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**GEOLOGY AND GROUNDWATER QUALITY  
ANALYSIS OF DOMESTIC WELLS AROUND  
KAMPUNG PANGLIMA BAYU, TANAH MERAH  
DISTRICT, KELANTAN, MALAYSIA.**

by

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A report submitted in fulfilment of the requirements for the  
degree of Bachelor of Applied Science (Geoscience) with  
Honours

**FACULTY OF EARTH SCIENCE  
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2023

**DECLARATION**

I declare that this thesis entitled “GEOLOGY AND GROUNDWATER QUALITY ANALYSIS OF DOMESTIC WELLS AROUND KAMPUNG PANGLIMA BAYU, TANAH MERAH DISTRICT, KELANTAN, MALAYSIA.” is the results of my own research except as cited in the references.

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## ABSTRACT

The current project is part of a final year undergraduate research project that focuses on geological mapping and groundwater quality analysis of domestic wells in and around Kampung Panglima Bayu, which is a district in Tanah Merah, Kelantan, with latitudes ranging from 05° 47' 30.00" N to 05° 50' 20.00" N and longitudes ranging from 101° 56' 20.00" N to 101° 59' 00.00" N. Several methods were used to create an updated geological map including fieldwork inputs such as sample collection from fresh outcrops, field observations such as geomorphological characteristics, drainage patterns, and others were that has not been mapped on a small scale. All field data, including petrographic study, was processed in a GIS-based platform to create geological and other relevant thematic maps. The objective of this research is to produce an updated geological map of the study area at a scale of 1:25000 and conduct groundwater quality analysis in the research region. Groundwater samples were obtained from 12 domestic wells for the analysis of physicochemical parameters. Temperature, pH, Electrical Conductivity, Turbidity, and Total Dissolved Solids were measured using Multiparameter and Turbidity meter on site. Atomic Absorption Spectroscopy (AAS) was used to analyse major trace elements such as potassium, sodium, calcium, magnesium, iron, and manganese, while titration was used to analyse bicarbonate and chloride and spectrophotometer methods were used to analyse fluoride, sulphate, and nitrate. Based on data analysis of the geology of Kampung Panglima Bayu, three lithologies can be concluded: granite is the most common kind of rock detected in the research region, followed by schist and alluvium. Furthermore, the geomorphology of the study area revealed elevation differences consisting of low land to high hills. The petrographic analysis revealed that the granites have acidic composition. The granite rocks identified are known as 'biotite granite porphyry' because of the high amount of biotite mineral in the thin section that correlated with previous research. Besides that, when the results of the analysis for groundwater quality were compared to World Health Organization (WHO) and Ministry of Health Malaysia (MoHM) standards values it was discovered that 7 of the 12 wells were contaminated because the Ph value that was below the normal level. Turbidity was high in wells 4, 5, and 11, and sodium ion levels surpassed the standard allowable limit in well 11. Besides that, according to the piper diagram the sodium bicarbonate facies is the most dominating group. Lastly, the study areas total water quality was also determined using the Water Quality Index (WQI), which showed that the overall well water quality is good.

Keywords: Kampung Panglima Bayu, Geological mapping, Domestic well, physicochemical parameter.

## ABSTRAK

Projek semasa ini adalah sebahagian daripada projek penyelidikan sarjana muda tahun akhir yang memberi tumpuan kepada pemetaan geologi dan analisis kualiti air bawah tanah telaga domestik di dalam dan sekitar Kampung Panglima Bayu, yang merupakan sebuah daerah di Tanah Merah, Kelantan, dengan garis lintang antara  $05^{\circ} 47' 30.00''$  N hingga  $05^{\circ} 50' 20.00''$  N dan longitud antara  $101^{\circ} 56' 20.00''$  N hingga  $101^{\circ} 59' 00.00''$  N. Beberapa kaedah telah digunakan untuk mencipta peta geologi yang terkini termasuk input kerja lapangan seperti pengumpulan sampel daripada singkapan segar, pemerhatian lapangan seperti ciri geomorfologi, pola saliran, dan lain-lain yang belum dipetakan pada skala yang kecil. Semua data lapangan, termasuk kajian petrografi, telah diproses dalam platform berasaskan GIS untuk mencipta geologi dan peta tematik lain yang berkaitan. Objektif penyelidikan ini adalah untuk menghasilkan peta geologi terkini kawasan kajian pada skala 1:25000 dan menjalankan analisis kualiti air bawah tanah di kawasan penyelidikan. Sampel air bawah tanah diperolehi daripada 12 telaga domestik untuk analisis parameter fizikokimia. Suhu, pH, Kekonduksian Elektrik, Kekeruhan, dan Jumlah Pepejal Terlarut diukur menggunakan Multiparameter dan meter kekeruhan di tapak analisis. Spektroskopi Serapan Atom (AAS) digunakan untuk menganalisis unsur surih utama seperti kalium, natrium, kalsium, magnesium, besi, dan mangan, manakala titrasi digunakan untuk menganalisis bikarbonat dan klorida dan kaedah spektrofotometer digunakan untuk menganalisis fluorida, sulfat, dan nitrat. Berdasarkan analisis data geologi Kampung Panglima Bayu, tiga litologi boleh disimpulkan: granit ialah jenis batuan yang paling biasa dikesan di kawasan penyelidikan, diikuti oleh sekis dan aluvium. Tambahan pula, geomorfologi kawasan kajian menunjukkan perbezaan ketinggian yang terdiri daripada tanah rendah kepada bukit tinggi. Analisis petrografi mendedahkan bahawa granit mempunyai komposisi berasid. Batuan granit boleh dikenali sebagai 'biotite granite porphyry' kerana jumlah mineral biotit yang tinggi di bahagian nipis yang berkorelasi dengan penyelidikan terdahulu. Selain itu, apabila keputusan analisis kualiti air bawah tanah dibandingkan dengan nilai piawai Pertubuhan Kesihatan Sedunia (WHO) dan Kementerian Kesihatan Malaysia (KKM) didapati 7 daripada 12 telaga telah tercemar kerana nilai Ph yang berada di bawah paras tahap biasa. Kekeruhan adalah tinggi di telaga 4, 5, dan 11, dan paras ion natrium melebihi had piawai yang dibenarkan dalam telaga 11. Selain itu, menurut gambar rajah piper fasies natrium bikarbonat adalah kumpulan yang paling dominasi. Akhir sekali, jumlah kualiti air kawasan kajian juga ditentukan menggunakan Indeks Kualiti Air (WQI), yang menunjukkan kualiti air telaga keseluruhan adalah baik.

Kata kunci: Kampung Panglima Bayu, Pemetaan geologi, Telaga domestik, parameter fizikokimia.

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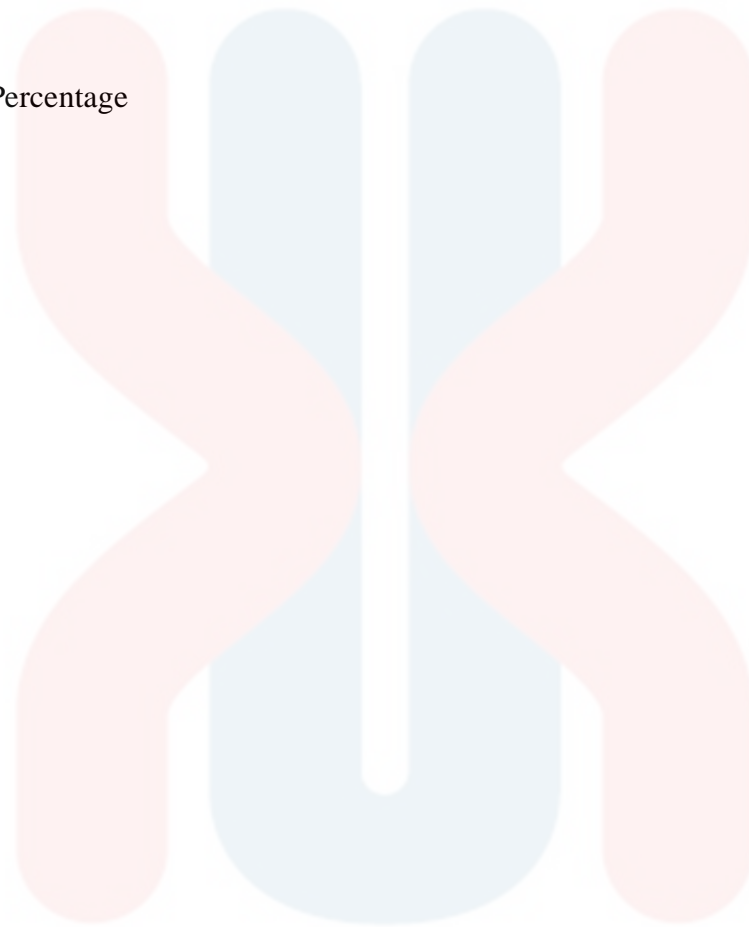


**LIST OF SYMBOLS**

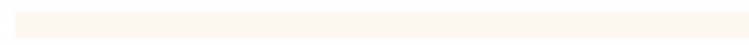
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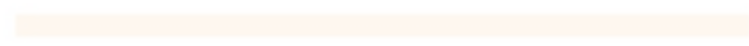
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## LIST OF ABBREVIATIONS

AAS	Atomic Absorption Spectroscopy
EC	Electrical Conductivity
GPS	Global Positioning System
GIS	Geographic Information System
MoHM	Ministry of Health Malaysia
WHO	World Health Organization
WQI	Water Quality Index
TDS	Total Dissolved Solids
EC	Electrical Conductivity
Ca <sup>2+</sup>	Calcium
Mg <sup>2+</sup>	Magnesium
Mn <sup>2+</sup>	Manganese
Na <sup>+</sup>	Sodium
K <sup>+</sup>	Potassium
Fe <sup>+</sup>	Iron
NO <sub>3</sub> <sup>-</sup>	Nitrate
SO <sub>4</sub> <sup>2-</sup>	Sulphur
Cl <sup>-</sup>	Chloride
F <sup>-</sup>	Fluoride
HCO <sub>3</sub> <sup>-</sup>	Bicarbonate

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## CHAPTER 1

### INTRODUCTION

#### 1.1 General Background

Geological mapping is a highly interpretative, scientific method that may produce a variety of maps to depict various aspects of geology, such as groundwater quality and pollution hazards (David, 2004). Thus, understanding the general geology of Tanah Merah is important because it is always changing due to the development activities and the involvement of geological processes that generate changes in the earth's surface, such as folding, fracture, and faulting. Therefore, the geomorphology and type of outcrop distribution on the subject region was covered in this study.

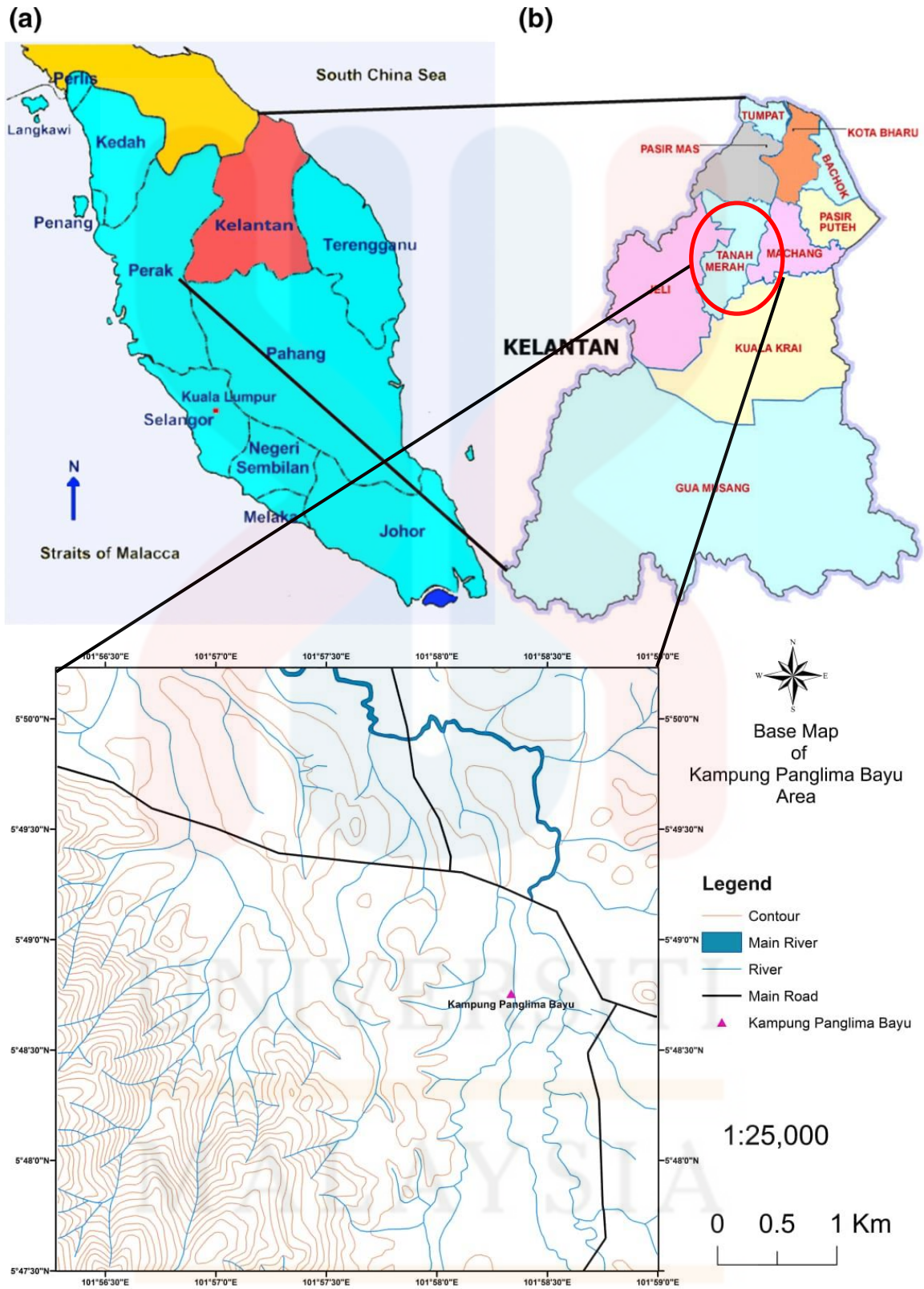
Groundwater is among the world's most important natural resources, and it can be used instead of freshwater. In Malaysia, less than 10% of groundwater is used for drinking purposes, particularly in the states of Kelantan, Terengganu, Pahang, Perlis, Kedah, Sabah, and Sarawak (Ong, 2007). Around 70% of Kelantan's total water supply comes from groundwater, especially in the Kota Bharu area like in Pasir Mas, Pasir Putih, Tanah Merah, and Kuala Krai. Groundwater is mostly used for domestic, industrial, and agricultural purposes by the people of northern Kelantan, particularly those who live in villages. They usually acquire their water from shallow aquifers, such as home wells, which are traditionally hand-dug wells, and built conventional wells which is less than 10 metres deep to withdraw groundwater (Islami, 2015).

Therefore, groundwater is the community's primary source of water, and it must be protected from contamination. This research study was divided into two sections which is the distinct viewpoints on general geology and specification portion on groundwater quality analysis of domestic wells near Kampung Panglima Bayu, Tanah Merah District, Kelantan, Malaysia. Applied understanding of geological mapping and hydrogeology was be used to gather critical data for evaluating the status of groundwater from domestic wells as both information correlates. (Rajaveni,2015)

## 1.2 Study Area

This study was focused on the Kampung Panglima Bayu village area in the Tanah Merah district, in Kelantan state as seen in figure 1.1.

The Kelantan River, which supplies water to agricultural plantations and domestic wells, has a significant impact on the landscape of Tanah Merah. Almost majority of the residences have a borehole and pump for groundwater withdrawal. Furthermore, some residents use hill water in addition to groundwater, as there is a Jedok forest reserve to the west of the study area that could be a source of hill water. The research region has largely flat and hilly areas that are not very high. Most of the land is used for plantation purposes, as this it is the villager's primary source of income. Most of the Tanah Merah district's geography is low lying, with an average elevation of less than 40 meters. Aside from that, the mountain height in Tanah Merah is not particularly high and is mostly from granite rock.



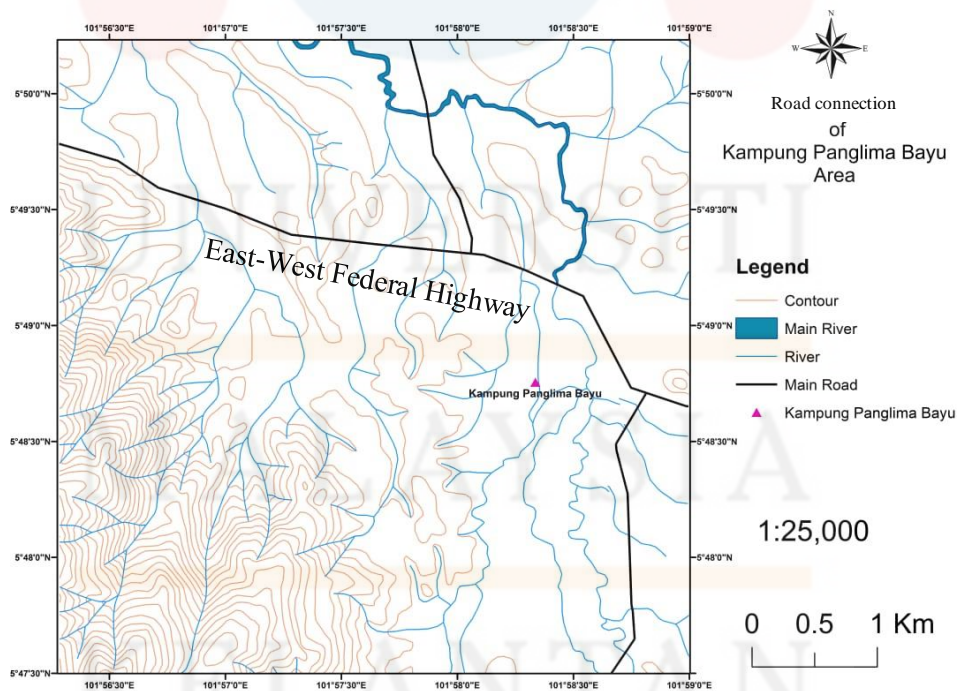
**Figure 1.1:** a) Map of Kelantan, b) Map of Tanah Merah District and c) Base Map near Kampung Panglima Bayu Area

1.2.1 Location

The study region is located between 05 47' 30.00"N and 05 50' 20.00"N latitude and 101° 56' 20.00"N and 101° 59'00.00"N longitude. Kampung Panglima Bayu is also surrounded by many villages and the study area encompasses of roughly 25 km<sup>2</sup> in Tanah Merah.

1.2.2 Road Connection

The road network in the research area is highly established. The East-West Federal Highway, which ran from Jeli district to Tanah Merah district, was used to get to the research location. While the path from Tanah Merah to Pasir Mas follows the Pasir Mas-Tanah Merah Street. The primary road utilized to access the research region is seen in Figure 1.2.



**Figure 1.2:** Road connection map of study area.  
Source: Generated from ArcGIS 2022

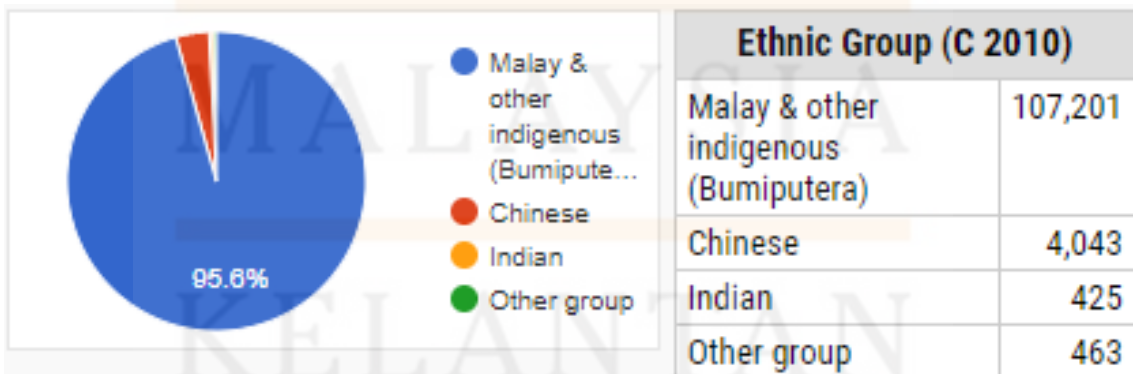


**Figure 1.3:** Road connection in study area  
Source: Google Earth Pro

### 1.2.3 Demography

According to the most recent data from the District Council of Tanah Merah, the total population in 2010 was 112132 people. The Tanah Merah district conducted a census survey of the community, which provided the population data. More detailed data from the census survey that differentiate the community based on ethnic group as shown in figure 1.4 below.

#### Ethnic group of Tanah Merah District



**Figure 1.4:** The Ethnic Group of Tanah Merah District  
Census Survey of Tanah Merah District

According to the pie chart in figure 1.4, the Tanah Merah district is dominated by the Malay community, and the community is densely populated in the Tanah Merah town area. Because of the easy access to any facilities and work, the community is usually centred in the city.

#### 1.2.4 Land-use

Plantations and industrial activity make up most of the Tanah Merah district's land usage. According to figures 1.5, 1.6 and 1.7, rubber and oil palm plantations are the most prevalent varieties in the region. The rural people also grow a variety of small-scale fruits and vegetables on their farms, including rambutan, durian, and banana. Other land use elements, like shops, housing areas, hospitals, schools, and many others, are used for construction. According to surveys and observations, there are several buildings close to the study area, including stores, government services, and local government and municipal institutions.



**Figure 1.5:** Rubber plantation at the eastern part of study area.



**Figure 1.6:** Rubber plantation at the eastern part of study area.



**Figure 1.7:** Oil palm plantation at the northern part of the study area.

### 1.2.5 Social economic

In the Tanah Merah district, plantation activity, business activity, industrial activity, and other activities provide for the majority of local income. The rural population typically engages in plantation work. The centre of Tanah Merah is where most commercial and industrial activities take place. The factory is one of numerous establishments in Tanah Merah that support the social and economic health of the community. Residents from rural places like Jeli, Ayer Lanas, Gual Ipoh, Kusial, and others frequently commute to Tanah Merah town since it is more developed than the surrounding area. As a result, the Tanah Merah community's revenue will rise, indirectly boosting the district's economy.



**Figure 1.8:** One of the grocery shops in the study area.



**Figure 1.9:** A 24-hours restaurant at Kampung Panglima Bayu



**Figure 1.10:** Masjid Kampung Panglima Bayu

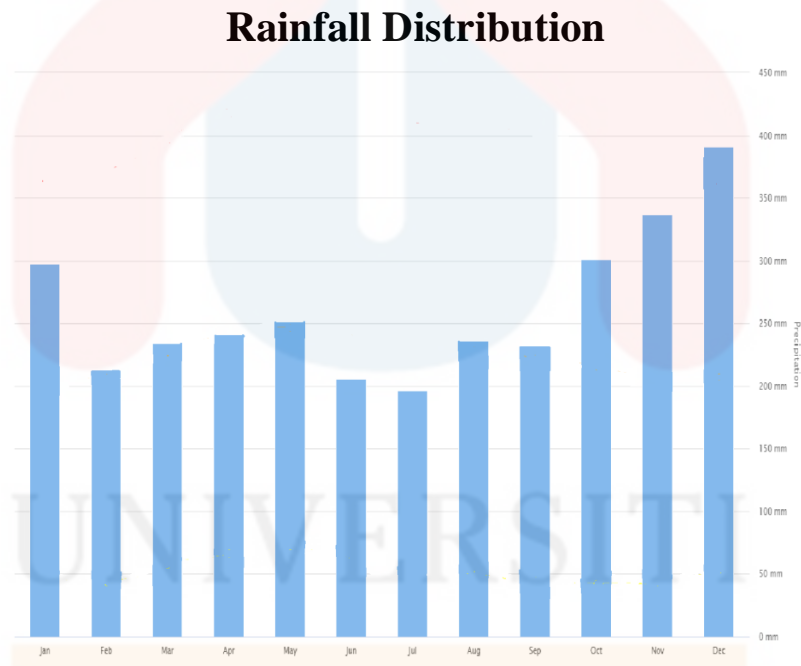


**Figure 1.11:** SMK Tan Sri Mohamed Yaacob

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### 1.2.6 Rainfall distribution

Rainfall is one of the most important factors influencing groundwater quality. Gases from vehicles, factories, carbon dioxide, nitrogen oxide, sulphur dioxide, and many other types of gases are commonly found in the atmosphere. Rainfall dissolves the presence of composition in the air. The high concentration of Sulphur dioxide and Nitrogen dioxide in the atmosphere causes the rainfall to become more acidic. Acidic rain will fall to the ground, infiltrate the subsurface, and eventually reach the water table. As a result of the contamination of groundwater, the acidity of groundwater rises.



**Figure 1.12:** Rainfall distribution for the year 2020.  
 Source: Department of Irrigation and Drainage Malaysia, 2020.

The total rain distribution in the study area was obtained from January to December of 2020. According to figure 1.12, the month of December in the year 2020 has the highest rainfall. The moonson season causes the most rainfall early in the year. The monsoon season in Malaysia lasted from October to March. The monsoon season

has a significant impact on the east coast of Peninsular Malaysia, specifically Kelantan. During the monsoon season, rainfall and river water levels are regularly monitored for flood warnings. Heavy rainfall typically occurs during the monsoon season and can last for an extended period. From April to September, the rainfall distribution is average. The post-monsoon season lasts from April to September, with lower rainfall than during the monsoon season. During this season, the rainfall is usually light to moderate.

### 1.3 Problem Statement

Most development activities, which includes road connections, railways, plantation, and others, can contribute to the changes in earth surface, and it was not mapped on a small scale that covers all aspects of geological knowledge like landuse, lithology, drainage pattern, and topography. In this study, an updated geological map with lithology, geomorphology, and drainage patterns was created on a 1: 25000 scale. As a result, geological mapping was done to re-update the existing topography and geomorphology of the study area, making it easier to understand geological maps and making it helpful for future researchers.

Kelantan is Malaysia's largest groundwater operator, particularly in Kelantan's northwestern region (Malaysian Water Association, 2011). Groundwater has supplanted surface water as the primary source of fresh water for household and agricultural purposes. Since many years, it has also been a viable alternative to municipal water. Chemical, agricultural, as well as domestic waste, plus human and geogenic activities have the potential to contaminate the shallow groundwater system especially in this study area (Ali Khan, 2018). Although much less polluted than surface water, overuse can

degrade the water's quality and render it dangerous to drink (Tan & Rohasliney, 2013). The domestic well was also limited to a shallow aquifer. Almost every home uses the same sewage system, which almost certainly increase the rate for contamination in the water sources, but they pay no attention to issues of groundwater management and quality. Human health problems can be caused by contaminated groundwater used for drinking.

#### 1.4 Objective

The objectives of this research are as follow:

- i. To produce an updated geological map of the study area at scale 1:25000.
- ii. To conduct groundwater quality analysis of domestic groundwater wells.

#### 1.5 Scope of study

This study was focus on the Kampung Panglima Bayu village area and some nearby villages in the Tanah Merah district. The general geology of the area comprised the study of geomorphology, lithology, stratigraphy, and structural geology in the study area that might have change due to the development and geological processes that alter the earth's surface. Geomorphology was also discussed as it is a branch of general geology that deals with drainage patterns, landforms, weathering processes and distribution of exposed rocks (outcrops) to demonstrate groundwater quality and potential hazards around the study area.

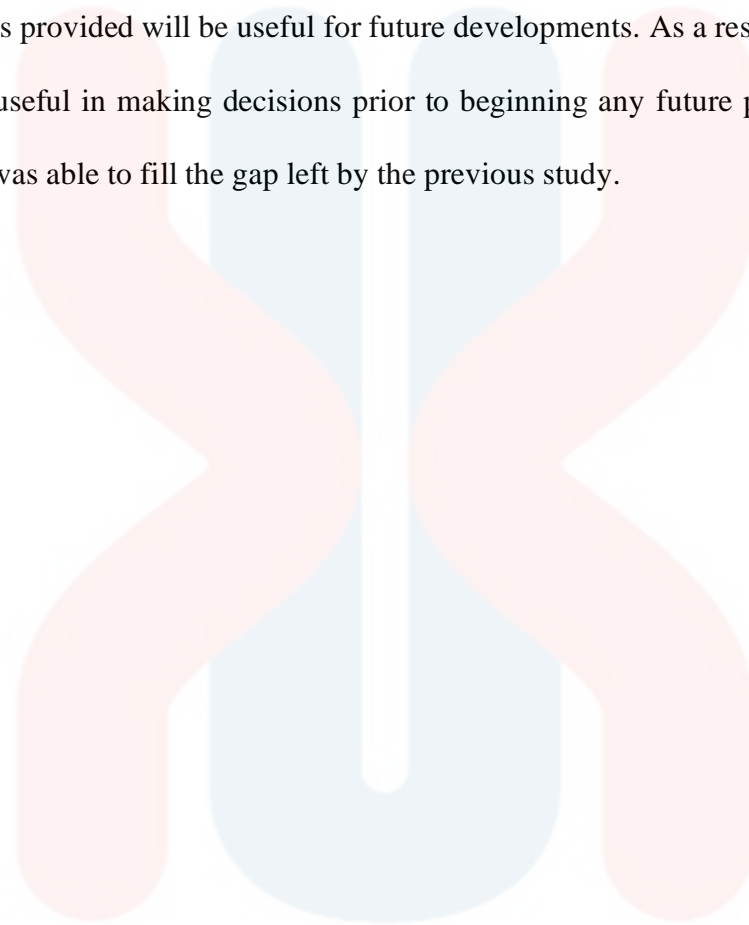
The study's specification was groundwater quality analysis of domestic wells around Kampung Panglima Bayu that measured the physical and chemical parameters of the water sample. Analyses of major cations and major anions are among the chemical parameters and , temperature, pH, Electrical Conductivity (EC), Turbidity, and Total Dissolved Solids (TDS) are among the physical parameters. Thus, this study was to ensure that the water is free of contamination and safe to drink when compared to WHO and Ministry of Health Malaysia standard values (MoHM). The Water Quality Index (WQI) is going to be used to determine the overall water quality of the study area and the groundwater's sensitivity to any potential sources of contamination.

#### 1.6 Significance of study

This research project was aimed to update the geological map of Tanah Merah. Any changes in geomorphology at the research region caused by natural processes or human action was updated in the geological map. Another important aspect of the investigation is to establish whether the groundwater from the household wells is suitable for domestic purposes, particularly for drinking. The groundwater analysis can establish whether the groundwater is fit for consumption.

This study will help identify the current state of groundwater quality and teach the villages how to sustainably manage groundwater and minimize unnecessary pollution. Groundwater samples are collected from groundwater wells throughout the research region, measured in situ and in laboratory to obtain a detailed picture of the overall quality and appropriateness of groundwater for use as drinking water. Furthermore, the database shall be shared in computerized form with both government and non-government

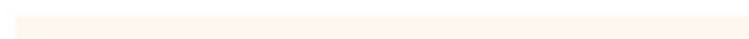
organizations, making sure that the regulations, legal, and institutional framework is in place, the resource will be managed to maintain in a sustainable manner, plus the data and analysis provided will be useful for future developments. As a result, this study was extremely useful in making decisions prior to beginning any future project or research because it was able to fill the gap left by the previous study.



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## CHAPTER 2

### LITERATURE REVIEW

#### 2.1 Introduction

This chapter provided a summary of past studies related to this research conducted by earlier researchers. As a reference and review for this project, existing research papers, journals, and articles were consulted.

#### 2.2 Regional geology and geological settings

Malaysia has a diverse range of rock types, including igneous, metamorphic, and sedimentary rocks as seen in figure 2.1. Some of these boulders are granitic rocks that came from the Titiwangsa Range. The Main Range, commonly known as Banjaran Titiwangsa, is Peninsular Malaysia's backbone. Peninsular Malaysia is separated into three belts: the Western belt, the Central belt, and the Eastern belt. The stratigraphy of these three types of belts is significantly different. Kelantan is situated between the Central and Eastern belts. The Central belt spans from Kelantan to Johor, with upper Paleozoic rocks of the Gua Musang and Aring formations in south Kelantan and Taku Schist in east Kelantan forming the western section of the band (Hutchison and Tan, 2009).

The granitic rocks are divided into two main groups. The primary granite masses are in the western half of Kelantan in the Primary Range. Significant mineralization, which is typically related to faulting, was produced by granitic emplacement. Faulting is possible throughout the entirety of the rock structure. There are three different sets of faults, the newest of which is thought to have existed at the beginning of the Cretaceous period (Hutchison & Tan, 2009).

Most Kelantan's sedimentary and metamorphic rocks are composed of granite rock, including the Granite Besar Range in the west and Granite Sempadan Range in the east. The Granite Sempadan Range is where the alluvial sediments of the Kelantan River are piled. In the northern part of Kelantan, it was covered in Quarternary sediment. A few intrusions, including the Kemahang Pluton, Stong Igneous Complex, and Batolith Ulu Lalat, may be found in Kelantan's central region. This bedrock connects with a granite stripe that runs from north to south in Pahang state's north. From the north to the south of Thailand, this stripe extends continuously across the west and centre of Kelantan.

