pollution.

CHAPTER 2

LITERATURE REVIEW

2.1 Water Quality

The Department of Environment (DOE) assesses the level of river water quality using the Water Quality Index (WQI) and the National Water Quality Standards for Malaysia (NWQS). The DOE-introduced Water Quality Index (WQI) has been used in Malaysia for about 25 years as the basis for assessing environmental water quality, whereas NWQS identifies the beneficial uses of the watercourse based on WQI (Huang et al., 2015).

Table 2.1: Classification of Water Quality Parameter base on categories (Source: Omer, N. H., 2019)

Categories	Examples
Physical	Turbidity, temperature, color, taste and odor, solids
Biological	Bacteria, algae, protozoa, viruses, indicator organisms,
Chemical	pH, acidity, alkalinity, chloride, chlorine residual, sulphate, nitrogen, fluoride, ion and manganese, copper and zinc, hardness, dissolved oxygen, Biochemical oxygen demand (BOD), Chemical oxygen demand (COD), Toxic inorganic and organic substances, Radioactive substances

Water quality parameters are categorized into three types: physical, biological, and chemical. Water quality parameters include chemical, physical, and biological qualities that may be tested or tracked depending on the desired water parameters of concern generation may suffer. If the water contains a lot of muck and silt, it might clog fish gills and bury fish eggs. Total dissolved solids (TDS) are the minerals and salts that dissolve in water. As a result, TDS is frequently associated with conductivity, salinity, alkalinity, and hardness measurements. Because freshwater fish and bugs are not accustomed to saline (salty) water, they cannot survive in it.

2.1.1 Physical Water Quality Parameters

Turbidity, temperature, color, taste, odor and solids are the six physical water quality characteristics. Turbidity is the degree to which the presence of suspended particles reduces water clarity. Turbidity can also correctly predict water consistency. Temperature may alter the biosorption of dissolved heavy metals in water. Most people prefer water temperatures ranging from 10 °C to 15 °C (Gray, 2017)

Water quality is a complex interplay of various physical parameters that collectively define the state of a water body. Temperature, a fundamental factor, influences the solubility of gases and the metabolic rates of aquatic organisms. Turbidity, indicating the clarity of water, is crucial for light penetration and consequently impacts the health of aquatic ecosystems. Conductivity measures the water's ability to conduct an electric current, reflecting the concentration of dissolved ions. pH level, a measure of acidity or alkalinity, plays a vital role in the survival of aquatic life and affects chemical reactions. Dissolved Oxygen (DO) is essential for the well-being of organisms in aquatic environments and is influenced by temperature and pollution. Total Dissolved Solids (TDS) encompass various substances dissolved in water, while salinity measures the concentration of salts. Additionally, Secchi Disk Depth serves as a measure of water transparency, aiding in the assessment of overall water clarity. Monitoring these parameters is instrumental in understanding and preserving the health of water ecosystems.

Colour in biologically deteriorating materials is defined as a physical category. Plants and inorganic debris, such as dirt, stones, and boulders, fall to the ground, which is unpleasant aesthetically as well as health-wise. Foreign substances that can taste and foul water include organic waste, inorganic chemicals, and dissolved gases (Davis et al., 2013). Domestic, natural, or agricultural resources may be used. Solids can exist as solutions or suspensions in liquids. By passing a water sample through a glass fibre filter, these two types of solids can be recognised. Suspended particles, by definition, remain at the top of the filter, whereas dissolved solids pass through the water filter. Brendaniman (2001).

The concentration of total suspended solids (TSS) in water is often related to its turbidity (cloudiness). When TSS levels are high and the water is murky, sunlight cannot penetrate effectively, making it difficult for plants and algae to grow. As a result, productivity (the amount of plant and animal life in a river or lake) and oxygen generation may suffer. If the water contains a lot of muck and silt, it might clog fish gills and bury fish eggs. Total dissolved solids (TDS) are the minerals and salts that dissolve in water. As a result, TDS is frequently associated with conductivity, salinity, alkalinity, and hardness measurements. Because freshwater fish and bugs are not accustomed to saline (salty) water, they cannot survive in it.

2.1.2 Biological and Chemical Water Quality Parameters

Biological and chemical water quality parameters provide critical insights into the overall health and ecological balance of aquatic environments. Biological parameters encompass a variety of indicators, such as the presence and abundance of aquatic organisms, including algae, bacteria, and macroinvertebrates. The diversity and composition of these communities offer valuable information about the impact of pollutants and the overall ecological integrity of the water body. Changes in biological parameters can signal disturbances in the ecosystem and serve as early warning signs of potential environmental issues.

Chemical parameters, on the other hand, focus on the composition of substances present in the water. This includes nutrients like nitrogen and phosphorus, essential for plant growth but potentially harmful in excess. Monitoring chemical parameters also involves assessing the levels of pollutants such as heavy metals, pesticides, and industrial chemicals. Elevated concentrations of these substances can have detrimental effects on aquatic life and pose risks to human health.

The integration of biological and chemical assessments provides a comprehensive understanding of water quality. By examining both the living organisms within the water and the chemical composition of the aquatic environment, scientists and environmentalists can identify sources of pollution, track the effectiveness of conservation efforts, and make informed decisions to protect and sustain water resources.

2.2 Metal

Metals play a multifaceted role in the context of water quality, serving both as essential elements for life and as potential pollutants with adverse effects on aquatic ecosystems. Essential metals like iron, copper, and zinc are vital for various biological processes in aquatic organisms, contributing to enzyme function, metabolism, and overall growth. These metals are part of the natural composition of water and are necessary for maintaining a balanced and healthy aquatic environment.

However, human activities, such as industrial processes, agriculture, and urban runoff, can introduce elevated levels of metals into water bodies, turning them into potential contaminants. Heavy metals, including lead, mercury, cadmium, and arsenic, are of particular concern due to their toxicity and persistence in the environment. These pollutants can accumulate in aquatic organisms, posing risks to both aquatic life and human consumers of contaminated water and seafood.

Monitoring metal concentrations in water is crucial for assessing environmental health and identifying potential sources of contamination. Regulations and water quality standards are in place to mitigate the impact of metal pollution and protect ecosystems and public health. Through proper management and remediation efforts, it is possible to maintain a balance, harnessing the benefits of essential metals while minimizing the detrimental effects of metal pollutants on water quality.

2.2.1 Heavy Metals Pollution in Water

Heavy metal pollution in water represents a significant environmental concern, with far-reaching implications for both ecosystems and human health. Industrial activities, mining operations, and urban runoff contribute to the release of heavy metals such as lead, mercury, cadmium, and arsenic into water bodies. These metals are persistent and can accumulate in sediments, posing long-term threats to aquatic life.

One of the primary consequences of heavy metal pollution is its impact on aquatic ecosystems. Heavy metals can disrupt the normal functioning of organisms, leading to physiological and behavioral changes. For example, elevated metal concentrations can impair the growth and reproduction of aquatic plants and animals. In some cases, it may result in the bio accumulation of metals in the tissues of organisms, leading to a magnification of metal concentrations up the food chain.

Beyond ecological concerns, heavy metals in water also pose serious risks to human health. Contaminated water supplies can expose communities to toxic metals through drinking water and the consumption of contaminated seafood. Chronic exposure to heavy metals has been linked to a range of health issues, including neurological disorders, developmental abnormalities, and various cancers.

