GEOLOGY MAPPING IN DABONG AND GROUNDWATER QUALITY ANALYSIS OF QUATERNARY AQUIFERS IN KOTA BHARU

BY

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A proposal of final year project submitted in fulfillment of the requirements for the degree of Bachelor of Applied Science (Geoscience) with Honours

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DECLARATION

I hereby declare that the work embodied in this report entitled " Geology Mapping in Dabong and Groundwater Quality Analysis of Quaternary Aquifers in Kota Bharu' is the result of my own research except as cited in the references. The thesis has not been approved for any degree and is not simultaneously submitted in candidature of any other degree.

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APPROVAL

"I/ We hereby declare that I/ we have read this thesis and in my/our Opinion this thesis is sufficient in terms of scope and quality for the Award of Bachelor of Applied Science (Geoscience) with Honours"

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ABSTRACT

GEOLOGICAL MAPPING USING REMOTE SENSING IN DABONG AND GROUNDWATER QUALITY ANALYSIS IN QUATERNARY AQUIFERS IN KOTA BHARU.

The quality analysis of groundwater extraction focuses predominantly on the coastal region of Kota Bharu. The field of research ranges from the lower part of Pengkalan Chepa to the upper part of Bachok. A 25-km box covers the study area. There are villages scattered throughout the study area, indicating that the annual groundwater withdrawal is high. The research aims to create an updated map of Kampung Durian Badak, Dabong by using Google Earth, Aerial Photograph and literature review were widely used by using GIS and to conduct quaternary aquifer quality analysis in the study area. In order to produce a geological map, the geology of the study region in Kampung Durian Badak was determined by geological mapping. The area of study has 4 kinds of lithology, mainly mudstone, followed by sandstone, slate, carbonaceous and mica schists. An updated geological map based on geological data produced by ArcGIS software. The result of water sampling indicates that the water from the aquifers are not suitable for drinking purposes due to high content of chemicals which is been eliminated from the Agricultural sectors.

Keyword: Kampung Durian Badak, Groundwater Extraction, Drinking Purposes

ABSTRAK

PEMETAAN GEOLOGI MENGGUNAKAN PENDERIAN JARAH JAUH DI DABONG DAN ANALISIS KUALITI AIR TANAH DI AKUIFER KUARTER DI KOTA BHARU.

Kawasan kajian ini terletak di Daerah Kota Bharu berdekatan dengan pesisir pantai. Analisis kualiti pengekstrakan air bawah tanah lebih diutamakan dengan wilayah pesisir Kota Bharu. Bidang penyelidikan dari bahagian bawah Pengkalan Chepa hingga bahagian atas Bachok. Oleh itu, kertas ini mengemas peta terkini sepanjang 25 km merangkumi kawasan kajian. Terdapat perkampungan berdekatan dengan kawasan kajian, yang menunjukkan bahawa pengeluaran air bawah tanah tahunan adalah tinggi. Penyelidikan ini bertujuan untuk mengemaskini peta geologi Kampung Durian Badak, Dabong dan melakukan analisis kualiti akuifer kuarter di kawasan kajian. Untuk menghasilkan peta geologi, wilayah kajian di Kampung Badak ditentukan oleh pemetaan geologi. Kawasan kajian mempunyai 4 jenis litologi, terutama batu lumpur, diikuti oleh batu pasir, batu tulis, karbonat dan mika. Peta geologi yang dikemas kini berdasarkan data geologi yang dihasilkan oleh perisian ArcGIS.

Kata Kunci: Kampung Durian Badak, Pengekstrakan air bawah tanah, Sumber Air Minuman

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LIST OF ABBREVIATIONS

CALC	Calcite
GPS	Global Positioning System
JMG	Jabatan Mineral Geosains
LS	Limestone
PPL	Plane Polarized Light
QTZ	Quartz
SS	Stratigraphy Section
UMK	Universiti Malaysia Kelantan
USGS	United States Geology Society

LIST OF SYMBOLS

%	Percentage
°	Degree
σ	Sigma

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Public water distribution in Kelantan is also inadequate compare to other states in Peninsular Malaysia. Until December 2017, the total population using public water sources was 1,086,840 (approximately 65 per cent) out of the Kelantan population (1,666,000). This also covers households utilising two sources of water supply (from public utilities as well as alternate sources of water supply, such as groundwater and gravity feed systems) (GFS). The rest of the population of Kelantan (35%) depends solely on the alternate source of water supply (groundwater and Gravity Feed System), especially in rural areas. This region is known permanently as the level platform. In fact, this zone contains brackish water (Klassen et.al, 2017).

The shortage of clean water and sufficient hygiene will have a significant effect on the well-being and well-being of human health. Diarrhea, for example, which is primarily derived from polluted water and poor sanitation, is responsible for 2.4 million deaths per year and contributes more than 73 million disability-adjusted years of life (a measure of disease burden, WHO 1999).

Diarrhea disorder ranked sixth in the world as a cause of death and seventh in the morbidity list. This health burden is mainly caused by people in developed countries and infants.

Water-borne disease outbreaks continue every year, including an undertaking to cut half of the world's population who cannot reach or afford safer potable drinking water by 2015, the Milliennium Development Objectives articulated by the UN General Assembly (2000)

The World Health Organisation recently speculated that development of water, sanitation and hygiene could prevent a minimum of 9, 1% of the world's disease burden (in life years adapted to disability), or 6, 3% of deaths (Pruss-Ustun et al 2008). In the past the US had also reported 243 cases, including 86 bloody diarrheses, 2 HADS and 4 deaths from E. coli 0157:H7, in a communal water source unchlorinated in Cabool, MO December 1989 to January 1990 (Swerdlow et al., 1992). This new millennium also includes cases of outbreak of waterborne disease in developed countries as happened in Walkerton, Canada, in May 2000. 2 300 members of the 4 800 inhabitants of the city suffered from Gastroenteritis, 65 were in hospital, 27 developed HUS, and 7 died.

The pathogen detected is E.coli 0157:H7 and Campylobacter jejuni with a cost of about $155 million for outbreak-related disease (Hrudey et al., 2003). Although remote sensing is used primarily in soil water analysis, it is also important for the consistency of soil water to be studied. Data that have been remotely sensed were used in this analysis for two key purposes. In the first place, the geographic distribution of vegetation, urban areas, land use and other significant variables for groundwater adjustments should be measured, and in the second place, geological features that can be defined in deciding groundwater flux direction should be developed and distributed.

1.2 Study Area

1.2.1 Location

The study area extends from 5˚24’30’’ N latitudes and 101˚56’30’’ E longitudes. The study area is located in the district of Dabong and comprises of very hilly terrain. Terrain of the study area is portrayed by almost flat landforms with elevation ranging from 20m to 16m.

The range of study area is nearly coextending to the coastline of North Kelantan. The study area represents the portion of the flat Kelantan alluvial plain. The Kelantan plain is covered with Quaternary sediments which overlies granite bedrock. Deep drilling demonstrates that this sediment overlie granite bedrock (Pfeifer and Tiedemann 1986).

The Quaternary deposit varies in thickness from 25 m inland to an abundance of 200 m at the coast. The Quaternary sediments are of alternating layers of gravel, sand (mainly marine), silt and clay. The biggest stream, the Kelantan River discharges streams and short streams into the study area. This includes the Jelawat River, Kemasin River, Dua River and Telong River which stream into the South China Sea. A broad division of the alluvium into marine and fluvial origin has been indicated, but intermixing of depositional processes is found near the larger rivers. Figure 1.1 shows the base up of study area.