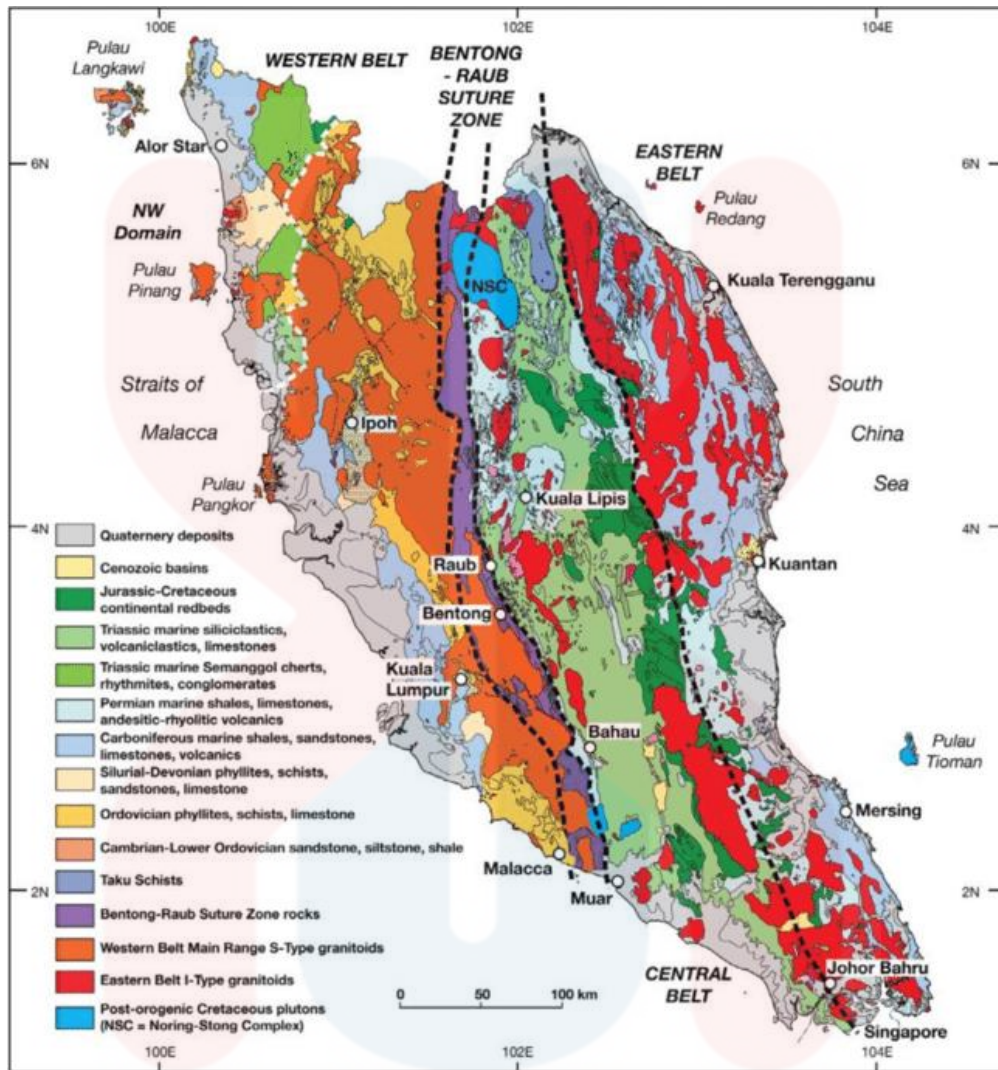
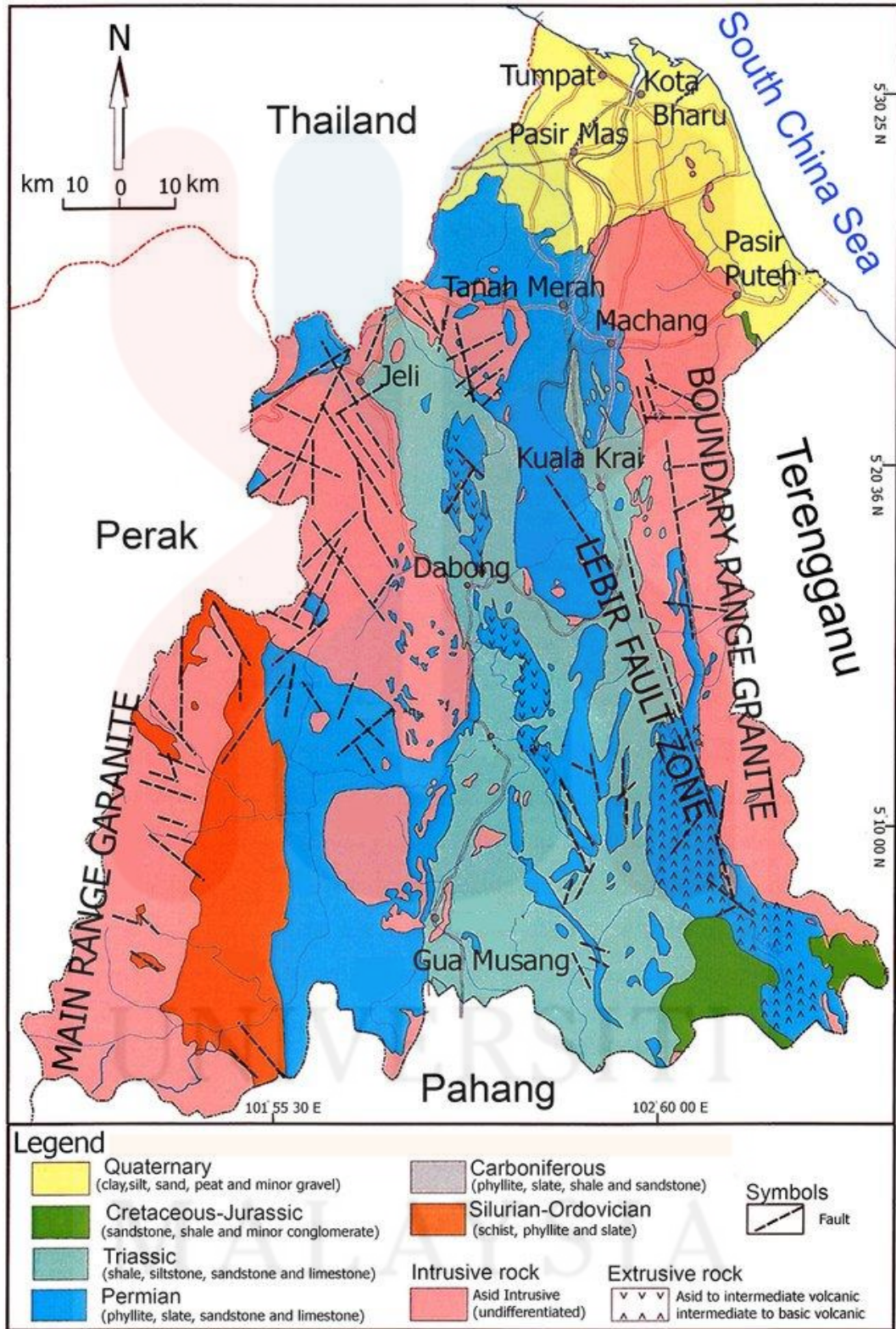


Figure 2.1: Geological Map of Peninsular Malaysia (Metcalf, 2013)

The earliest rock in Kelantan is from the Lower Paleozoic. The newly found outcrop had a stripe that ran from north to south, bordered by the Besar Range's slopes, and extended on the east side all the way to the Nenggiri River. Meta-phyllite makes up the majority of the rock, with small amounts of volcanic ash and arenite scattered throughout the calcareous material. Figure 2.2 shows the geological map of Kelantan.



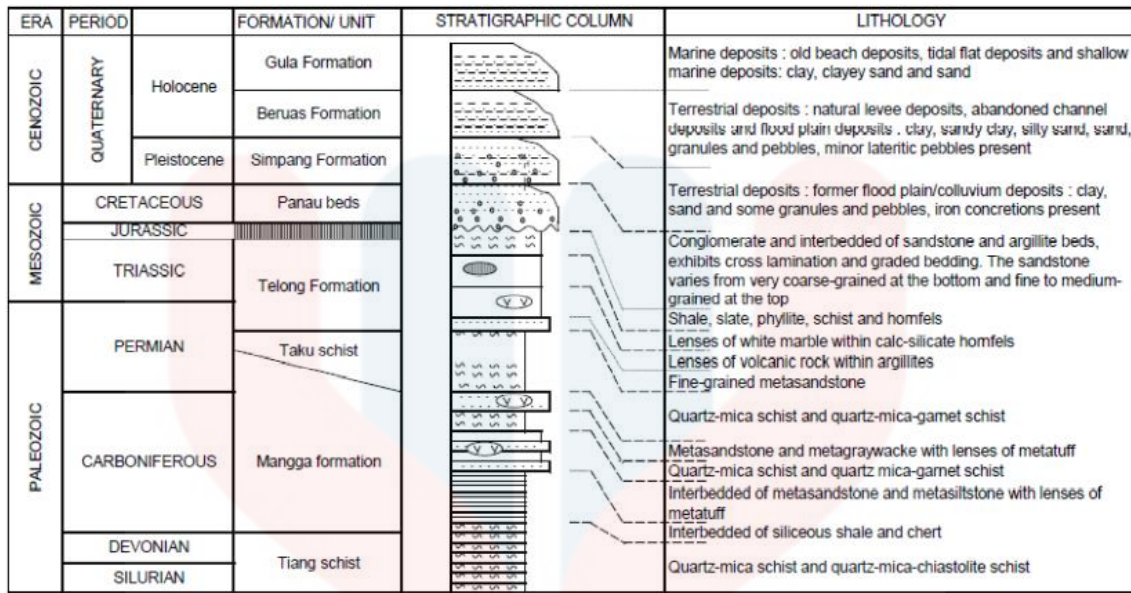
**Figure 2.2:** Structural geology Map of Kelantan.  
Source: Department of Mineral and Geoscience (2003)

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### 2.3 Stratigraphy

The stratigraphy investigations, which include layers of sediment, the type of material employed, and information about the prehistoric environment that caused the sediment to build, help establish the age of the formations in Kelantan. Most of the rocks in the state of Kelantan are metasedimentary and sedimentary. It is situated in the centre of the Kelantan state in terms of granitic intrusions. In this study region, quartz-rich schist and quartz-mica schist make up the majority of the rocks. 2009 (Hutchison & Tan). The majority of the quartz-rich schist found in that research region is made up primarily of quartz, with layers of additional minerals like biotite and muscovite.

Paleozoic, Mesozoic, and Cenozoic, with a range from the Lower Paleozoic to the Quaternary, were the three main chronologies involved in the geological creation of Kelantan (Hutchinson & Tan, 2009). Paleozoic formations involved are the Gua Musang Formation and the Aring Formation. The stratigraphy of Gua Musang originates in the upper Paleozoic. Rocks from the Raub group, which are argillaceous, volcanic, calcareous, and arenaceous, as well as the Gua Musang Formation, Aring Formation, and Kepis beds, are all Upper Paleozoic deposits (Hutchinson & Tan, 2009). The Gua Musang Formation's revealed strata included rocks from the middle Permian to the lower middle Triassic (Hutchinson & Tan, 2009). The basal conglomerate, which is situated to the west of the Gua Musang Formation, is the earliest unit. The carbonates rock covers the Gua Musang Formation to the east.



**Figure 2.3:** Schematic Stratigraphic Column of Western Kelantan Area (The Malaysian and Thai Working Groups, 2006).

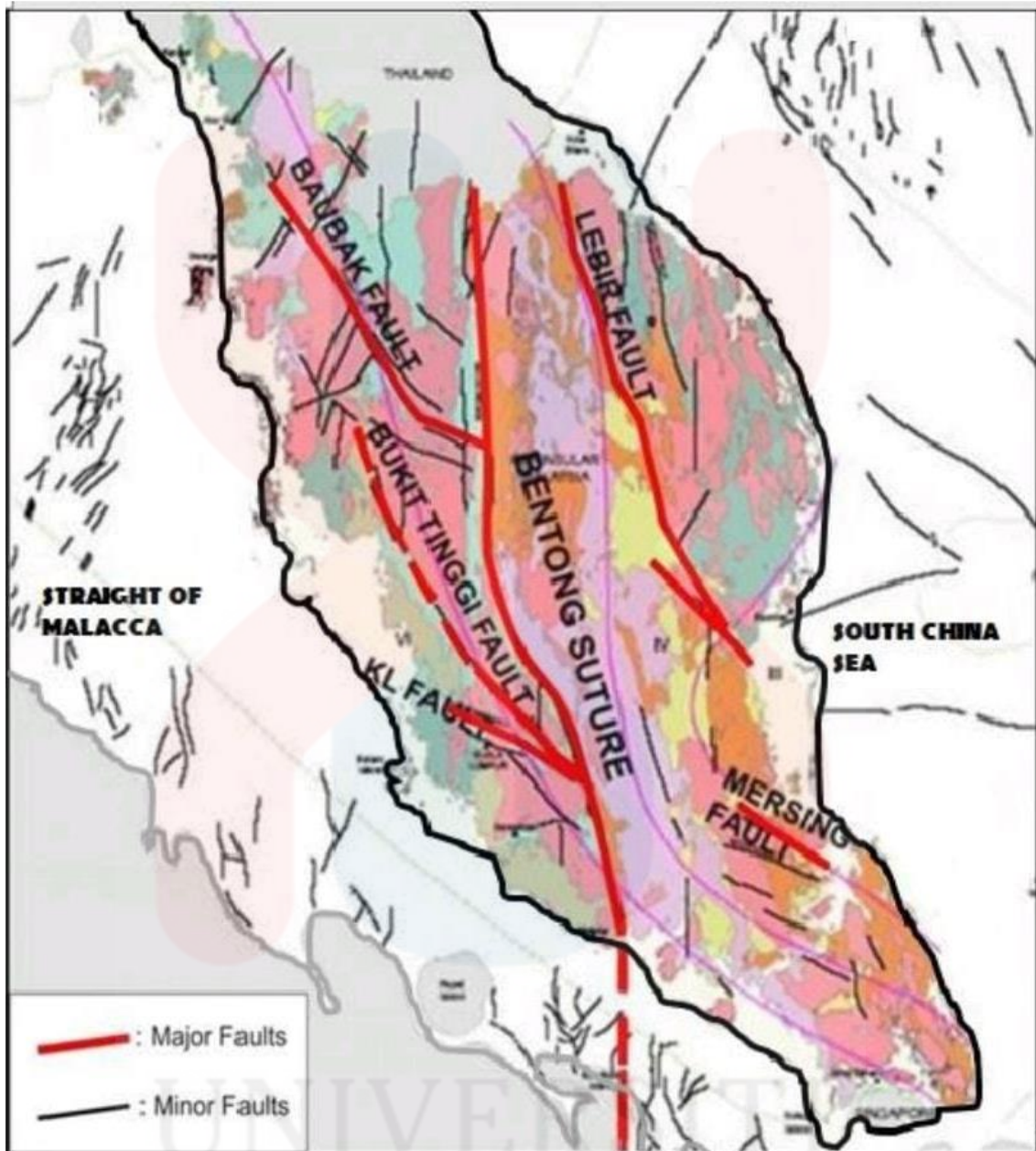
## 2.4 Structural geology

Peninsular has roughly 12 main faults that almost completely encompass the peninsula. The Bentong-Raub Suture Zone and the Lebir Fault Zone are both in Kelantan, and they extend from Gua Musang to Cameron and Sg. Another significant fault zone is the Galas fault zone, which cuts the Stong complex, Kemahang Granite, and the Tahan Range in Kelantan from the NNW-SSE (Hutchinson and Tan, 2009). In Kelantan, all of the surface characteristics connected to these three main fault zones are discernible, as shown in figure 2.4.

North Kelantan's alluvial plain is mostly covered in Mesozoic granites, with some metamorphic rocks (Saghravani et al., 2014). The alluvium deposit is a product of the Simpang Formation, which included the sungai Kelantan region and its delta. Peat from a terrestrial deposit is combined with clay, silt, and other materials to form this formation (Saghravani et al., 2014). In the Kelantan Delta, unconsolidated sediments get thicker as you move east, with the deepest bedrock being found at 150 metres. The Tanah Merah

region is rich in andesite, including andesite flow, andesite tuff, and andesite agglomerate, but pyroclastics predominate. Extrusive volcanic rock that is intermediate to basic makes up its composition. However, like the eastern belt granites, the longest lineament and longest cumulative length direction run roughly N-S. The Silurian-Devonian succession is characterised by numerous close folds. All rock units have some degree of faulting, which often manifests as broad, almost vertical fissures with minimal displacement. However, all the major faults were moving from northwest to northeast. (Hutchison & Tan, 2009).

The Kemahang granite's whole lineament distribution shows clearly how cracks developed because of the granite's cooling process and subsequent uplift, which turned it into high-level emplacement granite. The Stong Complex, Kemahang granite, and the Tahan Range are all impacted by the separate 80 km broad Galas Fault Zone, which runs from over the Thailand border to the Tembeling area (Mustaffa Kamal Shuib, 2009). It is described as a sizable area of sheared granite that forms the Kemahang granite's western boundary. Granitic apophyses of the Kemahang granite often appear as closely spaced veins parallel to the foliation, a lit-par-lit injection gneiss, at the contact with the Taku Schist (MacDonald, 1968)



**Figure 2.4:** Map of Peninsular Malaysia showing major and minor faults. (Kasim, S. A. 2020)

## 2.5 Historical geology

Peninsular Malaysia was clearly split into four zones by Hutchison (2009), each of which had distinct tectonic histories. One of them is the Eastern Belt, which is characterised by numerous elongate granitic plutons that have been intruded into primarily Permo-Carboniferous sedimentary formations that have undergone only mild

deformation, along with nearby pyroclastic and volcanic rocks that range in composition from acid to intermediate.

Because the Main Range Belt granites have been extensively uplifted since their crystallisation and the Eastern Belt granites have not, it can be inferred that the Eastern Belt has higher tectonic stability than the Main Range (Hutchison, 1977). The granites were deposited in a high-level environment throughout the Permian and Triassic periods so that fast water loss prevented the alkali feldspar from reaching a stable structural condition (Hutchison, 2009).

Apart from the west, where it is in contact with Permo Triassic strata that also include metamorphics such as slates, phyllites, marble, and metavolcanics, the Kemahang granite of MacDonald (1967) is a granitic mass of batholithic dimension in north-west Kelantan near to the Thai border (Khoo, 1980).

According to MacDonald (1967), the Kemahang granite is an intrusive magmatic material, and the shearing was thought to be the result of changes made to the granite during solidification and related tectonic motions that occurred both during and after the granite's emplacement and solidification. According to Hutchison (2009), the Kemahang granite is a sizable parautochthonous granite body composed in part of cataclastic granite and in part of foliated granite gneiss, and it includes several schist remnants.

According to Khoo (1980), the Kemahang granite is an excellent emplacement when considering characteristics like discordance to local rocks and the existence of contact metamorphism.

## 2.6 Petrography

The petrography analysis is used to categorise the different types of rocks, describe them, and understand where they came from. A little piece of rock collected in the research region is used for the investigation. The study area in Tanah Merah town has igneous rock. A tiny sliver of rock can reveal the rock's mineral makeup, colour, degree of crystallinity, and texture. The results of the petrography examination was utilised to categorise the type of rock by consulting with the International Union of Geological Sciences (IUGS). A nomenclature standard for igneous rocks has been developed by the IUGS.

Cataclastic porphyritic biotite granite known as Kemahang Granite has an outcrop that crosses the border into southern Thailand as the Buke pluton, which is located in the northern Taku Schist body (Cobbing et al., 1992). According to MacDonald (1967), the Kemahang Granite is made up of a variety of granitic rocks, the most common of which is a medium-to-coarse-grained, grey granite with large feldspar phenocrysts, a lot of biotite, and distinct lineation of feldspar phenocrysts in a few sites. The Taku Schist has been injected into the granite, which also has extensive schist enclaves (Hutchison, 2009). The Taku Schist is a north-south elongate body that spans from central east Kelantan at Manik Urai to the Thai border, measuring around 80 km long and 8 to 22 km wide. It is mostly made of quartz-mica-schist, quartz-mica-garnet and garnet mica schist.

## 2.7 Groundwater

About 95% of the freshwater on Earth comes from the ground, making it crucial to human survival and economic development. Water that is found below the surface of

the earth, between soil or rock particles, or in cracks and fissures in rocks, is known as groundwater. The majority of groundwater is found 100 metres or less below Earth's surface. But then again the use of groundwater is still quite minimal.

In contrast to those in large cities or towns where groundwater is frequently contaminated with hazardous poisonous compounds, groundwater is assumed to be a trustworthy supply of portable water. Groundwater contamination has become a problem of modern times due to its far-reaching effects on human health. The hydrochemical disposition of groundwater throughout its underground circulation is influenced by its chemical composition and geological formations. Across the use of diverse hydrochemical processes, this subversive pathway through the pore spaces and weathered zones may change the normal composition of the groundwater. Numerous anthropogenic causes can alter the chemistry of groundwater.

## 2.8 Hydrogeology

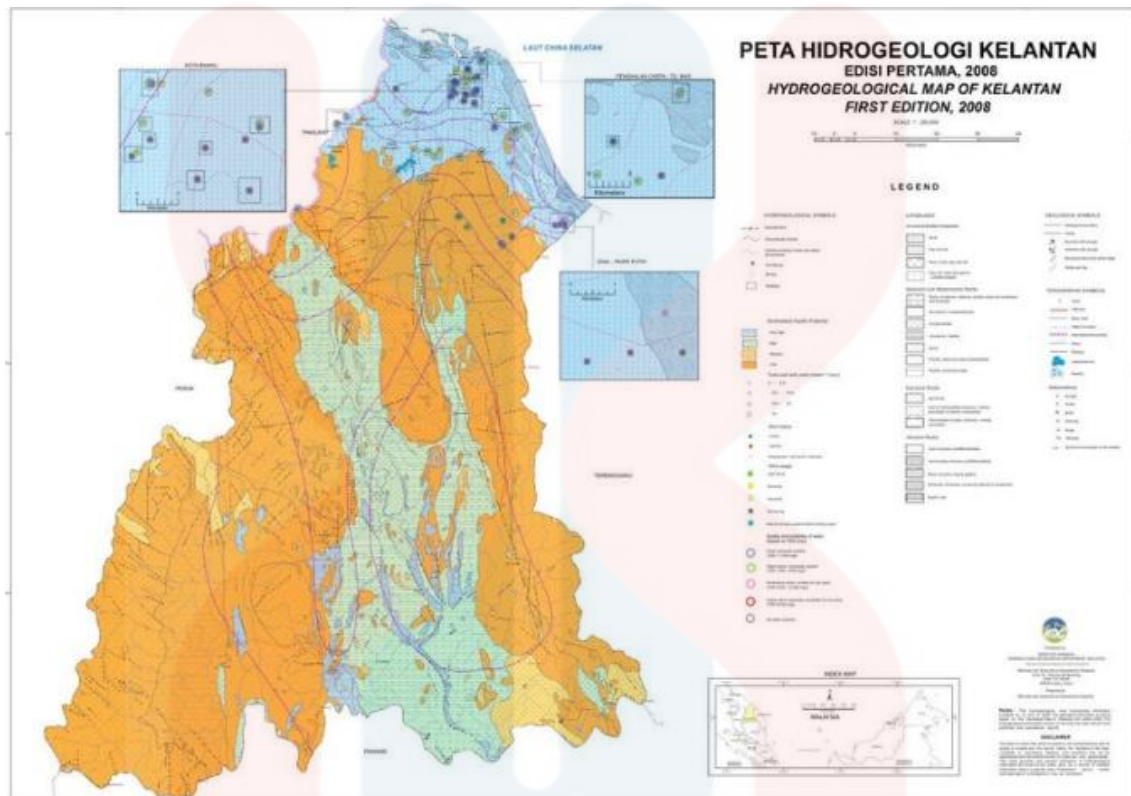
In general, the government's water supply in Tanah Merah is entirely reliant on surface water such as rivers. There are four water treatment centers in Tanah Merah, each of which supplies water to the entire town. The river, Jedok River, Jegor River, and Kelantan River are all sources of water as seen in figure 2.3. Groundwater resources are also present in Tanah Merah, in little amounts that are insufficient for the entire town. In most rural areas, locals rely on groundwater as their primary supply of water. However, the government does not monitor the presence of open wells in the village. Therefore, the villagers are solely responsible for the presence of an open well.

Hydrogeology also includes the study of aquifer systems. Aquifer is a geologic unit that allows water to be stored and transported to a well in an acceptable amount (Fetter, 2001). Confined and unconfined aquifers are the two basic types of aquifers. A confining layer covers and underlies a confined aquifer. A confining layer is a geologic formation with a low intrinsic permeability. Aquitard, aquifuge, and aquiclude are the three types of confining layer. Aquitard is a geologic unit capable of storing groundwater while transporting it slowly. Aquifuge is a device that can hold water yet is completely impervious to water transmission. The aquiclude is a single unit that is incapable of both storing and transmitting water.

The unconfined aquifer is a geologic unit that is underlain by an impermeable layer, while the zone of aeration is located above the water table. Unconfined aquifer water tables are frequently close to the earth's surface and follow the topography. The unconfined aquifer is recharged by direct infiltration from the earth's surface as well as surface water bodies. However, the recharging of the Confined aquifer comes through the leaky confining layer, as well as direct penetration. The potentiometric surface represents the unconfined aquifer's water level. Due to high water pressure in the restricted aquifer, the potentiometric surface represents the water level at which water will rise in the well (Fetter, 2001).

The porosity of an aquifer is one of its most essential characteristics. The amount of rock and soil that is not filled by solid material and can be inhabited by water is known as porosity; the spaces are known as voids, interstices, pores, and pore space. (Fetter, 2001). Primary porosity, secondary porosity, and tertiary porosity are the three types of porosity. The presence of void space during the creation of the rock is the main porosity. Secondary porosity refers to the fractures and joints that developed after the rock was formed. The occurrence of tertiary porosity is due to the dissolution process, and this type

of porosity is typically found in karst aquifers. The water storability of the rock was impacted by its porosity.



**Figure 2.5:** Hydrogeology Map of Kelantan.  
Source: Department of Mineral and Geoscience (2008)

## 2.9 Groundwater quality

Groundwater has long been used for household purposes, and it is well qualified for drinking because it is generally less polluted than surface water. Groundwater is filled in the pore gap between the rock, and water passes through the spaces. The rocks serve as a natural groundwater filter (Fetter, 2001). Groundwater quality and quantity are also critical. Because of the high drilling expense, it is not worthwhile to drill if the water quantity is very little. The same is true if the quantity is considerable yet the water is contaminated or of poor quality, making it unfit for drinking. Because of the high risk of being anthropogenically contaminated by many types of contaminants, groundwater

quality has become a major problem (Ali Khan, 2018). Minerals such as potassium, calcium, sodium, magnesium, and a few others are naturally abundant in groundwater. One of the most essential factors in determining and monitoring groundwater equality is the presence of main ions.

#### 2.10 Water quality standard

The World Health Organization (WHO) has emphasised the importance of preserving groundwater quality standards by providing guidelines for drinking water quality parameters as well as emphasising public health awareness.

The physiochemical analysis determines the quality of groundwater. The major ions, minor ions, and trace elements analyses are all part of the physiochemical analysis. The chemical content is extremely important in determining the groundwater's appropriate function. Because groundwater with a high chemical content might harm human health, it is best used for industrial purposes, municipalities, and everyday use. Groundwater that is fit for human consumption must meet WHO and MoHM standards.

**Table 2.1:** Groundwater Quality Standard based on MoHM and WHO

Physiochemical Parameter	Ministry of Health Malaysia (MoHM) standard	World Health Organization (WHO) standard, 2011
Temperature	-	-
pH	6.5-9.0	6.5-8.5
Total Dissolved Solid(TDS)	<1000mg/L	<1000mg/L
Turbidity	5NTU	< 5NTU
Electrical Conductivity	-	1400
Calcium	-	-
Chloride	250mg/L	200-300mg/L
Nitrate	10mg/L	-
Potassium	20mg/L	20mg/L
Iron	1.0mg/L	-
Magnesium	150mg/L	-
Sodium	200mg/L	200mg/L
Fluoride	0.4-0.6mg/L	-
Bicarbonate	-	-
Sulphate	250mg/L	<250mg/L
Manganese	-	0.4 mg/L

### 2.11 Past research studies regarding Groundwater quality

According to Khan, 2021, Meteoric water and streams naturally recharge the groundwater, allowing the resource in the aquifers. However, anthropogenic factors have had a significant impact on groundwater, making it unsustainable in terms of water supply and food security in many parts of Malaysia, where irrigation and domestic supply are heavily reliant on groundwater. Therefore, it is important to determine the groundwater quality by physical properties and chemical constituents such as major cations and anion, both of which change spatially and temporally because of natural processes, human activity, and seawater intrusion. (Kamal, Z. A., 2020). In a nutshell, adequate use of law and regulations, as well as competent water management, are essential to preserve the quality of this resource for future generations as the population grows. (Pillai, 2020).

### 2.12 Physicochemical parameters

Physical and chemical parameters are included in physiochemical parameters. Physical parameters like, temperature, pH, Electrical Conductivity (EC), Turbidity, Total Dissolved Solids (TDS) and Total Suspended Solid was measured using multiparameter probes and portable Turbidimeters. Chemical parameters like Calcium, Magnesium, Iron, Potassium, Sodium, Bicarbonates, Sulphate, Nitrate, Chloride, Silica, and Fluoride was tested in the laboratory using Atomic Absorption Spectroscopy (AAS), titration, spectrophotometer methods.

**Table 2.2:** List of physiochemical parameters

<b>Physical parameters</b>	<b>Chemical parameters</b>
Total Dissolved Solids (TDS)	Calcium
Temperature	Sodium
pH	Magnesium
Electrical Conductivity (EC)	Iron
Turbidity	Potassium
-	Fluoride
-	Bicarbonates
-	Sulphate
-	Nitrate
-	Chloride
-	Manganese

### 2.12.1 Temperature

Temperature does not have a significant impact on human health. It does, however, play an important role in controlling the chemical reaction that occurs in water. The microorganism can survive and multiply at high temperatures. The growth of microorganisms will speed up the reaction, which will eventually affect the taste, odour, colour, and corrosion of the water. Chemical contaminant that is more likely to occur at high temperatures. Low temperature water, on the other hand, has no discernible effect, and cold water has a more pleasant taste.

### 2.12.2 pH

PH is an important parameter in water quality. In terms of water quality, a neutral pH of 6.0 to 8.0 is preferred. A lower pH can cause corrosion in the pipe system. A vigorous corrosion will release metal elements such as zinc, iron, copper, and lead into the water and should be minimised by stabilising the water pH. High pH, which is higher in alkalinity, can affect the taste of water and hasten the formation of scale in water heating machines. As a result, pH stabilisation is critical before using the water.

### 2.12.3 Turbidity

Turbidity is the cloudiness of water caused by suspended particles, clay, silt, organic matter, and microorganisms that obstruct light transmission. The turbidity measurement is expressed in nephelometric turbidity units (NTU). Turbidity has no negative effects on health, but it can be an indicator of contamination. Turbidity problems can be solved through filtration, coagulation, and sedimentation. This procedure is critical in the production of safe drinking water.

#### 2.12.4 Total dissolved solids (TDS)

Total dissolved solids in water are the result of mineral and organic substance dissolution. Carbonates, bicarbonates, chloride, potassium, and many other elements are common components of dissolved solids. TDS levels in water are not harmful to human health, but they can affect water taste. Water with a high TDS value is also unsuitable for irrigation because it can increase soil salinity and cause plant death.

#### 2.12.5 Electrical Conductivity (EC)

The conductivity of the water aids in the transmission of electric current. The inverse of resistivity is electrical conductivity. Higher EC values indicate low resistivity, whereas low EC values indicate high resistivity. TDS and EC are also related. A higher TDS value indicated that the water contained more cations and anions. Ions increase the efficiency of water in conducting electric current. As a result, the TDS value can be estimated by only measuring the EC value. The measurement of conductivity is critical in determining the suitability of water for irrigation. However, conductivity has no negative effects on health.

#### 2.12.6 Calcium ( $Ca^{+2}$ )

Calcium is one of the naturally abundant substances found in surface and groundwater. The presence of calcium has no negative effects on human health or other living organisms. This is because calcium is one of the essential nutrients required for an organism's development. Calcium-containing rocks include limestone, dolomite, and chalk. The chemical weathering of the rock causes the release of calcium. Calcium hydroxide is formed when calcium reacts with water. Another source of calcium is waste

and sewage disposal. A high calcium content in the water will contribute to an increase in water hardness, rendering it unfit for drinking and irrigation.

#### 2.12.7 Magnesium ( $Mg^{2+}$ )

Magnesium is one of the most common major ions found in surface and groundwater. Because dolomite,  $CaMg (CO_3)_2$ , is a natural contributor of magnesium, magnesium ions frequently occur alongside calcium ions. Dolomite has a calcium to magnesium ratio of 1:1, resulting in a composition that is halfway between  $CaCO_3$  and  $MgCO_3$ . Other sources of magnesium include industrial waste and sewage. Magnesium in water poses no health risk, but in high concentrations it can have negative effects. A high magnesium concentration will contribute to the hardness of the water, and hard water is unfit for drinking.

#### 2.12.8 Manganese ( $Mn^{2+}$ )

Health risks can result from drinking water with high manganese concentrations. Babies still in the womb, infants, and young children are some of the more susceptible demographics in the population. Recent research indicates that the neurological system and brain development may be adversely affected by high manganese levels in drinking water. Long-term consumption of manganese-rich water may impair memory, attention, and motor skills in both children and adults. If young children (babies under one year old) consume water that contains an excessive amount of manganese, they may experience learning and behavioural issues.

#### 2.12.9 Sodium ( $Na^{2+}$ )

The naturally occurring cation is sodium. The cation is a major element found in igneous and sedimentary rocks. The elements are particularly abundant in limestone and dolomite, owing to the influx of seawater during formation and the presence of skeletal material. Another source of sodium in the environment is sodium-rich industrial and domestic waste. Because sodium is highly soluble in water, the concentration of sodium in freshwater is lower than that of calcium and magnesium. The presence of sodium in groundwater has no negative impact on human health; however, at very high concentrations, it may cause disease and change the taste of the water to be salty.

#### 2.12.10 Potassium ( $K^+$ )

Another naturally occurring element is potassium. Potassium can be obtained from the weathering process as well as from waste with a high potassium concentration. The presence of potassium in water poses no health risk, but at high concentrations, it may cause laxative effects in consumers.

#### 2.12.11 Iron ( $Fe^+$ )

Iron is a chemical element that is abundant in nature. Iron is highly soluble at acidic pH; the lower the pH, the easier iron oxidation. Acidic water that runs through soil releases iron, increasing the iron content in the water. Due to a lack of oxygen, groundwater iron content is frequently ferrous. However, at higher alkaline groundwater pH levels, the iron will be in the form of ferrous bicarbonate. The corrosion of the pipe system and the weathering process are both sources of iron in the water. Excess iron in the water will give it a rusty appearance and will affect the taste of the water.

#### 2.12.12 Nitrate ( $NO_3^-$ )

Nitrate is a byproduct of the nitrogen oxidation process. Nitrate accumulation in groundwater is caused by two types of sources: natural sources and anthropogenic sources. Natural sources of nitrate include soil mineralization and nitrogen in the atmosphere, whereas anthropogenic sources include industrial waste, intensive agriculture, and septic tanks (Noraziah Jamaluddin, 2013). Nitrate contamination in well water is a major concern because it poses a health risk to humans. Possible diseases include gastrointestinal illness, multiple digestive tract impairment, indigestion, and stomach inflammation.

#### 2.12.13 Sulphur ( $SO_4^{2-}$ )

Sulphur mineral element that reacts with oxygen. Sulphate is a naturally occurring mineral in both surface and groundwater. Rainwater can become a source of sulphate, especially in areas where there is a high concentration of sulphate in the atmosphere. Other sources of sulphate include industrial waste discharge and domestic sewage. Although sulphates are highly soluble in water, redox reactions can cause them to degrade into sulphur and hydrogen sulphide. Sulphate contamination of groundwater can have negative consequences such as scale build-up on pipe walls, water becoming bitter, and humans experiencing laxative effects.

#### 2.12.14 Chloride ( $Cl^-$ )

Chloride is found naturally in both freshwater and groundwater. Chloride concentrations are typically lower than those of sulphates and bicarbonates. However, the concentration rises if the water is contaminated by domestic waste discharge. A high chloride concentration can make water taste salty and cause a corrosive effect.

#### 2.12.15 Fluoride ( $F^-$ )

Fluoride is an anion formed when fluorine gains a negative charge. Fluoride ions make up 0.06 to 0.09 percent of the earth's crust. Fluoride concentrations in groundwater, on the other hand, can be relatively high or low depending on the rock type that contains fluoride-bearing minerals. Fluoride minerals are commonly found in igneous and sedimentary rocks. One of the very minor chemicals that has been shown to pose a health risk to humans through drinking water is fluoride anions. Fluoride in water, at low concentrations, can be very beneficial to teeth. However, high fluoride concentrations in drinking water can be harmful to humans.

#### 2.12.16 Bicarbonate ( $HCO_3^-$ )

The presence of bicarbonate ions in the water determines its alkalinity. Bicarbonate ions are formed during the dissolution of  $CO_2$  in water. Dissolved  $CO_2$  began to hydrate and form carbonic acid ( $H_2CO_3$ ), which was followed by the formation of bicarbonate ions. Surface and groundwater containing  $CO_2$  allow percolating water to dissolve calcite and carbonate minerals from rocks and soils. This contributes to an increase in the concentration of bicarbonate in the water. The presence of bicarbonate ions in water poses no health risk, but it can cause taste changes; at high concentrations of carbonates, water becomes salty.

## CHAPTER 3

### MATERIALS AND METHODS


#### 3.1 Introduction






Several approaches and materials are taken into consideration for the Kampung Panglima Bayu geological mapping and groundwater quality evaluation in order to fulfil the intended research project.

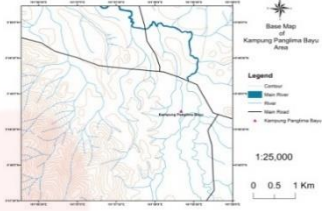

#### 3.2 Materials/ Equipment



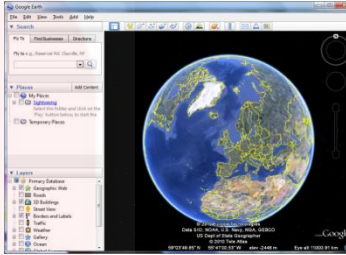


Materials are one of the key components utilised in conducting research. Several materials was utilised in the completion of this investigation which is given in Table 3.1.


**Table 3.1:** Materials/equipment to be for the research

Materials/Equipment	Use	Pictures
1) Hammer	Hammer was used to break and obtain samples from the outcrop.	

2) Measuring Tape	Measuring tape was used to measure the length and thickness of outcrops.	
3) Laptop	Laptop was used to look for information while processing data and writing the final thesis report.	
4) Stationary	Stationary such as a pen and notebook was commonly used to jot down crucial information that would subsequently be transferred to a laptop.	
5) Hydrochloric Acid	Hydrochloric acid are chemicals used to determine the type of rock present by examining the presence of calcium carbonate.	
6) Global Positioning System (GPS)	GPS was used to determine the location and elevation of the hills. Based on the satellites and the travel journey, the present location's coordinates were displayed.	