Addressing heavy metal pollution requires a multifaceted approach, including stringent regulations, pollution prevention measures, and remediation efforts. Monitoring metal levels in water, implementing sustainable industrial practices, and investing in wastewater treatment are essential steps to mitigate the impact of heavy metal pollution and safeguard the health of aquatic ecosystems and human populations.

2.3 Inductively Coupled Plasma - Optical Emission Spectrometry (ICP-OES)

Inductively Coupled Plasma-Optical Emission Spectrometry (ICP-OES) is a sophisticated analytical technique employed for the precise and comprehensive analysis of the elemental composition of various samples, particularly liquids. This method utilizes an inductively coupled plasma as the ionization source, generating temperatures of around 10,000 Kelvin. The high temperatures cause the sample to transition into a state of ionized particles, allowing for the detection and quantification of individual elements based on their characteristic emission spectra. The calibration is used to measure the wavelength-specific light intensity and convert it to a concentration (Radbound University, 2022).

ICP-OES is highly regarded for its ability to simultaneously analyze multiple elements within a single sample, providing detailed information about the elemental composition in a time-efficient manner. This technique is widely applied in environmental monitoring, geological studies, pharmaceuticals, and metallurgy, among other fields. Its sensitivity and accuracy make it invaluable for detecting trace elements and monitoring elemental concentrations at low levels.

In environmental science, ICP-OES is particularly instrumental in assessing water quality. By analyzing water samples, scientists can identify and quantify the presence of various elements, including heavy metals and other contaminants. The precision and speed of ICP-OES make it an indispensable tool for regulatory compliance testing and environmental research, helping to ensure the safety of water resources and ecosystems.

While ICP-OES offers remarkable analytical capabilities, it requires skilled operators, meticulous sample preparation, and expensive instrumentation. However, its unparalleled accuracy and ability to handle a wide range of sample types make it a cornerstone in the arsenal of analytical techniques for elemental analysis in diverse scientific and industrial applications.

CHAPTHER 3

MATERIAL AND METHODLOGY

3.1 Materials

A bottle was used to preserve the water samples that were taken from the selected area in Kelantan. Equipment utilized to measure in situ parameters included the YSI Multiparameter and turbidity meter. Nitric acid and hydrochloric acid were also used as solutions. Heavy metal concentrations in water samples were determined using ICP-OES (inductively coupled plasma-optical emission spectrometry). The Gold, Rare Earth, and Material Technopreneurship Centre (GREAT) lab on the UMK Jeli Campus, as well as its laboratory.

3.2 Method

3.2.1 Sampling

Water sample were collected using a bottles, each bottle having 250ml capacity. The bottle was thoroughly examined for bubbles inside it before being filled and cleaned with water three times. The bottle had a label on it and keep it in cool box. There were 7 bottles that had been collect in different rivers in Kelantan.

GPS coordinates, which are commonly stated in alphanumeric characters, can be used to uniquely identify a precise physical location on the planet. Coordinates are the intersections of a grid system in this context. GPS coordinates are typically formed by combining latitude and longitude. A river's depth is its depth. Depth fluctuations throughout a river channel are caused by material on the river bed.

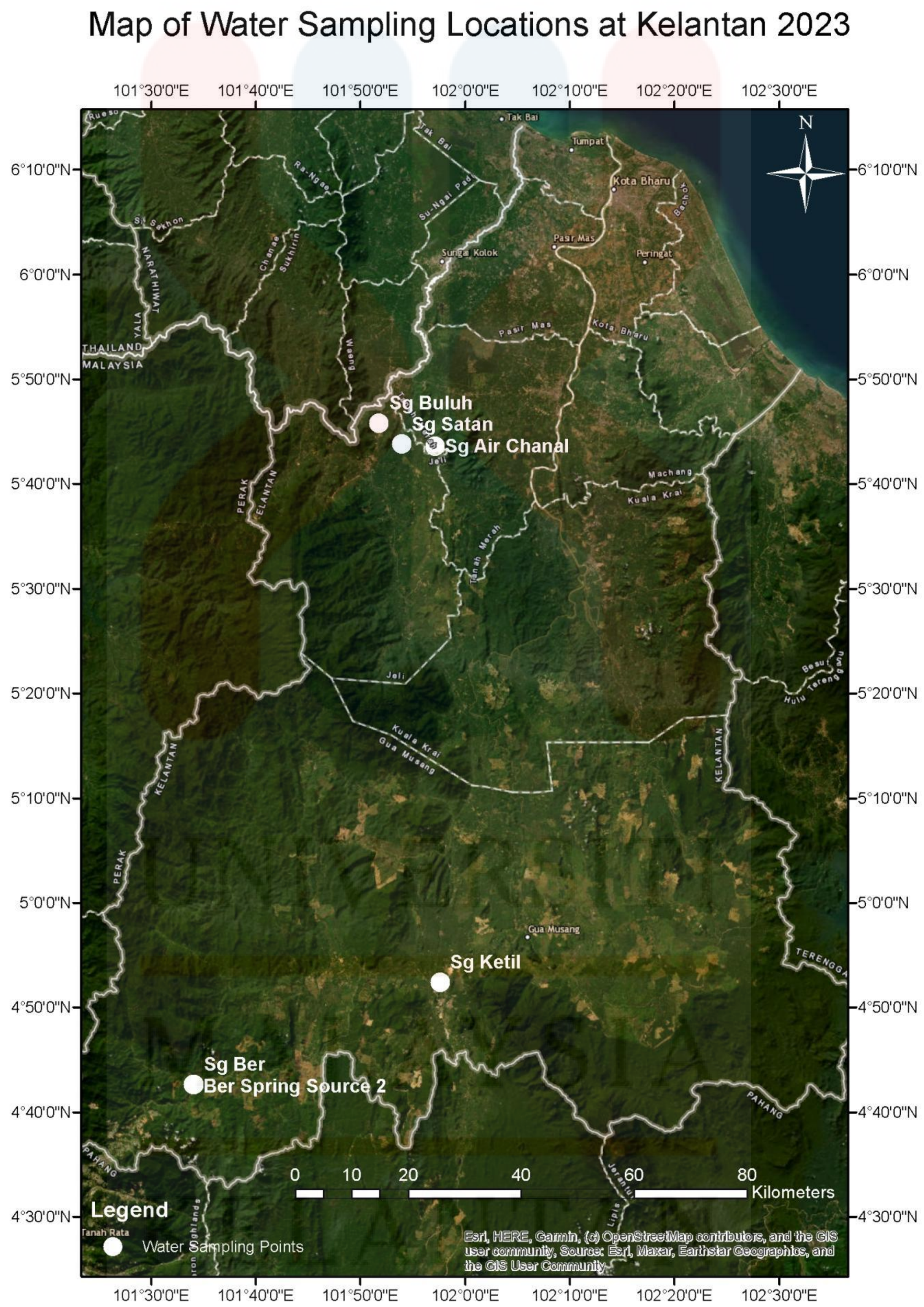
There are five point on locations used in this research. The precise coordinate is obtained with a GPSMAP metre. The location was chosen using judgmental sampling, a non-statistical sampling approach. This sort of sampling throws some bias into the measurement. For instance, Air Chanal, Ayer Lanas, Sungai Satan, Jeli, Sungai Buloh, Gemang, Sungai Ber and Sungai Ketil, Gua Musang. One of the tributaries of Sungai Ber is spring water from Air Panas Ber (Ber Spring). This sample was taken in river water where hot water collides with hot river water

The river coordinate was recorded using GPS. Furthermore, the rationale for selecting the coordinate first is due to accessibility, which is the ease of access to a site should be addressed when taking frequent samples. Aside from that, the safety and security of staff taking samples, as well as the general public, must constantly be taken into account.