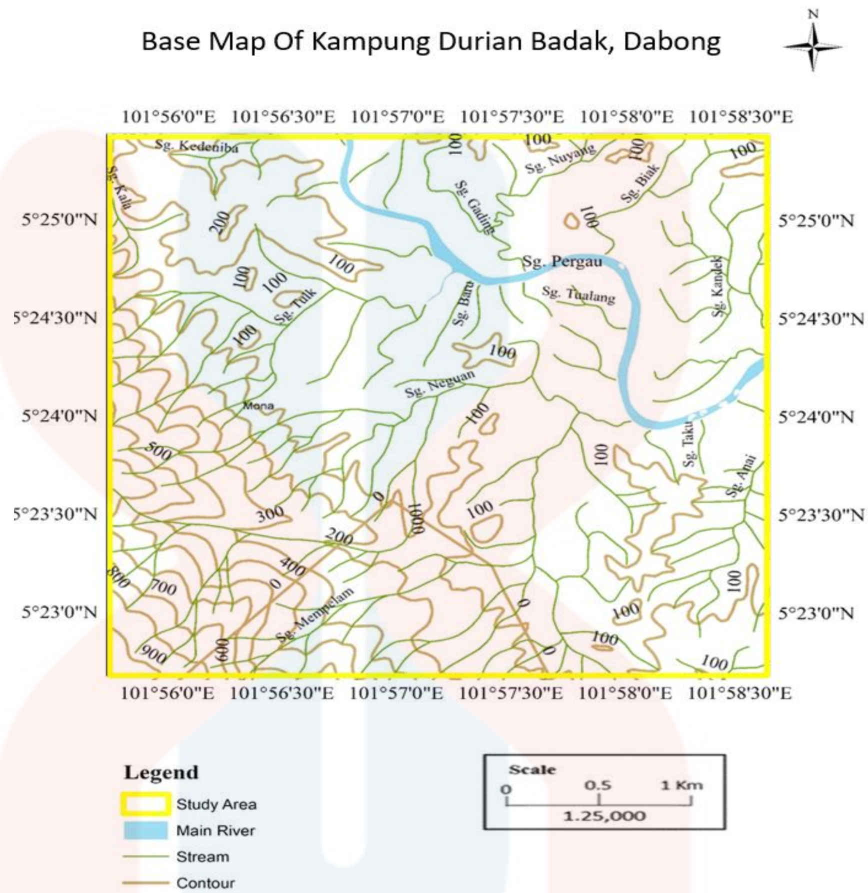


Figure 1.1: Base Map of Study Area in Kampung Durian Badak, Dabong.

Kota Bharu is the field of study for this research area. This research has been performed in order to improve understanding of the topographical setup of the multi-layered aquifers in the Lower Kelantan Basin and determine the hydrogeochemical features of groundwater resources. The research area in Kota Bharu has moved approximately 5 km along the Kelantan coast from the Sungai Pengkalan Datu mouth river to the Sungai Kemasin river system. At Pengkalan Datu and Kemasin, the river was constructed to facilitate navigation and surge moderation. The breakwaters connecting to the shore were consolidated. Deposition to the south of the breakwater and disintegration to the north were the results of the construction.

Three main aquifers can be classified in the study zone: shallow, moderate and deep. The groundwater samples for pH, ammonia, turbidity, magnesium, manganese and calcium were gathered and analysed from these three aquifers. The Minerals and Geosciences Division presented details (MGD). In addition, 70 control wells are located in levels 1, 2, and 3 of the North Kelantan Stream basin. Two openings are built in level 1, while two openings and 19 openings are separately built in levels 2 and 3. The water changes or water budget for an aquifer's energy spectrum were a valuable method for commitment (Eckhardt, 2008).

Moreover the development and temperature of precipitations influence the chemical groundwater inquiry. Figure 1.2 shows the research area in Kota Bharu.There are few ways to access to the study area. Based on my location of my study area which is located in Kampung Durian Badak, Dabong. The research area has been covered with several ways of access where the roadway had been passing is the intersection of the main road which is Jalan Sungai Sam. It's often been used by villagers for their work place and it is the main road which connects Dabong to Jeli. Lastly mobility such as a motorcycle, hilux and walking can be accessed to the the research area can be easily reached. The study area consists of many villages. The nature of flora covers most of the study area.

1.2.2 Demography

The area of study is situated in Kuala Krai, part of Kelantan. The distribution of people in Dabong can be seen. Total Dabong population is 40,659, Malay are 38,155, the largest population, and the lowest Chinese population, consisting of only 42. There are 71 Indians in population. In Dabong district, there are approximately 2376 non-Malaysian people. Table 1.1 shows the distribution of people.

Table 1.1: People distribution in part of Dabong. (Total population by ethnic, Local Authority area and state, Malaysia, 2010)

Total people distribution:	Malaysian Citizen				Non- Malaysian Citizen
	Bumiputera	Chinese	Indian	Others	
= 40659	38155	42	71	9	2376

1.2.3 Land Use

In view of its evaluation, 80% of the study region was settled by several industries, including forestry, agriculture and fertiliser and rubber estates. Therefore the majority of the villagers work on their livelihoods in the study area. Furthermore the field of study is strongly restricted and forested. Only some transportation such as motorcycle and hilux would access the field of the study from the junction of the rubber scrub factory as the route is unfit for passages in the vehicle. The path is approximately 25 km. Moreover, almost all of the region is also populated with vegetation, valuable trees and shrubs that are particularly suited as habitats for wild animals such as elephants and wild boars. Figure below shows the land use map of the study area.

1.2.4 Social Economic

Kampung Durian Badak, Dabong is a place dominated by employment, unemployment and labor force. Other than that, the development of tobacco sector and rubber plantation lead for their surviving and to gain money for their own. Moreover, they also very have known to the tourist because of the geological heritage and heritage of past kingdoms. Every Javanese has more than one association which serve governmental, economic, religious, and educational and recreations interests. Through these types of associations, they are able to help each other.

1. 3 Problem Statement

The current geological evidence area is not mapped on small scale which cover all aspect of geological informations. Present informations are very general such as landuse, lithology, drainage pattern and topography. In this study, a updated geological map generated on 1: 250000 scale which covers lithology, geomorphology, drainage patterns. With remote sensing, we can identify recent improvements in aquifer condition and land movement in the specific region. Two key factors in the existence of the issue of water shortages are hydrological and precipitation trends. In addition, it is difficult to carry out research and experiments and hydrograph interpretations because of the present condition of Covid-19 and various chemical properties. This study would also help advice and evaluate the creation of the system for water safety.

Furthermore, previous surveys have long been performed in the research field of land use changes which do not include updated changes in data. The study does not provide details. In Kota Bharu, every five years a map was drawn up of the coastal area and coastal erosion was noticed. With remote sensing, we can identify recent improvements in aquifer condition and land movement in the specific region. Two key factors in the existence of the issue of water shortages are hydrological and precipitation trends. In addition, it is difficult to carry out research and experiments and hydrograph interpretations because of the present condition of Covid-19 and various chemical properties. This study would also help advice and evaluate the creation of the system for water safety.

1. 4 Objective

I. To produce a geological map of Dabong, Kelantan in the scale of 1:25000.
II. To determine groundwater quality parameters from secondary data sources.

1.5 Scope of Study

5X5km in Dabong will be selected in producing geological mapping in the 1:25000 as it is always referred to the previous geological studies and researches through geological mapping which focuses three main scopes of the study in this research. It focuses on geomorphological mapping, structural geology and drainage pattern at the research area. This includes thematic maps related to particular geographical regions such as temperature variation and distribution of rainfall.

This research uses many types of methods such as hydro geo-chemicals and piezometer. The water quality of different aquifers were analyzed and interpreted which illustrate three dimensional interpretation. As we all know, Kelantan has a variety of potential freshwater aquifers. Aquifers serve as a regular source of water to certain rural areas. The coast of Kelantan faces the South China Sea. Seawater could intrude underneath the land and contaminate fresh aquifers. Using electrical resistance mapping, the events below the subsurface can be clearly observed. In order to discuss the findings, a 2D image will be generated. If this contamination of seawater continues, the source of fresh groundwater would be immediately close off.

1.6 Significance of Study

The importance of this analysis is that more geological data will be applied to the study area and a more efficient geological map could be created. The map that has been created by the use of satellite imaging, certain human activity, and geomorphology. The key theme of this study is to determine the potential location of aquifers. The identification and mapping of this aquifer quality analysis will provide even more information about future studies and in the coming years, researchers could come up with an idea to avoid the pollution which may give a drastic impact in groundwater extraction. This research can help future research in groundwater development as well as groundwater management.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In this chapter, an overview of the previous study carried by previous researchers relating to this research had been done. Source of papers, publications and articles of previous research were be used as a reference and review to this present works.