<p>7) Base Map</p>	<p>Basemap were used as a starting point for overlaying data from layers and visualising geographic data.</p>	
<p>8) Atomic absorption spectroscopy (AAS)</p>	<p>AAS are used to analyse and identify the principal cations and anions in a studied water sample.</p>	
<p>9) Multi parameter</p>	<p>Multi parameter was used to measure in-situ parameters like pH, temperature, Total Dissolved Solids (TDS) and electrical conductivity.</p>	
<p>10) Turbidity meter</p>	<p>Turbidity metre was used to determine the value of turbidity content in the samples water</p>	
<p>11) Spectrophotometers</p>	<p>Spectrophotometers assessing the electromagnetic spectrum's ultraviolet and visible light absorption</p>	

<p>12) Aluminium foil</p>	<p>Aluminium foil was used as an insulator because the barrier can keep the water at a constant temperature without changing its chemical composition.</p>	 <p>Heavy-duty Aluminum Foil Grease-proof, water-proof, heat-resistant</p>
<p>13) Plastic sample Polyethylene and Bottles</p>	<p>Plastic bag and Polyethylene sample bottles was used to collect rock and water samples from the outcrop and well.</p>	
<p>14) Google Earth software</p>	<p>Google Earth Software was widely used to monitor and recognise the image of Earth landscapes in 2D and 3D based on satellite imagery.</p>	
<p>15) ArcGIS 10.3 software</p>	<p>This software allows us to create several geological maps on the study area, such as topography, drainage, and land use.</p>	 <p><b>ArcGIS</b></p>
<p>16) Surfer 16 software</p>	<p>To create a 2D and 3D graphic that depicts all the factors that go into determining the vulnerability of groundwater resources.</p>	 <p><b>Surfer</b></p>

17) Microscope	This equipment was used in petrography thin section to identify the rock or mineral sample	
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### 3.3 Methods

Several methods for conducting geological mapping and groundwater quality analysis was used. The flow of the research study can be seen in the flow chart in figure 3.1.

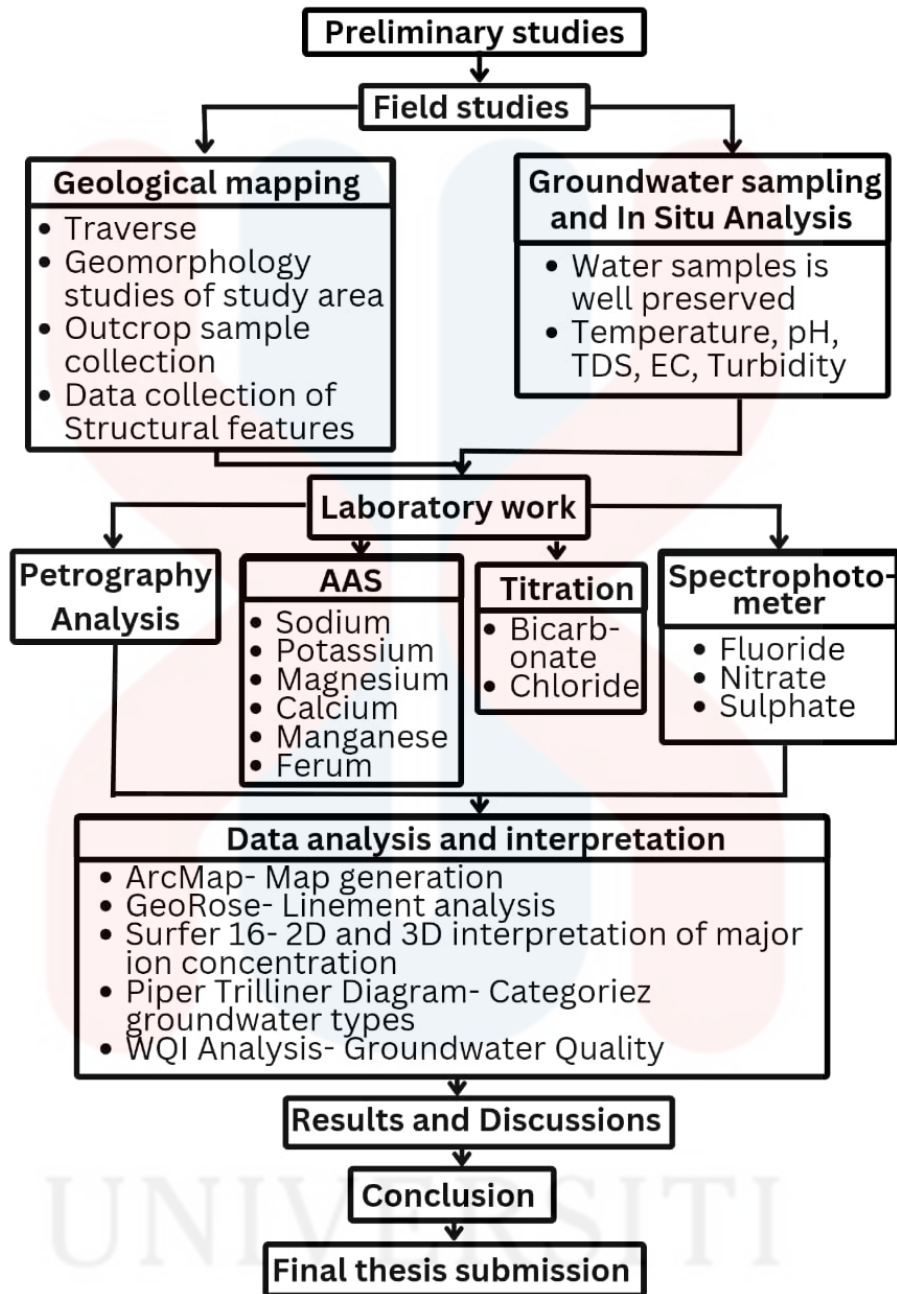


Figure 3.1: Flowchart of methodology

### 3.3.1 Preliminary studies

The preliminary investigation in this study was carried out by looking at previous studies on groundwater quality and the preceding case study was employed as a reference. It was carried out to investigate the geologic setting of the area based on its morphology, structural geology, and characteristics. Studies using Google Maps and Base Maps was also help reveal a clear picture of the geological phenomenon and its characteristics. Additionally, a preliminary investigation was conducted to determine the study area's accessibility, the presence of a groundwater well for groundwater quality analysis, and an outcrop for sampling in order to create a lithological map and better understand the type of lithology present in the chosen research region.

### 3.3.2 Field studies

Field studies include geological mapping and groundwater analysis. Furthermore, secondary data was gathered to support the analysis and interpretation of data. The Mineral & Geosciences Department of Kelantan, the Mineral & Geosciences Department of Ipoh, the Air Kelantan Office, and other relevant sources were also used to gather the secondary data. Likewise, fieldwork instruments and equipment was in good working order to prevent breakdowns later on or while doing field studies.

#### 3.3.3.1 Geological mapping

The geological mapping was done regularly throughout the FYP study. Completing the traverse in the Tanah Merah town area took two to three weeks. Additionally, an outcrop was obtained for petrography analyses. The following observations were photographed and marked in GPS, including outcrops, geomorphology, and landforms. Geological contact was established in order to analyse

an outcrop, which required obtaining measurements around the research region, including the outcrop's coordinates, structural lineament, strike and dip, and other measurements.

### 3.3.3.2 Groundwater sampling and In Situ Analysis

For accurate sampling and analysis of the water quality, there should be enough groundwater. In-situ analysis used was multiparameter probes, and portable Turbidimeters to record EC, Turbidity, TDS, temperature, and pH. These physical criteria need to be taken on the spot because it easily changes in respond to the environment changes. Groundwater samples was collected in polyethylene bottle, then covered with aluminium foil and put in a cool box for preservation. This process was necessary to preserve the water sample from unnecessary contaminants before going to the laboratory.



**Figure 3.2:** Water sample wells around Kampung Panglima Baru utilised 2100P portable turbidity metre to record the turbidity.



**Figure 3.3:** Water sample wells around Kampung Panglima Baru utilised YSI 556 MPS Multi-parameter instrument to record in-situ parameters.

### 3.3.3 Laboratory Work

The study of the origin, content, distribution, and structure of rock was done by petrography analysis, and mineralogical examination, which together make up the field of petrology (Boggs, 2009).

The sample was taken from domestic wells and was analysed in the laboratory. The concentrations of the major cations, including calcium ( $\text{Ca}^{2+}$ ), magnesium ( $\text{Mg}^{2+}$ ), sodium ( $\text{Na}^+$ ), iron ( $\text{Fe}^+$ ), manganese ( $\text{Mn}^{2+}$ ) and potassium ( $\text{K}^+$ ), was determined in the laboratory using an atomic absorption spectrophotometer (AAS). Spectrophotometer and titration methods was used to determine the concentrations of sulphate, chloride and bicarbonate, nitrate, and fluoride ions, respectively (Mathialagan, K. R. P, 2021).

**Table 3.2:** Method Classification for physicochemical analysis

<b>Method</b>	<b>Measured parameters</b>
Atomic absorption Spectroscopy (AAS)	Calcium, Magnesium, Iron, Potassium, Sodium, Manganese
Titration	Bicarbonate, Chloride
Spectrophotometers	Fluoride, Nitrate, Sulphate

### 3.3.3.1 Petrography Analysis

The outcrop sample taken from the study area will then be processed into thin section for the petrography analysis. Petrography analysis involves examining thin sections under a microscope (Winter, 2001). The texture, distribution, composition, and tiny scale structure are seen and analysed in petrography studies. According to Heffaran and O'Brien (2010), a light transmitting microscope is primarily used to investigate the optical characteristics of rocks, minerals, and other earth materials. Polarizing plates, filters, and a conoscopic lens are distinctive elements of the petrography microscope that are used to assess a variety of crystallographic properties (Blatt, 2005).

### 3.3.3.2 Atomic absorption Spectroscopy (AAS)

The AAS machine will be used in the laboratory as this method necessitate the initial filtering of the sample. Otherwise, the sample liquid introduced into the flame chamber via a small size pipe may become clogged. AAS machines are unable to read higher reading ranges. To dilute the sample, distilled water in the proper ratio was

required. The concentration of a particular element in a sample was proportional to the amount of light absorbed.



**Figure 3.4:** The AAS PinAAcle 900F instrument used to analyse major cation concentration

### 3.3.3.3 Titration

Acidity and alkalinity determination entails titrating a sample with strong acid or strong alkali to determine the amount of acid required to reach the inflection points. Either read off the inflection point pH and note the corresponding acid volume or use a graphic method to determine the inflection point. The end point was determined using an indicator that depicts pH changes.



**Figure 3.5:** Titration method used to determine bicarbonate and chloride ions in water samples around Kampung Panglima Bayu.

a) Bicarbonates

The total alkalinity of the water sample may be measured more precisely and at a lower cost using the titration method. The ability of water to neutralise a strong acid was assessed by total alkalinity titration.

Strong acid was used to titrate the sample, which was placed in an Erlenmeyer flask with 100 ml of previously prepared material. The sample was initially given two drops of phenolphthalein indicator. There are noticeable colour variations. There are two options for colour changes: either the sample colour stays colourless or it turns pink. According to the examination, none of the samples displayed any colour changes, which rule out the existence of hydroxyl ions and carbonate ions.

The same sample was then added along with two drops of methyl orange, and the solution was titrated with 0.1 HCl until a light pink colour appears. To guarantee the accuracy of the titration, the end point of the HCl that was used was noted, and the sample was titrated three times for each sample. The concentration and formulas used for bicarbonate ion is given in Appendix B.

#### b) Chloride

Silver nitrate solution was utilised in the chloride titration to react with the chloride, producing a small white precipitate of AgCl. Following the complete precipitation of the chloride, the free silver ions will react with the chromate to produce reddish-brown silver chromate.

In order to conduct the titration, 50 ml of prepared water sample was placed in an Erlenmeyer flask, and 2 ml of  $K_2CrO_4$  was added to the solution. The solution was then titrated against 0.02 N of used  $AgNO_3$ , and the results are recorded. For each sample, the titration was performed three times to assure accuracy. The concentration and calculation of chlorine ion is given in Appendix B.

#### 3.3.3.4 Spectrophotometer

A spectrophotometer is an instrument that measures the number of photons (the intensity of light) absorbed after it passes through sample solution. With the spectrophotometer, the amount of a known chemical substance (concentrations) can also be determined by measuring the intensity of light detected. The spectrophotometer was used to measure the concentrations of Fluoride, Nitrate, Sulphate in groundwater samples.



**Figure 3.6:** The Spectrophotometer DR6000 instrument used to analyse major anion concentration

#### 3.3.4 Data Analysis and Interpretation

To evaluate the data collected in the study region, secondary data was utilised to correlate the data then uploaded to ArcGIS 10.3 and Corel Draw x5 that helped monitor and measure the major section of this report. ArcGIS 10.3 was then used to create maps such as the topographic maps, drainage patterns map, geomorphological map, and geology map to guarantee that the information on the field of study is correct and accurate before it was produced. The linkages, patterns, and trends of the field was then understood to do data analysis and interpretation. Geomapping field data was analysed using GIS software to create a desired geological map and highlight groundwater samples. GeoRose software analyses will be used to interpret the lineament of the region.

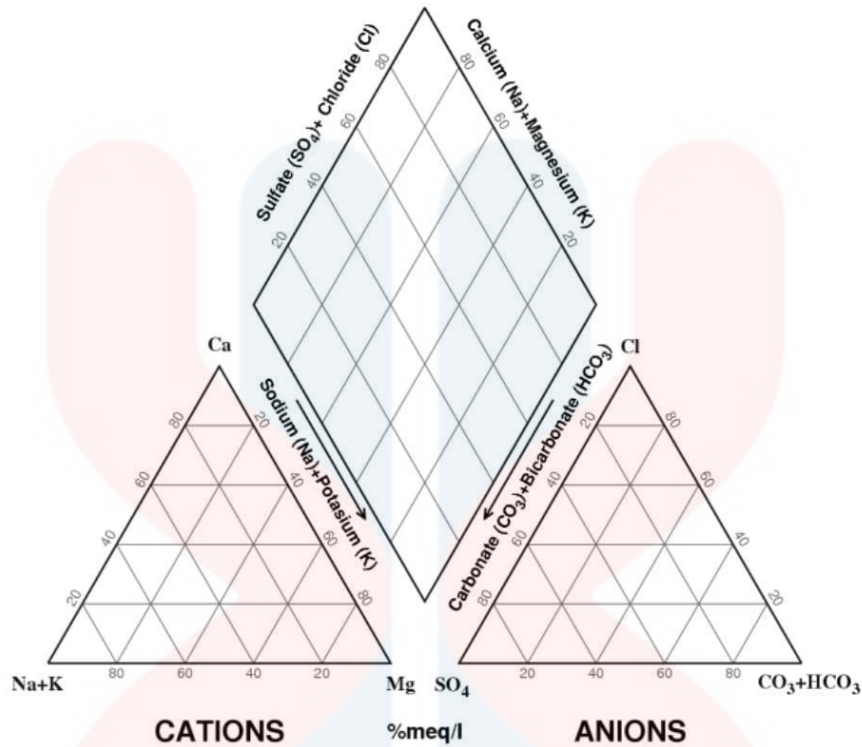
The data from groundwater sampling was then compared to the MoHM and WHO values to determine whether the elements value in the water samples are in a safe limit for domestic use.

The Water Quality Index (WQI) was used to determine the overall water quality at Tanah Merah and the groundwater's sensitivity to any potential sources of contamination. Water Quality Index (WQI) is an interpretive approach that uses physicochemical parameters to estimate the overall quality of groundwater. WQI was calculated using the value of the physicochemical parameter. The WQI was calculated in a few steps, beginning with the parameter weightage calculation ( $W_i$ ), followed by the computation of water quality rating ( $q_i$ ) for each of the water quality parameters, and finally the sum of these sub-indices in the overall index (Sirajudeen & R, 2014). The WQI calculation is given in Appendix D.

The WQI calculation result was then used to determine the groundwater quality status. The number range represents the quality of the groundwater from very good, good, poor, and very poor, with values ranging from 0 to 75. Given in Appendix D, the table provided shows the water status based on the WQI number range. When the WQI result reaches the extremely poor level, it indicates that the groundwater is unfit for drinking.

In addition, Microsoft Excel was used to create graphs and charts for the understanding and interpretation of this research. The data will be converted into percentage form and plotted using a piper trilinear diagram for determination of elements.

The Piper Trilinear Diagram is a graphical representation of the type of water facies. This method aids in the interpretation of water chemistry using the fundamentals of cations and anions. Piper diagram is a mixture of cations and anions triangles with a diamond shape in between. Figure 3.3 is an illustration of a Piper-Trilinear diagram. Calculation used for plotting Piper-Trilinear diagram is given in Appendix C.



**Figure 3.7:** Piper Trilinear Diagram

Source: <http://pubs.sciepub.com/ajwr/6/5/1/figure/2> (last accessed on Nov 2022)

Lastly, Surfer 16 was used to create a 2D and 3D graphic that depicts all the factors that were used to assess the vulnerability of groundwater resources to pollution. This software was useful as it quantifies several hydrogeologic parameters that determine the potential of pollution to transport through soil and seep into an aquifer.

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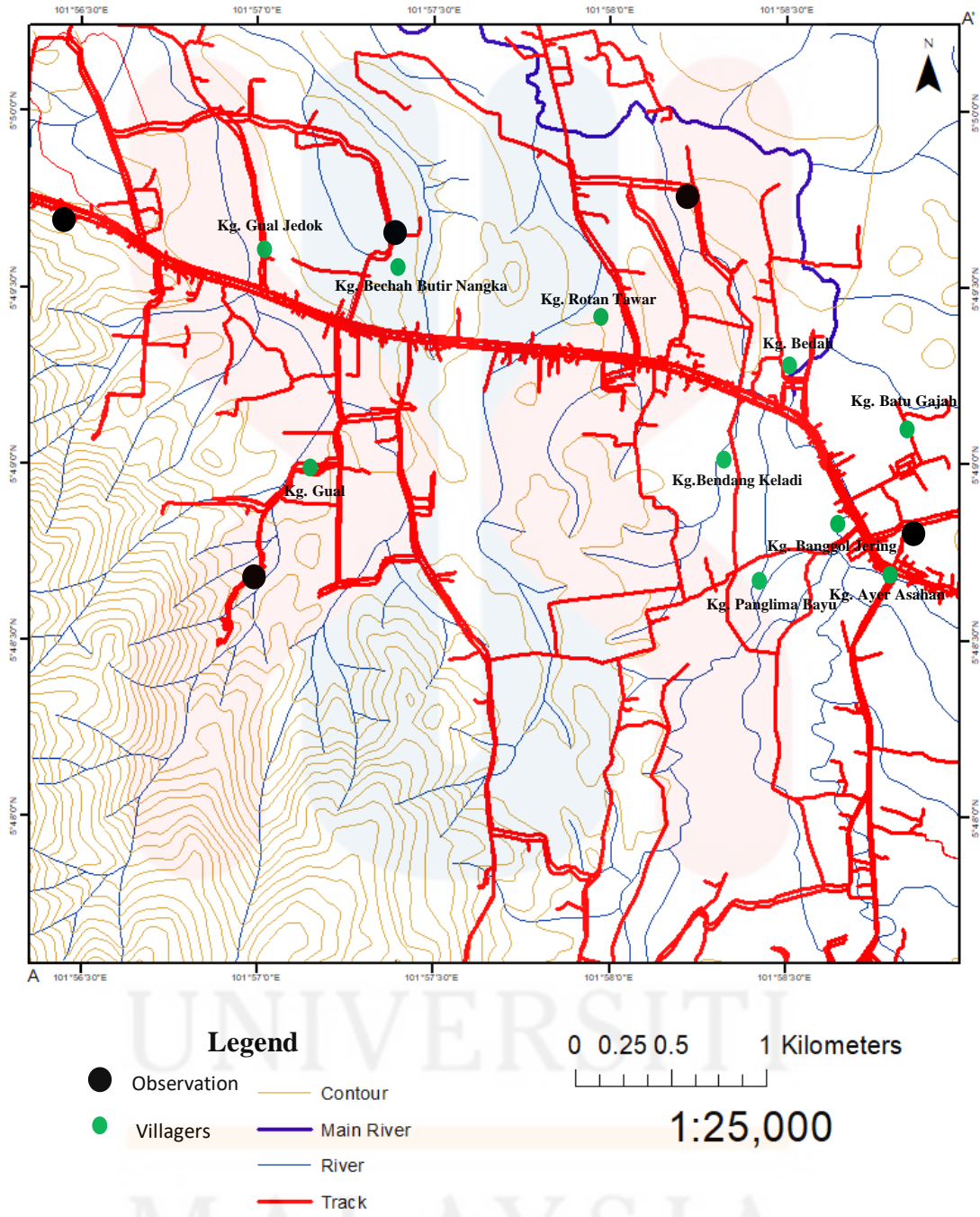
## CHAPTER 4

### GENERAL GEOLOGY

#### 4.1 Introduction

The primary geological concepts covered in this chapter include geomorphology, structural geology, and historical geology. Geomorphology covered the processes that led to the formation of the landforms in the research area, including weathering and erosion. Three types of weathering exist: physical, biological, and chemical weathering. Figure 4.1 shows traverse map marked with observation points that was made throughout geological mapping. There are 9 villagers around Kampung Panglima Bayu in the study area which is shown in Figure 4.1

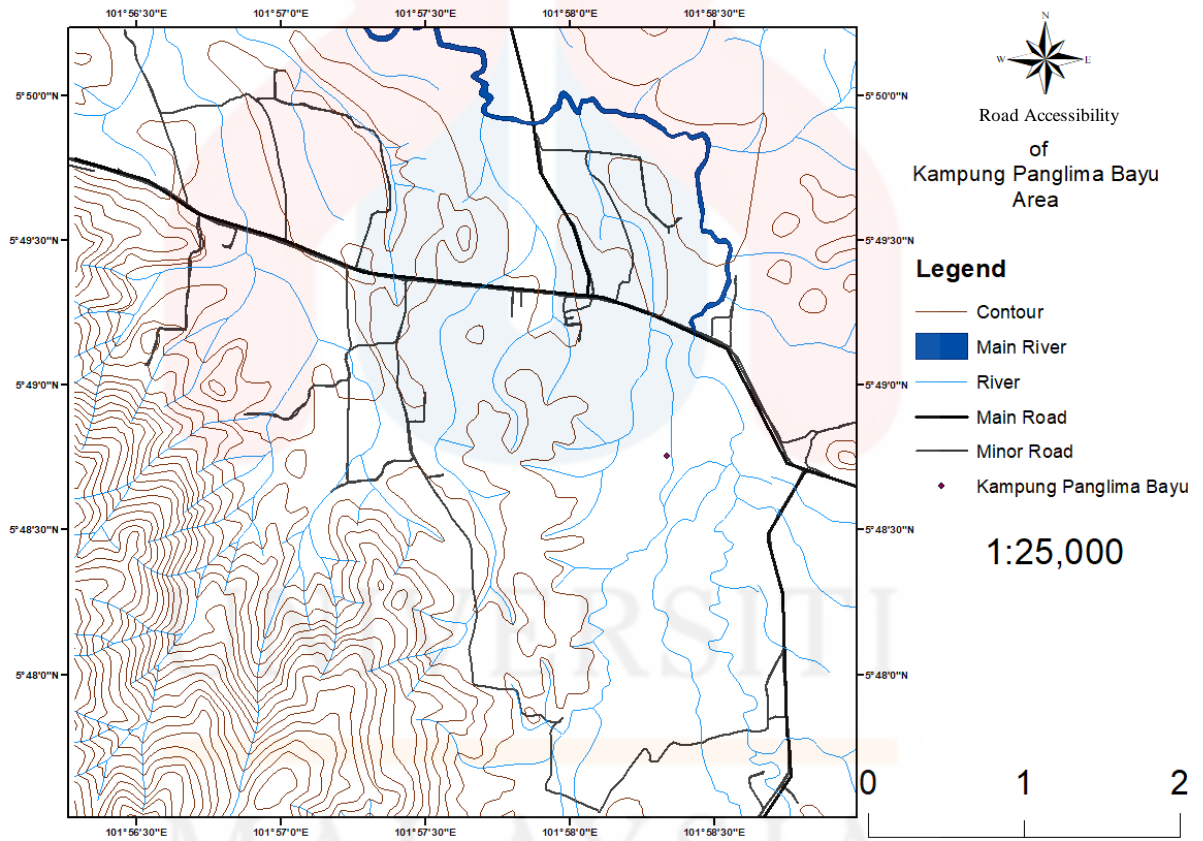
### Traverse map around Kampung Panglima Bayu



**Figure 4.1:** Traverse map around Kampung Panglima Bayu  
Source: Generated from ArcGIS 2022

#### 4.1.1 Accessibility

Most of the roads, whether main or secondary, are well paved. However, several villages and plantations located far from the town have unpaved roads. This was since the communities are small and located in a rural area, respectively. Additionally, the plantation region is situated and includes oil palm and rubber plantations that are too deep, with only sand roads accessible for connectivity, allowing only motorcycles and extreme vehicles to travel through. Figure 4.1 shows Road accessibility in the study area.



**Figure 4.2:** Road accessibility map around Kampung Panglima Bayu  
 Source: Generated from ArcGIS 2022

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## 4.2 Geomorphology

This research area's geomorphology is made up of topography, drainage, weathering, and erosion. The study of landforms' origin, evolution, form, processes, and deposits at the Earth's surface is known as geomorphology. By examining landscapes created by the fusion of landforms like hills, valleys, caves, sand dunes, etc., researchers can better understand how the earth's surface behaves. The Earth's surface changed because of all physical, chemical, and biological processes, forming landscapes.

These processes often progress slowly, but occasionally they drastically alter the environment and even put people's lives in danger because geological hazards like landslides, earthquakes, tsunamis, floods, and volcanic eruptions can occur at any time. The three types of geomorphological processes are exogenic, endogenic, and extraterrestrial. Water, wind, and glaciers are the key geomorphological factors that affect the process.

The exogenic processes that alter the landform of the Earth's surface include weathering and erosion. At the Earth's surface, weathering is the process through which rocks, soils, and minerals deteriorate and disintegrate by physical, chemical, or biological processes (Thompson & Turk, 1997). By erosive forces like flowing water, wind, glaciers, and gravity, erosion is the removal of exposed worn rocks, minerals, and soils (Thompson & Turk, 1997). The eroded materials, also known as sediment, are then transported by these same agents from their point of origin to specific locations where the sediment is deposited.

#### 4.2.1 Geomorphologic classification

In the research region, physical, biological, and chemical weathering observations from field mapping have been found. Physical weathering, which is triggered by temperature changes on the rocks and occasionally helped by water, leads in the breaking up of large boulders into smaller ones without modifying the chemical makeup or minerals of the rock. The process of weakening and subsequent rock disintegration brought on by either plants, animals, or bacteria is referred to as biological weathering, also known as organic activity. Chemical weathering is a chemical process between air, water, and rock that modifies the mineral content and composition of the rock.

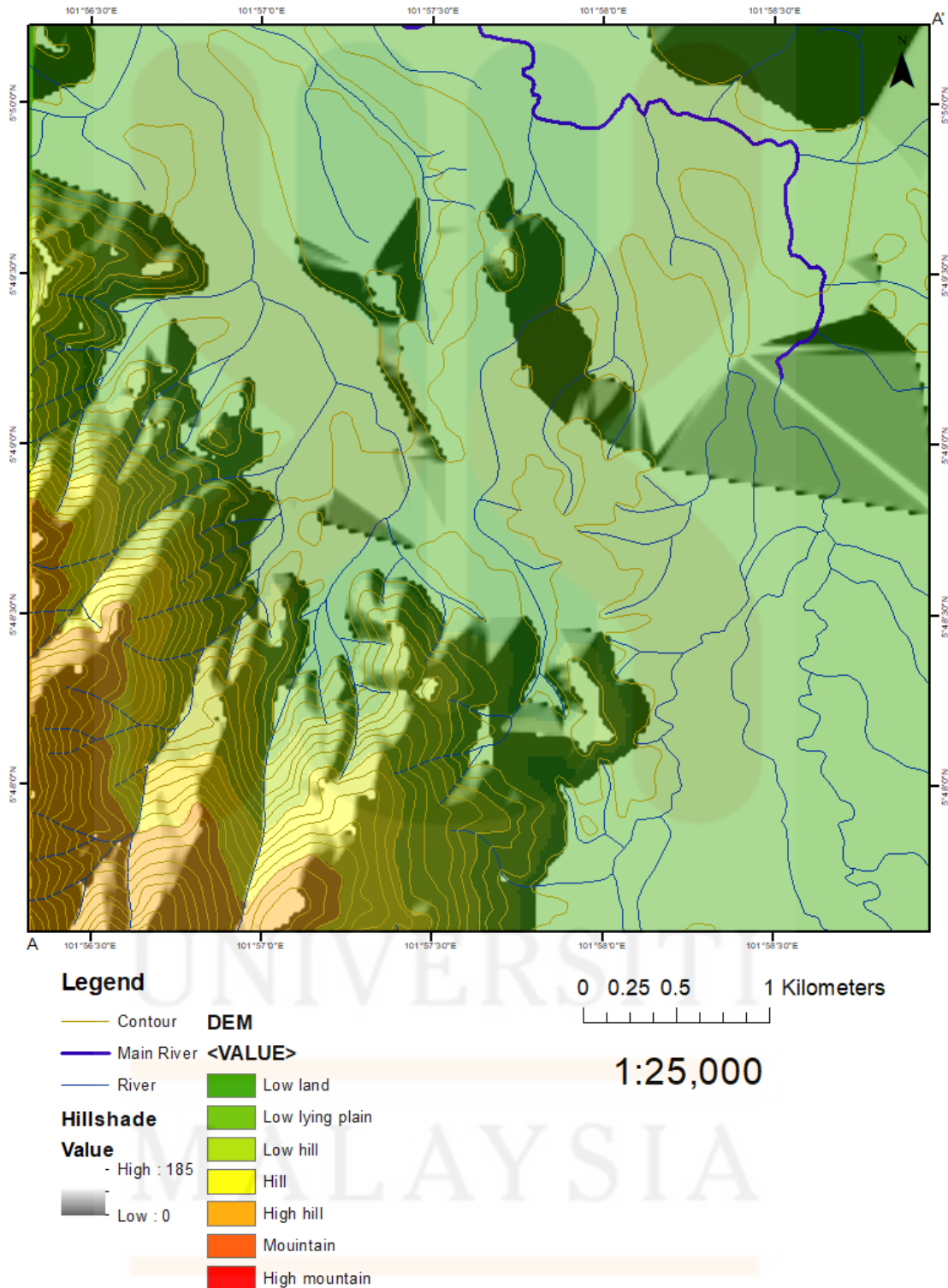
The Earth's surface has diverse gradations in part because its crust is made up of a variety of rocks and structural types, making it resistant to various geomorphological processes. Except in recent catastrophe areas where it can be assumed that the region with a high topographic position is formed of hard rock, while the region with a lower topographic position is composed of soft rocks, a very little variation of geomorphological processes nevertheless has a very important meaning. The variety in geomorphology and regional topography was reflected in the variations in rock composition and structure.

Since sea levels are locations with no height, the elevation difference is often calculated from the sea surface. Knowing the difference in elevation is essential for describing the morphology and morphogenetic history of a landform, such as a hill, a mountain, or a plain. Based on Van Zuidam's (1985) research on the connections between elevational differences and morphographical features in Table 4.1, a elevation map is shown in Figure 4.3.

Table 4.1: Relations between the absolute elevations with the morphology elements  
(Van Zuidam, 1985)

<b>Absolute Elevation</b>	<b>Morphology Elements</b>
< 50 metres	Low Land
50 – 100 metres	Low Lying Plain
100 – 200 metres	Low Hill
200 – 500 metres	Hill
500 – 1500 metres	High Hill
1500 – 3000 metres	Mountain
> 3000 metres	High Mountain

### Elevation map around Kampung Panglima Bayu area



**Figure 4.3:** Elevation map around Kampung Panglima Bayu area  
 Source: Generated from ArcGIS 2022

## 4.2.2 Weathering

### a) Physical Weathering

The study area exhibits physical weathering that has been classified as pressure-release weathering, as seen in Figure 4.4. At a depth of between 5 and 20 kilometres during the Triassic, where pressure from the weight of the overlying rocks is hundreds of times greater than at the Earth's surface, the granitic pluton forms from the intruded magma. The batholith was formed over a lengthy period when tectonic forces raised the pluton as the pressure decreased and the surrounding rock eroded away. As the pressure decreased, the rock expanded but fractured since it was now cool and brittle. Igneous rocks frequently experience this type of weathering, notably granitic plutons.



**Figure 4.4:** Physical Weathering on Rock

### b) Biological Weathering

The biological weathering depicted in the illustration is another type of weathering affecting the rock formation. Figure 4.5 depicts a fracture in the rock that allowed a seed to fall into it and sprout because dirt had gathered there. The roots gradually force the rock apart as they spread out and move deeper into the gap as the plant grows.



**Figure 4.5:** Biological Weathering on Rock

### c) Chemical Weathering

One of the most crucial aspects of chemical weathering is chemical oxidation. It describes how metal elements found in rocks, such as iron, copper, lead, and zinc, react with oxygen. Rusting, a common manifestation of oxidation reaction, is one example. Rock tends to turn reddish-brown when iron and oxygen interact. Figure 4.6 depicts an outcrop that has rusted because of oxidation. The rock's lithology cannot be determined because of its extensive weathering.



**Figure 4.6:** Chemical Weathering on Rock

#### 4.2.3 Drainage pattern

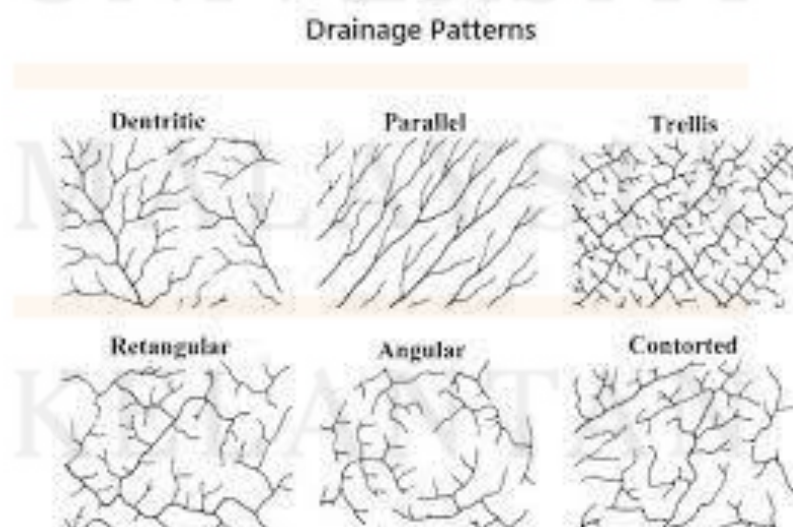
A drainage pattern is a specific drainage basin's network of streams, rivers, and lakes. They are controlled by the geography of the ground, the gradient of the land, and whether a particular region is dominated by hard or soft rocks. Streams are frequently considered to be a component of drainage basins. The regions of land that river system drains are known as drainage basins. Numerous processes, including precipitation, snowmelt, and sediments, provide them with their inputs. Evaporation, deposition, and stream flow are the main ways that drainage basins lose water and sediments. In a drainage basin, a multitude of variables, such as topography, soil type, bedrock type, climate, and vegetation cover, affect the input, outflow, and transit of sediments and water.

The topographical area from which runoff, through flow, and groundwater flow into a stream are received is known as a drainage basin. Watersheds are topographic

barriers that separate drainage basins from one another. Every stream tributary that empties into a particular spot along a stream channel is represented by a watershed. The number, size, and shape of the drainage basins that can be found in a region varies, and the topographic map's scale affects how much information is available about the drainage basin.

Where there is a preponderance of eroding rock type and structure, drainages frequently form. As a result, several kinds of drainage patterns emerge in a location, and these drainage patterns mirror the rock structure. Drainage classification frequently includes categorising channel patterns like straight type, meandering type, and braided type. Other factors like grain size, sediment load, riparian vegetation, channel roughness, width, and depth frequently have an impact on the channel pattern (Dr.Montgomery, 2013).

There are three different types of drainage patterns, such as dendritic, rectangular, and parallel, that govern the amount of drainage in the area, which is an interesting feature of the drainage pattern found in the research area in figure 4.10 as the drainage varies from North to South. Figure 4.10 illustrates how the South River's drainage patterns vary from those that originate in the North River.