Table 3.1: The Coordinate of Selected River in Kelantan

Coordinate	Latitude	Longitude	Altitude (m)
Air Chanal	5°726698333	101°952835	169.2
Sg Satan	5°729883333	101°8994617	46
Sg Buluh	5°762978333	101°8634733	26
Source 1	4°709731667	101°5677867	274
Source 2	4°709771667	101°5677867	262.3
Sg Ber	4°709796667	101°5689733	256.5
Sg Ketil	4°872858333	101°9611317	100

Figure 3.1: The Location of Selected River in Kelantan

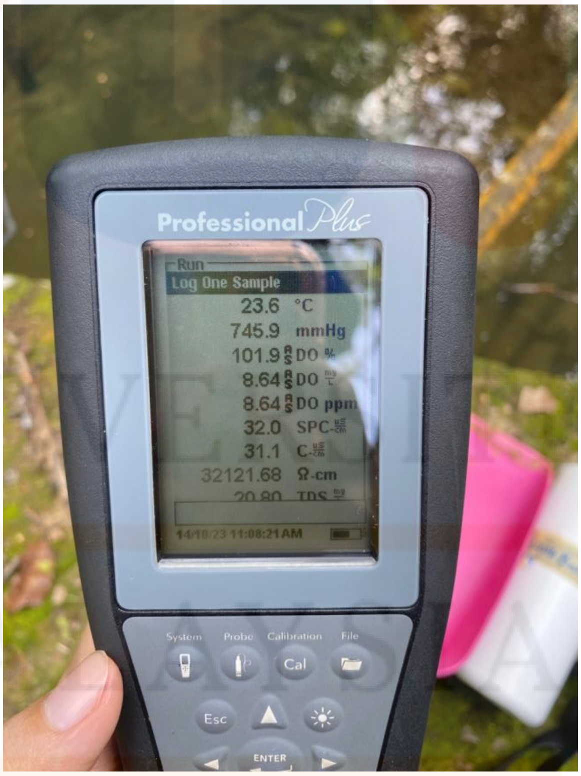


3.2.3 Physical Paremeters

The physical properties of the sample, such as colour and odour, will be evaluated. Temperature, pH, and dissolved oxygen were among the in-situ parameters measured using the YSI Multiparameter. The YSI in picture 3.2.3 is used to check the pyhsicals parameters. Meanwhile, the turbidity of the sample was measured using a device known as a turbidity metre. The chemical and biological oxygen requirement were also determined in the laboratory.

The chemical oxygen demand (COD) test is often used to quantify the quantity of organic compounds in liquid waste in an indirect manner. It is measured in milligrams/grams per litre and represents the amount of oxygen absorbed per litre of solution. (Hu and Grasso, 2005)

Figure 3..2.3 : Record physical parameters using YSI Multiparameter



3.2.4 Heavy Metal Analysis

For heavy metal analysis, it's particularly useful because it can detect a wide range of elements at trace levels. The plasma torch reaches temperatures of around 10,000 K, ensuring complete atomization and ionization of the sample. The emitted light is then passed through a spectrometer to identify and quantify the elements present. Reserve approximately 100 mL of your source water sample for direct analysis using the ICP-OES. The samples was filtrated using filter paper, and then add 3.24 ml nitric acid (HNO_3).

This approach is reliable since it considers the entire range of components present in the sample, providing precise data on water quality. Furthermore, when compared to other methods, this one requires a relatively small quantity of chemicals, which helps to greatly minimise expenses. This test also provides speedy findings. For example, the samples can be evaluated promptly and easily analysed. It's obviously preferable to having to wait days or weeks for laboratory results. Using this technique has also helped us have a better knowledge of what we're dealing with when it comes to water contamination.

3.2.5 Nitrogen, Ammonia

Firstly, fill a sample cell with 10mL of deionized water. Secondly,fill a second sample cell with 10 mL of sample. Then, added the contents of one ammonia salicylate powder pillow to each sample cell. Put the stopper on the sample cell. Shake to dissolve the reagent. Start the instrument timer in 3 minutes time starts. After the timer expires, add the contents of one Ammonia Cyanurate powder pillow to each sample cell. Put the stopper on the sample cell. Shake to dissolve the reagent. Start instrument timer 15 minutes reaction. A green color shows when ammonia-nitrogen is present. When the timer expired, clean the blank sample cell and insert the blank into the cell holder.

3.2.6 Nitrogen Total

The procedure for the Total Nitrogen (TN) test using the TNT Method involves several steps. First, the contents of one Total Nitrogen Reagent A Powder Pillow are added to each vial, and the vials are shaken for 30 seconds. Then, the instrument timer is started for a 3-minute reaction time. After the timer expires, the caps are removed from the vials and one TN Reagent B Powder Pillow is added to each vial. The caps are put back on and the vials are shaken vigorously for 15 seconds to mix. Next, 0.5 mL of the sample is added to one vial, and 0.5 mL of deionized water is added to the second vial. The caps are put on both vials and shaken vigorously for at least 30 seconds. The vials are then placed in a reactor and left for exactly 30 minutes. After 30 minutes, the vials are removed from the reactor and allowed to cool to room temperature. The prepared sample is then transferred into one TN Reagent C vial, and the blank is transferred into the second TN Reagent C vial. The caps are put on both vials and inverted 10 times to mix. Finally, the instrument timer is started, and the specific instructions for the instrument are followed to complete the test and obtain the results.

3.2.7 Total Phosphorus Test

The procedure for the Total Phosphorus Test using the PhosVer 3 TNT Method. Start the program on the instrument. Add 5.0 mL of sample to the Total Phosphorus Test Vial. Add the contents of one Potassium Persulfate Powder Pillow for Phosphonate to the vial. Put the cap on the vial and shake to dissolve the powder. Insert the vial into the reactor and close the reactor. Start the instrument. Measure the concentration of the standard solution using the test procedure. Compare the expected result to the actual result. Adjust the factory calibration if necessary. Clean all glassware with hydrochloric acid and rinse with deionized water. Dispose of reacted solutions according to local, state, and federal regulations. Install the instrument cap and light shield before starting the test. Measure the reagent blank value for each new lot of reagent. Add the contents of one PhosVer 3 Powder Pillow to the vial and shake to mix. Start the instrument timer and measure the sample within 8 minutes after the timer expires. Clean the vial and insert it into the cell holder. Push READ to obtain the results in mg/L PO4-3. Dispose of reacted samples as hazardous waste. Use the required reagents and consumables for the test. Follow the method summary for the conversion of phosphates and measurement of the complex. Remove the vial from the reactor and let it cool before adding Sodium Hydroxide Standard Solution. Clean the vial and insert it into the cell holder to zero the instrument. Be aware of potential interferences from substances such as aluminum, arsenate, chromium, copper, sulfide, iron, nickel, silica, silicate, turbidity, and color. Follow proper sample handling and preservation techniques. Adjust the test result for dilution caused by volume additions. Start the DRB200 Reactor and preheat it to 150 °C for acid persulfate

CHAPTER 4

RESULT AND DISCUSSION

4.1 Physical Parameter

4.1.1 In Situ Test Results

In situ water quality sampling involves measuring physical and chemical parameters in a water body at the time of sampling. This is typically done when the measured parameters change rapidly. The data is equally legitimate as data acquired in a laboratory if the field sensors are calibrated. Temperature, pH, and DO values were obtained using a YSI multiparameter, while turbidity was measured with a HACH turbidity metre.