2.1 Regional Geology and Tectonic Setting

The first geological survey in Kelantan was carried out in 1922-1925 and later in 1950-1960 by the savages, followed by MacDonald and Santokh Singh (MacDonald 1967). Kelantan geology as shown in Figure 2.1. Geological rocks vary in age from Quaternary to Lower Paleozoic and can be classified into three major chronological groups, Paleozoic, Mesozoic and Quaternary (Noor, 1980). Quaternary deposits consist of unconsolidated and semi-consolidated sediments, which are primarily found in the coastal area of the State. Low winding ridges arise in the south, and are broader to the west and narrower to the east.

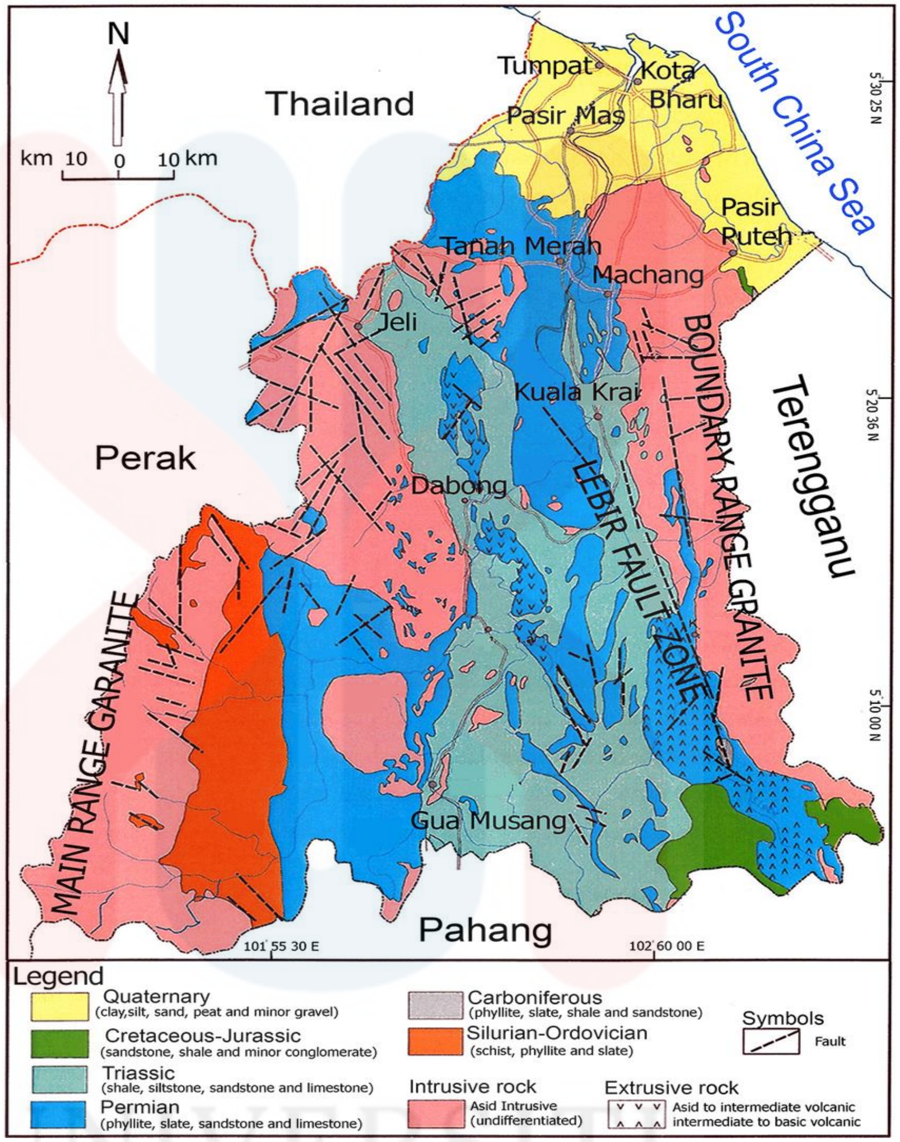


Figure 2.1: Geological Map of Kelantan

Source: Department of Mineral and Geoscience (2003)

2.2 Mainstream Hydrogeology of the Northern Kelantan.

The major potential run for groundwater is the northern Kelantan which is beneath lain by Quaternary alluvium. This alluvium nearby covers extend around 1500 km2 from the by and large zone of Kelantan state of I 4922km2, which is around 10% of the state region. Agreeing to MacDonald (1967), the alluvium may be of marine or fluviatile beginning, but it is persistently conceivable to recognize the two particular sorts of deposits which is underlain by granitic and sedimentary or metasedimentary bedrock, the last-mentioned comprising basically of shale, sandstone, phyllite, and slate. There are two essential sorts of aquifer system which may be a shallow aquifer and profound aquifer. figure 2.2 indicates the Geomorphology and Hydrogeology Of Kelantan.

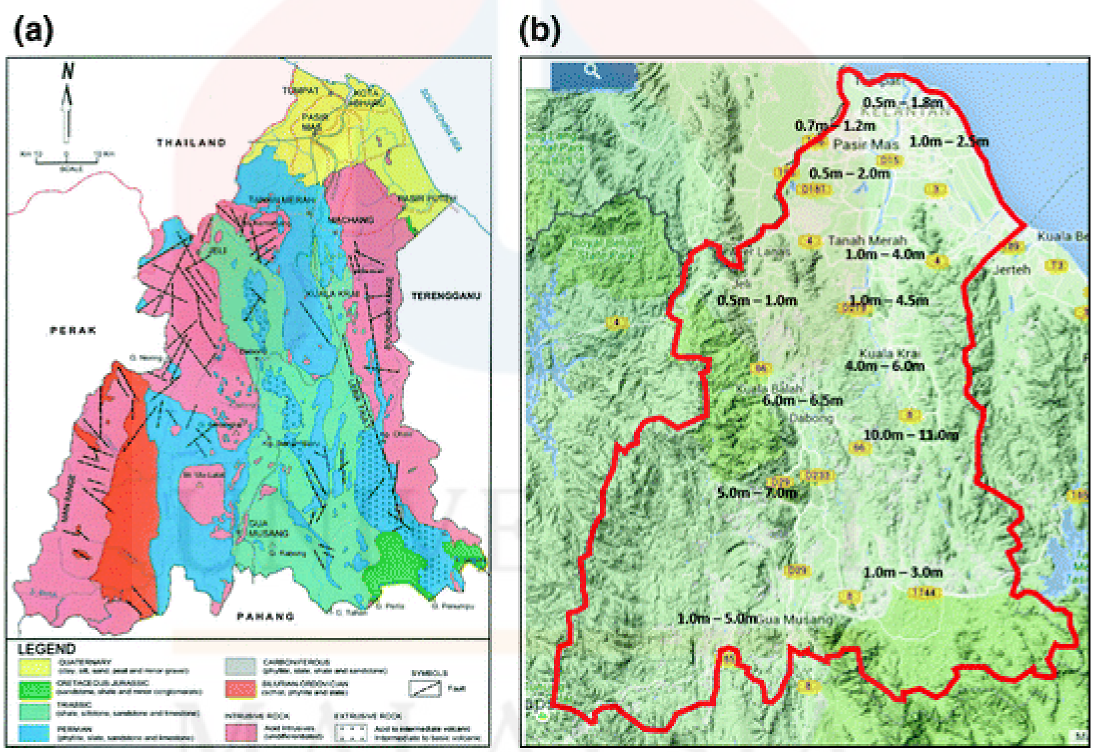


Figure 2.2: Geomorphology and Hydrogeology of Kelantan

Source: DID (Drainage and Irrigation Department), 2014/2015.