**Figure 4.7:** Types of drainage pattern (Hutchison, 2009)

Where the river channel follows the terrain's slope, a dendritic pattern forms. In this system, the streams cross each other in a distinctive V-pattern as viewed from a map. The V's downstream-facing tip has the appearance of a tree with several branches. This pattern was created by the layering of homogenous, weather-resistant crystalline rocks or relatively flat sedimentary rocks. The watershed is located in a region with moderate slopes and a drainage plan that creates branches that stretch out like a shady tree.

Where there is a clear slope to the surface, a parallel drainage pattern develops in the meantime. In areas with parallel, elongate landforms, such as outcropping resistant rock bands, a parallel pattern also emerges. In general, tributary streams follow the slope of the surface by spreading out in a parallel-like pattern. Sometimes a parallel suggests the presence of a significant fault that traverses a region of highly folded bedrock..

The next drainage pattern is rectangular. It happens when a rock formation directs streams to run parallel to one another, with tributaries connecting at almost a right angle. Although the pattern is less apparent, this drainage is comparable to the trellised drainage. These can be discovered in areas that have experienced faulting.



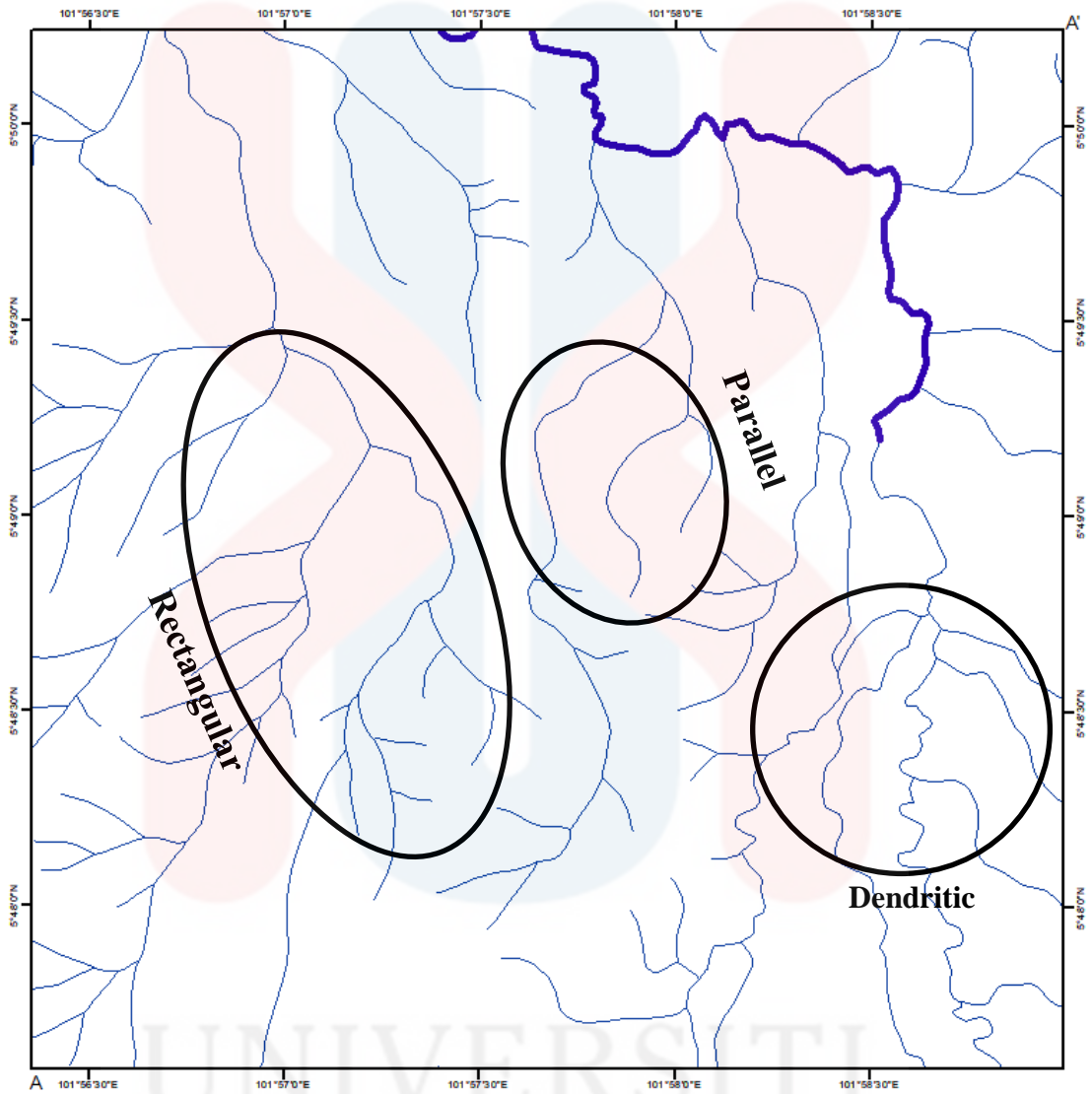
**Figure 4.8:** Waterfall in study area



**Figure 4.9:** River in study area close to sample well 4

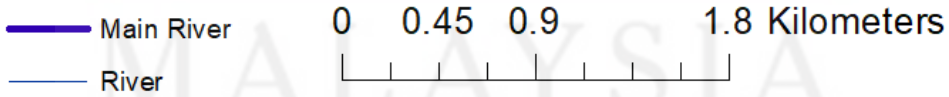
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### Drainage map around Kampung Panglima Bayu



**Legend**

1:25,000

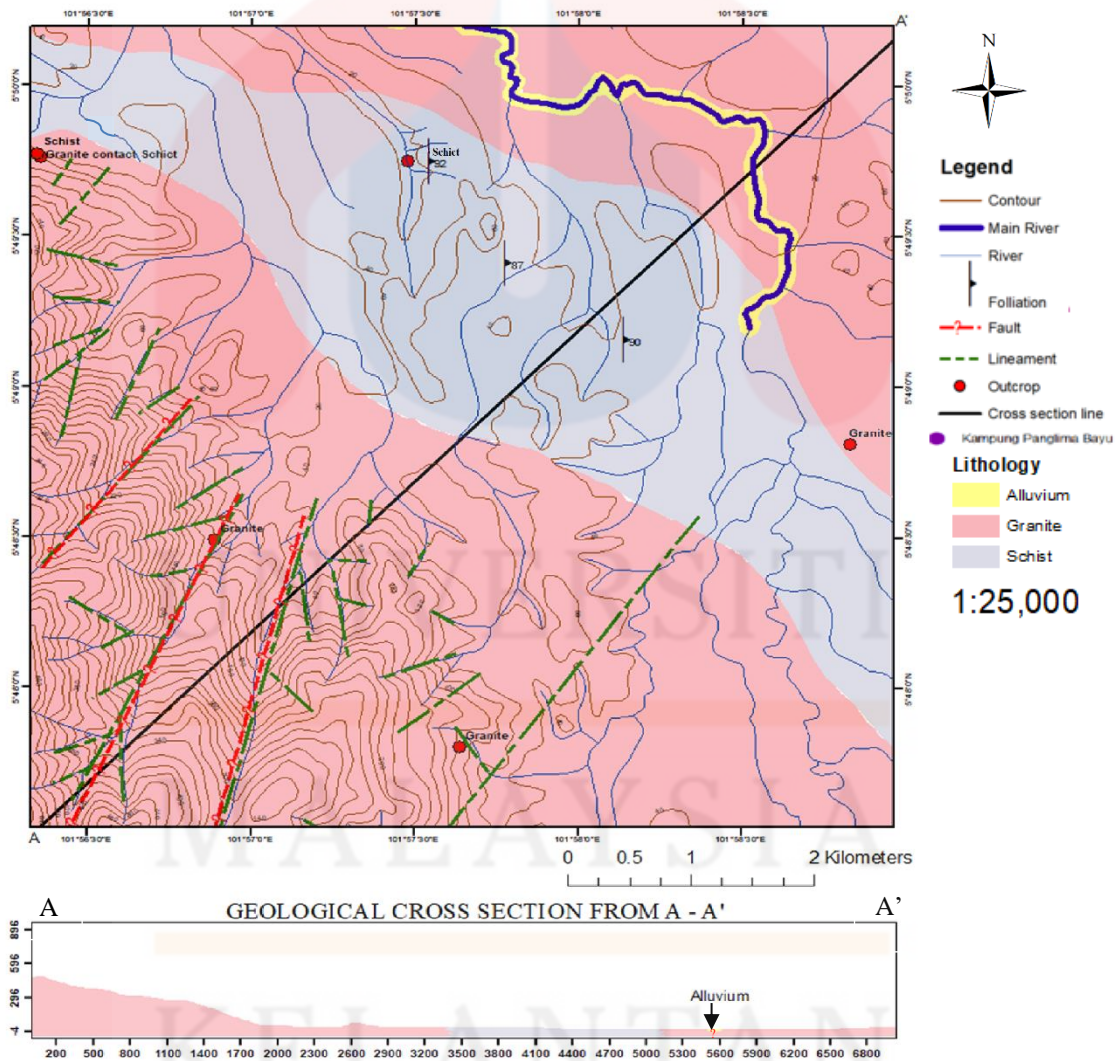


**Figure 4.10:** Drainage map around Kampung Panglima Bayu  
Source: Generated from ArcGIS 2022

### 4.3 Lithostratigraphy

Geological lithostratigraphy is the study of rock layers and how they are interpreted in terms of the geological time scale. By connecting the rock successions with geological occurrences and processes, it establishes a framework for historical geology. Based on the physical properties of the rocks and the changes in the environment over time, it is possible to infer the historical habitats of a region. Based on figure 4.11 there are three major fault line that can be determined through landforms and lineament.

#### Geological Map around Kampung Panglima Bayu



**Figure 4.11:** Geological map around Kampung Panglima Bayu  
Source: Generated from ArcGIS 2022

### 4.3.1 Stratigraphy

A subset of stratigraphy known as lithologic stratigraphy or lithostratigraphy examines the relationships between rock units using information about their lithology (rock type), physical qualities, and petrographic features. Schist, granite, and alluvium are the three lithostratigraphic units that can be found in the research region, as depicted in Figure 4.13. A representation of the vertical positioning of rock units in a certain area is called a stratigraphic column. Schist, granite, and alluvium are three separate lithologic units found in the Kampung Panglima Bayu area, according to a stratigraphic column depicted in Figure 4.12. According to Khoo and Lim (1983), the Taku Schist is Permian Triassic in age, but the Kemahang Granite is thought to have been encroached upon during the Cretaceous (Hutchison, 2009). In the rivers close to the research region, there is an abundance of alluvium, which is a deposit of clay, silt, and sand. It is thought to have been deposited during the Quaternary period.

#### a) Schist

Schist, a medium grade metamorphic rock, can be found throughout the study area, but is most prevalent in the area's northwest. The Taku Schist body is represented by the schist outcrop that was discovered in the study region. The name Sungai Taku, which is a river in eastern Kelantan, serves as the inspiration for Taku Schist. A field sample of rock reveals that it is foliated, light grey in colour, and has grains that range from medium to coarse.

#### b) Granite

Most of the study area is covered in granite, with the northwest region being the lone exception. Due to its high silica concentration, granite is a type of igneous rock that

is bright in colour. It is made of acidic magma composition that exists beneath the surface of the Earth. The granite rocks in the research region are a part of the Kemahang granite, one of the granitic bodies in peninsular Malaysia's eastern strip. The age of this granitic mass is a subject of considerable debate. According to information gathered during fieldwork, the rock sample taken has a light grey colour and a roughness ranging from medium to coarse grain. The majority of the discovered rocks have plagioclase feldspar megacrysts that can reach a diameter of 3 cm.

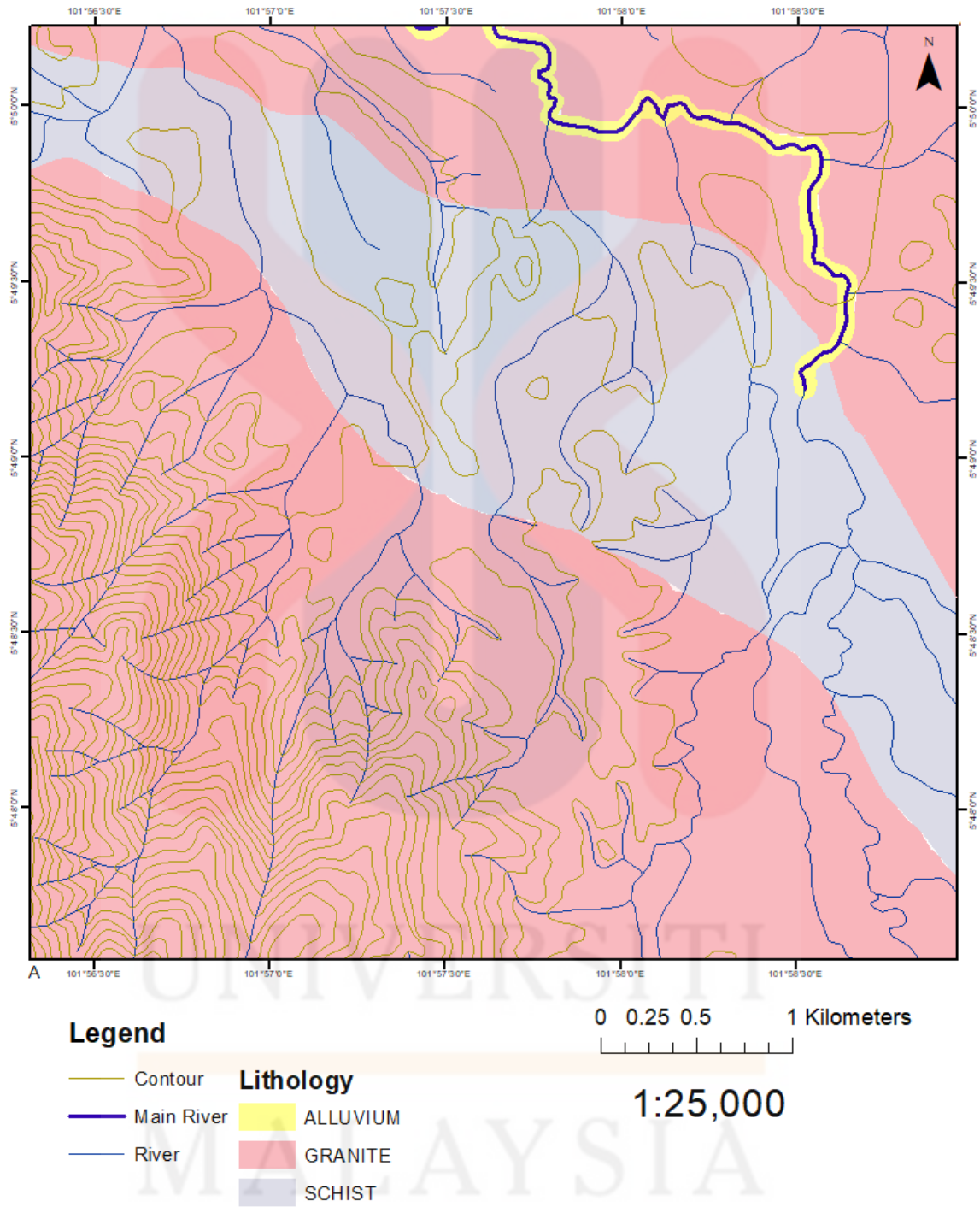
c) Alluvium

Alluvium deposits can be found along the stream channels in the low, flat area. These deposits are primarily poorly sorted sands, gravels, and boulders. Fine sands, silts, and clay are found in the lower reaches of stream channels whereas coarse sands and gravel are found in the upper reaches. Small rock fragments and sediments that had been subjected to early weathering and erosion processes before being carried downstream by river flows made up the majority of alluvial deposits. The finer particles in these sediments settle out on top of the larger ones to form well-sorted deposits. These sediments are deposited starting from the largest particles when the current slows down to the finest particles when the water stops.

EON	ERA	PERIOD	LITHOLOGY	
Phanerozoic	Cenozoic	Quaternary	Alluvium	
	Mesozoic	Cretaceous	Granite	
		Triassic	Schist	
	Paleozoic	Permian		

**Figure 4.12:** A Stratigraphic Column around Kampung Panglima Bayu

### Lithology Map around Kampung Panglima Bayu



**Figure 4.13:** Lithology Map around Kampung Panglima Bayu  
 Source: Generated from ArcGIS 2022

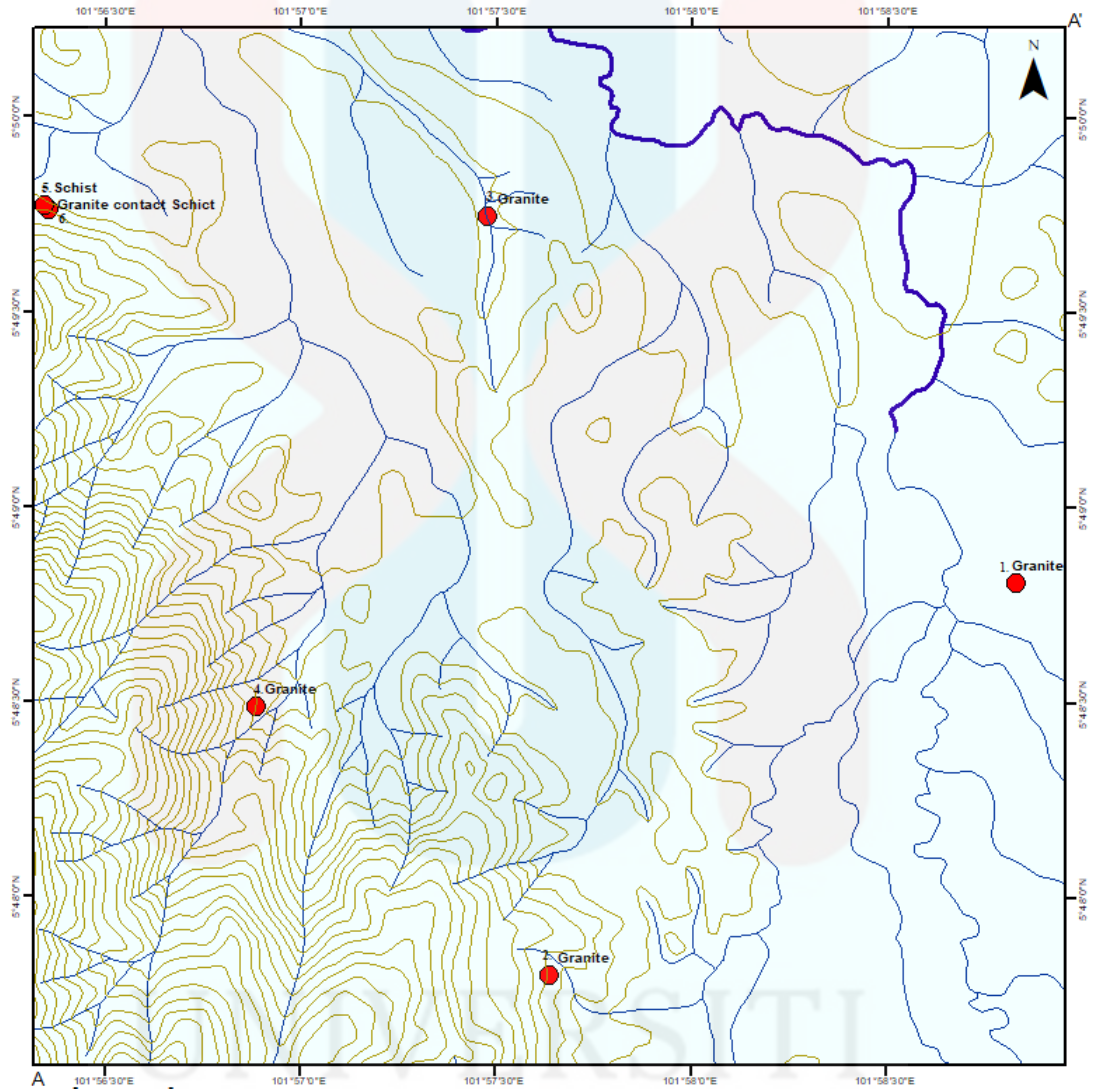
#### 4.4 Petrography

Granite and schist, two different types of rocks, have each been examined in this study. Thus, the samples are subjected to a thorough examination. Six samples in total have been subjected to petrographic analysis. The feldspar, quartz, and biotite included in the rock indicate that it is an acidic kind of igneous rock. It can be classified as an acid intrusive igneous rock based on its texture. The rock's mineral makeup established that it is granite.

**Table 4.2:** Sampling location of outcrop in study area

<b>Samples</b>	<b>Location</b>
Sample 1 (Granite)	5°48'48.50"N, 101°58'49.90"E
Sample 2 (Granite)	5°47'48.00"N, 101°57'38.20"E
Sample 3 (Granite)	5°49'44.85"N, 101°57'28.59"E
Sample 4 (Granite)	5°48'29.30"N, 101°56'53.10"E
Sample 5 (Schist)	5°49'46.38"N, 101°56'20.40"E
Sample 6 (Granite contact with Schist)	5°49'45.65"N, 101°56'21.03"E

## Sampling location map for petrography analysis around Kampung Panglima Bayu



**Legend**

- Contour
- Main River
- River
- Outcrop
- Acid intrusives (undifferentiated)

0 0.25 0.5 1 Kilometers

1:25,000

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4.4.1 Petrographic analysis

Sample 1



Figure 4.15: Outcrop, Hand specimen and Thin section for Granite Sample 1

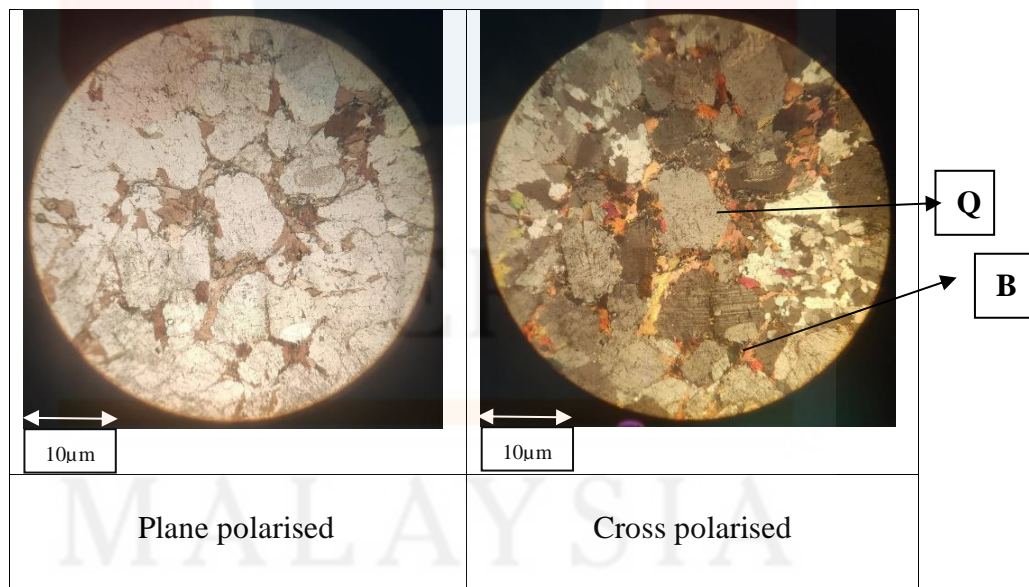


Figure 4.16: Microscopic view of Granite Sample 1

Sample 2



Figure 4.17: Outcrop, Hand specimen and Thin section for Granite Sample 2

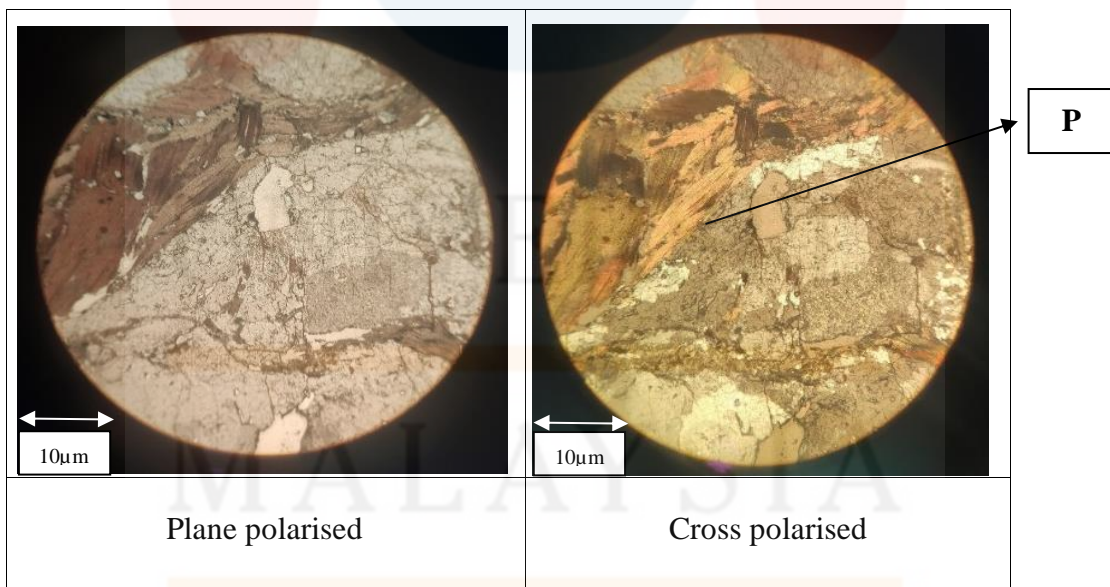


Figure 4.18: Microscopic view of Granite Sample 2

Sample 3



**Figure 4.19:** Outcrop, Hand specimen and Thin section for Granite Sample 3



**Figure 4.20:** Microscopic view of Granite Sample 3

Sample 4



Figure 4.21: Outcrop, Hand specimen and Thin section for Granite Sample 4

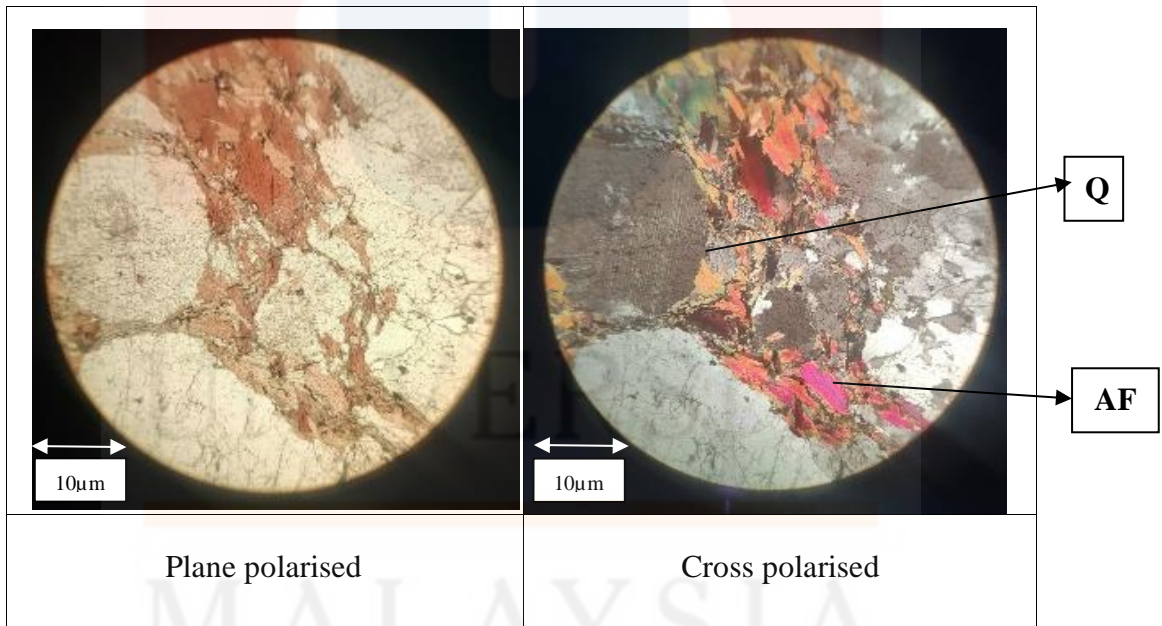


Figure 4.22: : Microscopic view of Granite Sample 4

Sample 5



Figure 4.23: Outcrop, Hand specimen and Thin section for Schist Sample 5

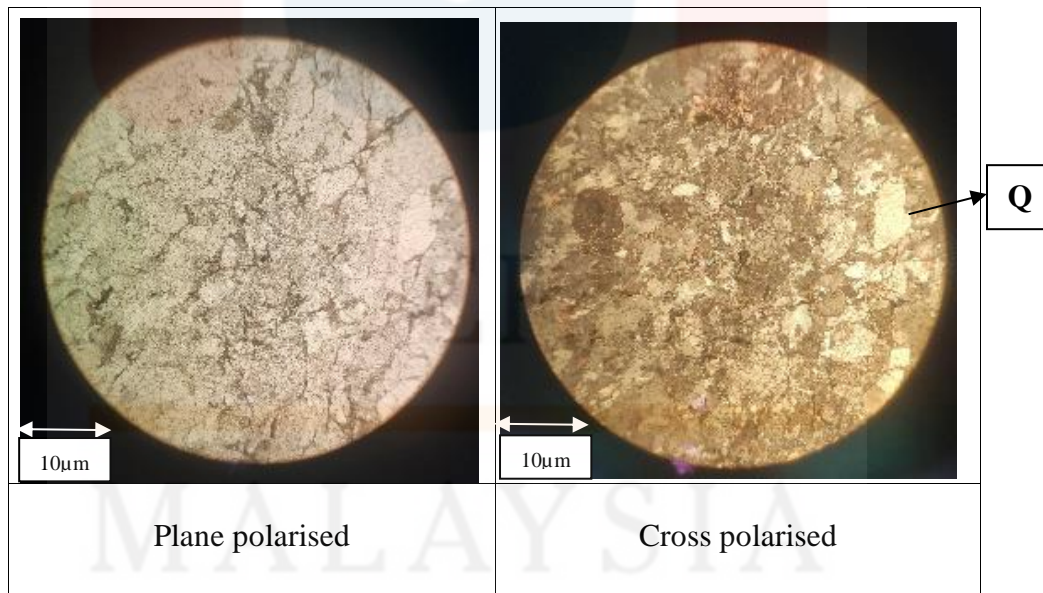
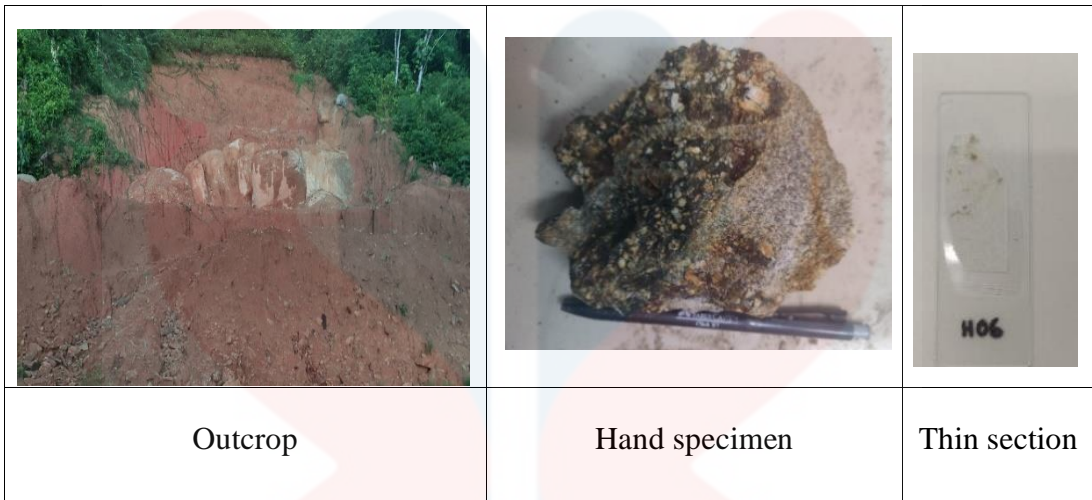
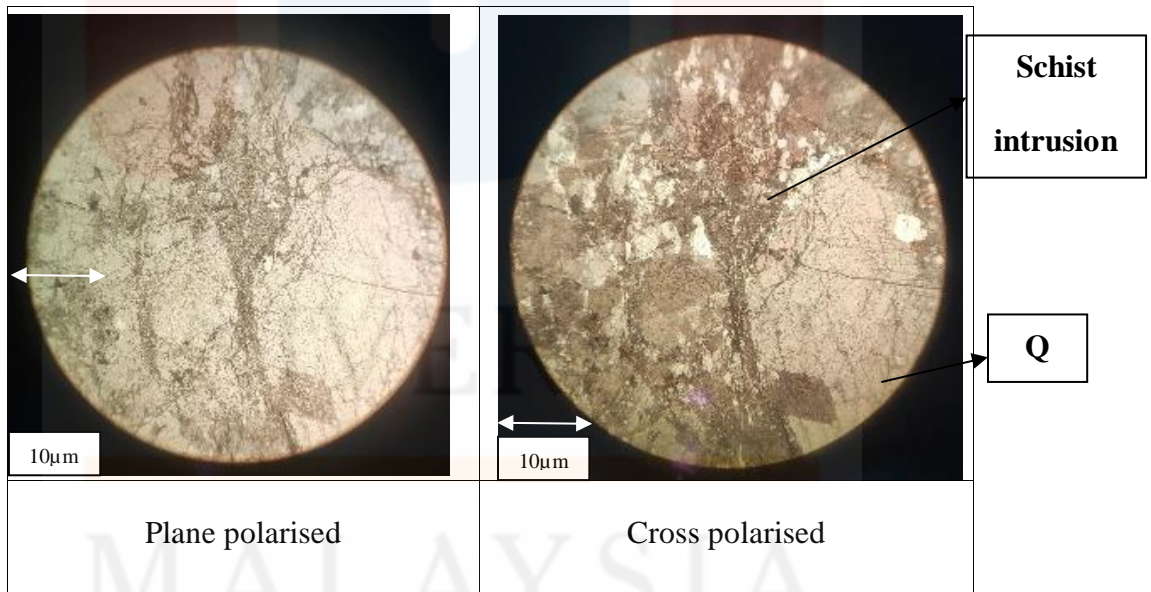


Figure 4.24: Microscopic view of Schist Sample 5

Sample 6



**Figure 4.25:** Outcrop, Hand specimen and Thin section for Granite Sample 6



**Figure 4.26:** Microscopic view of Schist Sample 6

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**Table 4.3:** Optical properties observed under microscope view

<b>Optical properties</b>	<b>Quartz (Q)</b>	<b>Alkali feldspar (AF)</b>	<b>Plagioclase (P)</b>	<b>Biotite (B)</b>	<b>Muscovite (M)</b>
Colour and pleochroism	Colourless	Colourless	Colourless	Show pleochroic properties, dark brown to light yellow	Colourless
Refractive index	Low	Low	Low to moderate	Moderate to high	Moderate to High
Cleavage	Absent	2 sets	2 sets	1 set	1sets
Shape	Anhedral	Anhedral	Subhedral	Subhedral	Subhedral
Isotropic/ anisotropic	Anisotropic	Anisotropic	Anisotropic	Anisotropic	Anisotropic
Interference index	1st drop (yellow)	1st order(grey)	1st order(white)	High	High
Birefringence	Low	Low	Low	High	High
Extinction	None	Inclined	Inclined	Straight	Parallel
Twinning	None	Present	Present	None	Present

**Table 4.4:** Physical properties of outcrop

<b>Physical properties</b>	<b>Granite</b>	<b>Schist</b>
Texture	Coarse (Phaneritic)	Medium- coarse (Foliated)
Colour	Varies shades of whitish grey with shiny, flat crystal faces	Greyish colour
Weathered	Yellowish brown colour	Reddish brown colour
Crystal size	Large	Fine – medium
Crystal Grains	Interlocking grains	Elongated minerals

**Table 4.5:** Mineral Constituents in Samples

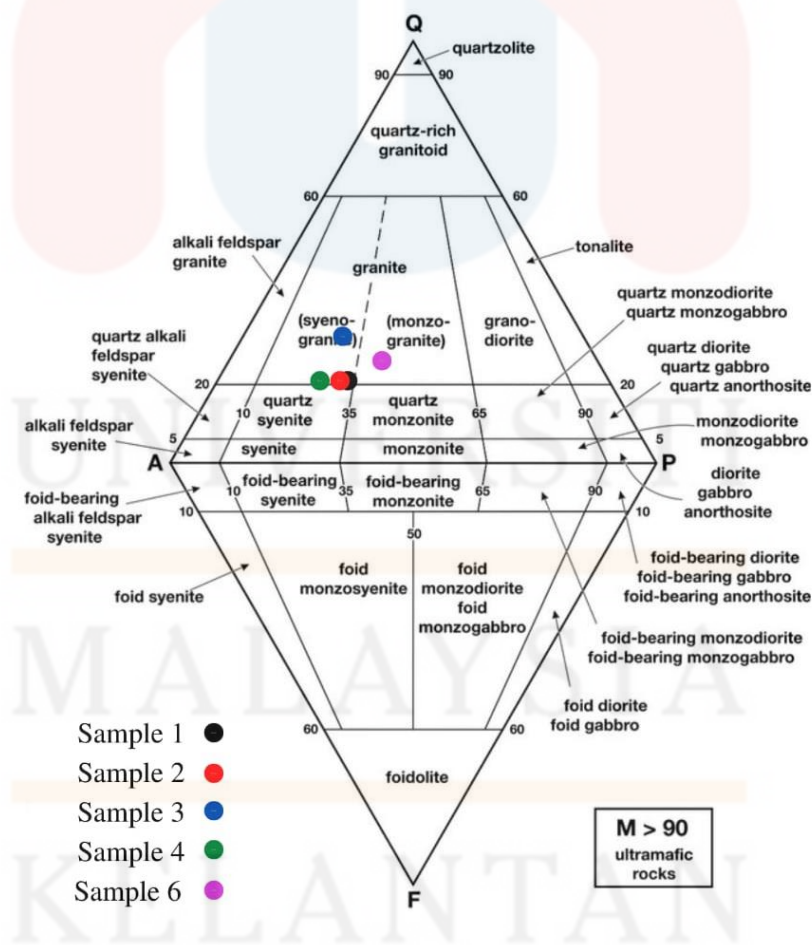
<b>Sample</b>	<b>Type of rock</b>	<b>Mineral Composition</b>	<b>Other Minerals</b>
1	Granite	Alkali Feldspar: 45% Quartz: 20% Plagioclase Feldspar: 15% Biotite: 10% Amphibole: 5% Other Minerals: 5%	Pyroxene, Olivine
2	Granite	Alkali Feldspar: 50%	Pyroxene, Olivine

		<p>Quartz: 20%</p> <p>Plagioclase Feldspar: 10%</p> <p>Biotite: 10%</p> <p>Amphibole: 5%</p> <p>Other Minerals: 5%</p>	
3	Granite	<p>Alkali Feldspar: 40%</p> <p>Quartz: 30%</p> <p>Plagioclase Feldspar: 10%</p> <p>Biotite: 10%</p> <p>Amphibole: 5%</p> <p>Other Minerals: 5%</p>	Pyroxene, Olivine
4	Granite	<p>Alkali Feldspar: 50%</p> <p>Quartz: 20%</p> <p>Plagioclase Feldspar: 10%</p> <p>Biotite: 10%</p> <p>Amphibole: 5%</p> <p>Other Minerals: 5%</p>	Pyroxene, Olivine

5	Schist	<p>Quartz: 45%</p> <p>Feldspar: 20%</p> <p>Muscovite: 15%</p> <p>Biotite: 10%</p> <p>Amphibole: 5%</p> <p>Other Minerals: 5%</p>	<p>Graphite, Chlorite, Garnet, Talc</p>
6	Granite contact schist	<p>Alkali Feldspar: 35%</p> <p>Quartz: 25%</p> <p>Plagioclase Feldspar: 20%</p> <p>Biotite: 10%</p> <p>Amphibole: 5%</p> <p>Other Minerals: 5%</p>	<p>Pyroxene, Olivine</p>

#### 4.5 Igneous Rock Classification

The feldspar and quartz concentration in igneous rocks with visible mineral grains (phaneritic texture) is used to identify them using the QAP diagram. All the minerals have crystallised into discernible grains in igneous rocks. First, the mode—a percentage—of quartz (Q), alkali feldspar (AF), and plagioclase feldspar (P) is calculated. To determine the igneous name categorization in Figure 4.27, the corresponding points are shown in the QAP diagram. Points 1, 2, 3, 4, and 6 are grouped together into a column known as a granite column. The collected igneous samples fall within the main group of granite column, according to the plotted points.