Table 4.1. The observation is also done on site to record the color and odor at the point of locations.

Physical	Sg Air Chanal	Sg Satan	Sg Buluh	Source 1	Source 2	Confluence	Sg Ber	Sg Ketil
T °C	23.6	26.4	28.6	44.7	48.8	31.1	23.9	26.3
mmHg	745.9	752.2	752.2	734.6	735.1	735.1	735.1	746.8
DO mg/L	7.84	6.73	6.46	4.67	4.18	7.93	9.51	6.87
SPC uS/cm	32.1	85.1	64	276.3	269.1	1.5	35.4	1.2
C uS/cm	31.3	87.5	68.4	380.1	391.5	1.7	34.7	1.2
R Ω-cm	31979.6	11431.6	14612.96	2631.15	2554.21	581421.06	28839.54	816347.5
TDS mg/L	20.8	55.3	41.6	179.4	174.8	1.3	22.8	0.7
SAL ppt	0.01	0.04	0.03	0.13	0.12	0	0.02	0
pH	7.46	7.13	6.79	9.06	8.83	8.09	7.64	7.3

The provided dataset presents various physical characteristics of water quality across different sampling points, namely Sg Air Chanal, Sg Satan, Sg Buluh, Source 1, Source 2, Confluence, Sg Ber, and Sg Ketil. Temperature (T), pressure (mmHg), dissolved oxygen (DO), specific conductance (SPC), conductivity (C), resistivity (R), total dissolved solids (TDS), salinity (SAL), and pH are the parameters considered.

The temperature ranges from 23.6°C to 48.8°C, indicating notable variations among the sampling locations. Pressure, measured in mmHg, shows marginal differences between the sampling points, ranging from 734.6 mmHg to 752.2 mmHg. Dissolved oxygen levels vary from 4.18 mg/L to 9.51 mg/L, with higher values indicating better oxygen saturation and potentially healthier aquatic environments. Specific conductance and conductivity exhibit significant fluctuations, suggesting varying levels of dissolved solids or ions across the sampling points.

Resistivity values vary considerably, ranging from 2631.15 Ω-cm to 816347.5 Ω-cm. Lower resistivity values may suggest higher ion concentrations or pollution. Total dissolved solids and salinity levels show notable disparities, with concentrations ranging from 0.7 mg/L to 179.4 mg/L and salinity ranging from 0 ppt to 0.13 ppt across the sampling points. pH levels range from 6.79 to 9.06, indicating slight acidity to slightly alkaline conditions. These variations in pH can influence the overall health of aquatic ecosystems, with extreme values potentially indicating pollution or natural variability.

4.1.2 Anion and COD Readings

Table 4.1.2 and Figure 4.1.2 shows the chemical oxygen demand values for samples collected with HACH low and high range vials. COD is widely used to assess the oxidation susceptibility of organic and inorganic compounds in water bodies as well as effluents from sewage and industrial units. COD is most commonly used to determine the amount of organic matter in a lake or river. The COD test is used to determine the chemical composition of a sample of wastewater.

Table 4.1.2: COD reading of Selected River in Kelantan

	Sg Air Chanal	Sg Satan	Sg Buluh	Source 1	Source 2	Sg Ber	Sg Ketil
Anion (mg/L)							
NH_3	0.07	0.01	0	0.41	0.05	0.1	0.83
NO^{-2}	0	0	2	1	1	4	2
PO_4^{3-}	0	0.03	0.03	0.11	0.13	0.07	0.07
SO_4^{2-}	0	0	0	4	5	0	0
COD	8	2	7	23	11	5	2

Ammonia nitrogen (NH_3)concentrations vary across the channels, with the highest levels observed in Sg Ketil, indicating possible contamination from agricultural or industrial activities. Nitrite (NO^{-2}) is primarily detected in Sg Buluh and Sg Ketil, suggesting potential pollution sources like agricultural runoff or wastewater discharge.

Phosphate (PO_4^{3-}) concentrations are generally low in most channels but slightly elevated in Source 1 and Source 2, indicating potential pollution from agricultural activities or detergent usage. Sulfate (SO_4^{2-}) concentrations are notably elevated in Source 1 and Source 2, potentially signaling pollution from industrial sources or natural sources such as mining.

Chemical Oxygen Demand (COD) levels are highest in Source 1, indicating organic pollution possibly from sewage discharge or agricultural runoff. Overall, the data highlights varying levels of anions across the channels, suggesting the presence of multiple pollution sources.

4.2 Heavy Metal Analysis Result

After the computations are completed, the concentration of heavy metals can be determined. Table 4.2 displays the data after it has been calculated using a formula that multiplies ICP-OES raw data by the dilution factor, which in this case is 100 ml. It was then divided by the sample volume, which was 50 mL. In comparison, it was discovered that the results of the calculation were doubled from the first data obtained from the raw data of ICP-OES. As a result, all of the highest and lowest data from the initial raw readings are the same highest and lowest data after calculation.

Table 4.2: The Data of Heavy Metal in Selected River in Kelantan

Element	Sg Air Chanal	Sg Satan	Sg Buluh	Source 1	Source 2	Sg Ber	Sg Ketil
Unit	ppb						
Ag	-2.484	0.962	0.19	-3.066	-1.907	-1.067	-3.066
Al	125.371	170.957	659.093	111.609	74.562	2355.351	494.424
Ba	7.313	38.354	22.331	2.415	2.156	13.365	28.946
Be	0.028	-0.223	0.048	0.226	0.397	0.157	0.005
Bi	-8.321	-6.919	0.005	-11.224	0.783	-24.572	3.739
Ca	2124.74	8954.872	5418.871	1977.375	2086.104	1894.465	15212.226
Cd	-0.376	-1.294	-0.911	0.236	-0.267	-0.509	-0.531
Ce	1.949	0.95	1.68	1.425	0.059	2.514	-0.531
Co	4.427	1.251	-0.009	-1.823	-5.322	-6.186	-1.997
Cr	-4.111	0.916	0.02	-0.187	0.428	2.506	-1.493
Cu	-9.134	2.679	0.075	-2.888	0.13	2.545	-100
Dy	0.397	1.137	0.908	0.71	0.31	1.876	0.834
Er	0.529	0.508	-0.212	0.437	0.355	1.198	-0.276
Eu	0.686	0.839	0.744	0.633	0.77	0.756	0.893
Fe	104.702	672.348	855.798	36.278	2.545	929.487	602.614
Ga	-17.189	-33.961	-22.803	-25.069	-5.955	-21.322	-18.372
Gd	1.329	1.397	0.708	0.883	0.664	1.56	1.05
In	-25.095	-17.211	-26.217	-36.034	-12.23	-8.535	-34.339
K	1189.817	1584.243	2009.196	2657.647	2572.868	2349.736	11882.184
La	2.105	5.824	4.126	1.714	2.026	3.459	11.053
Li	-0.909	4.299	-1.292	48.587	47.532	-3.044	-2.109
Mg	575.609	1629.182	871.912	105.453	115.14	547.345	1870.349