2.3 The geology of North Kelantan Stream Basin

Quaternary Deposit

The study range is secured by alluvium deposits of Quaternary age. These Quaternary stores can be divided into the Pleistocene and Holocene deposit as mapped by Bosch (1986). The Pleistocene contain of the Simpang Formation while Holocene comprises the Gula Formation and Beruas Formation that was underlain by rock bedrock. Figure 2.2 shows up the Geology Layout of North Kelantan. The Quaternary stores contain of unconsolidated to semi solidified rock, sand, clay, and residues that have inside the north of Kelantan state and along the stream valley (Md Hashim J002). The essential 13 to 15-meter store is afterward of age (Soh, 1972 and Noor, 1979) and composes of silty to clay as shown in Figure 2.3.

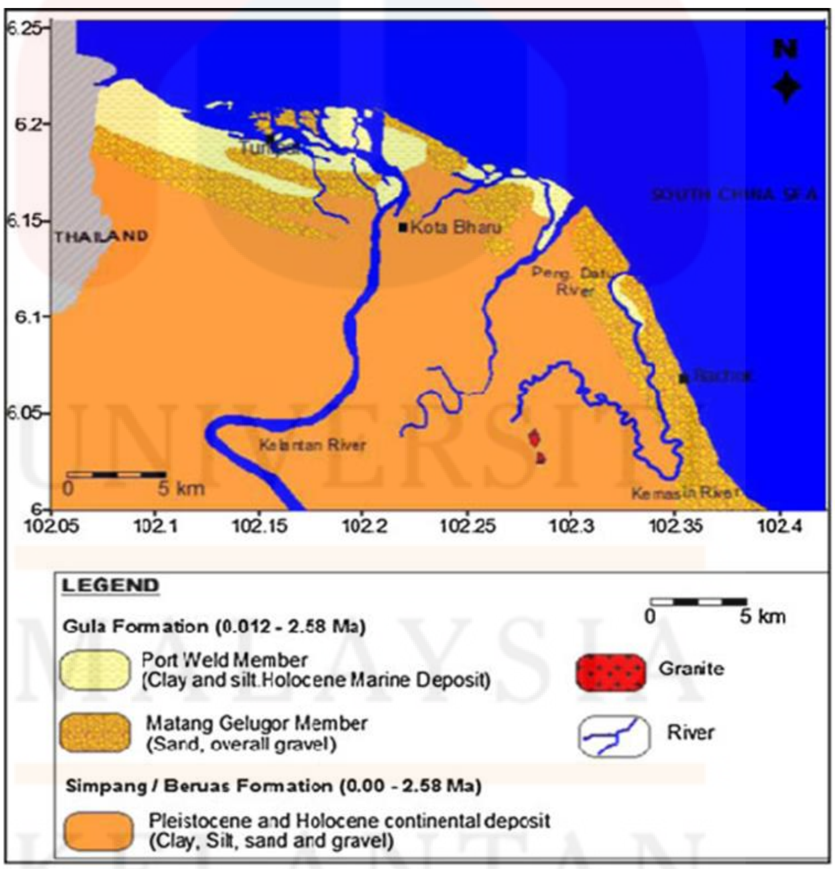


Figure 2.3: The Geology Layout of North Kelantan

2.4 Seepage

There are four essential streams inside the North Kelantan, named Kelantan Stream, Pengkalan Datu Stream, Pengkalan Chepa Stream, and Kemasin Stream. The North Kelantan leakage system is dendritic with Kelantan Stream is the foremost stream. Kelantan Waterway is the greatest and longest stream in Kelantan State. The foremost extraordinary length and breadth of the catchment are 150 km and 140 km exclusively. The waterway is around 248 km long and channels a region of 13,100 km2, including more than 85% of the State of Kelantan (lbbit et al., 2002). lt partitions into the Galas and Lebir Streams near Kuala Krai, nearly 100 km from the conduit mouth. The Galas Waterway is formed by the crossing point of Nenggiri and Pergau Streams. The Nenggiri Stream starts inside the southwestern part of the central mountain range (Primary Range). The Lebir Stream starts from the Tahan mountain range.

The Kelantan Stream system northward passing through major towns such as Kuala Krai, Tanah Merah, Pasir Mas, and Kota Bharu, sometime recently releasing into the South China Sea (lbbit et al., 2002). The other three streams in North Kelantan (Pengkalan Datu, Pengkalan Chepa, and Kemasin Stream) are small Waterway that's less than 10 km long. These streams discharge inside the zone of Kelantan Delta. Other than these streams, it allocate of small artificial leakage system can be found inside the whole Kelantan Delta. lt is utilized as a country reason.

2.5 Weather

Weather could be a significantly vital factor within the change of landforms. The components of climate incorporate precipitation, temperature, and wind. The hydrogeological condition of a certain region is influenced by climate amid the change of the region. The climate of Kelantan is humid and tropic and possibly an agent of Peninsular Malaysia. lt is characterized by high temperature, high humidity, and high precipitation (Malaysian Meteorological Division (M MD), 2008). Four seasons are recognized by the southwest rainstorm, northeast storm, and two shorter periods of inter-monsoon seasons. The southwest rainstorm season is commonly built up within the last specified half of May or early June and closes in September (M MD, 2008). The Northeast Storm which blows over the South China Sea from late October to March be a great figure influencing the climate in Kelantan.

The overall impact of the rainstorm wind is experienced in Kelantan in the midst of late November to early January. The precipitation occasion in the midst of this period could be a rule of exceedingly concentrated and falls in overwhelming storms over a huge region. The precipitation terms are routinely longer in the midst of these periods (November — January) than at any other time of the year. This circumstance persistently causes heavy flooding covering about the full North Kelantan region.

2.6 Aquifer

Noor (1979) utilized investigation wells to seem that Kelantan Stream Delta is composed of deposited quaternary silt. The deposit of sediment makes the aquifers' system. The (Pfeiffer and Tiedernenn, 1986). The aquifer breadth of each run is particular due to the contrasts of basement deepness. The aquifer comprises of fine to coarse sand or rock and a few' aquifers may be consolidated with rock. The other aquifer was found to have minor clay consolidate 40 meters, the third aquifer is 40 — 130 meter and the fourth aquifer is 130 — 150 meters.

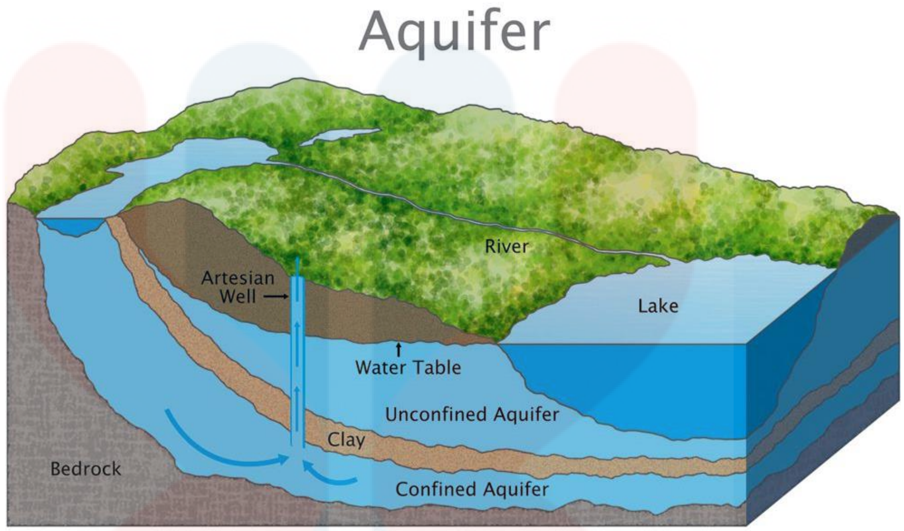


Figure 2.4: Types of Aquifers in Groundwater

Source: USGS.gov

2.7 Stratigraphy

Stratigraphy of Dabong described that the state of Kelantan includes a broad range of rocks. This include igneous, sedimentary and metamorphic rocks. The distribution of rocks in Kelantan is in the north-south direction. The distribution of igneous rock in Kelantan lies within the western and eastern boundaries of the state of Granite Most Range and Granite Boundary Range. It's also starting to happen in the middle of the state. The granite rocks in Kelantan can be partitioned into two fundamental bodies, the Most Range and the Boundary Range. Typically, the Office of Minerals and Geoscience itself has also stated this. For much of the Late Triassic period, Granite is between 200 and 230 million a long time ago (Metcalfe, 2013).