**Figure 4.27:** QAP Diagram for Igneous Rock Classification

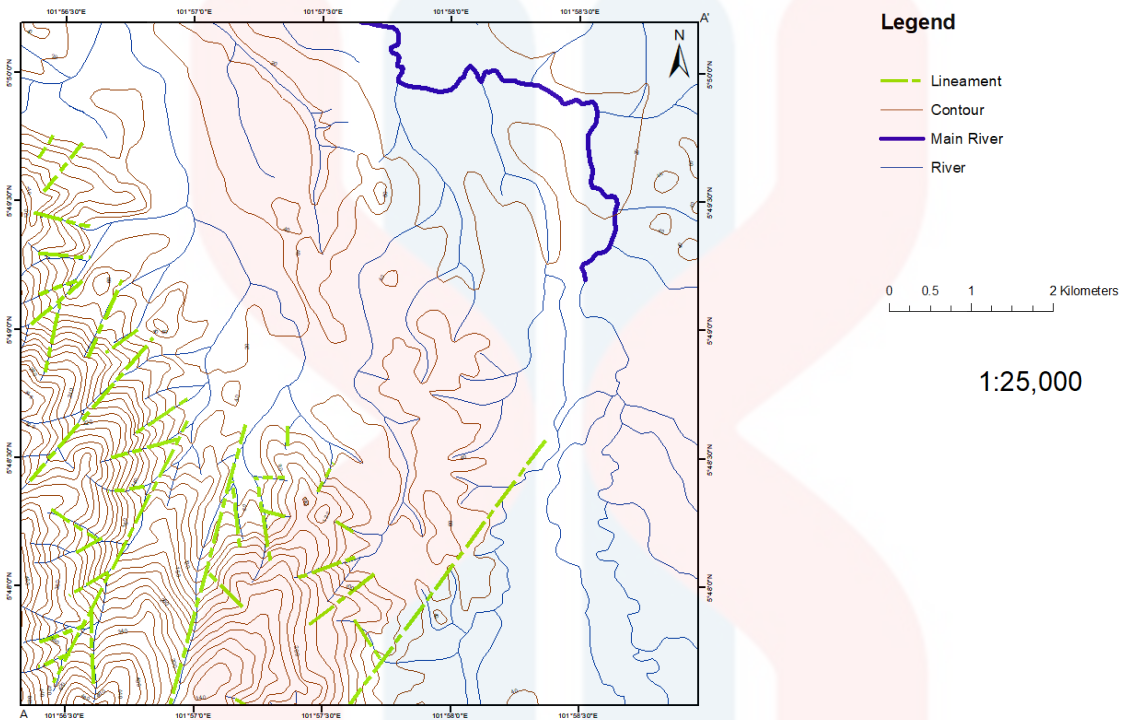
## 4.6 Structural Geology

By examining the causes and effects of rock deformation as well as the distribution of rocks in three dimensions, structural geology is a method in geology that tries to understand the previous geological settings. In this study, the historical deformation systems were identified by lineament analysis.

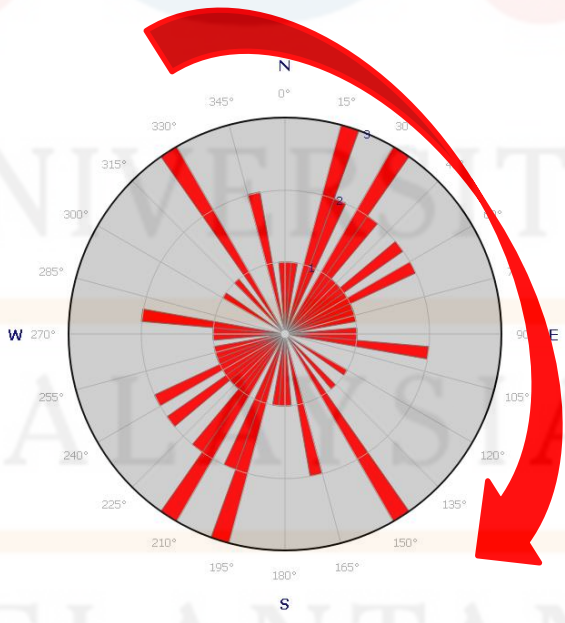
### 4.6.1 Lineament

A linear topographic feature called a lineament is thought to reflect an underlying geological structure. Satellite photography of the study area and its surrounding area is used in this research's lineament analysis since it can provide a quick indication of the direction of the force that was applied there. Readings were obtained by measuring the lineament's angle. GeoRose software was used to interpret the values. According to Figure 4.29, the analysis's findings, shows the trend lineament from Northeast to Southwest.

### Lineament map around Kampung Panglima Bayu



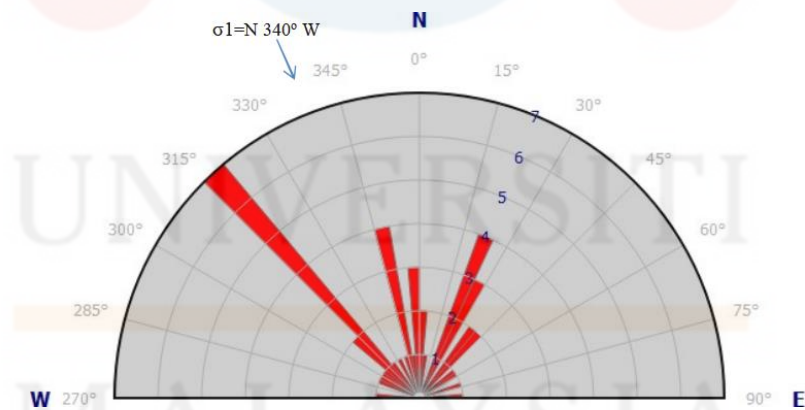
**Figure 4.28:** Lineament map around Kampung Panglima Bayu  
 Source: Generated from ArcGIS 2022



**Figure 4.29:** Rose Diagram of Lineament Analysis  
 Source: Generated from GeoRose

#### 4.6.2 Joint

Joints are rock cracks that do not involve rock displacement. The primary and secondary joints are the two types of joints. The secondary joint will be analyzed in structural geology. Shear joints are created as a result of tectonic forces. The joint orientation of granite rocks was measured in order to establish the force direction that generated the joints on the body of the rocks. The shear joint is the most common type of joint created in the research area. During the analysis, a geologic compass was used to measure the joint bearings, and after recording all identifiable joint data, GeoRose software was used to construct a rose diagram, which is simple and useful for assessing regional organization features. It primarily reflects the alignment of the major joints more clearly. The Joint reading in Granite rocks is given in Appendix E. Figure 4.30, shows the rose diagram with major joint set trend from 310° and 360°. Therefore, the principle stress  $\sigma_1$  is assumed from N340°W.



**Figure 4.30:** Rose diagram from joint analysis  
Source: GeoRose

#### 4.7 Historical Geology

Historical geology is a branch of geology concerned with reconstructing and comprehending the Earth's geological past, encompassing geomorphology, lithostratigraphy, and structural geology. The studied area's historical geology began in the Cretaceous, Permo-Triassic, and Quaternary periods, and was based on three lithologies: granite, schist, and alluvium. Granite was the most common rock followed by schist then alluvium. Geology is a research area that encompasses geomorphology, which ranges from low ground to high hills. Weathering was also shown to be physical, biological, and chemical in nature. There are three types of drainage patterns in the research area: dendritic, parallel, and rectangular.

As observed in outcrop 6, the Kemahang granite body is a batholithic dimension that is in contact with the Taku Schists. The petrographic investigation found that the granites in the research area are rich in quartz, K-feldspar, plagioclase, biotite, and other minerals, indicating an acidic composition. Aside from that, quartz is the most common mineral in granite and is present there. Despite the fact that it is distributed and sheared in every sample, quartz contains the highest proportion of the key elements in granite rocks. Therefore based on the findings of both investigations, the granite rocks of Kampung Panglima Bayu, which are composed of the Kemahang Granite, may be referred to as "biotite granite porphyry". This is due to the presence of the mineral biotite in significant abundance in the hand specimens, which also correlates with the early study.

## CHAPTER 5

### RESULTS AND DISCUSSION

#### 5.1 Result and Discussion

This chapter discusses major cation, major anion analyses and in-situ parameters used to assess the quality of domestic water well. The outcome is contrasted with the safe limit value for each parameter set by the WHO and MoHM. The In-situ parameter result is shown in table 5.2, and the results for major cation and anion results are shown in tables 5.3 and 5.4, respectively. Figure 5.1 depicts the coordinates of the water sampled.

**Table 5.1:** Coordinates of sampling location of groundwater and their monitoring data near Kampung Panglima Bayu.


Well No.	Latitude	Longitude	Elevation (m)
W 1.	5°47'35.70"N	101°58'37.10"E	52
W 2.	5°48'8.20"N	101°58'44.10"E	54
W 3.	5°48'33.70"N	101°58'38.10"E	58
W 4.	5°49'10.80"N	101°58'49.90"E	46
W 5.	5°49'28.91"N	101°58'25.90"E	45
W 6.	5°50'05.70"N	101°57'02.30"E	21

W 7.	5°50'03.50"N	101°56'48.70"E	27
W 8.	5°49'14.80"N	101°57'12.90"E	42
W 9.	5°49'50.71"N	101°57'51.30"E	45
W 10.	5°49'28.40"N	101°58'6.40"E	42
W 11.	5°49'12.87"N	101°58'1.05"E	48
W 12.	5°48'36.49"N	101°58'13.11"E	40

**Table 5.2:** Result of In-Situ parameters

Well No.	Temperature (C)	pH	Turbidity (NTU)	TDS (mg/L)	EC ( $\mu$ S/cm)
W 1.	27.9	6.55	0.65	94.85	135.57
W 2.	27.0	6.60	1.50	119.25	170.52
W 3.	28.0	7.50	2.19	91.6	131.52
W 4.	27.6	5.22	7.54	221.6	316.76
W 5.	27.0	6.72	42.6	179.35	258.38
W 6.	28.0	7.71	0.71	98.10	142.19
W 7.	27.0	5.25	3.02	95.50	136.57


W 8.	27.9	4.73	1.27	116.75	168.43
W 9.	27.5	5.74	1.55	160.3	225.79
W 10.	28.0	6.15	0.37	86.4	121.84
W 11.	26.7	4.65	25.2	94.20	132.87
W 12.	28.4	5.05	0.53	106.55	151.79

 Values exceed WHO and MOHM limit

**Table 5.3:** Result for Major Cations

Well No.	Na <sup>+</sup>	K <sup>+</sup>	Ca <sup>2+</sup>	Mn <sup>2+</sup>	Fe <sup>+</sup>	Mg <sup>2+</sup>
W 1.	3.500	2.985	2.512	0.059	0.037	0.617
W 2.	9.967	2.307	12.83	0.001	0.005	0.364
W 3.	2.668	2.670	1.549	0.021	0.096	0.432
W 4.	5.805	1.499	6.757	0.045	0.178	0.344
W 5.	0.856	0.726	6.942	0.025	0.220	0.322
W 6.	2.496	1.449	1.036	0.024	0.182	0.376
W 7.	2.103	3.988	3.181	0.099	0.009	0.669

W 8.	12.34	0.763	1.223	0.027	0.009	0.310
W 9.	2.474	2.897	17.70	0.283	0.076	0.828
W 10.	50.39	0.791	0.345	0.025	0.026	0.412
W 11.	463.1	4.005	0.028	0.001	0.009	0.463
W 12.	4.264	2.470	4.622	0.024	0.009	0.458

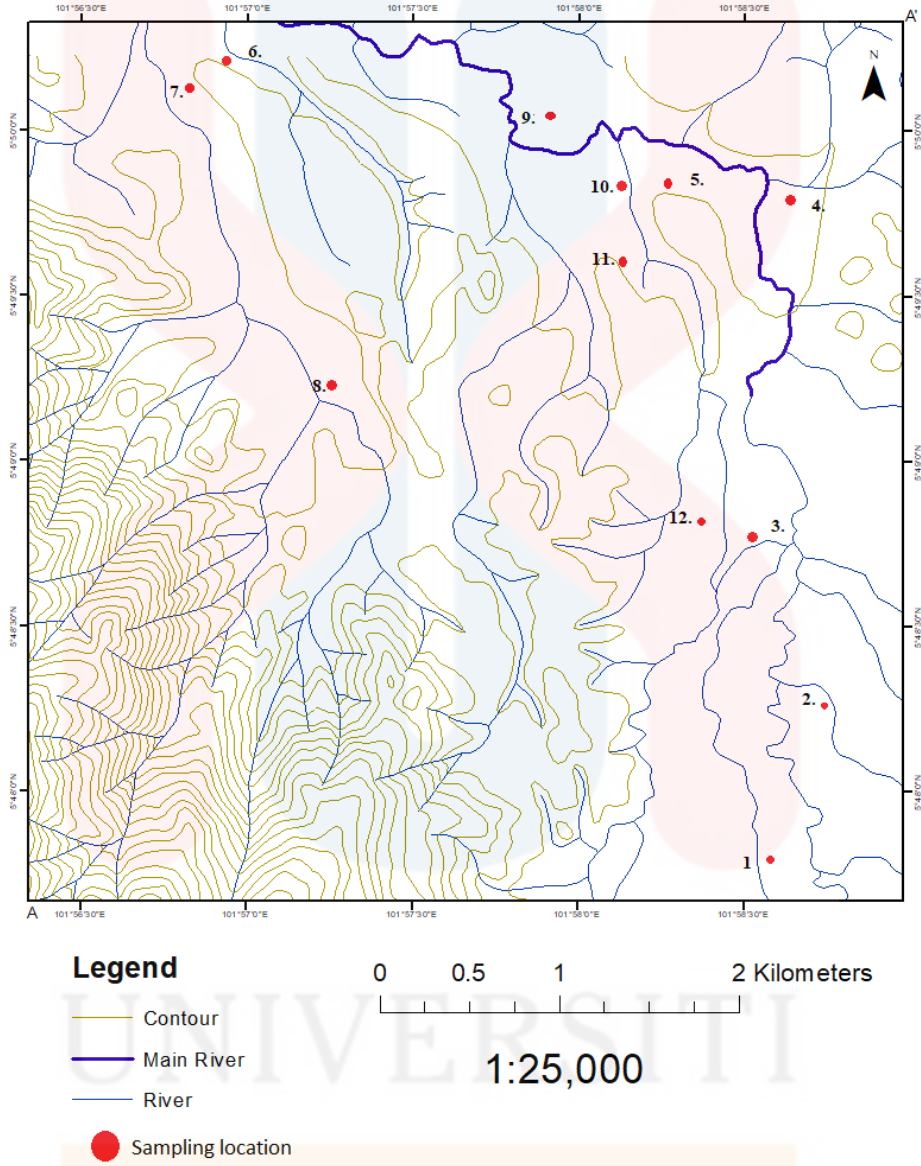
 Values exceed WHO and MOHM limit

**Table 5.4:** Result for Major anions

Well No.	$F^-$	$NO_3^-$	$SO_4^{2-}$	$HCO_3^-$	$Cl^-$
W 1.	0.05	2.8	0	130.000	10.4
W 2.	0.02	2.4	2	250.330	21.7
W 3.	0.04	0.9	2	300.000	32.5
W 4.	0.02	0.7	0	383.670	22.3
W 5.	0.05	1.0	0	120.000	28.5
W 6.	0	2.8	1	230.330	18.8
W 7.	0	2.6	3	346.000	38.9

W 8.	0.16	1.5	0	180.330	27.2
W 9.	0	3.9	0	306.670	46.9
W 10.	0.09	2.8	0	175.000	20.9
W 11.	0.03	2.3	6	325.000	55.7
W 12.	0	2.5	5	296.67	15.9

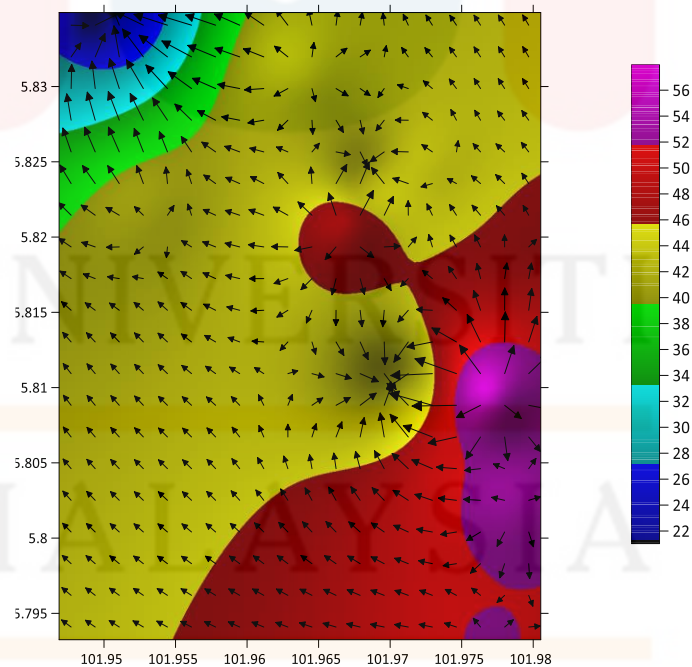
### Sampling well map around Kampung Panglima Bayu area



**Figure 5.1:** Sampling well map around Kampung Panglima Bayu area  
Source: Generated from ArcGIS 2022

## 5.2 Groundwater Movement

The direction of the aquifer's water flow was revealed via groundwater movement. The lithology and topography of the studied area affect the behaviour of water movement. This is due to gravity, water frequently flows from high elevations toward low lying areas. One important factor that affects the circulation of groundwater in the research area is the subsurface lithology. There are two different lithologies that could exist: permeable layers and impermeable layers. Sandstone is a common component of permeable layers because of its high permeability and propensity to act as an aquifer. Although less permeable than sandstone, the shale layer nevertheless allows for water movement and can serve as an aquitard. Regarding impermeable layers, these include clay layers that prevent water from passing through them and are suitable for aquifuge. The water level contour map in figure shows the direction of groundwater migration.



**Figure 5.2:** Groundwater flow direction based on elevation around Kampung Panglima Bayu area.

Source: Surfer 16

### 5.3 In-situ Parameters

In situ parameters include TDS, EC, pH and Turbidity that are measured on site.

#### 5.3.1 Total Dissolved Solid (TDS)

Total dissolved solid in water was influenced by the dissolved cations, anions and also organic materials. The TDS presence in the study area ranges from 86.4 mg/l to 221.6 mg/l. From the figure 5.4, the distribution map display the highest concentration is toward north direction (North vicinity of river), while the lowest concentration is toward north east direction. The highest value are observed at Well 4 which is located around SMK Tan Sri Mohammed Yaacob at west direction and the lowest in well 10 that located near Kg. Rotan Tawar heading northwest direction. From the figure 5.3, the scale of overall TDS values presence in the study area are still within safe limit of WHO and MoHM standard. High value of TDS at well 4 is correlate with the value of cations, nitrate, chloride, high concentration bicarbonate and sulphate contain in the groundwater. Other organic matter also contributes to the TDS value. As for the lowest TDS at well 10 is due to low concentration in bicarbonate and chloride.

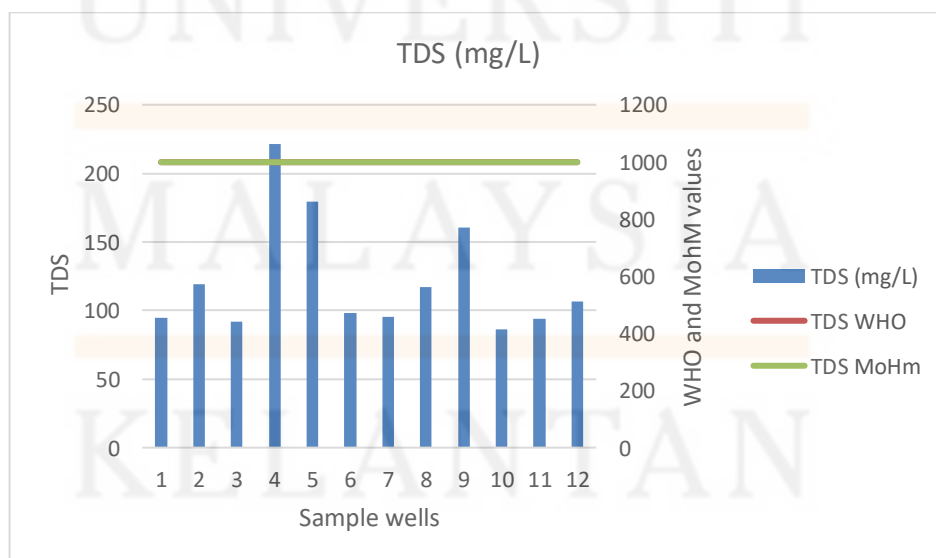
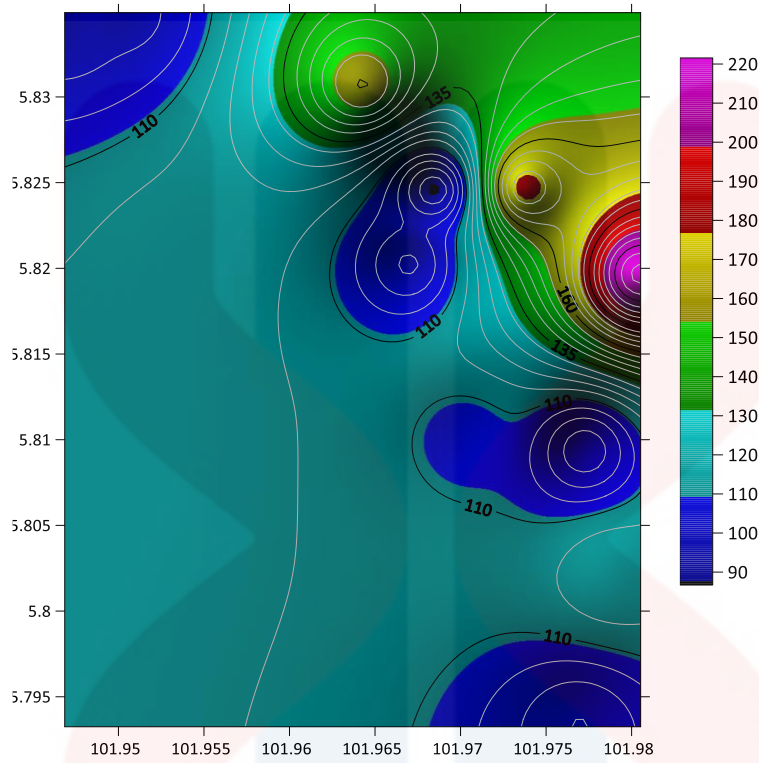
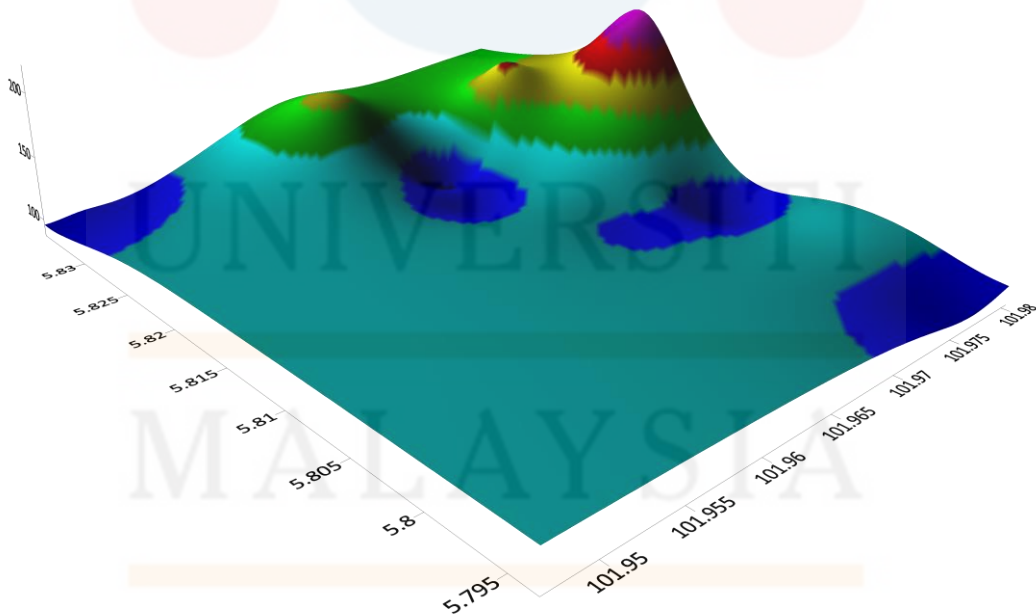


Figure 5.3: TDS bar chart of study area



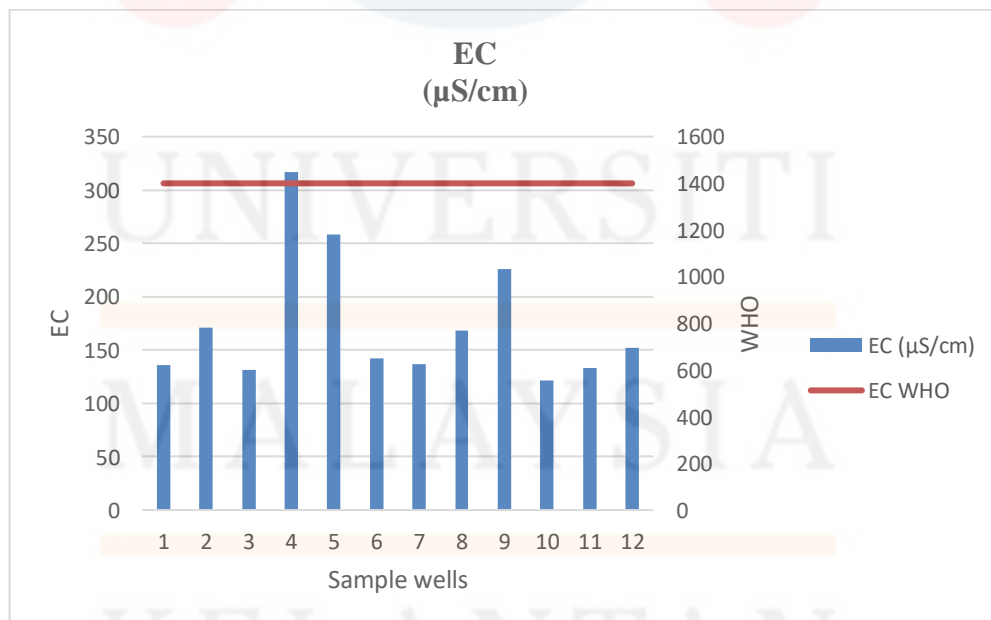
**Figure 5.4:** Distribution map of TDS concentration  
Source: Surfer 16



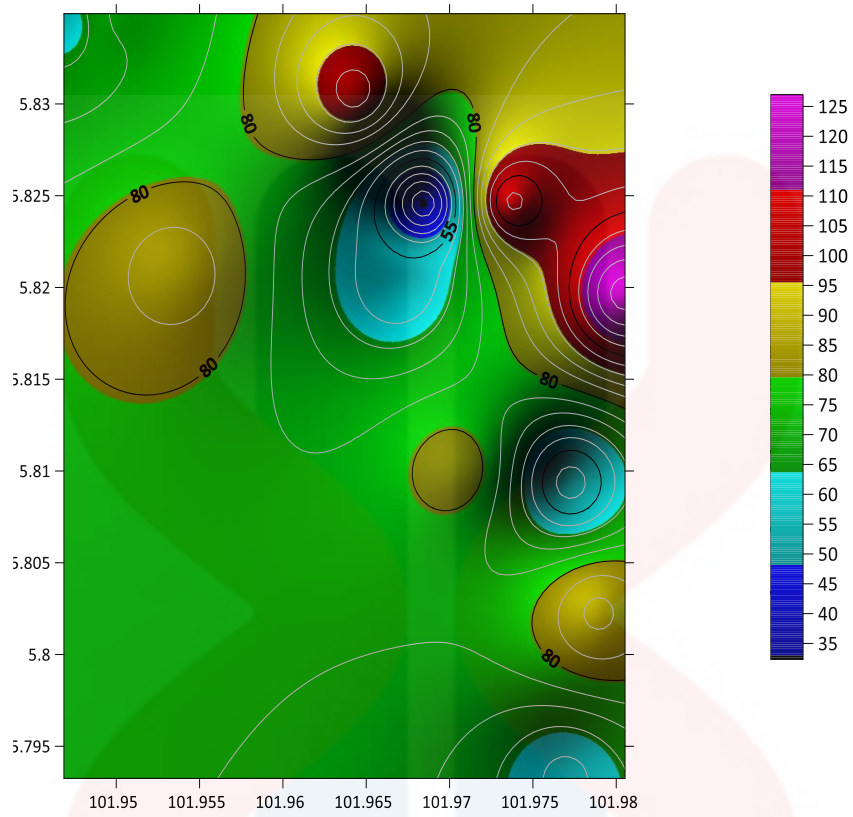
**Figure 5.5:** 3Dimensional Map of TDS concentration  
Source: Surfer 16

### 5.3.2 Electrical Conductivity (EC)

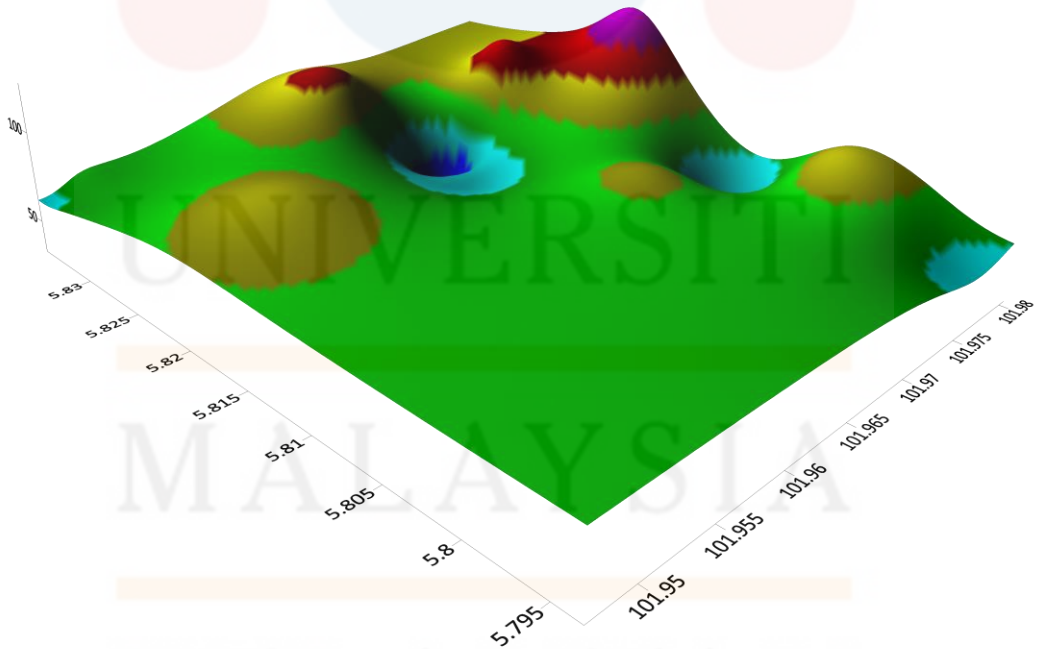
Electrical conductivity, is a property of water, governs how well it conducts current. In the study area, EC values range from 121.84  $\mu\text{S}/\text{cm}$  to 316.76  $\mu\text{S}/\text{cm}$ . Figure 5.7 shows that well 4 around SMK Tan Sri Mohammed Yaacob had the highest value which is located at the North vicinity of river. The value of EC is significantly influenced by the amount of total dissolved cations and anions. Ions help transmit electricity through water; more ions mean higher electrical conductivity (EC) in the water. This made sense as well 4 has high EC value, which was related to its high Mg, Na, K, and Fe content. The quantity of charge ions in the water rises when allocations are present. The high cation measurements are consistent with the high TDS value at well 4, which is 316.76 mg/l. With regard to well number 10, which has the lowest EC, the low EC result is compatible with the low TDS level in the groundwater. According figure 5.6, the well 10 with the lowest TDS reading is 121.84mg/l .