Mn	4.394	58.301	55.631	0.063	1.453	9.452	41.932
Mo	-1.151	0.471	-0.912	1.516	5.489	2.153	-1.667
Na	3803.113	4176.05	4594.929	47511.643	47300.946	3323.517	1970.929
Nd	-15.671	-16.781	-13.709	-13.922	-4.614	-7.648	-10.215
Ni	2.024	-0.445	-1.147	-0.372	8.381	8.698	2.704
Pb	0.97	2.926	-8.155	-3.048	-13.442	-3.96	18.582
Pr	1.455	1.95	1.471	2.046	0.082	1.585	6.099
Sc	0.473	0.532	0.585	0.6	0.443	0.747	0.539
Sm	0.168	-0.36	-0.8	1.39	0.533	0.603	-0.979
Tb	2.246	1.901	0.895	1.247	0.868	1.426	2.003
Th	1.989	2.548	5.246	2.089	1.163	1.11	3.885
Tl	-28.194	-19.228	-21.867	-2.014	-13.355	-6.252	-18.994
Tm	0.218	0.457	0.332	-0.079	-0.001	0.213	0.518
V	-3.177	-1.671	0.577	-1.482	-2.434	1.41	0.01
Y	0.596	0.786	0.933	0.693	0.936	2.129	0.884
Yb	0.179	0.294	0.238	0.254	0.199	0.408	0.281
Zn	10.594	35.008	5.893	10.564	8.866	11.587	17.363

The provided dataset presents concentrations of various heavy metals across different sampling points, Sg Air Chanal, Sg Satan, Sg Buluh, Source 1, Source 2, Sg Ber and Sg Ketil.Figure 4.2 show the heavy metal in water sample from the selected rivers. Heavy metals in water can have significant implications for environmental and human health due to their toxicity and persistence. Analyzing these concentrations can help identify potential sources of pollution and assess the overall water quality.

4.3 Evaluation of Pollution

4.3.1 Physical Parameter

In-situ Evaluation

Starting with Dissolved Oxygen (DO) levels, the highest reading of 9.51 mg/L is observed in the Confluence River, indicating well-oxygenated water, which is conducive to supporting aquatic life. Conversely, the lowest DO reading of 4.18 mg/L is recorded at Source 2, suggesting potentially poorer oxygenation levels in that particular location. Such lower levels could negatively impact aquatic organisms, leading to potential environmental concerns.

Examining the Total Dissolved Solids (TDS) parameter, the lowest reading of 0.7 mg/L is documented at Sg Ketil, indicating relatively low concentrations of dissolved solids in that area. On the other hand, the highest TDS reading of 380.1 mg/L is found at Source 1, indicating significantly elevated levels of dissolved solids, potentially indicating pollution or natural mineral content. High TDS levels can affect water taste, clarity, and overall suitability for various uses.

The pH levels exhibit variations as well. The lowest pH reading of 6.79 is recorded at Sg Buluh, suggesting slightly acidic conditions in that location. In contrast, the highest pH reading of 9.06 is observed at Source 1, Such variations in pH levels can influence the water's chemical properties and impact aquatic life and ecosystem health.

Table 4.3.1: National Water Quality Standards for Malaysia

(Source: Malaysian Department of Environment, 2005)

Parameter	Class I	Class II	Class III	Class IV	Class V
Ammoniacal Nitrogen	<0.1	0.1-0.3	0.3-0.9	0.9-2.7	>2.7
BOD	<1	1-3	3-6	6-12	>12
COD	<10	10-25	25-50	50-100	>100
Dissolved Oxygen	>7	5-7	3-5	1-3	<1
pH	>7	6-7	5-6	<5	<5
Turbidity	<5	<50	-	-	-
Total Suspended Solids	<25	25-50	50-150	150-300	>300
Total Dissolved Solids	<500	<1000	<1000	<4000	-
Total Coliform	<10	<100	<5000	<5000	-
Water Quality Index	>92.7	76.5-92.7	51.9-76.5	31.0-51.9	<31.0

The comparison of the provided water quality parameters with the National Water Quality Standards for Malaysia allows for an assessment of the overall condition of the water samples. Considering parameters such as Ammoniacal Nitrogen, BOD (Biochemical Oxygen Demand), COD (Chemical Oxygen Demand), Dissolved Oxygen (DO), pH, Total Suspended Solids (TSS), Total Dissolved Solids (TDS), and Total Coliforms, we can evaluate the population of water based on these standards.

For instance, comparing the Dissolved Oxygen (DO) levels in the samples to the national standards, Sg Air Chanal, Sg Satan, and Sg Buluh exhibit DO levels within Class I (DO > 7 mg/L), indicating good to excellent water quality in terms of oxygenation. However, Source 1 and Source 2 fall within Class II (DO 5-7 mg/L), suggesting slightly lower oxygen levels but still within acceptable limits. Conversely, the Sungai Ber and Sg Ketil surpass the Class I standard for DO, suggesting exceptionally good oxygenation in these areas.

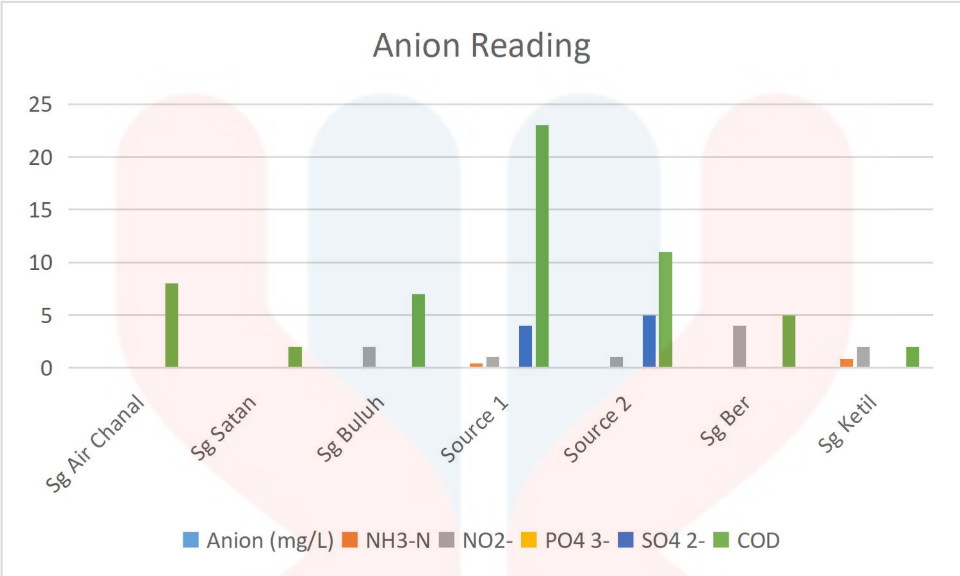
Moreover, pH levels in the samples vary, with Sg Buluh, Confluence River, and Sg Ketil displaying values within the acceptable range of >7 (Class I), indicating neutral to slightly basic conditions. However, Source 1 and Source 2 exhibit higher pH values, potentially indicating alkaline conditions, which might deviate from the Class I standard.