The Eastern part of the Kelantan map consists of areas such as Tumpat, Pasir Mas, Bachok, Kota Bharu and Pasir Puteh (Metcalfe, 2013) (Metcalfe, 2013) Based on surveys and field observations made by past geologists, these sections of the Kelantan Map include quaternary-period rock types. The most common examples of rocks found in these areas are clay, silt, sand, peat and small rock. Since all these rocks were formed during the

Quaternary and later periods, they are all considered to still be young rocks in the topographical rock strata. Another research area included in this research, Kota Bharu, is the southern part of the Kelantan map. Based on earlier investigations and evidence, geologists have classified rock species in the Kota Bharu region according to the topographic time scale chronology. Other than that, the molten rocks found here were mainly intrusive (undifferentiated) water.

Permian is a geological age from 299 to 252 million years ago. That is the last stage of the Palaeozoic era since the Carboniferous period, and it existed in geochronology before the Triassic period of the Mesozoic era. At that time, our world was dominated by a single supercontinent called Pangaea, surrounded by a global ocean called Panthalassa. The massive tropical rainforests of the Carboniferous period have all ended, leaving only the major dry desert areas covering the interior of the continent. The depth of the ocean during the Permian period stayed relatively low, and the near-shore ecosystems were limited by the aggregation of all the dominant landforms on one continent, the Pangaea. This may have been the cause for the main aquatic species to be extinct at the end of the time by critically declining shallow coastal areas containing variations of marine creatures.

The Triassic period was the first ever period of the Mesozoic era and occurred between 251 million and 199 million years ago. It was followed by a large mass extinction called the Permian-Triassic extinction at the final stage of the Permian period. This period of time was when the aquatic animals started to form and diversify at the same time (Erwin, 2015). By the end of the Triassic period, which was around 199 million years ago, the Earth's supercontinent started to be separated into two main sections due to tectonic forces and plate motions. The first continent was renamed Laurasia, which is situated in the north, while the second continent was named Gondwana, which is located in the south.

The Quaternary Period is the most recent time of the Geological Time Scale and began 2.6 million years ago and continues to this day. Climate change and developments caused by this period are reflected in Earth's history. Generally, the Quaternary phase is one of the most observed parts relative to the other time scale in the geological record. The explanation is that it has been proven that most of the sections have been very well preserved and undisturbed as opposed to the other geological time scales. For example, a relatively small amount was destroyed due to natural hazards such as deforestation. Furthermore the mechanisms of rock formation did not change the existing sediments. Gua Musang Formation was introduced by Yin in 1965 for the rocks located around Gua Musang, South Kelantan. Yin 1965 recommended that Gua Musang's stratigraphic unit be included in Table 2.1.

Table 2.1: Displays the Gua Musang Formation stratigraphic unit

Time	**Lithology**
Middle Triassic	Granite, limestone and volcanic rock
Early Triassic	Argilitic granite, shale and molten rock.
Late Permian	Shale and Siltstone.
Middle Permian	Limestone with some shale.

(Source: Mohamed, 2016)

2.8 Structural Geology

Structural geology is the study of the any geological features that formed during the rock formation. In fact, several factors contribute to the development of structural geology, such as tectonic mechanism, energy force, sediment deposition and others. There are several options for the formation of structural geology. It can be formed just before the forming of a rock, during or after the formation of a rock. There are various faults in the formations. A fracturing or fracture zone between two blocks of rock is called a fault. Blocks will shift relative to each other while there is a fault. There are two types of fault motions. Earthquake happens when the shift is very fast where, as if it were going to happen slowly, fault is going to happen in the form of a slide. In addition, faults can range from a thousand kilometres to a few millimetres in length. Most of the faults are typically triggered by frequent movements over geological time.

The rock from one side of the fault slips all of a sudden as the earthquake strikes the other side. The fault surface may be either vertical or horizontal, or any random angle in between. The angle of the fault with respect to the floor, defined as the dip and the direction of the slip along the fault, is used by earth scientists to recognize the forms of faults (USGS, 2014).

The rocks are usually hitting with the NW-SE. The dips are usually relatively steep to sub-vertical and to the east. Numerous anastomizing faults have been carved through these cliffs. The vast number of faults that pervade the region make up a complicated pattern. Faults are trending in different ways. However, most of these faults are trending NNW, parallel-sub-parallel to the pattern of the suture zone. Most of the faults occur in conjugate sets.

There is a lot of evidence of dip displacements, particularly the low angle faults that clearly display the initial low angle fold-thrust geometry. These are the oldest faults, and most of them dip into the NE. Few low-angle faults and most high-angle faults do not exhibit traditional fold-thrust geometry. They also show constructive flower systems, pushing along faults ranging from mild to steep and sub-vertical. Vertical displacements found along faults are complex and can differ in seas and magnitudes along individual faults. Both of these characteristics indicate that a major strike-slip motion is involved in the development of these faults. The rocks within the suture tend to be a few tectonic units. Tectonic units can vary in diameter from a few metres to a few kilometres. The vast number of high-angle faults with major strike-slip motion may indicate that the tectonic units may be bound by strike-slip faults.

2.9 Historical Geology

Gua Musang formation through South Kelantan-North Pahang was mapped to classify Middle Permian to Late Triassic argillite, carbonate with pyroclastic/volcanic facies within Gua Musang region. Today the term is also being used for almost all Permo-Triassic carbonate-argillite-volcanic sequences in the northern part of Central Belt Peninsular Malaysia (Mohamed et al, 2016).

Broad spread of argillite-carbonate-volcanic across northern Central Belt has created problems with the new names assigned. For example, related lithologies to the Gua Musang Formation in Felda Aring are called the Aring Formation, where the Sungai Telong Formation is called the Telong Formation. This lateral facies changes may be collected within the same group as long as these sediments were deposited in the shallow marine ecosystem of the Gua Musang Platform during the Permo-Triassic period. The importance of grouping these formations is focused on paleontological and sedimentological aspects. Figure 2.5 indicates Stratigraphy of Gua Musang Formation.