**Figure 5.6:** EC data at study area.



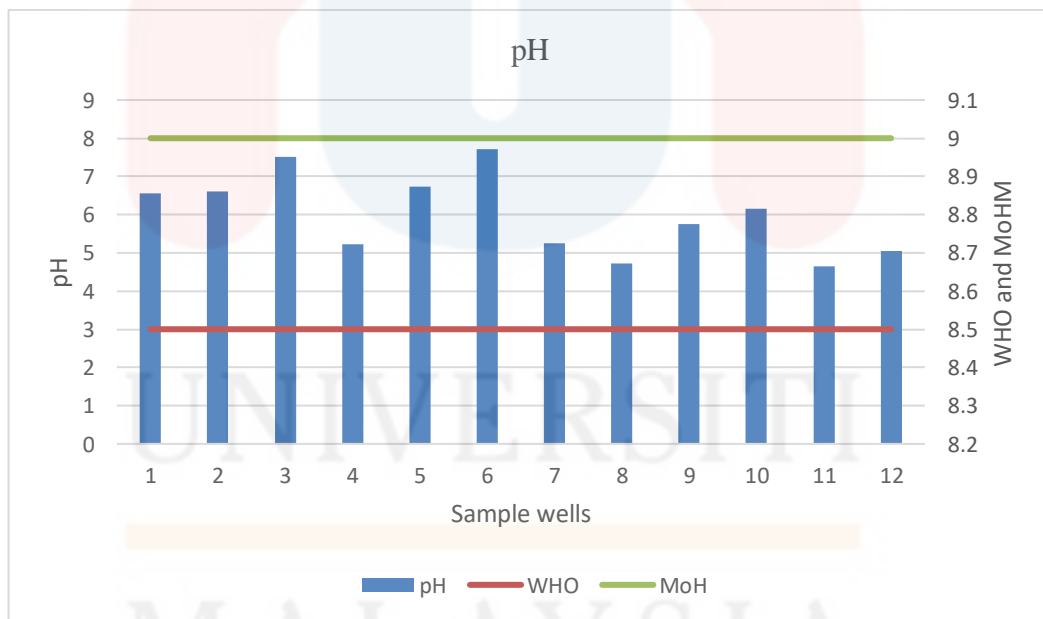
**Figure 5.7:** Distribution map of EC concentration  
Source: Surfer 16



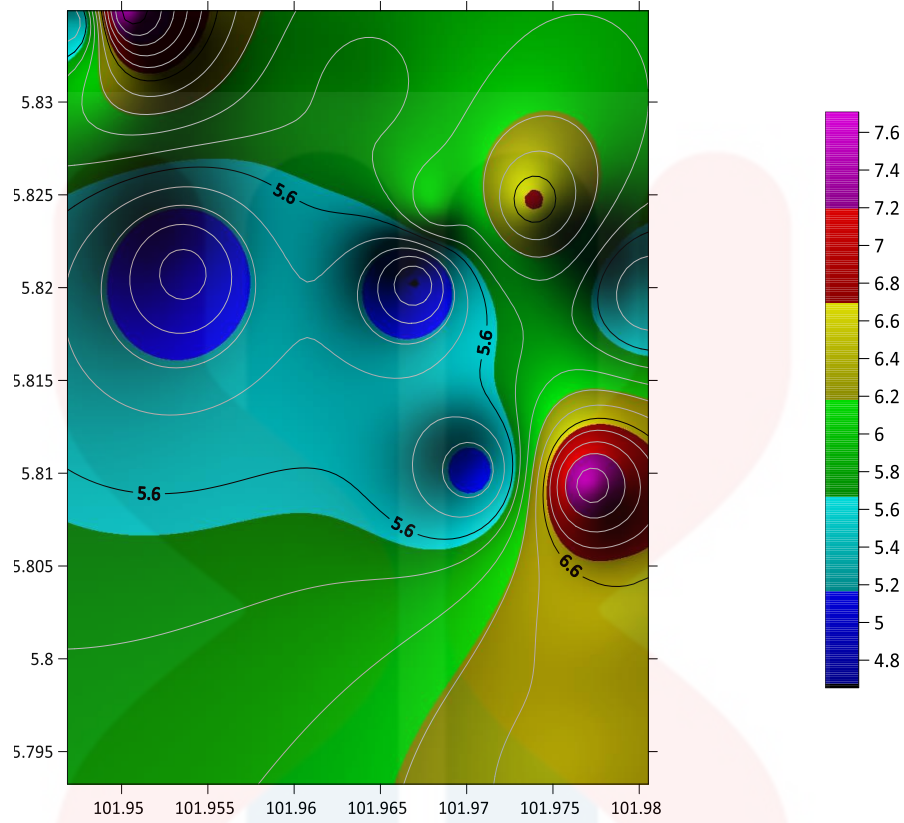
**Figure 5.8:** 3Dimensional Map of EC concentration  
Source: Surfer 16

### 5.3.3 pH

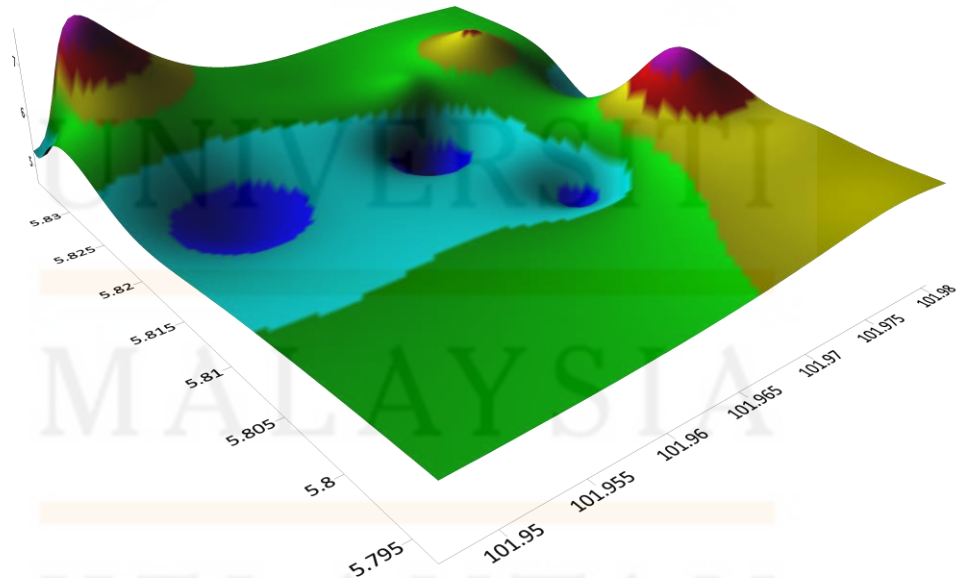
According to figure 5.9, the pH ranges for the research area's groundwater are 4.65 to 7.71. The pH range between 6.0 and 9.0 is considered to be the safe limit for drinking water by the WHO and MoHM. Therefore, with the exception of well 4, 7, 8, 9, 11, and 12, which demonstrated that the water is acidic, the majority of domestic well are within the safe level. Strong mineral acids, weak acids, salts of strong acids, and weak bases are all indicated by the acidic water. Typically, the main cause of the acidity in groundwater is the dissolving of carbon dioxide. The pH of the well water is a key factor in determining its overall alkalinity. The pH has an impact on the presence of carbonates and bicarbonate ions.



**Figure 5.9:** pH bar chart of study area



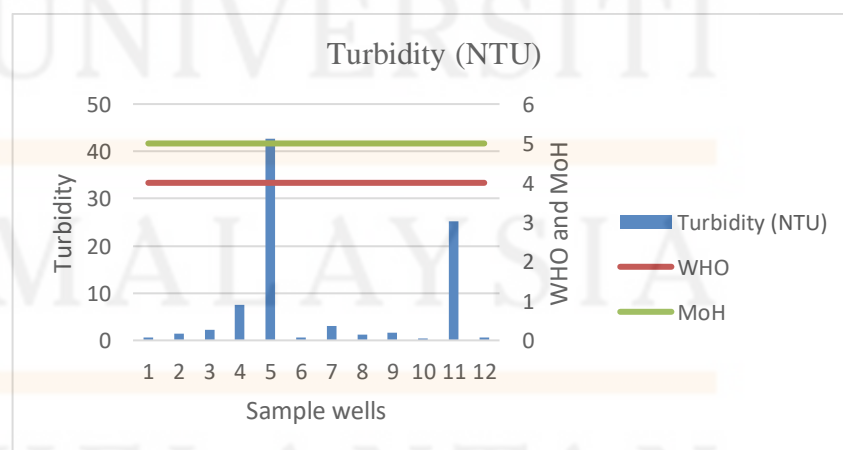
**Figure 5.10:** Distribution map of pH concentration  
Source: Surfer 16



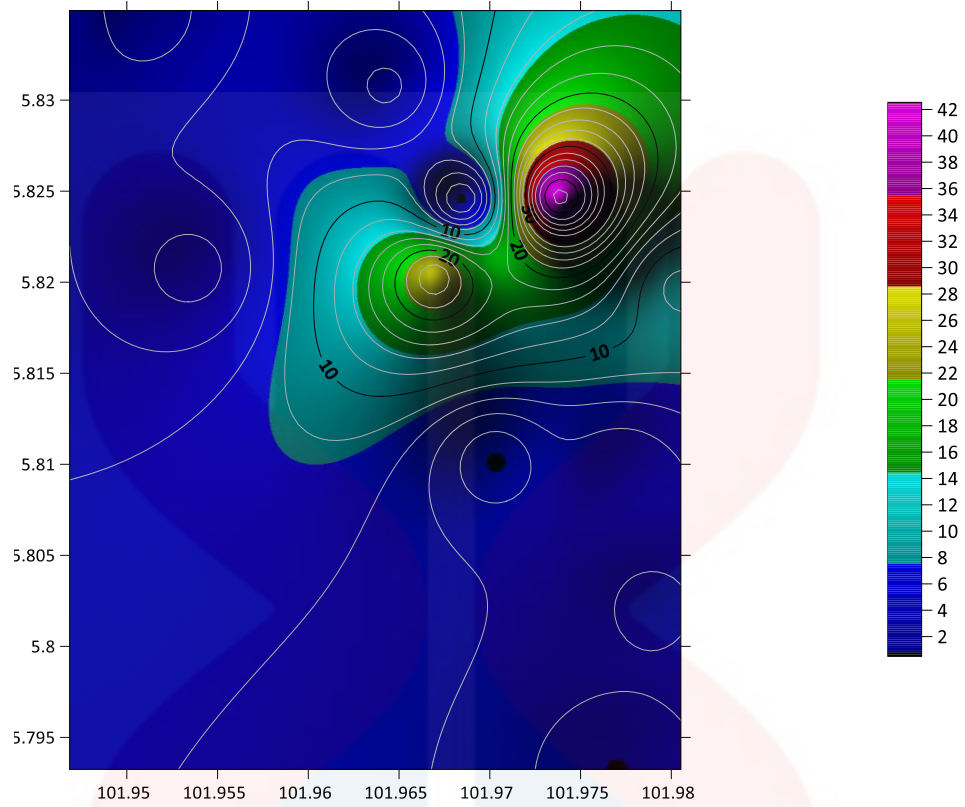
**Figure 5.11:** 3Dimensional Map of pH concentration  
Source: Surfer 16

### 5.3.4 Turbidity

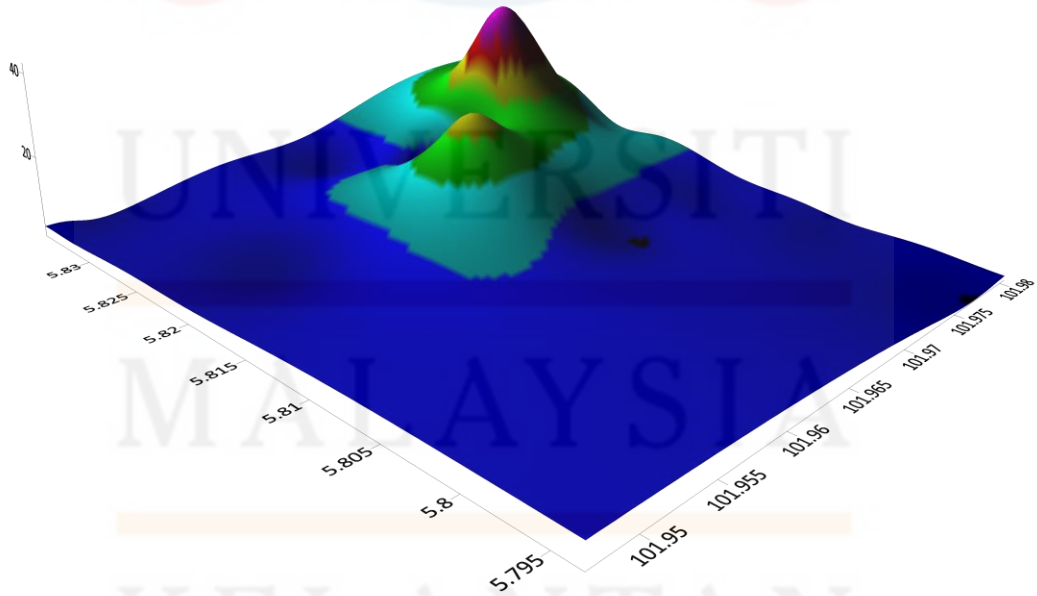
The occurrence of turbidity in the research region ranges from 0.37 mg/L to 42.6 mg/L, as shown in the figure 5.12. According to the graph, well 5 had the highest turbidity at 42.6 mg/L, while well 10 had the lowest at 0.37 mg/L. According to the WHO drinking water turbidity should ideally be less than 1 NTU and should not exceed 5 NTU. This indicates that 1, 6, 10, and 12 are completely clear. Large, well-maintained municipal water systems should be able to achieve less than 0.5 NTU before disinfection at all times and an average of 0.2 NTU or less, regardless of the type and quality of the source water. The highest turbidity well, number 5, is damaged. The heat from the sunshine is absorbed by the suspended particles. Water that is turbid warms up due to the suspended particles absorbing heat from the sun, which lowers the amount of oxygen in the water (oxygen dissolves better in colder water). Additionally, certain creatures cannot endure in warmer water. The light is scattered by the suspended particles, which reduces the photosynthetic activity of plants and algae and lowers the oxygen content. Particles that settle to the bottom cause small lakes to fill up more quickly, cover and smother fish eggs and bug larvae, and clog or harm gill structures.



**Figure 5.12:** Turbidity bar chart of study place



**Figure 5.13:** Distribution map of Turbidity concentration  
Source: Surfer 16



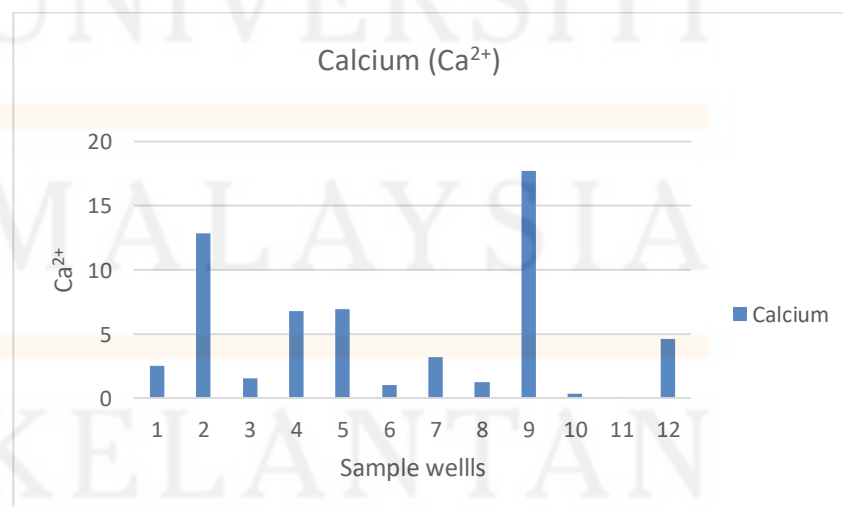
**Figure 5.14:** 3Dimensional Map of Turbidity concentration  
Source: Surfer 16

## 5.4 Major Cation Analysis

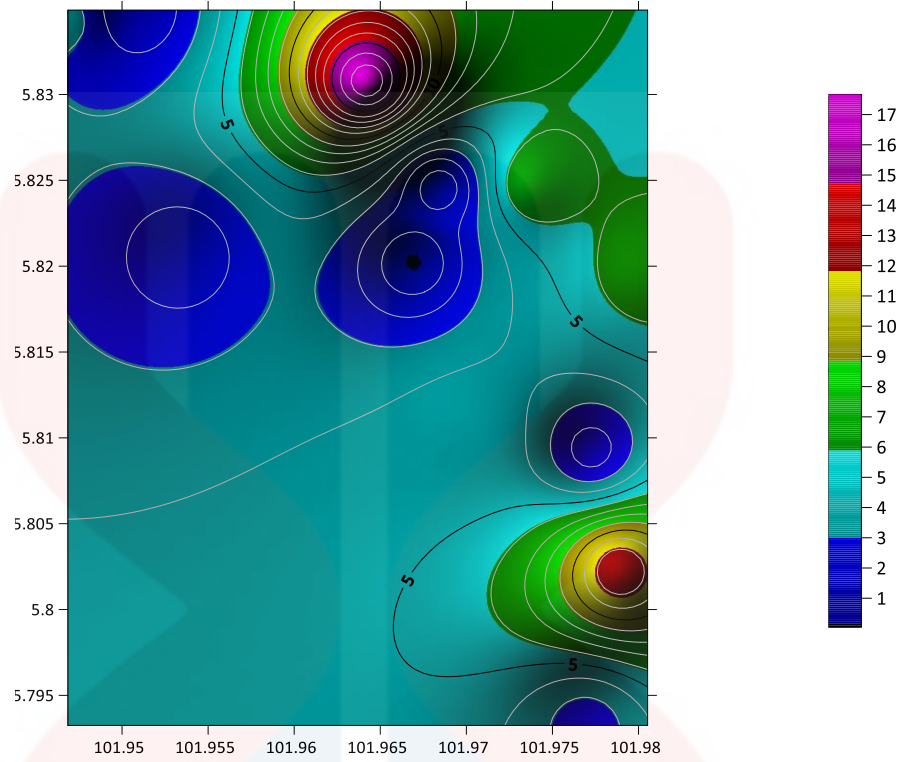
Major cations concentration includes elements of Calcium, Magnesium, Manganese, Iron, Potassium and Sodium.

### 5.4.1 Calcium ( $\text{Ca}^{2+}$ )

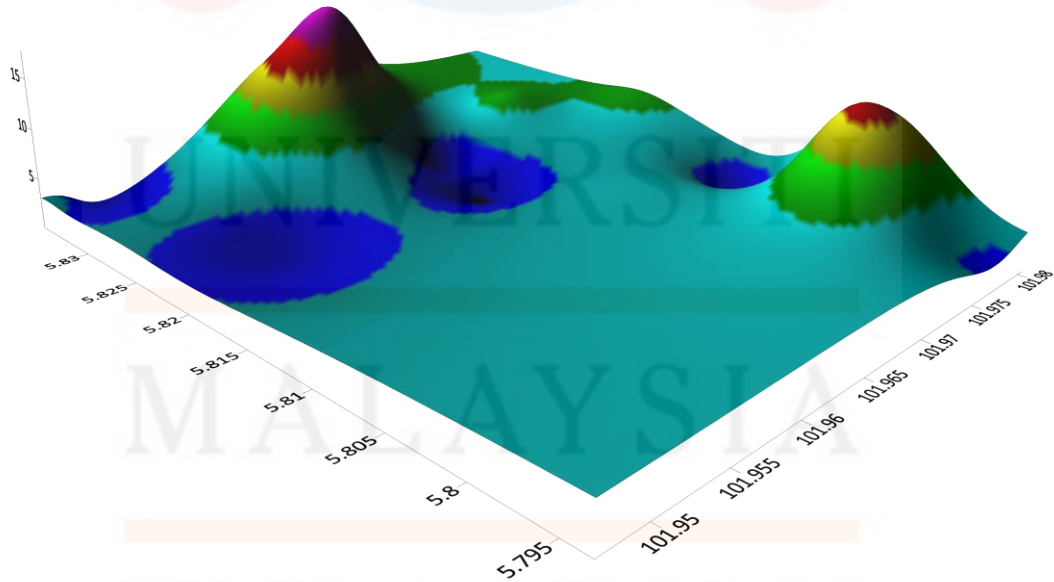
The calcium readings in figure 5.15 range from 0.028 mg/L, which is the lowest reading, to 17.7 mg/L, which is the highest. The lowest Ca value was found in well 11, and the highest was found in well 9. The location of Well 9 is close to Panglima Bayu rubber field. The main sources of calcium concentration are the weathering of calcium-bearing minerals at the nearby outcrop area and the solubility of calcium in the soil. The calcium will be broken down by rainfall precipitation during seepage runoff and water infiltration into the aquifer. The well with the lowest calcium is number 11, which is close to Kg. Panglima Bayu. Other wells, particularly well 2, revealed a rather high calcium concentration as well. There is no precise criterion for calcium in water set by the WHO or MoHM. However, because calcium is one of the nutrients that must be consumed daily, its presence in the water may be advantageous to humans.



**Figure 5.15:**  $\text{Ca}^{2+}$  bar chart of study area



**Figure 5.16:** Distribution map of  $\text{Ca}^{2+}$  concentration  
Source: Surfer 16



**Figure 5.17:** 3Dimensional Map of  $\text{Ca}^{2+}$  concentration  
Source: Surfer 16

5.4.2 Iron ( $Fe^{+}$ )

The research area has an iron concentration range of 0.002 mg/L to 0.178 mg/L. The distribution map in figure 5.19 demonstrated how the concentration of iron increased from south to east. The well 5 location, which is north-east of the Kg. Bedah area, has the highest iron concentration. While well 2 near Kg. Batu Gajah in a southerly direction has the lowest value. In figure 5.20, the iron concentration is depicted in three dimensions. Due to the oxidation process being accelerated by rising water acidity, the pH value and iron content are tightly correlated. Because well 5 water is more acidic than well 2 is, this explains why well 5 has a larger concentration of iron, Nevertheless, even though the water's pH is acidic, the concentration of iron will be reduced if the soil and rocks nearby lack iron. According to figure 5.18, the overall level of iron, in groundwater is below the 0.25 mg/L WHO and MoHM limit. All of the wells are lower than 0.25 mg/L which is exceptional.

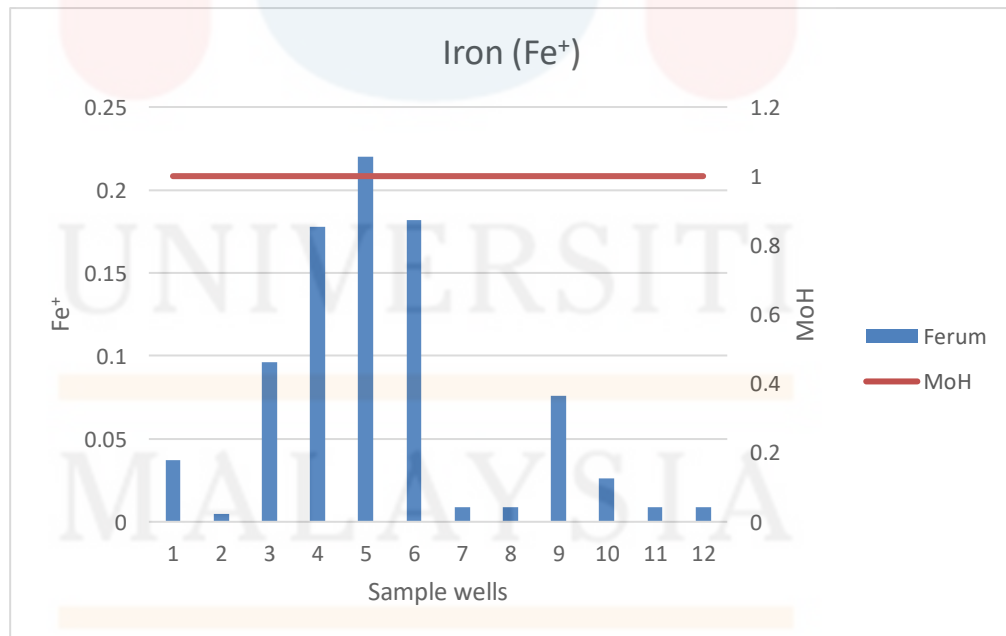
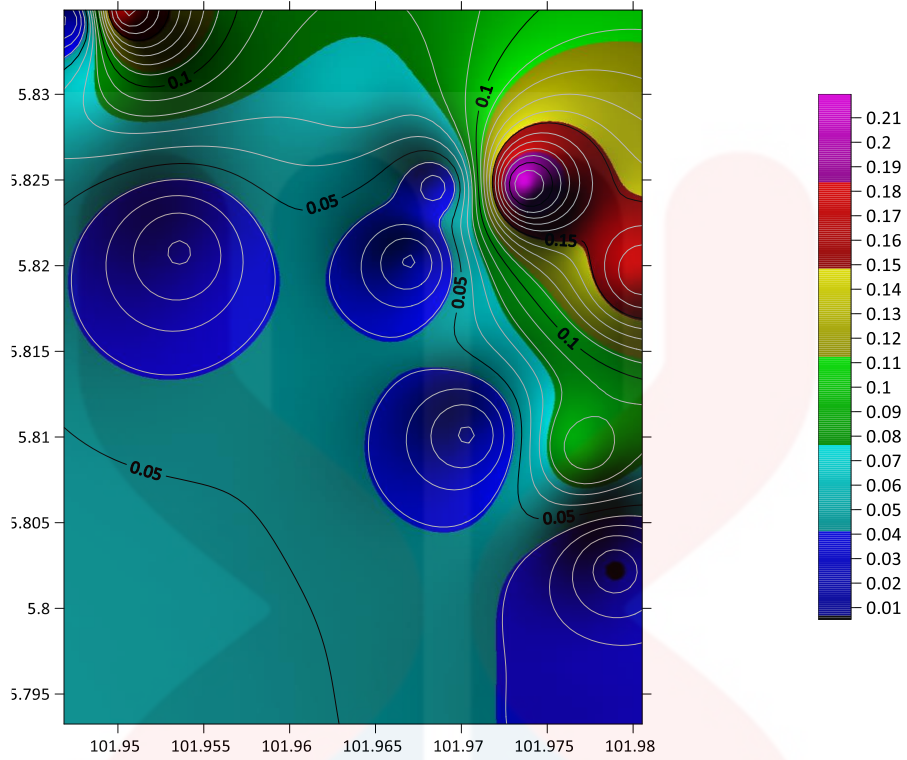
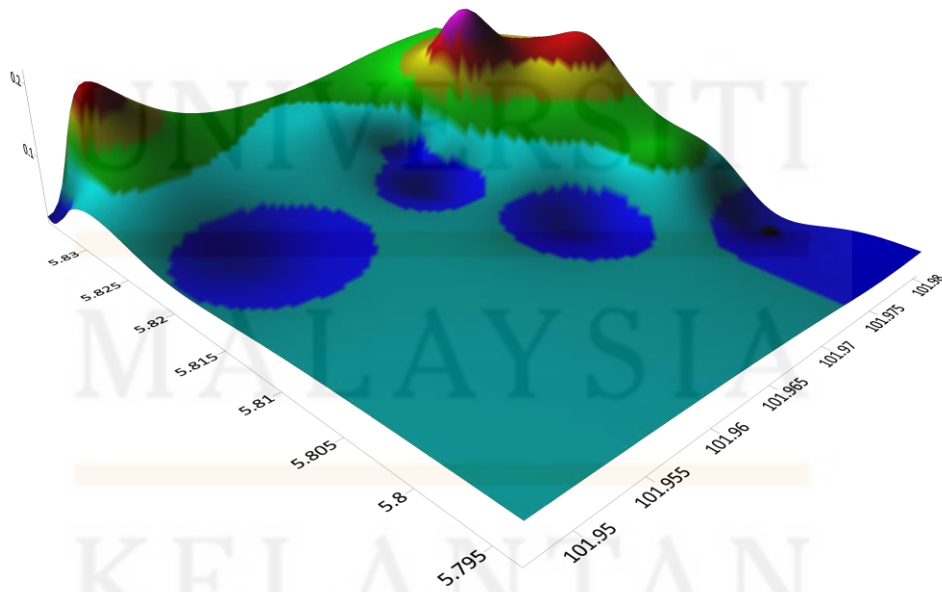


Figure 5.18:  $Fe^{+}$  bar chart of study place



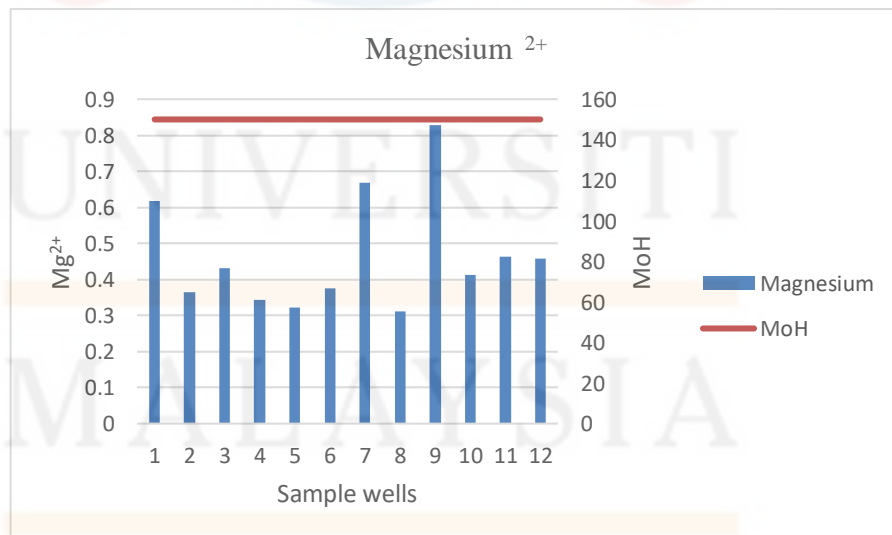
**Figure 5.19:** Distribution map of Fe<sup>+</sup> concentration  
Source: Surfer 16



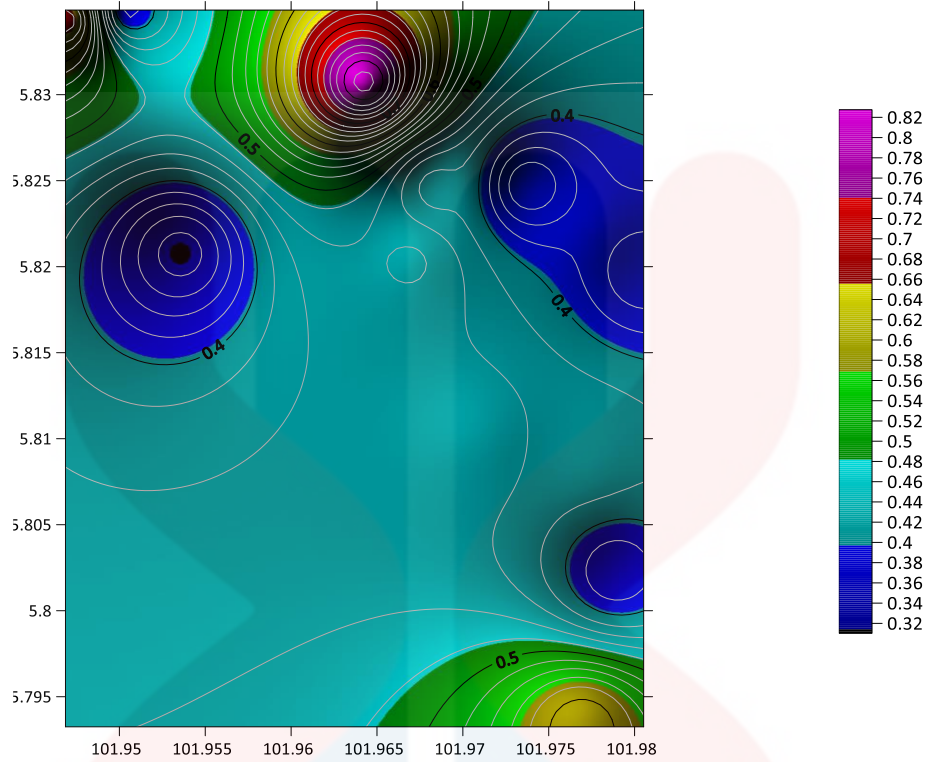
**Figure 5.20:** 3Dimensional Map of Fe<sup>+</sup> concentration  
Source: Surfer 16

### 5.4.3 Magnesium ( $Mg^{2+}$ )

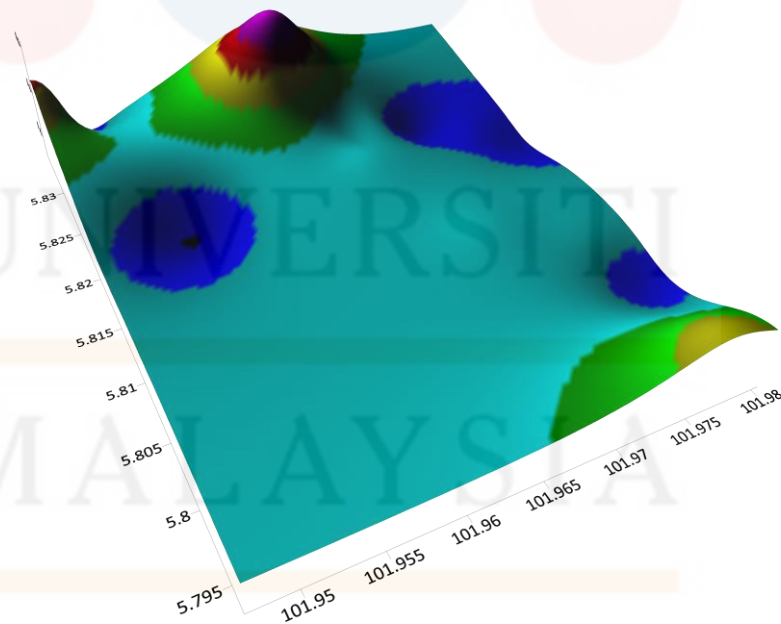
The distribution map of magnesium concentration in figure 5.22 shows that the highest concentration is in the north and the lowest concentration is in the west. Figure 5.14 shows the magnesium concentration in a three-dimensional view. According to figure 5.21, the research area's magnesium concentration ranges from 0.310 mg/L to 0.828 mg/L. The well with the highest magnesium content is well 9, which is close to Panglima Bayu rubber field in the north, and the well with the lowest magnesium concentration is well 8, which is close to Kg. Gual Jedok in the west. The maximum amount of magnesium that can be found in drinking water is 150 mg/L, as per MoHM standards. Since the overall Mg readings in every well fall under the MoHM threshold, there is no magnesium pollution in the well water. Because magnesium is one of the essential nutrients that should be consumed every day, its presence in drinking water is essential. Human health may be at danger if daily consumption of mg is inadequate.