In terms of Total Dissolved Solids (TDS), all samples except Source 1 and Source 2 fall within Class I standards of <500 mg/L, indicating low levels of dissolved solids and generally good water quality. Source 1 and Source 2, with TDS levels of 179.4 mg/L and 174.8 mg/L respectively, meet the Class II standard (<1000 mg/L) but may indicate slightly elevated levels of dissolved solids.

In comparison, the lowest data can be classified as class one due of its extremely low turbidity. Turbidity is a metric that measures a liquid's relative clarity. It is a measurement of how much light is dispersed by water components when light is flashed through a water sample. It is one of water's optical properties. Turbidity increases in proportion to the intensity of scattered light. High turbidity can also bury and kill eggs on the bottom of lakes and rivers, making it harder for fish to spot and catch prey. Particles that create turbidity may also be covered in pollutants and dangerous germs (Huang et al., 2015).

Overall, while some parameters meet or exceed Class I standards, others exhibit variations that suggest potential areas for improvement or further investigation, highlighting the importance of ongoing monitoring and management of water resources to ensure they meet national water quality standards.

Figure 4.1.2: COD Reading of Selected Rivers in Kelantan



Sg Air Chanal and Sg Satan exhibit relatively low anion concentrations, with values ranging from 0.01 to 0.83 mg/L. This suggests a minimal presence of dissolved ions in these sources, indicating potentially lower contamination by inorganic pollutants. Conversely, Sg Buluh presents a higher anion concentration of 2 mg/L, hinting at a possible influence from anthropogenic activities or nearby sources of pollutants. Meanwhile, the anion concentrations in Source 1, Source 2, River, and Sg Ketil vary but generally remain within the range of 0 to 5 mg/L, indicating comparatively stable water quality concerning anion composition across these sources.

The COD levels provide insights into the organic pollutant load within the water sources. Source 1 and Source 2 demonstrate notably higher COD levels, with values of 23 mg/L and 11 mg/L, respectively. These elevated COD levels suggest the presence of a higher load of organic pollutants, potentially stemming from industrial discharges, agricultural runoff, or domestic wastewater. Sg Buluh also presents a moderate COD level of 7 mg/L, indicating the presence of organic pollutants to a lesser extent compared to Source 1 and Source 2. Conversely, Sg Air Chanal, Sg Satan, and Sg Ketil display relatively lower COD levels, ranging from 2 to 8 mg/L, indicating lower organic pollutant loads and potentially better water quality in terms of organic contamination.

4.3.2 Heavy Metal Analysis

Comparing the highest and lowest concentrations of elements in the water samples to both the Malaysian water quality standards and human health considerations is crucial for understanding potential risks and impacts.

Among the heavy metals listed in Table 4.2, the lowest concentration is found for Lithium (Li), with a value of -3.044 ppb observed at Source 1, while the highest concentration is detected for Sodium (Na), with a concentration of 47511.643 ppb recorded at Source 1 as well.

Comparing these concentrations to the National Water Quality Standards for Malaysia, it's evident that both Lithium and Sodium concentrations surpass the recommended limits. Lithium is not explicitly mentioned in the standards, but its presence in significant amounts might indicate potential contamination from industrial or anthropogenic sources, warranting further investigation. Additionally, the high Sodium concentration exceeds the recommended limits, potentially indicating salinity issues, which can adversely affect freshwater ecosystems and water quality for various uses.

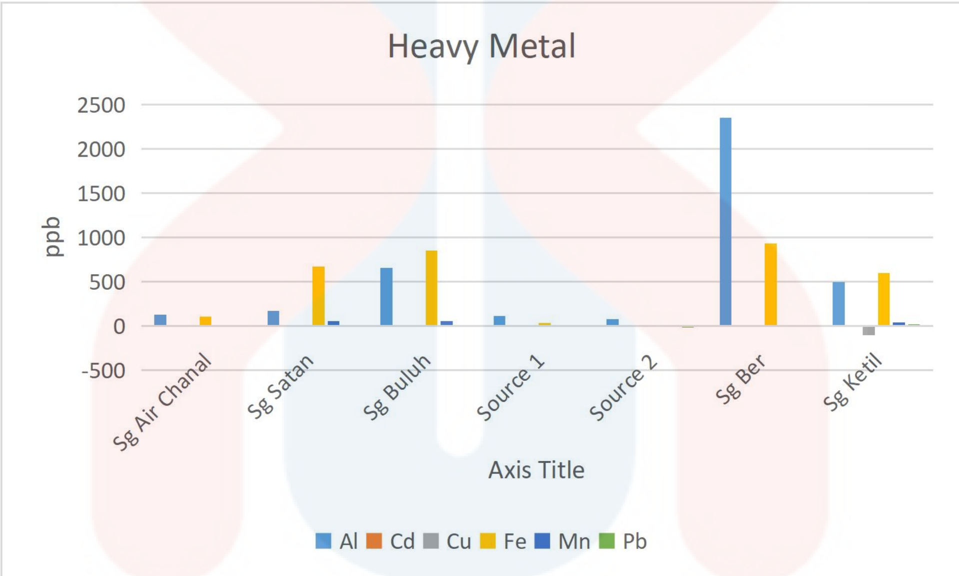
While other heavy metals such as Lead (Pb) and Zinc (Zn) also exhibit elevated concentrations in some samples, they generally fall within the acceptable limits specified by the standards. However, continuous monitoring and management practices are crucial to prevent any potential accumulation or adverse effects on aquatic ecosystems and human health.

The presence of elevated concentrations of heavy metals, particularly Sodium and Lithium, in the water samples suggests the need for thorough monitoring and management strategies to ensure compliance with national water quality standards and safeguard freshwater resources in Malaysia.

When considering human health, Lead (Pb), Cadmium (Cd), and Mercury (Hg) can lead to various health problems, including neurological disorders, kidney damage, and even cancer. Therefore, even if concentrations are within regulatory limits, continuous monitoring and efforts to reduce exposure are necessary to safeguard public health.

Overall, while some elements may fall within regulatory limits, it's imperative to consider their potential cumulative and synergistic effects on human health and the environment. Continuous monitoring, strict regulatory enforcement, and public awareness are essential to ensure the safety and sustainability of water resources for present and future generations.

Figure 4.3.2 Show The Heavy Metal In Water Sample From The Selected Rivers.