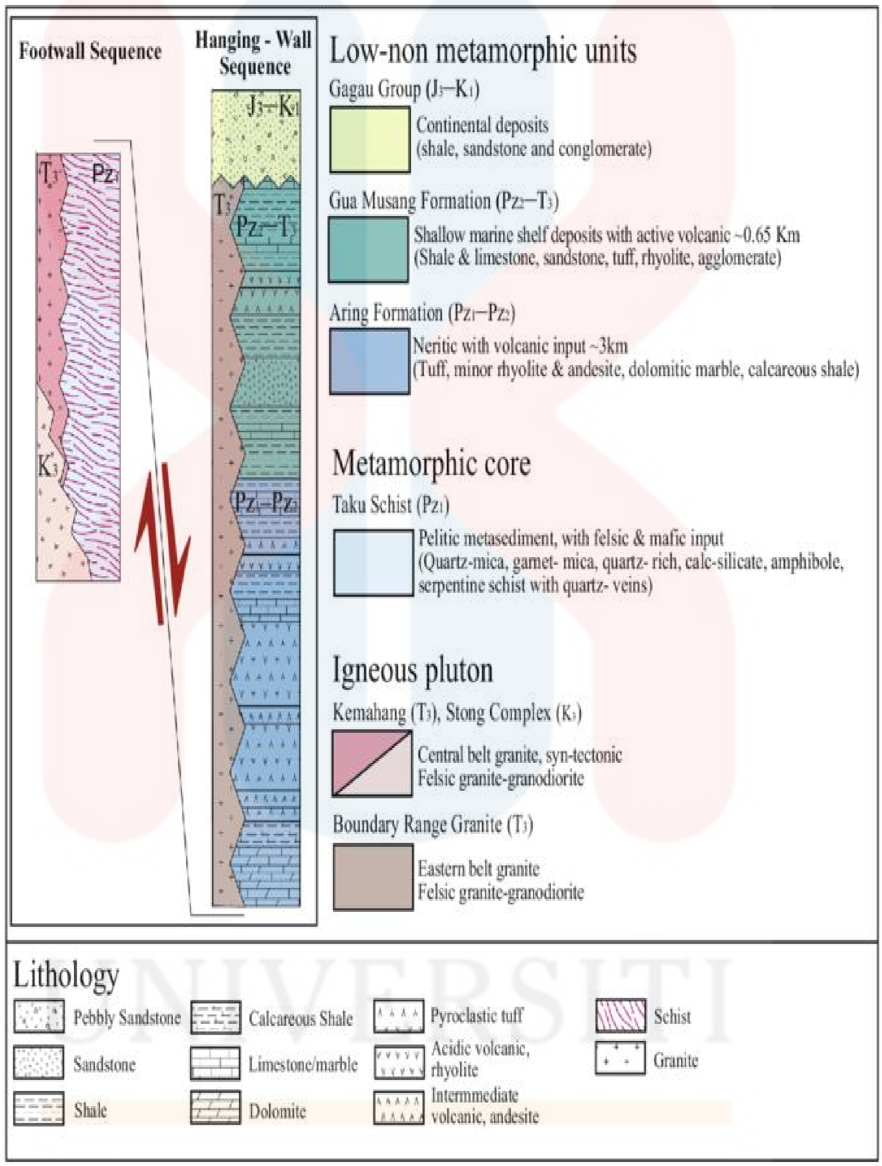


Figure 2.5: Stratigraphy of Gua Musang Formation

Source: Bulletin of the Geological Society of Malaysia, Volume 62, December 2016

2.10 Groundwater Contamination

Agriculture is known as a surface pollutant source. A major source of groundwater contamination in chemical agriculture in Bachok (northern part of the study area) is the considerable potential for fertilisation within the paddy and tobacco sectors. An additional ability of soil toxin production is also offensive behaviour, such as the hazardous use for creeping. The most widespread source of groundwater infections may be provincial practises in the area around Kota Bharu, including irrigation systems and mechanical activities. In high communities such like Kota Bharu, Tumpat, Wakaf Bharu, Pengkalan Chepa, and Bachok, a continuity in the waste water disposal system is the primary issue with which efforts to turn improved groundwater into a primary water resource.

The flow water penetrates the water frame in the range through the waste drainage system or directly through the pores of the surface of the soil in the adjacent transmission water sources. In an area with a high population primarily a pumping well station is built. In the pumping area of shallow water, such as Kampung Puteh, Kubang Kerian and Pangkalan Chepa, the capacity is exceptionally high for sullied water (Ismail and Kiat, 1995). There was a mistake (Ismail and Kiat, 1995). Jabatan Mineral and Geosains Malaysia have detailed annually significant amounts of Fe in groundwater from a few wells. According to Noor (1979), Fe levels in nearly all Kelantan state places were found in —14 Mg/l.

CHAPTER 3

MATERIALS AND METHODS

3.1 Introduction

One of the important aspects for the flow and the methodologies used in doing research is materials and procedures. Geological analysis and specification research was carried out in several ways. The methods of mapping are combined with the methods of analysis of geological characteristics of the study. In general, Figure 3.1 shows both the general geology flow map and the interpretation of the Groundwater quality analysis in Quaternary aquifers.

3.2 Materials and Equipment

There are various materials used for study such as base map, Suunto compass, GPS, hammer, hydrochloric acid (HCL), sample bags, notebook, hand lens and tape. For further comparative study, all data obtained by geological mapping are recorded in the notebook.

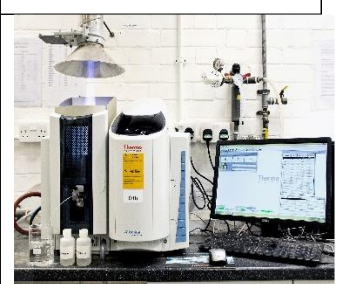
Base map produced through the help of software such as Google Maps, Google Earth and, ArcGIS 10.3. In the research area and its structure, Google maps update the geomorphology of the study area. In using ArcGIS 10.3, this software can observe the geographical structures of drainage, contour, rivers and terrain can be observed and digitized on a base map. Suunto compass for identifying the outcrops bearing or azimuth. The compass even helped to drive in the right direction.

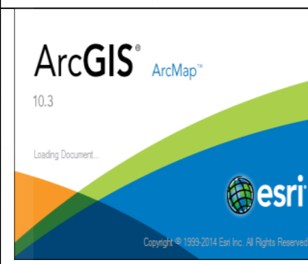
In addition, the distance journey is marked and each checkpoint is displayed in elevation. The reaction between acids and rocks is tested with hydrochloric acid. For examples, the calcium carbonate steel reacts strongly to HCL. The outcrop samples are obtained in the sample bags and in each bag by name and properties.

The note book is also used to record research and information gathered in the field of research. The hand lens is used to analyze the minerals found in samples of rock. Certain minerals cannot be seen in naked eyes and the composition of the mineral is important to the manual lens. Tape is used to measure the stratigraphy of bedrock during the measuring section in order to do stratigraphy log of the study area. Table 3.1 shows the materials and equipment used in the completion of study.

Table 3.1: Materials/equipment used for the research

Materials/Equipment	Use	Pictures
1) Hammer	Hammer are been used to breakdown and obtain samples from the outcrop.	
2) Measuring Tape	Measuring tape helps to measure the length and thickness of the outcrops.	
3) Laptop	Laptop enable us to search information for processing data and completing final thesis report.	

4) Stationaries	Stationary such as pen and note book were widely used to jot down the important information which will be transferred to laptop later on.	
5) Hydrochloric Acid	Chemicals such as hydrochloric acid is used to examine the presence of calcium carbonate in order to determine the type of rock that were present.	
6) Global Positioning System (GPS)	GPS were used to detect the location as well as the elevation of the hills. Coordinates of the current location were shown based on the satellites and the travel journey.	
7) Atomic absorption spectroscopy (AAS)	AAS are used to evaluate and determine the types of major of cations and anions in the sampled water.	
8) Multi parameter	In-situ parameters such as pH, temperature and electrical conductivity were measured using multi parameter.	

9) Turbidity meter	Turbidity meter were used to determine the value of turbidity content in the sampled water.	
10) Portable TSS meter	Portable TSS meter are used to identify the total suspended solid in the sampled water.	
11) Total Dissolved Solids (TDS) meter	TDS meter were used to determine the total dissolved solid from the sampled water.	
12) Plastic sample and bottles	Plastic bag and sample bottle were used to obtain sampling water and rock sample from the outcrop.	 
13) ArcGIS 10.3 software	This software enables us to produce different types of geological maps such as topography, drainage map and land use map on the study area.	
14) Google Earth software	Google Earth Software were widely been used to observed and identify the view of Earth landscapes based on satellite imagery in 2D and 3D.	

3.3 METHODOLOGY

3.3.1 Preliminary Studies

Preliminary research were done to get access on understanding the study area before fieldwork session. It were conducted to study the geological setting of the area by its morphology, structural geology as well as its features. Studies from Google map as well as base map had given a clear look about its geological phenomenon along with its features. Interpretation were done by observing the lineament on the base map as well as geomorphology.

3.3.2 Field Study

There are some geological methods that were performed while geological mapping in study area. Data were collected from the field studies because geological mapping were all about the gathering geological information of an area. So that, able to have better understanding and overview on what is the geology of the study area is all about. In addition, there are two types of data that were collected in this research which are known as primary data and secondary data collection. The primary data collected directly from the observation made in the field such as sample of the outcrop.

The secondary data were obtained from other parties such as JMG and USGS. The data are information such as correlation data, topographic data and geological map. The field research is done by traversing study area. Field survey is all about the gathering of information about study area more accurately. The interpretation were done through the base map and previous studies compared because the direct observations and applications on the field study are more accurate. This aids to decide the direction and control the track. By traversing, it helped to note down the findings and outcrops precisely.