**Figure 5.21:**  $Mg^{2+}$  bar chart of study place



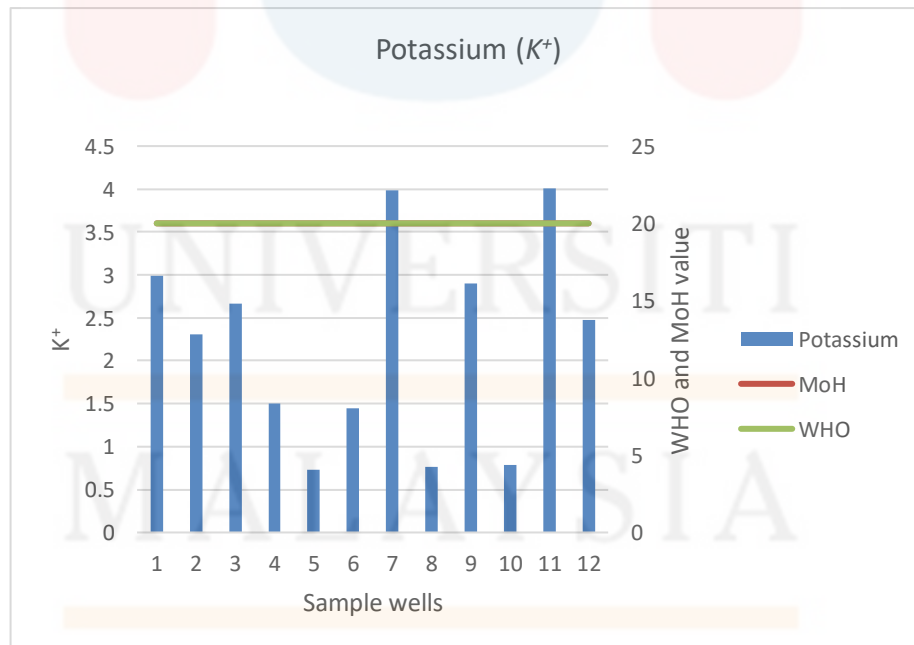
**Figure 5.22:** Distribution map of  $Mg^{2+}$  concentration  
Source: Surfer 16



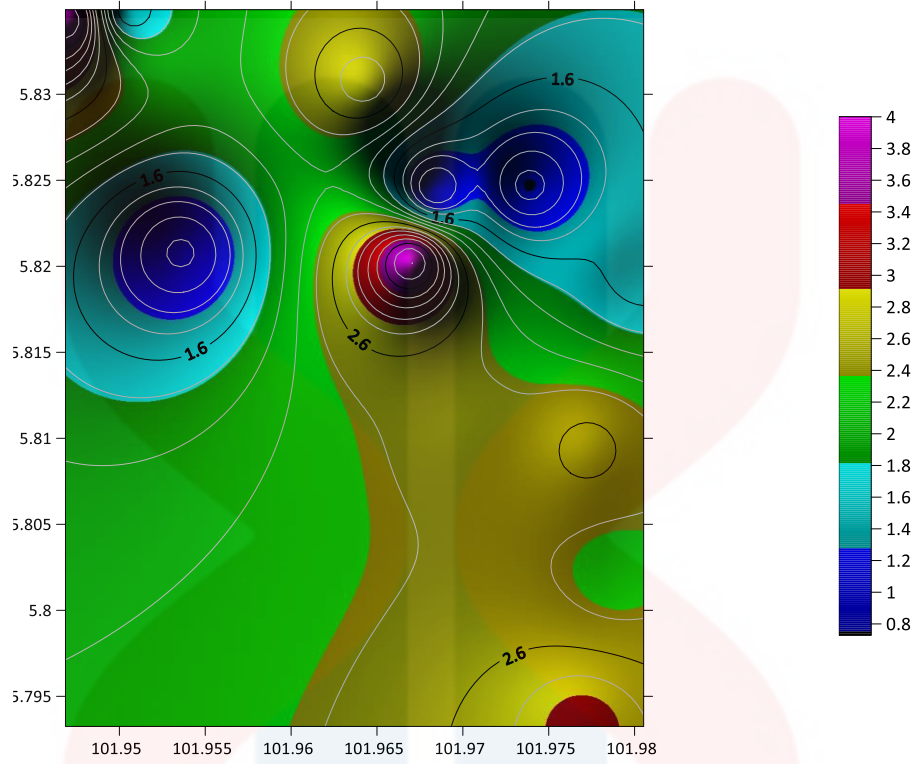
**Figure 5.23:** 3Dimensional Map of  $Mg^{2+}$  concentration  
Source: Surfer 16

#### 5.4.4 Potassium ( $K^+$ )

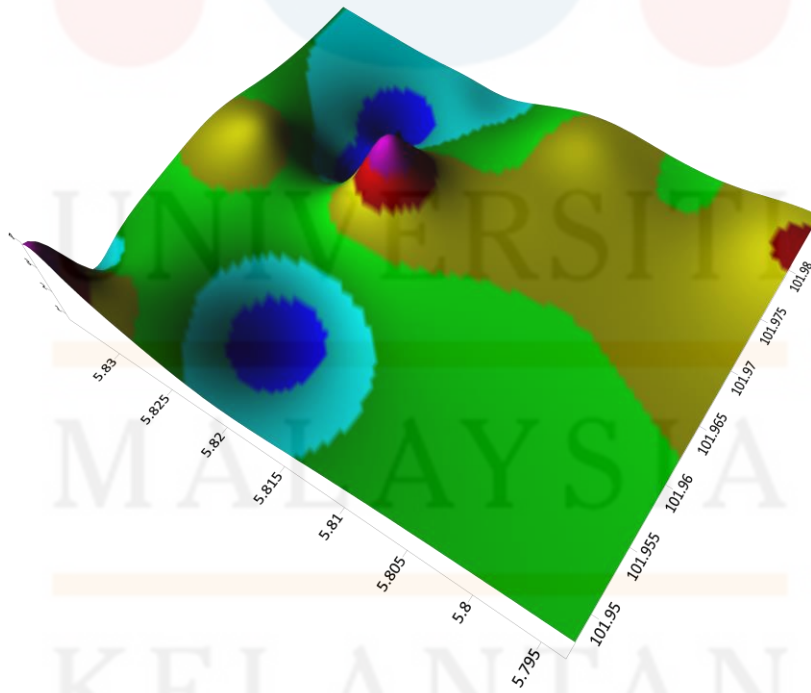
The distribution map in figure 5.25 indicated that the north is where there is the greatest concentration. Southward is where there is the lowest concentration. Figure 5.24 shows that the research area's potassium values range from 0.726 mg/L to 4.005 mg/L. While well 5 is in a low-lying location close to Kg. Bedah in the north east, well 12 is close to Kg. Bendang Keladi and has the greatest potassium concentration. The presence of potassium, a naturally occurring element, in water results from the breakdown of potassium-containing rocks and soil. According to figure 5.24, all of the potassium in well water is below the 20 mg/L WHO and MoHM threshold. Figure 5.26 shows a three-dimensional representation of the potassium concentration in the research area. All well water containing potassium can be very helpful in giving humans with the potassium nutrient. The presence of nutrients in drinking water can lead to an increase in the daily potassium intake.



**Figure 5.24:**  $K^+$  bar chart of study place



**Figure 5.25:** Distribution map of  $K^+$  concentration  
Source: Surfer 16



**Figure 5.26:** 3Dimensional Map of  $K^+$  concentration  
Source: Surfer 16

5.4.5 Sodium ( $Na^+$ )

Another naturally occurring element that is frequently found in igneous rock and sedimentary rock is sodium. The distribution of sodium concentration was shown in Figure 5.28, with the lowest concentrations in the south-east and increases in the north. The overall ranges of sodium present in well water are between 0.856 mg/L and 463.1 mg/L, according to figure 5.27. The well at Kg. Panglima Bayu with the highest concentration was well 11, and the well at Kg. Bedah with the lowest concentration was well 5. The well 11 sampling point has the highest sodium present with 463.1mg/L. The influent flow of surface water from the river into the aquifer may be the cause of the sodium present in the well. This clarified why well 11's salt content was so high. In figure 5.29, the sodium concentratin at the research region is shown in three dimensions. According to figure 5.27, the average sodium concentrations across all wells are still within the 200 mg/L drinking water level set by the WHO and MoHM. As a result, there is no risk of pollution for the well water at any sampling location.

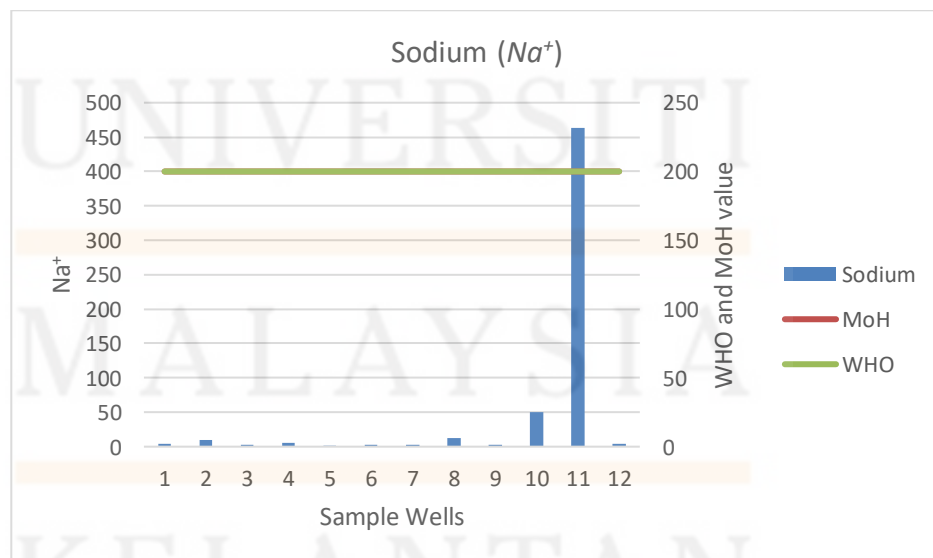
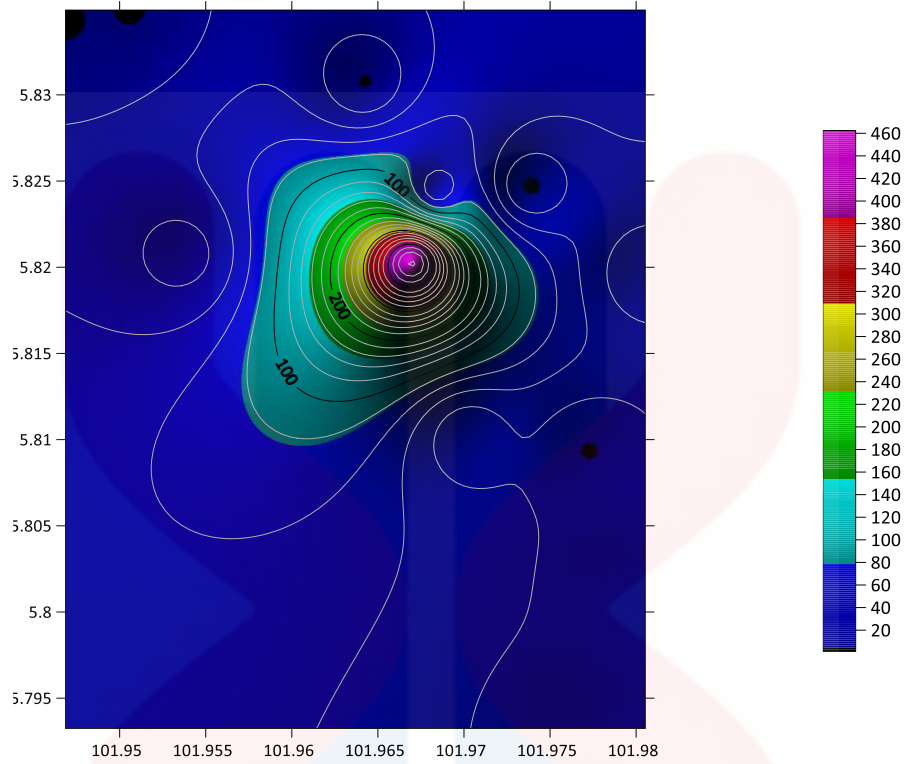
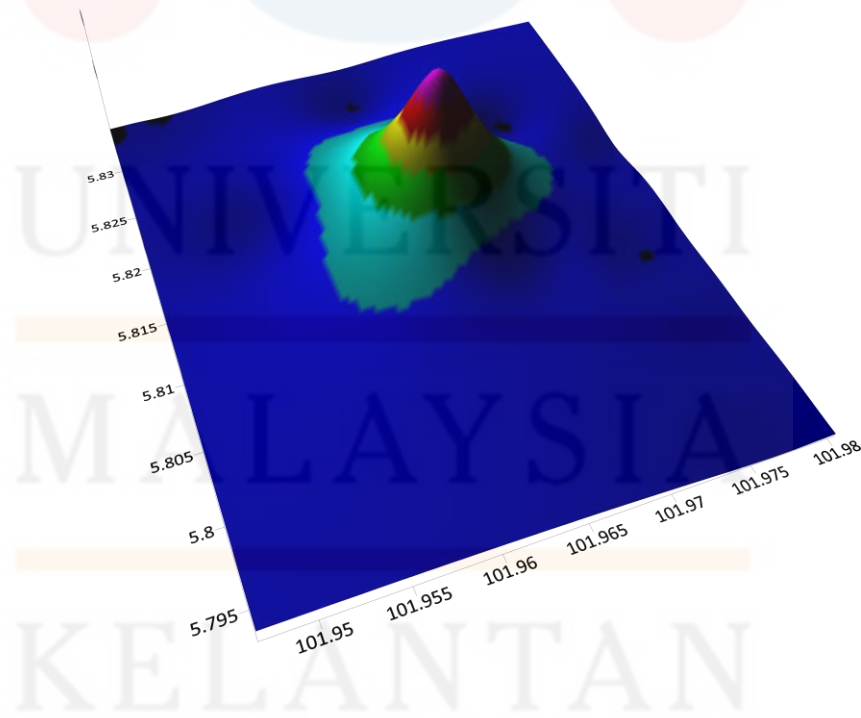


Figure 5.27:  $Na^+$  bar chart of study place



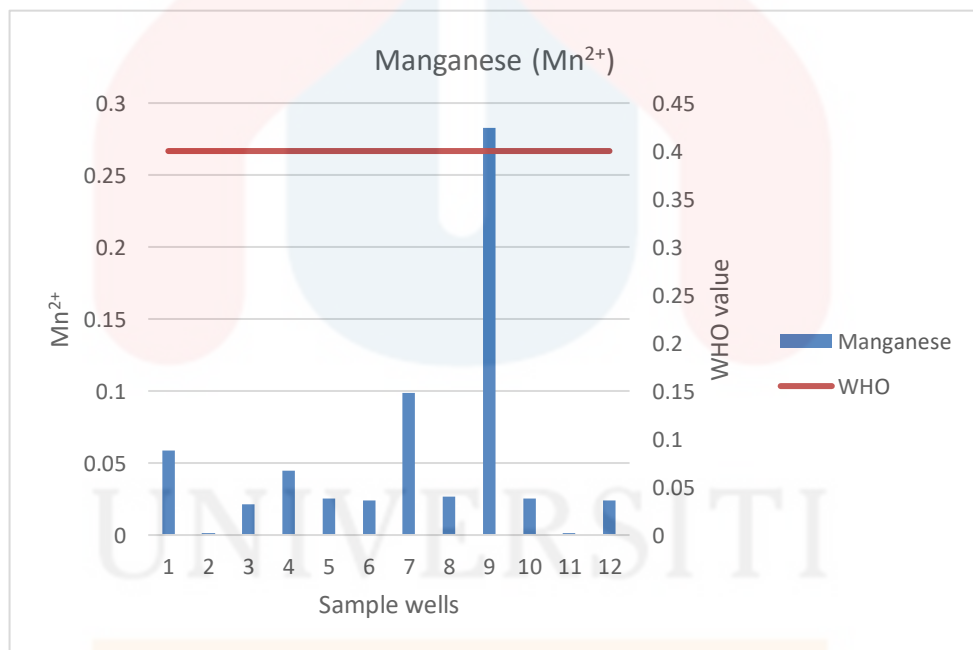
**Figure 5.28:** Distribution map of Na<sup>+</sup> concentration  
Source: Surfer 16



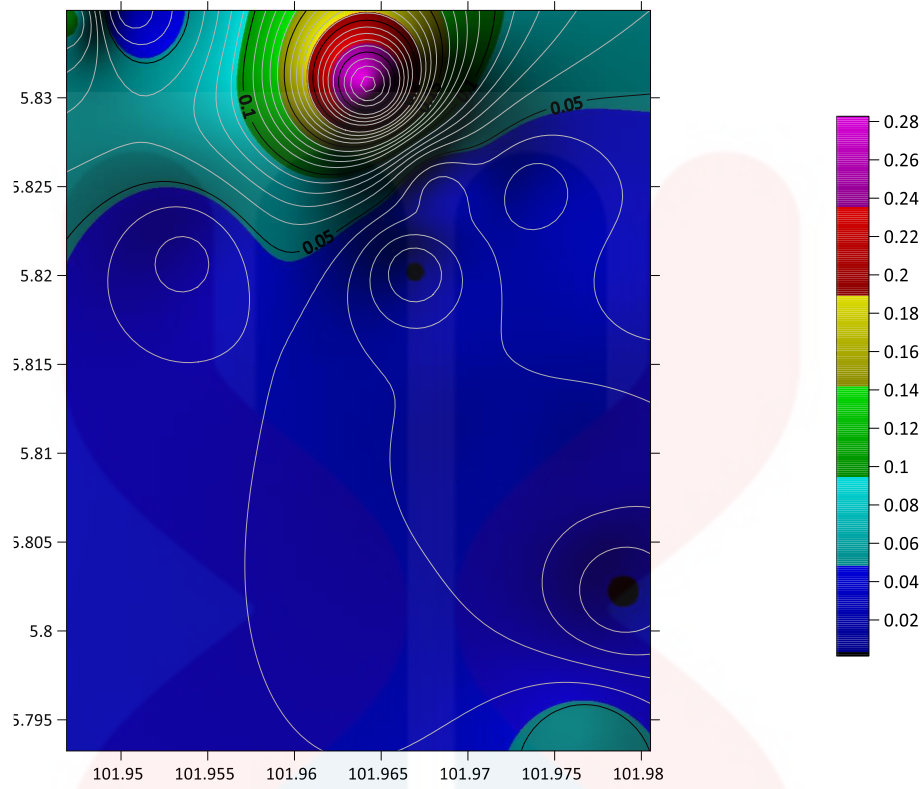
**Figure 5.29:** 3Dimensional Map of Na<sup>+</sup> concentration  
Source: Surfer 16

### 5.4.6 Manganese (Mn<sup>2+</sup>)

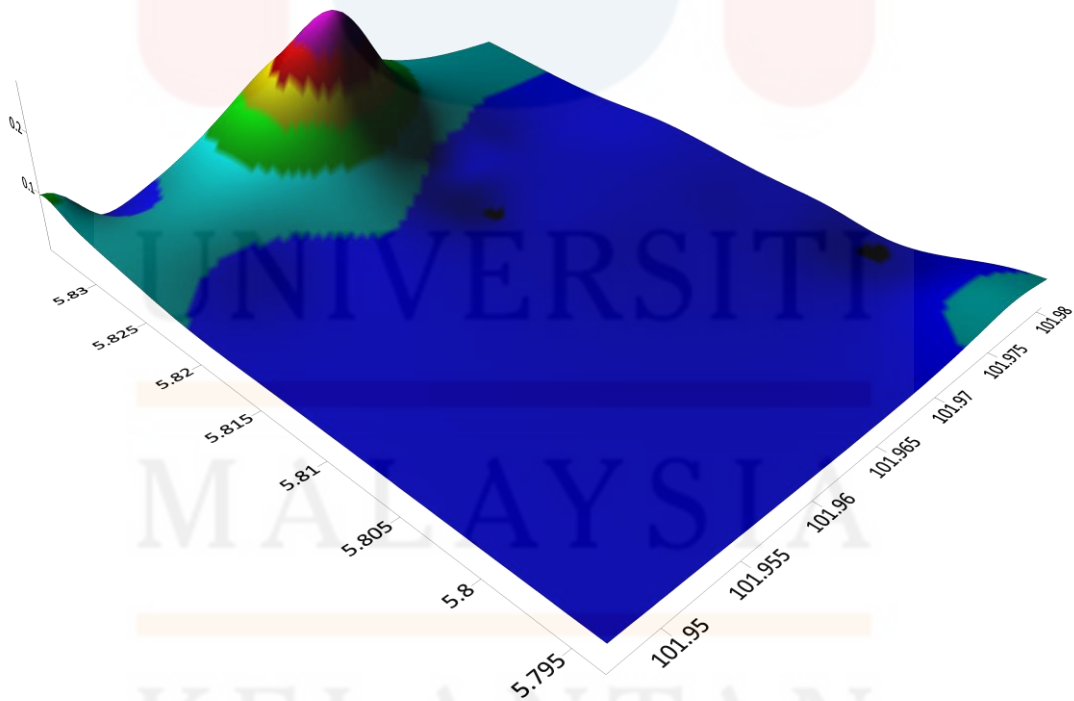
Manganese is one of the more abundant elements in the earth's crust and is widely distributed in soils, sediments, rocks, water, and biological materials. The major sources of man-made environmental pollution by manganese arise in the manufacture of alloys, steel, and iron products. Average manganese concentrations levels in drinking water range is below 0.4 mg/l according to MoHM and WHO. In Figure 5.30, the lowest level is at well 2 with 0.001 mg/l while the highest is at 0.283mg/l. This indicate that all the wells are below the standard level of MoHM and WHO. In figure 5.32 shows a three-dimensional representation of the manganese concentration in the research area



**Figure 5.30:** Mn<sup>2+</sup> bar chart of study place



**Figure 5.31:** Distribution map of Mn<sup>2+</sup> concentration  
Source: Surfer 16



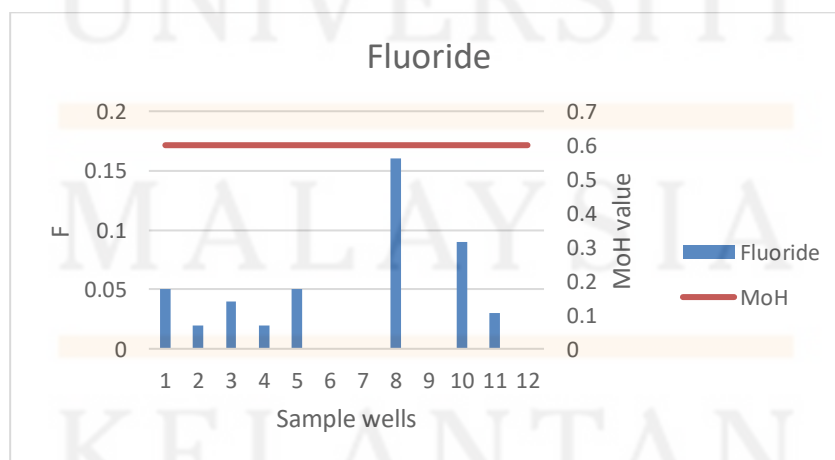
**Figure 5.32:** 3Dimensional Map of Mn<sup>2+</sup> concentration  
Source: Surfer 16

### 5.5 Major anions concentration

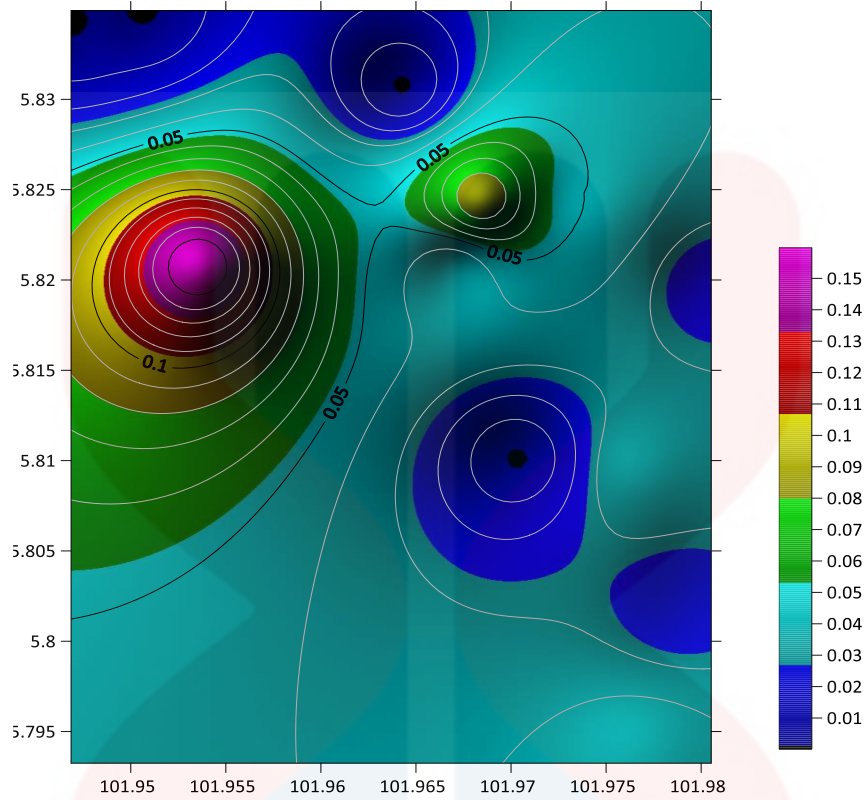
Major anions concentration includes elements of Nitrate, Sulphate, Fluoride, Bicarbonate and Chloride.

#### 5.5.1 Fluoride (F<sup>-</sup>)

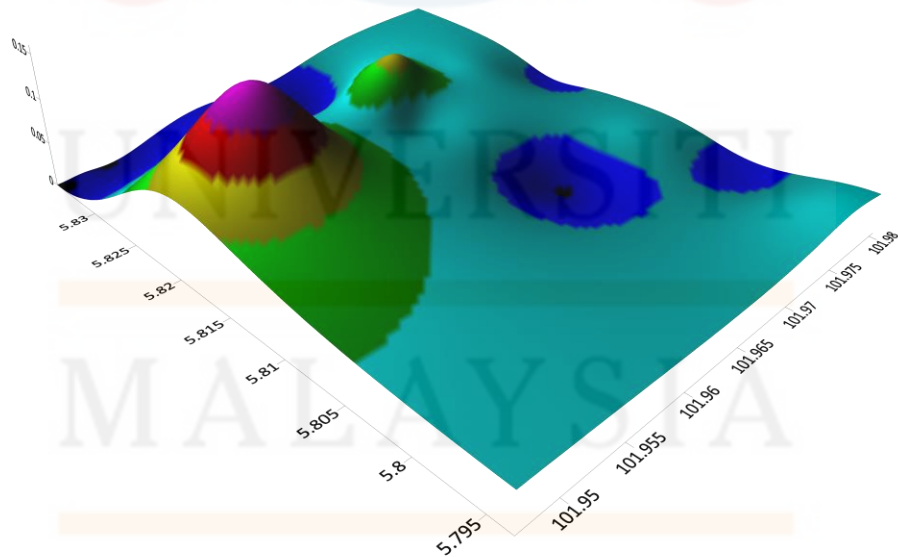
The fluoride content in well water varied from 0-0.16 mg/L, according to figure 5.33. The area with the highest concentration is well 8, which is around Kg. Gual. The environment of the region near the andesite quarry can have an impact on the amount of fluoride in the well. Igneous rock and sedimentary rock both include fluoride minerals that are poorly soluble. The availability of fluoride-bearing minerals has contributed to the fluoride content in well water. The majority of the research area's wells lacked fluoride anions. This is as a result of the absence of fluoride-bearing minerals in the region. WHO and MoHM have established acceptable fluoride levels for drinking water varied between 0.4 and 0.6 mg/L. The average fluoride concentration was estimated to be 0 which is less than standard value recommended by WHO and MoHM. This is because the wells contains less fertilizer which make it below the standard level.



**Figure 5.33:** F<sup>-</sup> bar chart of study place



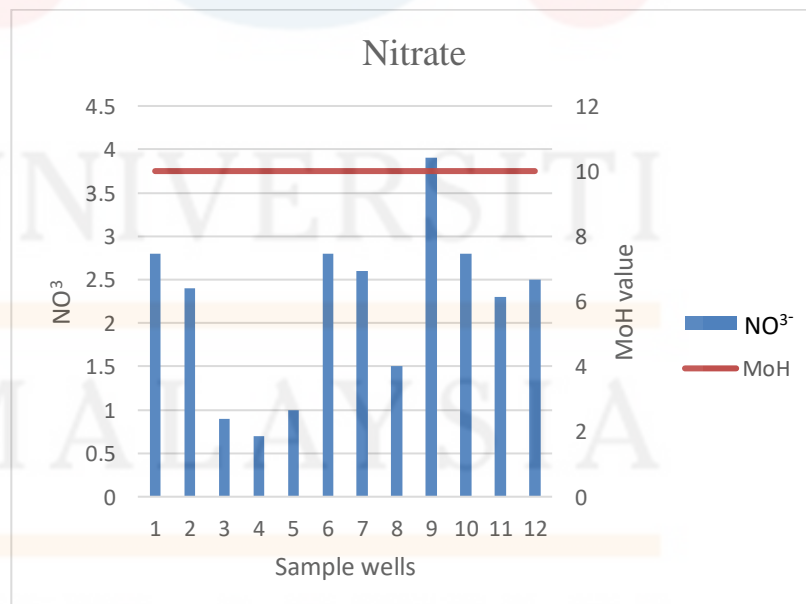
**Figure 5.34:** Distribution map of F-concentration  
Source: Surfer 16



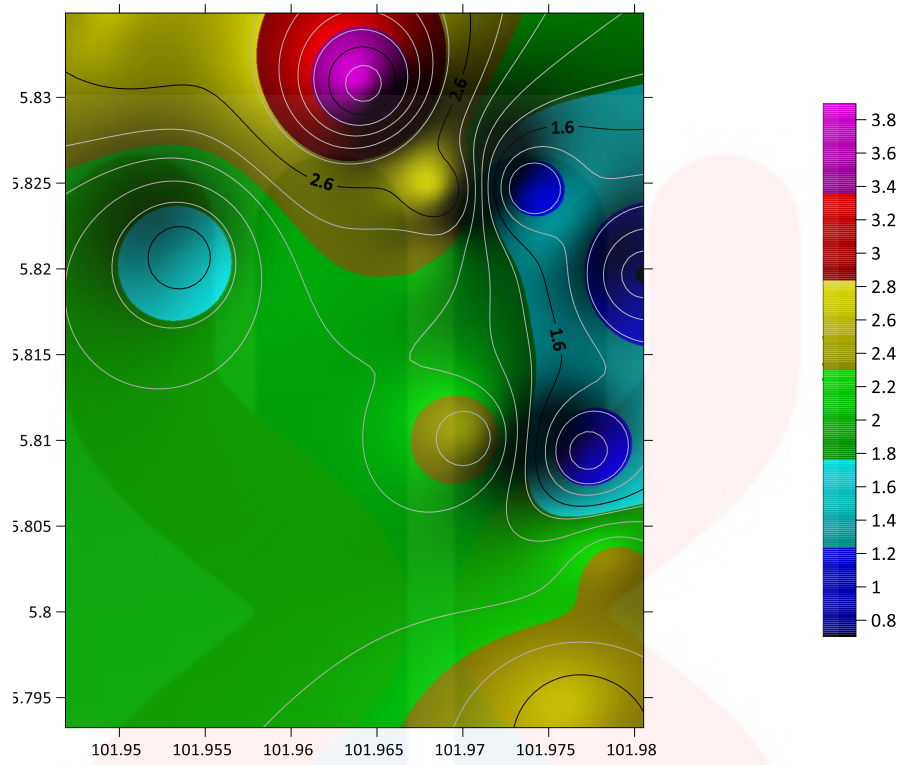
**Figure 5.35:** 3Dimensional Map of F- concentration  
Source: Surfer 16

### 5.5.2 Nitrate

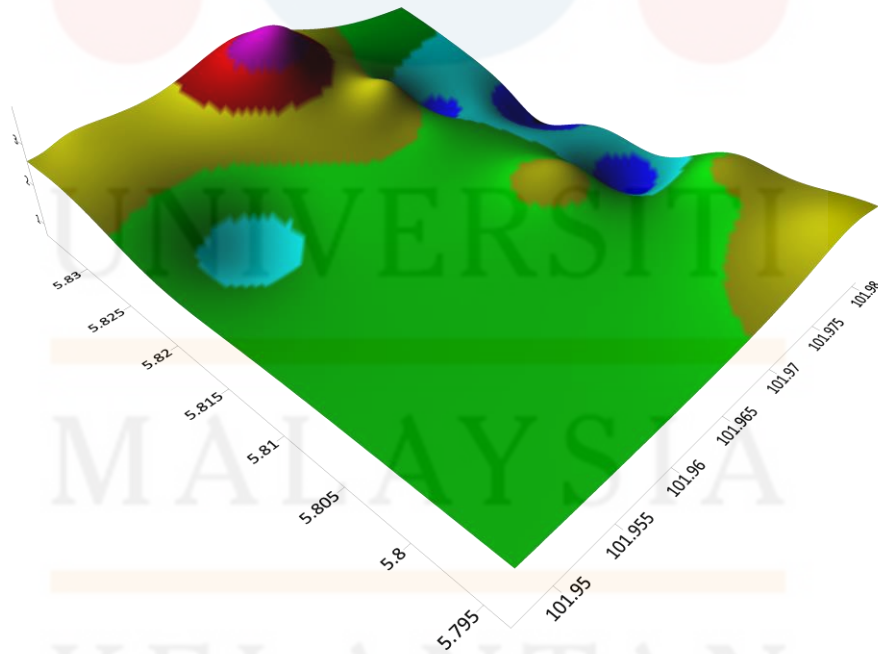
According to figure 5.36, the study area's nitrate concentrations range from 0.7 mg/L to 3.9 mg/L. The wells with the greatest and lowest nitrate concentrations are 9 and 4, respectively, which are both northeast of the study area. The land usage in the Panglima Bayu area is mostly for the agriculture of palm oil and rubber plants; plantations occupy the majority of the territory there. Because agriculture fields are one of the nitrate sources, the land use had an impact on the well 9's high nitrate concentration. The increase in nitrate levels in well water is caused by nitrate-rich agricultural fields' surface runoff. With regard to well 4, which is situated in a hilly terrain, the concentration is lower as a result of the natural sources of soil mineralization, atmospheric nitrogen, and the absence of agricultural plantations. All of the sampling wells' average nitrate concentration measurements fall within the MoHM standard of 10 mg/L. So, there are no nitrate contamination issues with any of the well water.



**Figure 5.36:** NO<sub>3</sub><sup>-</sup> bar chart of study place



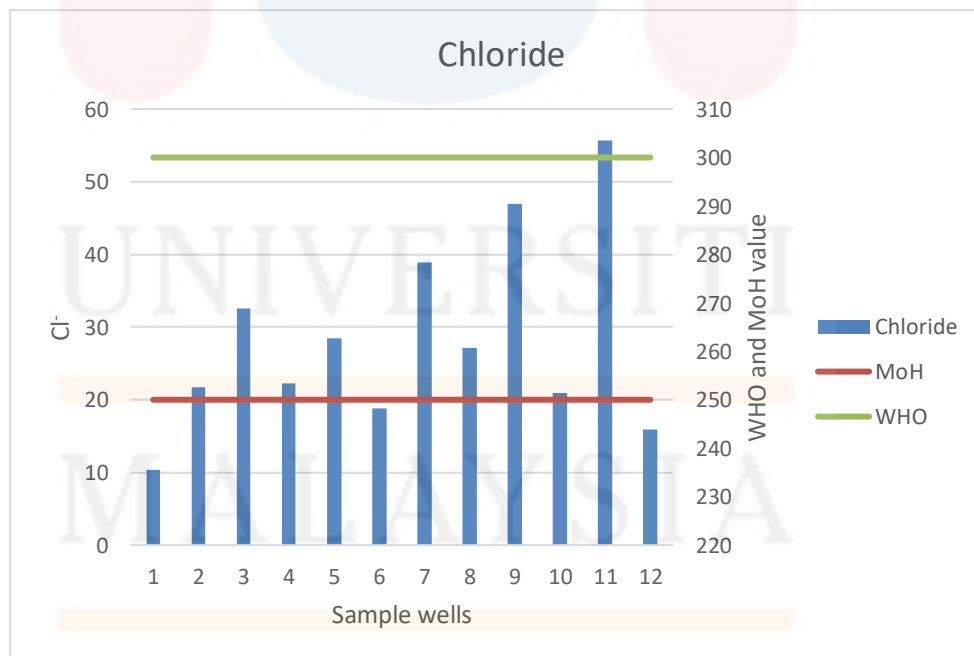
**Figure 5.37:** Distribution map of NO<sub>3</sub><sup>-</sup> concentration  
Source: Surfer 16



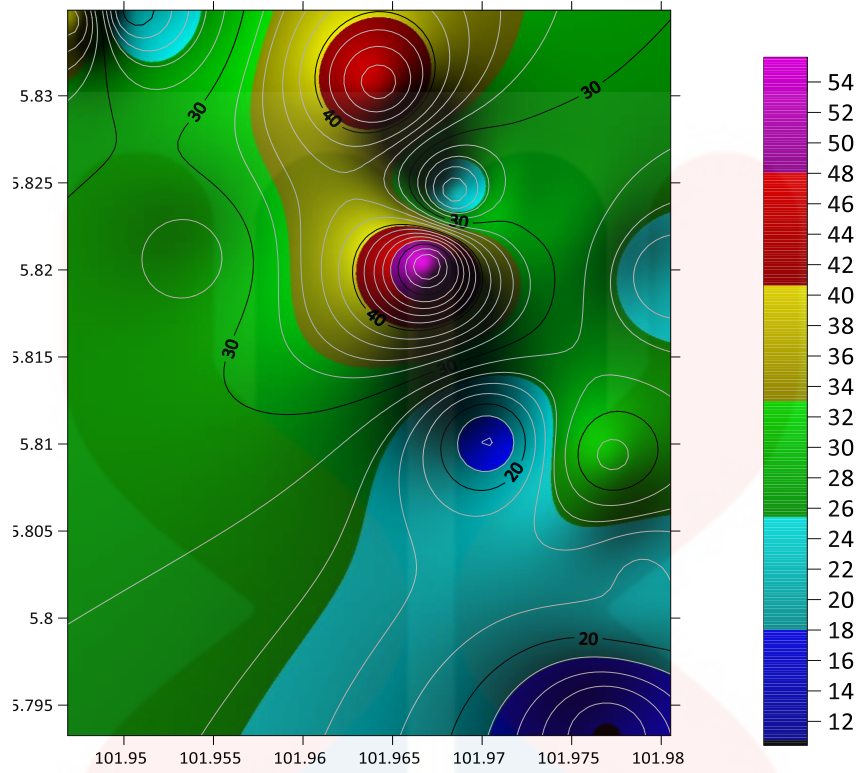
**Figure 5.38:** 3Dimensional Map of NO<sub>3</sub><sup>-</sup> concentration  
Source: Surfer 16

### 5.5.3 Chloride

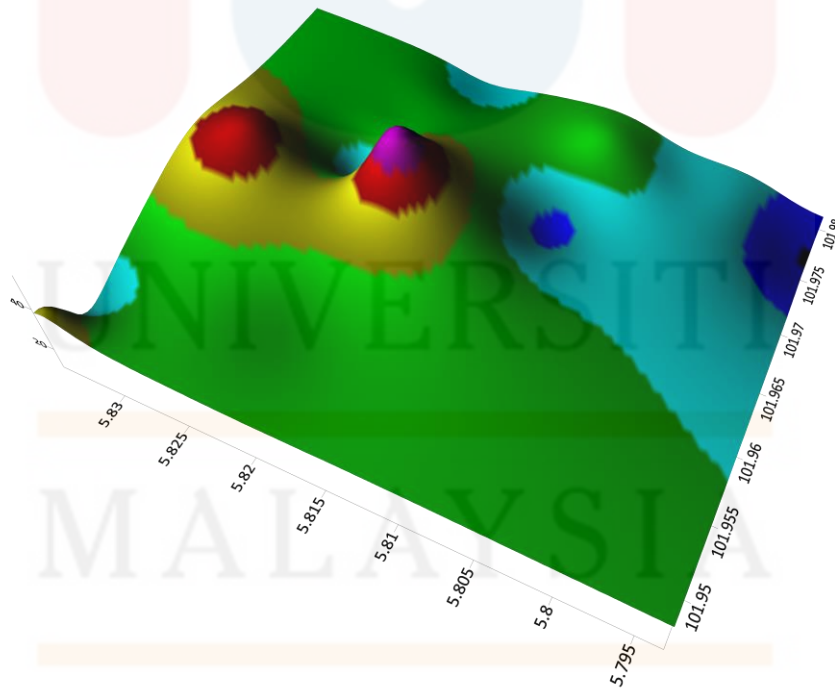
According to figure 5.39, the research area's chloride concentration ranges from 11.4 mg/l to 51.1 mg/l. Well 4 has the greatest concentration of chloride, whereas well 12 has the lowest. According to the overall findings, the well water's chloride content is still within the permissible range set by the WHO and MoHM. Therefore, there is no chloride pollution in any of the domestic wells in the study region. Figure 5.40 shows distribution map displays the concentration of chloride. The distribution map indicated that the north-west and west directions had the highest distribution. The areas with the lowest concentration are located in the southwest direction. The distribution map and the three-dimensional chloride concentration distribution map in figure 5.41 are connected. There are many high-concentration chloride peaks visible in three dimensions, with well 4's position in the north-west of the image. The other peak revealed that wells 1,5, 7, and 11 had a rather high concentration.