The analysis of water quality across different channels reveals significant variations in the concentrations of several key elements. Aluminum levels range from 74.562 to 2355.351, potentially indicating contamination from industrial runoff or soil leaching, posing risks to both aquatic ecosystems and human health. Cadmium, a toxic heavy metal, shows negative concentrations in some channels, possibly below detection limits, yet even low levels can pose threats through bioaccumulation. Copper concentrations vary widely, with potential natural presence but also indicating possible industrial discharge or pipe corrosion, posing toxicity risks to aquatic life. Iron levels, ranging from 2.545 to 929.487, suggest both natural and industrial sources, with potential impacts on water aesthetics and taste. Manganese, occurring naturally but also influenced by industrial discharges, ranges from 0.063 to 58.301, potentially affecting water quality and plumbing fixtures. Lead concentrations, spanning negative to positive values, raise concerns over old plumbing systems or industrial sources, with even low levels posing severe health risks, particularly for children. These findings underscore the need for comprehensive investigation and remediation measures to ensure water safety for both ecosystems and human consumption, emphasizing the urgency of addressing potential pollution sources.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

The comprehensive analysis of water quality parameters, including physical characteristics, chemical parameters, and heavy metal concentrations, provides valuable insights into the overall health of the water bodies in the selected area in Kelantan.

From the in-situ evaluation of physical parameters, it is evident that while some sampling points meet or exceed national water quality standards, others exhibit variations that suggest potential areas for improvement or further investigation. Parameters such as dissolved oxygen, pH, and total dissolved solids are crucial indicators of water quality and ecosystem health, and deviations from optimal levels could indicate pollution or environmental stressors.

The evaluation of heavy metal concentrations also highlights potential risks to human health and the environment. While some heavy metals fall within acceptable limits according to national standards, others, such as sodium and lithium, exceed recommended thresholds, indicating potential contamination from industrial or anthropogenic sources. Continuous monitoring and management practices are essential to prevent adverse effects on aquatic ecosystems and public health.

In conclusion, the findings underscore the importance of ongoing monitoring and management of water resources to ensure compliance with national water quality standards and safeguard freshwater ecosystems. Effective regulatory enforcement, public awareness campaigns, and collaborative efforts between government agencies, industries, and local communities are necessary to address pollution sources and promote the sustainable use of water resources for present and future generations.

5.2 Recommendation

Based on the comprehensive analysis of water quality parameters and heavy metal concentrations in the selected rivers of Kelantan, several recommendations emerge to address the identified challenges and enhance the overall health of the water bodies. Firstly, it is imperative to establish and implement enhanced monitoring programs that encompass a wide range of physical, chemical, and biological indicators. Regular monitoring will facilitate the early detection of any changes or trends in water quality, enabling prompt intervention and management strategies. Furthermore, efforts should focus on identifying specific sources of pollution, particularly those contributing to elevated levels of heavy metals and other contaminants. Implementing pollution control measures, such as improved wastewater treatment facilities and agricultural best management practices, is essential to mitigate the discharge of pollutants into water bodies. Public awareness campaigns should also be launched to educate local communities, industries, and policymakers about the importance of water conservation and pollution prevention. Collaborative governance involving government agencies, industries, NGOs, and local communities is crucial to developing and implementing effective water management plans. Additionally, investment in water infrastructure, research, and innovation initiatives will be vital to address water-related challenges and ensure sustainable water management practices. By implementing these recommendations, stakeholders can work together to safeguard water quality, protect aquatic ecosystems, and ensure access to clean and safe water for present and future generations in Kelantan.

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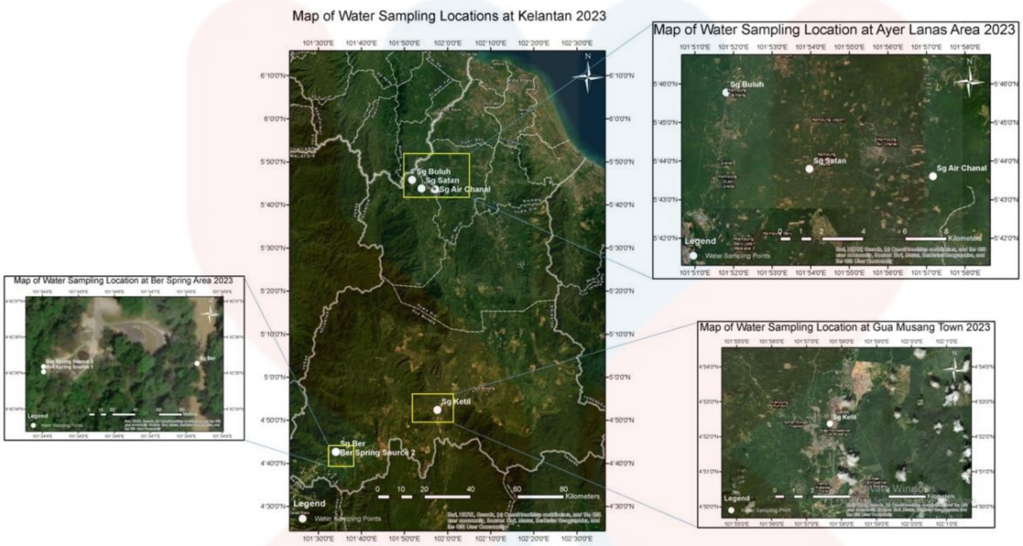
APENDIX A