3.3.3 Laboratory Work

The sample was obtained from the aquifer and the sample will be assessed in laboratory. Chemical examination of component parts in water and rocks were used in the chemical analysis machines such as spectrophotometer for atomic absorption (AAS) and inductive pairing of mass-spectrophotomètre (ICP-MS). Chemical analysis includes chemical parameters of nitric acid, hydrochloric acid HCl, sulphuric acid, water-region, hydrofluoric acid, lithium metaborate and sodium perborate. Apparatus for water chemical analysis that were used in the analysis consists of volumetric flasks, beakers, conical flasks, crucibles, Falcon tubes, funnel and paper, glass rods, measuring cylinders, syringe and micropipettes.

3.3.4 Data Processing

In geology, data from secondary data used to correlate with previous studies are obtained. Maps such as base map, drainage patterns map, topography map and geological map were produced with the help of ARCGIS 10.3. Furthermore, graphs and charts were produced using the help of Microsoft Excel for the interpretation and understandings in this research.

3.3.5 Data Analysis and Interpretation

The data were transferred into ArcGIS 10.3 and Corel Draw x5 to analyze the data obtained in the study area. By using this software, we can monitor and measure the major part to ensure that data on the field of study are corrected and accurate before the report is written. In order to make a data analysis and interpretation, the relationships, patterns and trends of the field are understood. The geomapping field data will be transformed into GIS software to process it into a desired geological map and indicate the samples of groundwater. The Earth's strength and tension is analyzed and interpreted with GeoRose software. In addition, the software is very helpful every day to update the base map. In the field study, the base map used is different from the recent map. Any geomorphological additions or adjustments must have their software records were updated. Figure 3.1 shows overall research methodology of this research.

RESEARCH FLOW CHART

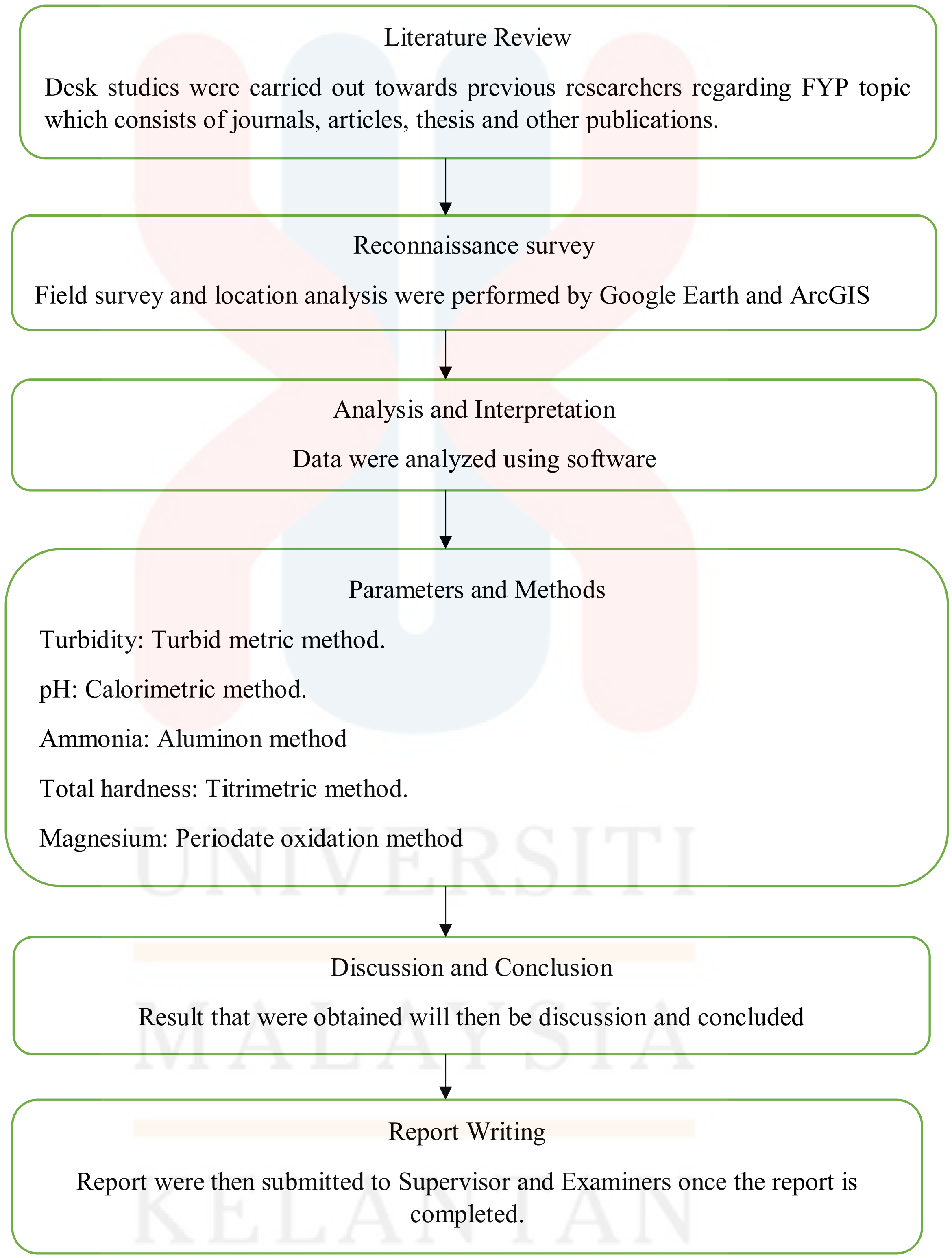


Figure 3.1: Overall research methodology of this research.

CHAPTER 4

GENERAL GEOLOGY

4.1 Introduction

4.1.1 Brief content of Chapter 4

This chapter discusses the general geology based on the secondary data and satellite imagery data gathered. The geology of the research area is discussed extensively on the bases of geomorphology and lithostratigraphy. The accessibility, settlement, vegetation and weathering of the study area will be discussed first before discussing about the subtopics.

a) Research area accessibility

Accessibility were identified by observing the road connection which leading to the study area. There roads enables to connect from one place to another through transportation such as motorcycle, hilux and cars. Based on the observation on the study area, few roads were observed which interconnects between residential areas and town area. The main road is Jalan Sungai Sam that connects between Dabong to Jeli Kelantan. Most of the road that were identified in the study area connects many villages. The nature of flora covers most of the study area. Figure 4.1 shows the main road to Dabong which often been used by villagers for their work place and it is the main road which connects Dabong to Jeli.

Figure 4.1: The main road to Dabong which often been used by villagers for their work place and it is the main road which connects Dabong to Jeli

b) Soil Use.

In Kelantan, nearly 25% of the land is alienated, while 41% is State land while 33% are under reserved land. As in the study area, the majority of the land is clearly used for extracting rubber. In comparison, the majority of local people involved in the field of research often rely on agriculture, rubber tapping and fruit production in part related to their side profits. Therefore, agriculture and vegetation are the most soil used in the research area.

c) Settlement

In view of its evaluation, 80% of the study region was settled by several industries, including forestry, agriculture and fertiliser and rubber estates. Therefore the majority of the villagers work on their livelihoods in the study area. Furthermore the field of study is strongly restricted and forested. Only some transportation such as motorcycle and hilux would access the field of the study from the junction of the rubber scrub factory as the route is unfit for transportation in the vehicle. The path is approximately 25 km. Moreover, almost the region is also populated with vegetation, valuable trees and shrubs that are particularly suited as habitats for wild animals such as elephants and wild boars. Figure 4.2 shows the land use map of the study area.