**Figure 5.39:** Cl<sup>-</sup> bar chart of study place



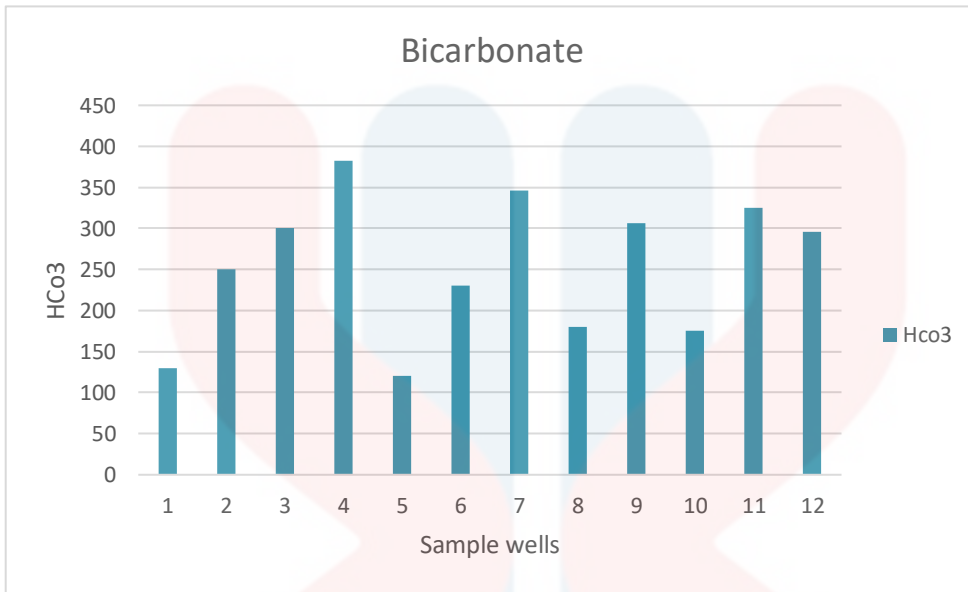
**Figure 5.40:** Distribution map of Cl<sup>-</sup> concentration  
Source: Surfer 16



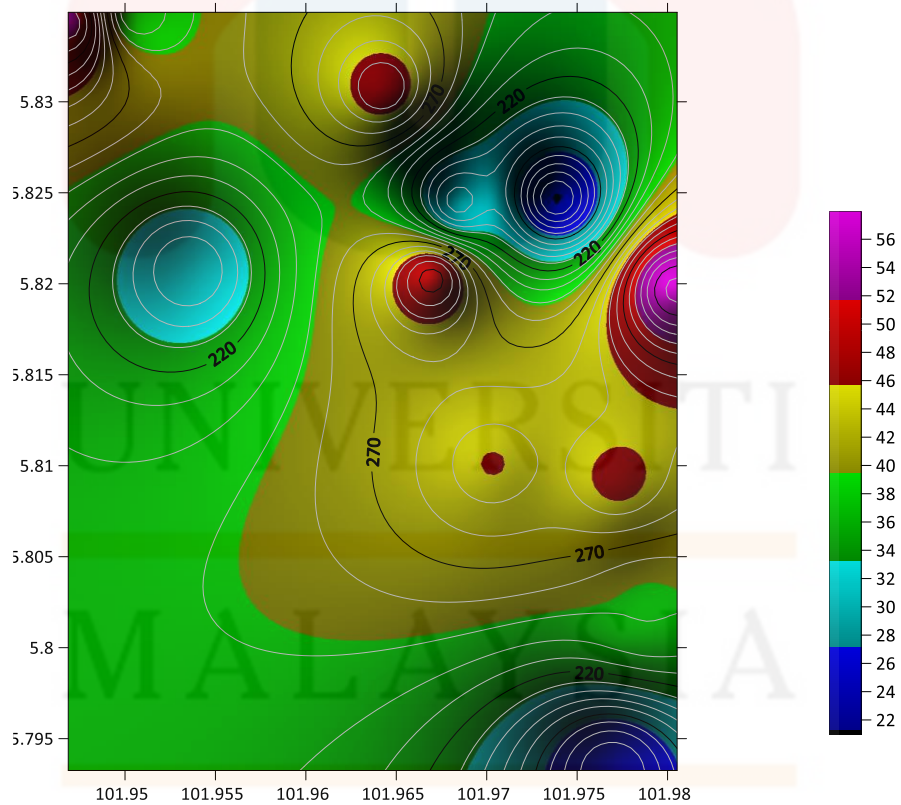
**Figure 5.41:** 3Dimensional Map of Cl<sup>-</sup> concentration  
Source: Surfer 16

#### 5.5.4 Bicarbonate

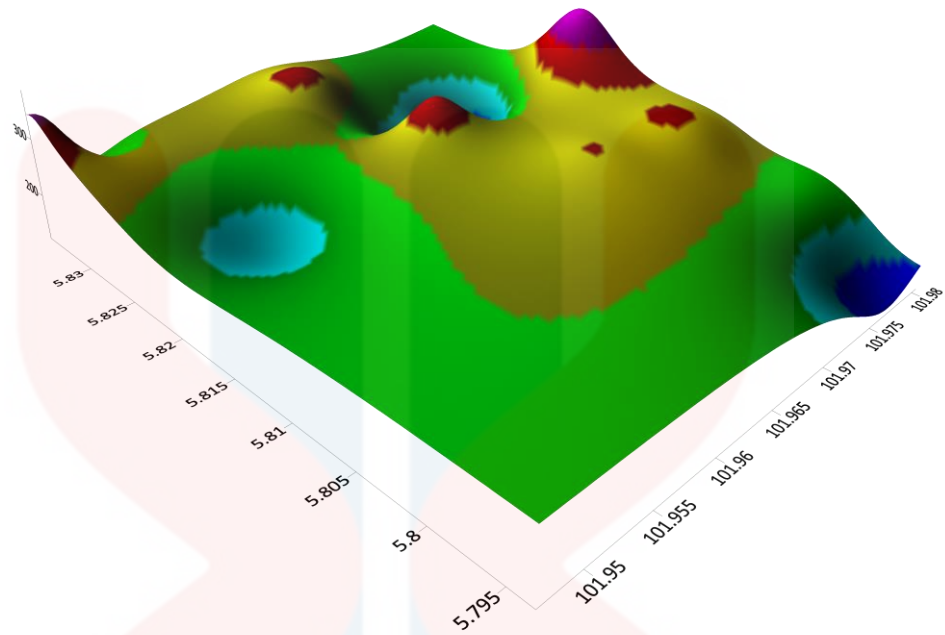
Figure 5.43's distribution map of bicarbonate concentration revealed an increase in concentration moving from east to west. In figure 5.44, the distribution is shown in three dimensions. The tallest peak is shown facing west on the three-dimensional map. According to figure 5.42, the research area's bicarbonate concentration ranged from 120 mg/L to 383mg/L. Well 4 has the greatest bicarbonate level, while well 5 has the lowest. The well water's contact with carbonic acid can produce bicarbonate ions, as can silicate weathering. When silicate minerals are chemically weathered, carbon dioxide in the soil reacts to form dissolved bicarbonate, which contaminates groundwater (E.K. Berner, 2005). River water entering the aquifer might be another source of bicarbonate. River water may include dissolved inorganic carbon ( $\text{HCO}_3^-$ ), which comes from the weathering of noncarbonated minerals like feldspar, mica, and olivine in carbonic acid. Another source is the dissolving of carbonate minerals found in the river (M.Meybeck, 2005). The high concentration of bicarbonate in well 4 is due to silicate weathering and influent river flow. Although there is no health danger associated with bicarbonate, it might make water taste saltier. The bicarbonate concentration of the water is not subject to any precise standards set by the WHO or MoHM. So long as the flavour is agreeable, it is safe to drink the residential well water in the research region.



**Figure 5.42:** HCO<sub>3</sub><sup>-</sup> bar chart of study place



**Figure 5.43:** Distribution map of HCO<sub>3</sub><sup>-</sup> concentration  
Source: Surfer 16

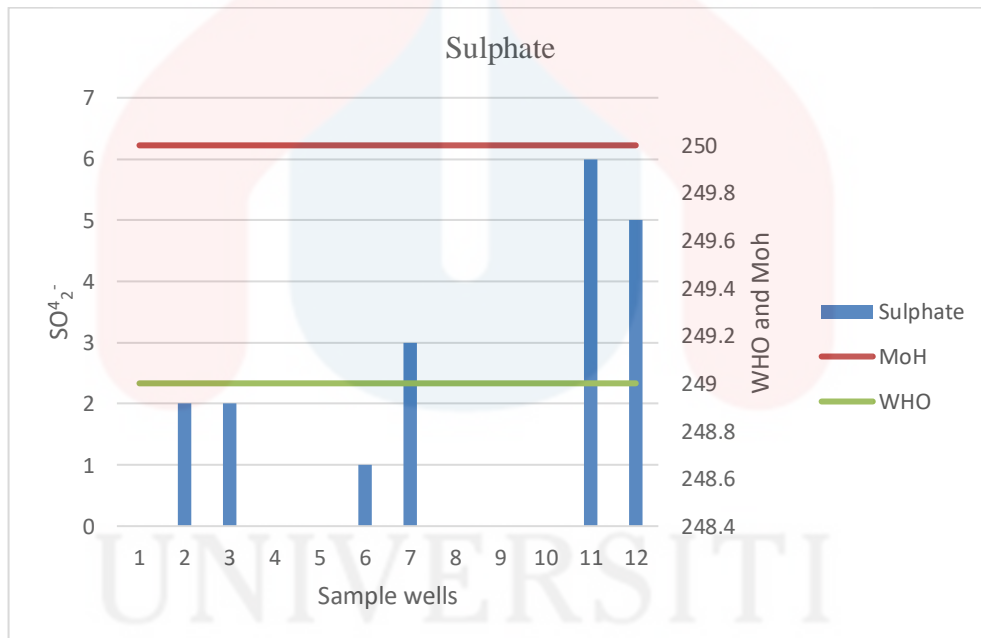


**Figure 5.44:** 3Dimensional Map of  $\text{HCO}_3^-$  concentration  
Source: Surfer 16

### 5.5.5 Sulphate ( $\text{SO}_4^{2-}$ )

Sulfate is a naturally occurring anion that is frequently found in groundwater and surface waters. According to figure 5.45, the research area's sulphate concentrations range from 0 mg/L to 6 mg/L. The majority of the sulphate readings, according to the results, are 0 mg/L; only wells 2,3,6,7,11 and 12 have slightly higher sulphate concentrations. Well 11 has the greatest concentration, while well 1,4,5,9, and 10 has 0 mg/L sulphate concentration. The state of the neighbourhood can have an impact on the sulphate content in well water. Well 11 displayed the largest peak of sulphate content in figure 5.45. Rainfall that is high in sulphate can cause a rise in sulphate concentration, especially in areas where there is air pollution. The town's densely inhabited and industrially active region is where Well 11 is situated. The local environment may contribute to air pollution in the vicinity, therefore rainfall near well 11 may be sulfate-rich due to reactions with

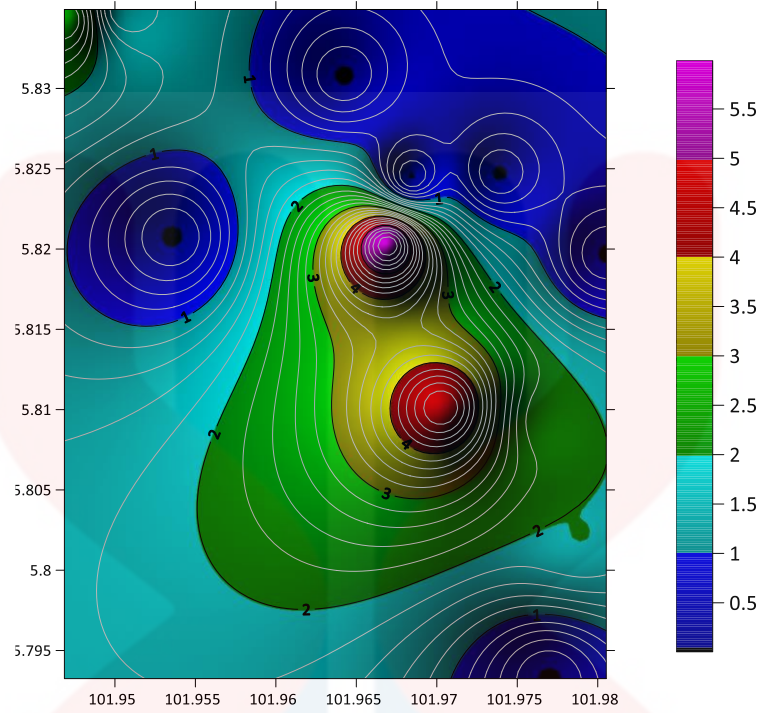
atmospheric pollution. The buildup of soluble salt in the soil may be another cause of sulphate at well 1. This is explained by the well 11's high sodium content. Since well 1,4,5,9, and 10 has the lowest sulphate content, the area experiences less air pollution than the town area does. This element indirectly contributes to the well 1,4,5,9, and 10 lowest sulphate content. All of the reported sulphate levels are still within the safe standard limit, according to figure 5.45. Given that all of the well water in the study region has sulphate concentrations below the level set by the WHO and MoHM (below 250 mg/L), the well water is safe to drink and poses no health risks.



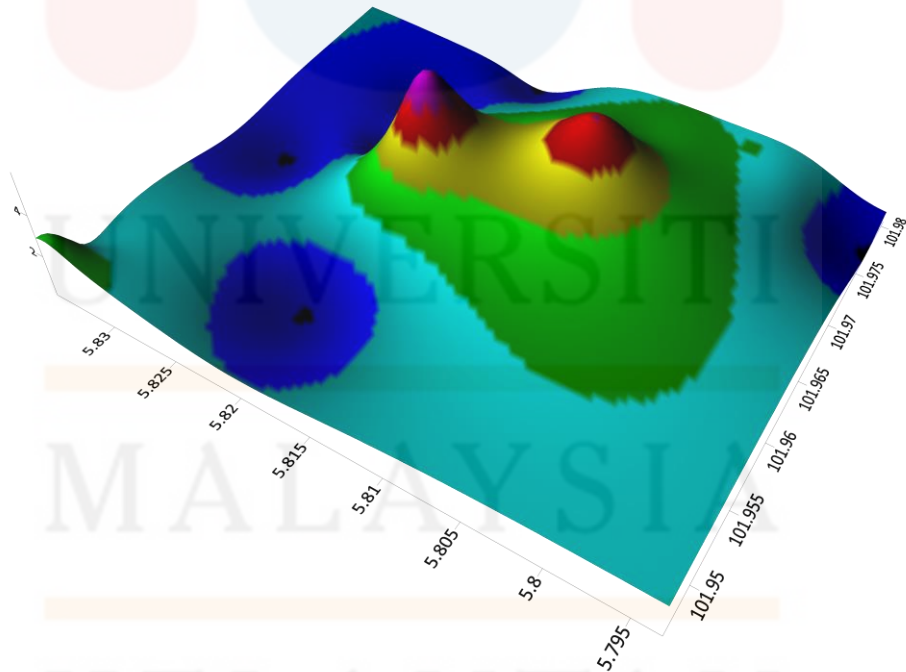
**Figure 5.45:** SO<sub>4</sub><sup>2-</sup> bar chart of study place.

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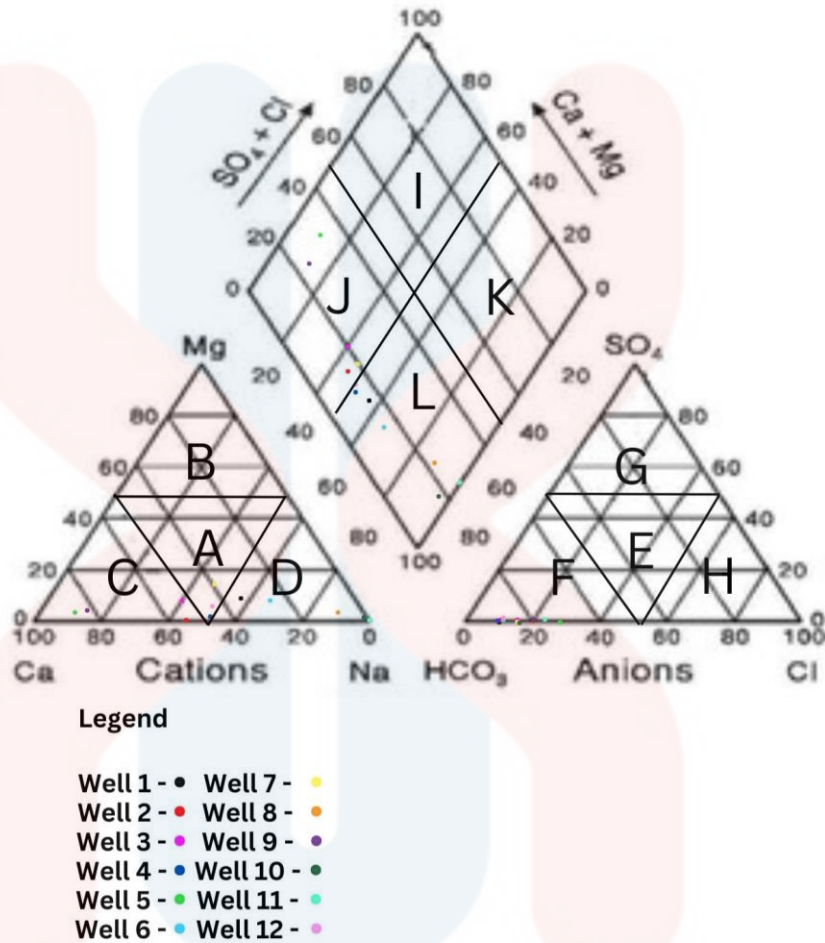


**Figure 5.46:** Distribution map of  $\text{SO}_4^{2-}$  concentration.  
Source: Surfer 16



**Figure 5.47:** Distribution map of  $\text{SO}_4^{2-}$  concentration  
Source: Surfer 16

## 5.6 Piper Diagram Analysis



**Figure 5.48:** Concentration of Anions and Cations in all wells plotted in Piper Trilinear Diagram

A & E : No dominant type

B : Magnesium Type

C : Calcium Type

D : Na+K Type

F : Bicarbonate Type

G : Sulphate Type

H : Chloride Type Analysis

I: Calcium sulphate facies

J: Calcium bicarbonate facies

K: Sodium chloride facies

L: Sodium bicarbonate facies

Calculation for Concentration of Anions and Cations plotted in Piper Trilinear Diagram is given in Appendix C

**Table 5.5:** Ions dominant in water according to piper.

<b>Ions dominant</b>	<b>Well number</b>
Calcium	W2, W3, W5, W9
Magnesium	No wells
Bicarbonate	All wells
Sodium+ Potassium	W1, W6, W8,W10, W11
Sulphate	No wells
Chloride	No well
No dominant	W4, W7, W12

The cations and anions values were placed on the diamond configuration in figure 5.48. The hydrochemical facies are categorized into four types based on the superimposed ions prominent on the diamond shape: calcium sulphate facies, calcium bicarbonate facies, sodium chloride facies, and sodium bicarbonate facies. With 7 wells, the majority of the domestic well water is classified as sodium bicarbonate facies. Calcium bicarbonate facies is the second minority facies, with only 5 wells. According to the piper diagram analysis, the domestic well water in the research area is dominated by the sodium bicarbonate facies.

## 5.7 Water Quality Index Analysis

Water Quality analysis is carried by included all the physico-chemical parameter that have standardize limit of elements by WHO. The element that are included can be seen in table 5.6.

Calculation of WQI value is given in Appendix D:

$$WQI = \frac{\sum_{i=1}^n qiWi}{\sum_{i=1}^n wi}$$

$$WQI = 41.01290/1$$

$$WQI = 41.013$$

The value of WQI is compared with table 5.6, then the water quality status is determined according to the range. From the comparison in table 5.6, the value of WQI at the study area is qualified good status.

**Table 5.6:** Groundwater status from WQI

<b>WQI</b>	<b>Groundwater quality</b>
0 – 25	Very Good
26 – 50	Good
51 – 75	Poor
Above 75	Very Poor

## CHAPTER 6

### CONCLUSION AND RECOMMENDATION

#### 6.1 Conclusion

The primary objectives of this research were to map the study area's geology and determine the quality of the groundwater in the area's domestic groundwater wells. Three lithologies—schist, granite, and alluvium—along with their ages make up the geological map. Schist is Permo-Triassic in age, granite is Cretaceous, and alluvium is Quaternary in age.

The granite rocks have been examined using petrographic analysis. Some of the principal minerals that have been identified through petrographic research are quartz, alkali feldspar, plagioclase, and biotite. Petrography examination revealed the presence of quartz, alkali feldspar, plagioclase, and biotite, with quartz being the most prevalent. Quartz is the most prevalent mineral in granite, and it is present there. Despite being scattered and sheared in every sample, quartz has the greatest proportion of the major elements in granite rocks.

Based on the findings of both investigations, the granite rocks of Kampung Panglima Bayu, which are composed of the Kemahang Granite, may be referred to as "biotite granite porphyry". This is because the mineral biotite is present in significant amounts in the hand specimens and it also correlates with the early study.

The quality of the groundwater around Kampung Panglima Bayu was analyzed in a variety of ways. Based on the physical and chemical parameters that have been

examined, it can be said that the groundwater in the alleged research area is still safe for drinking and other domestic uses. This is due to the fact that the majority of the main ion concentrations recorded are still within the permitted level set by the World Health Organization and Ministry of Health, despite the fact that a few parameters, notably in the agricultural sector, marginally above the threshold is one of the in-situ parameters that showed some of the well water's pH was below the normal limit and that the well water is highly acidic, making it unsuitable for drinking and irrigation purposes.

Other factors that influence the main ion concentration level in the studied region, aside from agricultural activities, may include geological features, time or duration of concentration, attenuation by recharge, presence of stream and tributaries, and others. The sodium bicarbonate facies dominate the domestic well water in the research area, according to the piper diagram analysis. These conclusions are based on the sorts of aquifers that are present, the lithology of the study area, and other factors that have been considered. Since Kelantan's public water supply is still underutilised in comparison to other states, it is essential that the general people use groundwater as a substitute source. The WQI investigation also revealed an overall result in the study area indicating that the water quality is good.

## 6.2 Recommendation

The majority of Tanah Merah's domestic wells were developed in rural areas. The people primarily use the well for daily needs. Government is not responsible for the water quality of the domestic well in the study region because wells are not a part of government. The well's owners must make sure that any non-government consultancy regularly monitors the well's water quality. Regular groundwater quality monitoring is crucial to ensuring that the water is safe to drink and has no harmful impacts on human

health. Controlling the discharge rate is another crucial element in preventing excessive water flow from happening.

Setting up a methodical sewage drainage system is another way to prevent the tainting of well water. The sewage waste can be kept from combining with groundwater by having an organised drainage system. By using this technique, the risk of contaminated well water is reduced.

Another technique that can be highly beneficial as a first step in the avoidance of groundwater contamination is drilling into the deep aquifer. Aquifers that are shallow can get contaminated. A deep aquifer, on the other hand, is uncontaminated and difficult to taint. This is because the aquifer has the property of being covered by an impermeable layer, which prevents contaminating sources from penetrating the aquifer.

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APPENDIX A

Sampling location



Figure 6.1.1: Well location 1



Figure 6.1.2: Well location2



**Figure 6.1.3:** Well location 3



**Figure 6.1.4:** Well location 4

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**Figure 6.1.5:** Well location 5



**Figure 6.1.6:** Well location 6



**Figure 6.1.7:** Well location 7



**Figure 6.1.8:** Well location 8



**Figure 6.1.9:** Well location 9



**Figure 6.1.10:** Well location 10



**Figure 6.1.11:** Well location 11



**Figure 6.1.12:** Well location 12

## APPENDIX B

### Titration

#### 6.2.1 Concentration of reagent used for titration.

- Methyl orange indicator, 0.05%. This reagent was prepared by dissolving 0.5g of methyl orange in 100ml of distilled water.
- Phenolphthalein indicator. The reagent was prepared by dissolving 0.5g of phenolphthalein in 50ml of 95% ethanol and 50ml distilled water. 0.05N CO<sub>2</sub> solution was added dropwise until the solution changes colour to faintly pink.
- Hydrochloric Acid, 0.1N

6.2.2 The amount of HCl included into formula 3.1, which determines the amount of total alkalinity in the well water

Calculation 3.1:

$$\text{PA as CaCO}_3, \text{mg/l} = \frac{(\text{A} \times \text{Normality}) \text{ of HCl} \times 1000 \times 50}{\text{ml of sample}}$$

$$\text{TA as CaCO}_3, \text{mg/l} = \frac{(\text{A} \times \text{Normality}) \text{ of HCl} \times 1000 \times 50}{\text{ml of sample}}$$

Where,

A = volume of HCl used with only phenolphthalein.

B = Volume of HCl used with phenolphthalein and methyl orange

PA = Phenolphthalein alkalinity

TA = Total alkalinity

6.2.3 Concentration of carbonates, hydroxyl ions and bicarbonates that can be determine from the table 6.2.1

Table 6.1 Values of Hydroxyl ions, carbonates and bicarbonates from the values of phenolphthalein and total alkalinities.

<b>Result of titration</b>	<b>OH alkalinity as CaCO<sub>3</sub></b>	<b>CO<sub>3</sub> alkalinity as CaCO<sub>3</sub></b>	<b>HCO<sub>3</sub> allalinity as CaCO<sub>3</sub></b>
$P = 0$	0	0	T
$P < \frac{1}{2} T$	0	2P	T-2P
$P = \frac{1}{2} T$	0	2P	0
$P > \frac{1}{2} T$	2P-T	2(T-P)	0
$P = T$	T	0	0

#### 6.2.4 Concentration of chloride reagent used for titration

- Silver Nitrate, 0.02N. The reagent was prepared by dissolved 3.4g of dried  $\text{AgNO}_3$  in distilled water to produce 1L of solution.
- Potassium Chromate, 5%. This solution was prepared by dissolving 5g of  $\text{K}_2\text{CrO}_4$  in 100ml of distilled water.

#### 6.2.5 Computation that uses the average reading into formula 3.2

Calculation 3.2:

$$\text{Chloride, mg} = \frac{(\text{ml} \times \text{N}) \text{ of } \text{AgNO}_3 \times 1000 \times 35.5}{\text{ml of sample}}$$

## APPENDIX C

### Piper trilinear diagram

#### 6.3.1 Conversion factor Chemical equivalence in table 6.3.1

Table 6.3.1: Conversion factor Chemical equivalence

Chemical constituents	Conversion factor
Bicarbonate, $HCO_3^-$	0.01639
Chloride, $Cl^-$	0.02821
Sulphate, $SO_4^{2-}$	0.02082
Sodium, $Na^+$	0.04350
Potassium, $K^+$	0.02557
Calcium, $Ca^{2+}$	0.04990
Magnesium, $Mg^{2+}$	0.08226

6.3.2 Anion concentration after multiplied by perspective conversion factors in milliequivalent per liter (meq/L) in Table 6.3.2:

Table 6.3.2: Anion concentration after multiplied by perspective conversion factors in milliequivalent per liter (meq/L)

Location	$HCO_3^-$	$Cl^-$	$SO_4^{2-}$
W1	2.1307	0.2934	0
W2	4.1030	0.6122	0.0416
W3	4.917	0.9168	0.0416
W4	6.288	0.6291	0
W5	1.970	0.8040	0
W6	3.775	0.5303	0.0208
W7	5.671	1.0974	0.0625
W8	2.955	0.7696	0
W9	5.026	1.3230	0

W10	2.868	0.5896	0
W11	5.327	1.5713	0.1249
W12	4.862	0.4485	0.1041

6.3.3 Cation concentration after multiplied by perspective conversion factors in milliequivalent per liter (meq/L)

Table 6.3.3: Cation concentration after multiplied by perspective conversion factors in milliequivalent per liter (meq/L)

Location	Na <sup>+</sup>	K <sup>+</sup>	Na <sup>+</sup> + K <sup>+</sup>	Ca <sup>2+</sup>	Mg <sup>2+</sup>
W1	0.1523	0.0763	0.2286	0.1253	0.0508
W2	0.4335	0.0590	0.4925	0.6402	0.0299
W3	0.1160	0.0683	0.1843	0.0773	0.0355
W4	0.2525	0.0383	0.2908	0.3372	0.0283
W5	0.0372	0.0186	0.0558	0.3464	0.0265
W6	0.1085	0.0371	0.1456	0.0517	0.0310
W7	0.0915	0.1019	0.1934	0.1587	0.0550

W8	0.5368	0.0195	0.5563	0.0610	0.0255
W9	0.1076	0.0740	0.1816	0.8832	0.0681
W10	2.1920	0.7910	2.9830	0.0172	0.0339
W11	20.1448	0.1024	20.247	0.0014	0.0380
W12	0.1855	0.0631	0.2486	0.2306	0.0376

#### 6.3.4 Anion Concentration in percentage value (%)

Table 6.3.4: Anion Concentration in percentage value (%)

Location	$HCO_3^-$ (%)	$Cl^-$ (%)	$SO_4^{2-}$ (%)	Total (%)
W1.	88	12	0	100
W2.	87	13	1	100
W3.	83	16	1	100
W4.	91	9	0	100
W5.	71	29	0	100

W6.	87	12	1	100
W7.	83	16	1	100
W8.	79	21	0	100
W9.	79	21	0	100
W10.	83	17	0	100
W11.	76	22	2	100
W12.	90	8	2	100

### 6.3.5 Cation Concentration in percentage value (%)

Table 6.3.5 Cation Concentration in percentage value (%)

<b>Location</b>	<b>Na<sup>+</sup> + K<sup>+</sup>(%)</b>	<b>Ca<sup>2+</sup> (%)</b>	<b>Mg<sup>2+</sup>(%)</b>	<b>Total (%)</b>
W1.	56	31	13	100
W2.	42	55	3	100
W3.	62	26	12	100
W4.	45	51	4	100
W5.	13	81	6	100

W6.	64	23	13	100
W7.	47	39	14	100
W8.	87	9	4	100
W9.	16	78	6	100
W10.	98	1	1	100
W11.	100	0	0	100
W12.	48	45	7	100

## APPENDIX D

### Water Quality Index

6.4.1 The WQI is calculated using the following formula 3.3:

Calculation 3.3:

$$WQI = (\sum_{i=1}^n qiWi / \sum_{i=1}^n wi)$$

Where,

n = the total number of water quality parameter

Wi = Weightage factor of the parameter, the value is calculate by using the equation

$$Wi = K/Si$$

K = constant of proportionality with the value of 1

Si = standard value of the ith water quality parameter

6.4.2 Water quality parameter was calculated by using the formula 3.4:

Calculation 3.4:

qi = the water quality rating for the ith water quality parameter

Calculation 3.4:

$$qi = 100V / Si$$

Where,

$V_i$  = the value of  $i$ th parameter in mg/L, and

$S_i$  = the standard value for the  $i$ th parameter (Sirajudeen J. and Abdul Vahith R, 2014).

6.4.3 Groundwater status from WQI in table 6.4.1

Table 6.4.1 Groundwater status from WQI analysis

WQI	Groundwater quality
0 - 25	Very Good
26 - 50	Good
51 - 75	Poor
Above 75	Very Poor

6.4.4 Calculation of WQI values for Groundwater Sample Collection in table

6.4.2

Table 6.4.2 Groundwater Calculation of WQI values for Groundwater Sample Collection

Physico-chemical Parameter	Mean value in ppm ( $V_i$ )	Highest Permitted Value (WHO) ( $S_i$ )	Unit Weightage ( $W_i$ )	$W_i \times Q_i$
pH	5.99	8.50	0.02596	1.8290

Electrical Conductivity (EC)	174.35	1400.00	0.00016	0.0020
Total Dissolved Solid (TDS)	122.04	9000.00	0.00022	0.0027
Turbidity (NTU)	7.26	4.00	0.05517	10.0130
Nitrate	2.18	10.00	0.02207	0.4810
Chloride	28.31	300.00	0.00074	0.0069
Iron	0.07	0.25	0.8827	28.5300
Potassium	2.21	20.00	0.01103	0.1220
Sodium	46.66	200	0.00110	0.0257
Sulphate	1.58	249	0.00087	0.0006

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## APPENDIX E

### 6.5.1 Joint Reading in Granite

Bearing	Frequency	Bearing	Frequency	Bearing	Frequency
0° - 10 °	--	121 °- 130 °	5	241 °-250 °	2
11°- 20 °	--	131 ° - 140 °	12	251 °-260 °	--
21 ° - 30 °	-	141 °- 150 °	2	261 °-270 °	-
31 ° - 40 °	3	151 °- 160 °	5	271 °-280 °	-
41 ° - 50 °	1	161 °-170 °	9	281 °-290 °	-
51 ° - 60 °	-	171 °- 180 °	11	291 °-300 °	6
61 ° - 70 °	-	181 °- 190 °	6	301 °-310 °	3
71 ° - 80 °	-	191 °- 200 °		311 °-320 °	7
81 ° - 90 °	2	201 °-210 °	16	321 °-330 °	-
91 ° - 100 °	2	211 °- 220	9	331 °-340 °	-
101 ° - 110 °	3	221 °-230 °	4	341 °-350 °	-
111 ° - 120 °	-	231 °-240 °	3	351 °-360 °	2