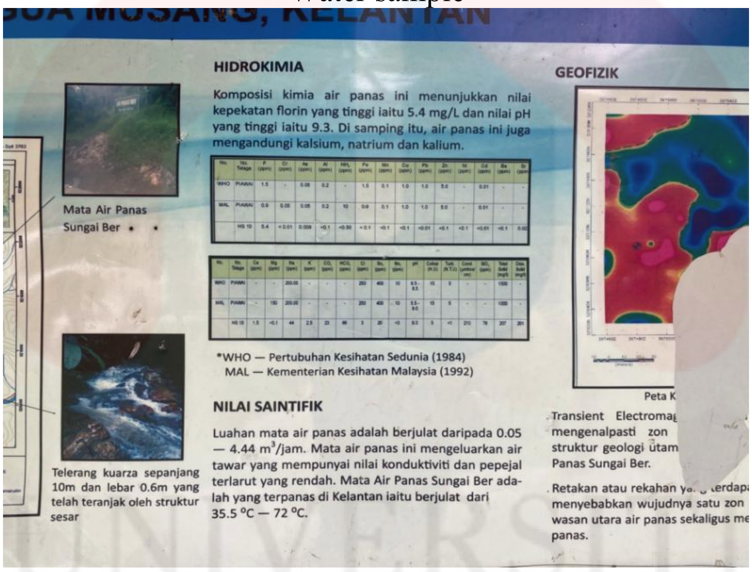
Map of water sampling

Prepare the equipment for sampling

Turbidity meter

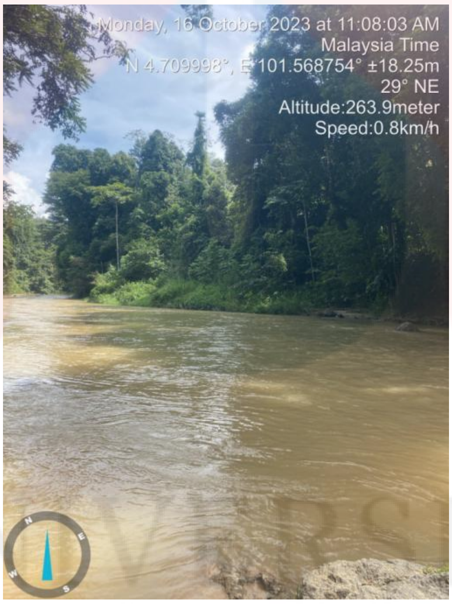
Check the coordinated of location

Water sample



The data from Spring Water Sungai Ber

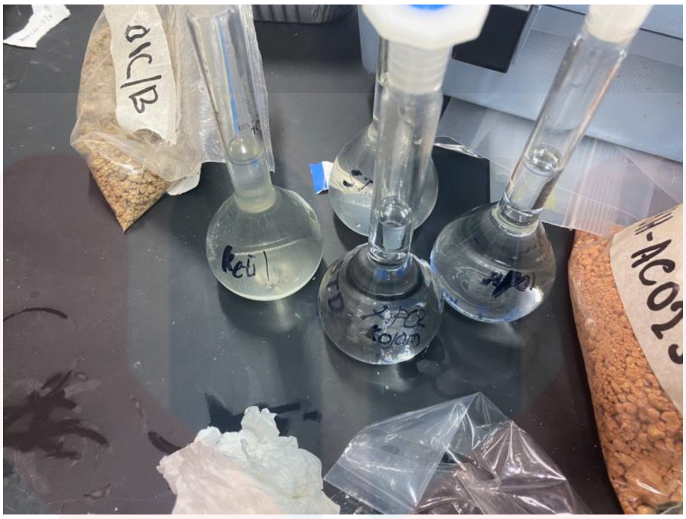
Sampling at Sungai Buloh



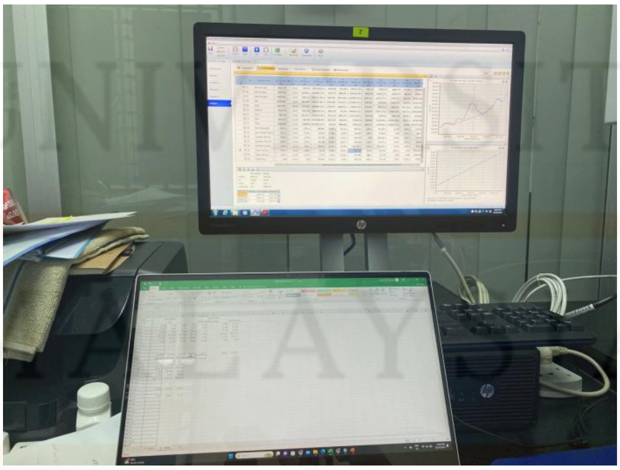
Sungai Ber

Ammonia test using HACH

Heavy metal analysis



Heavy metal analysis



Collecting the heavy metal data from ICP-OES

APENDIX B

NATIONAL WATER QUALITY STANDARDS

PARAMETER	UNIT	CLASS				
		I	IIA/IIB	III#	IV	V
Al	mg/l	NATURAL LEVELS OR ABSENT	-	(0.06)	0.5	LEVELS ABOVE IV
As	mg/l		0.05	0.4 (0.05)	0.1	
Ba	mg/l		1	-	-	
Cd	mg/l		0.01	0.01* (0.001)	0.01	
Cr (VI)	mg/l		0.05	1.4 (0.05)	0.1	
Cr (III)	mg/l		-	2.5	-	
Cu	mg/l		0.02	-	0.2	
Hardness	mg/l		250	-	-	
Ca	mg/l		-	-	-	
Mg	mg/l		-	-	-	
Na	mg/l		-	-	3 SAR	
K	mg/l		-	-	-	
Fe	mg/l		1	1	1 (Leaf) 5 (Others)	
Pb	mg/l		0.05	0.02* (0.01)	5	
Mn	mg/l		0.1	0.1	0.2	
Hg	mg/l		0.001	0.004 (0.0001)	0.002	
Ni	mg/l		0.05	0.9*	0.2	
Se	mg/l		0.01	0.25 (0.04)	0.02	
Ag	mg/l		0.05	0.0002	-	
Sn	mg/l		-	0.004	-	
U	mg/l		-	-	-	
Zn	mg/l		5	0.4*	2	
B	mg/l		1	(3.4)	0.8	
Cl	mg/l		200	-	80	
Cl_2	mg/l		-	(0.02)	-	
CN	mg/l		0.02	0.06 (0.02)	-	
F	mg/l		1.5	10	1	
NO_2	mg/l		0.4	0.4 (0.03)	-	
NO_3	mg/l		7	-	5	
P	mg/l		0.2	0.1	-	
Silica	mg/l		50	-	-	
SO_4	mg/l		250	-	-	
S	mg/l		0.05	(0.001)	-	
CO_2	mg/l		-	-	-	
Gross-α	Bq/l		0.1	-	-	
Gross-β	Bq/l		1	-	-	
Ra-226	Bq/l		< 0.1	-	-	
Sr-90	Bq/l		< 1	-	-	
CCE	µg/l		500	-	-	-
MBAS/BAS	µg/l		500	5000 (200)	-	-
O & G (Mineral)	µg/l		40; N	N	-	-
O & G (Emulsified Edible)	µg/l		7000; N	N	-	-
PCB	µg/l		0.1	6 (0.05)	-	-
Phenol	µg/l		10	-	-	-
Aldrin/Dieldrin	µg/l		0.02	0.2 (0.01)	-	-
BHC	µg/l		2	9 (0.1)	-	-
Chlordane	µg/l		0.08	2 (0.02)	-	-
t-DDT	µg/l		0.1	(1)	-	-
Endosulfan	µg/l		10	-	-	-
Heptachlor/Epoxide	µg/l		0.05	0.9 (0.06)	-	-
Lindane	µg/l		2	3 (0.4)	-	-
2,4-D	µg/l		70	450	-	-
2,4,5-T	µg/l		10	160	-	-
2,4,5-TP	µg/l		4	850	-	-
Paraquat	µg/l		10	1800	-	-

PARAMETER	UNIT	CLASS					
		I	IIA	IIB	III	IV	V
Ammoniacal Nitrogen	mg/l	0.1	0.3	0.3	0.9	2.7	> 2.7
Biochemical Oxygen Demand	mg/l	1	3	3	6	12	> 12
Chemical Oxygen Demand	mg/l	10	25	25	50	100	> 100
Dissolved Oxygen	mg/l	7	5 - 7	5 - 7	3 - 5	< 3	< 1
pH	-	6.5 - 8.5	6 - 9	6 - 9	5 - 9	5 - 9	-
Colour	TCU	15	150	150	-	-	-
Electrical Conductivity*	µS/cm	1000	1000	-	-	6000	-
Floatables	-	N	N	N	-	-	-
Odour	-	N	N	N	-	-	-
Salinity	ppt	0.5	1	-	-	2	-
Taste	-	N	N	N	-	-	-
Total Dissolved Solid	mg/l	500	1000	-	-	4000	-
Total Suspended Solid	mg/l	25	50	50	150	300	300
Temperature	°C	-	Normal + 2 °C	-	Normal + 2 °C	-	-
Turbidity	NTU	5	50	50	-	-	-
Faecal Coliform**	count/100 ml	10	100	400	5000 (20000)ª	5000 (20000)ª	-
Total Coliform	count/100 ml	100	5000	5000	50000	50000	> 50000

WATER CLASSES AND USES

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