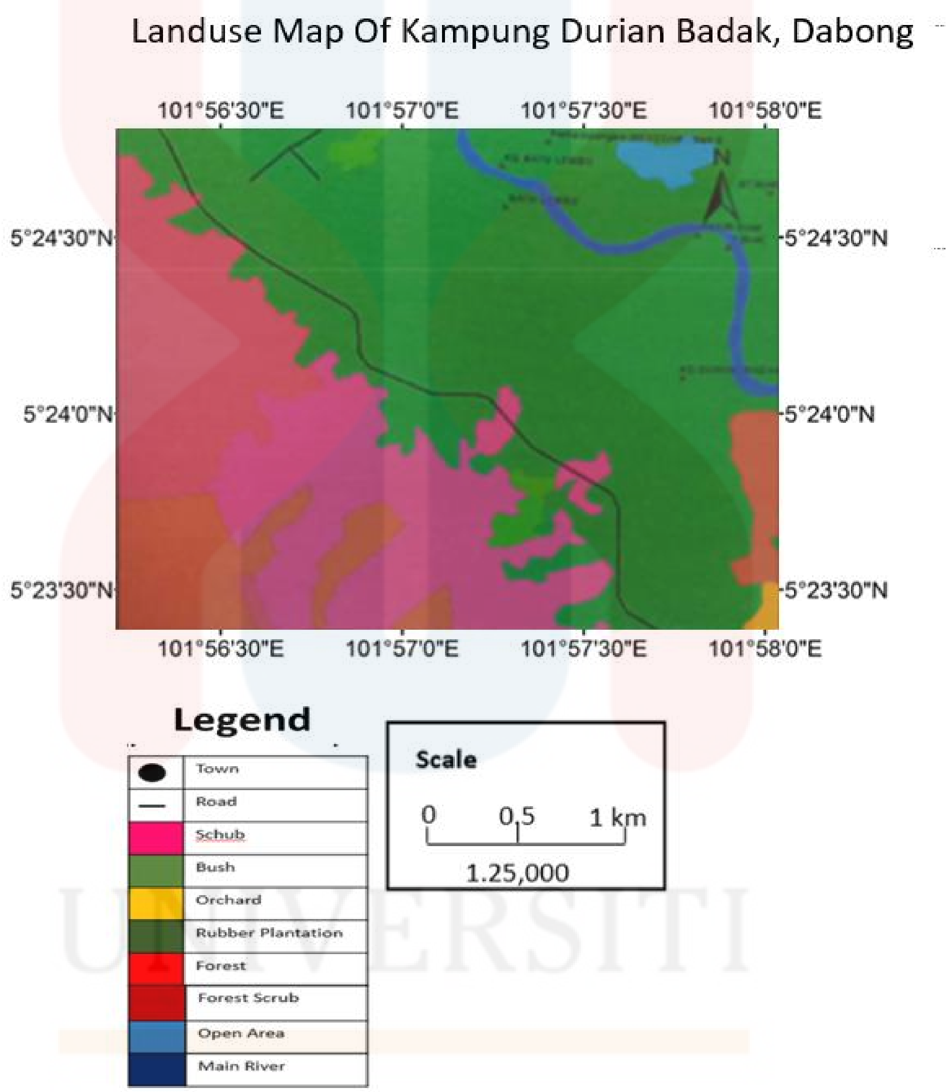


Figure 4.2: Land use map of the study area.

d) Road connection

The road connections in the study area are in great condition as few areas of the study area are now in the state government's plan of development. Accessibility by the local people as well as by the village are by highways, trains and boats. It might be a good opportunity for both the villagers and the surrounding community to move safer and easily from one location to another. Figure 4.3 shows the landuse transportation in the study area.

Figure 4. 3: The land use transportation of the study area.

e) Climate

Temperatures and rainfall of around 35°C, or about 91°F, are predicted in May during summer months in Table 4.1.The most thrilled temperature in May is 36°C, in other words 98°F, with a reported lowest temperature of 22°C, around 72°F. The annual heat and low temperature figures for each month of the year. It also displays the maximum and minimum temperatures reported.

Table 4.1: Monthly rainfall from 2018-2020

Year	2018	2019	2020
Jan	89.5	186.93	363
Feb	13	0	22.5
Mac	103.5	303.02	240
Apr	91.5	7.61	60
May	104.5	103.88	6
Jun	240.5	169.91	26.5
July	290.07	159.75	192
Aug	78.99	159.75	204.5
Sept	104.89	99.05	198
Oct	191.5	266.18	318
Nov	372.11	89.67	656
Dec	389.12	0	548

Source (A.Azlan, Aweng Eh Rak, & C.O.Ibrahim, 2011)

f) Rainfall

The research area is in tropical rainforest surroundings on the eastern coast of Peninsular Malaysia. The variability influencing monthly and yearly precipitation is regulated by two kinds of monsoon regime. The southwestern occurs in a warm and sunny environment between February and October, with less precipitation. The Northeast monsoon is caused by overwhelming precipitation and high soil humidity between November and March. During this time, rainfall is high and generates considerable storms. (Retrieved from Average, Monthly Rainfall, Temperature, Humidity, Precipitation, 2019)

In the month of March, the research area enters low rainfall. In comparison to natural circumstances, the declining total amount of precipitation and dry weather contributed to forest and tourism fire at numerous sites throughout the study area. A normal tropical atmosphere with high rainfall is present in the study region. Furthermore, in those territories, the intense climate is virtually constant, for example, strong precipitation and exceptionally dry conditions. The mean monthly rain dispersion calculation of approximately 110mm is expected in the sample area, which is eight inches. On 11 days a month, you could assume to be seeing precipitation. (Wan, Siti, & Zullyadini, December 2014)

Temperatures of around 35°C, or about 91°F, are predicted in May during daytime. The most thrilled temperature in May is 36°C, — in other words 98°F, with a reported lowest temperature of 22°C, around 72°F. The annual heat and low temperature figures for each month of the year are given in Figure 4.4. It also displays the maximum and minimum temperatures reported.

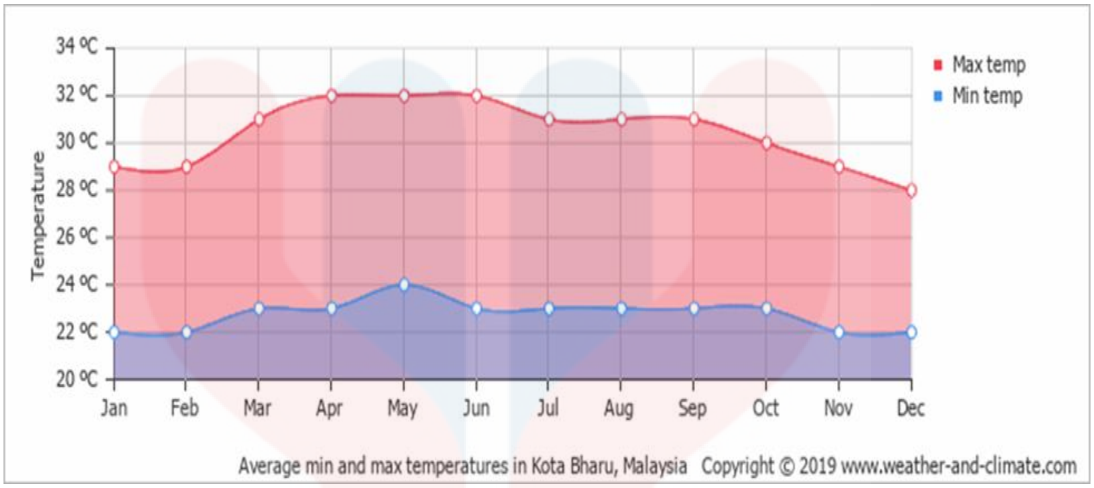


Figure 4.4: Maximum and minimum temperature over the year 2019 in Kota Bharu

4.2 Geomorphology

4.2.1 Geomorphologic classification

a) Topography

The research area of the topography showed variation between 20 and 940 in elevation. Referring to the data collected from the field of study, it could be found that the topography trend in the map indicates high in steep, while low in steep in the line indicates low in contour. This is stated according to the topographical unit and the elevation scale for each unit according to the observation at the area in Table 4.1.

Table 4.2: The classification of topographic unit and the range of elevation for each unit.

Class	Elevation (M)	Topographic unit	Slope (%)	Sloping
1	< 50	Lowlands	0-2	Flat / almost flat
2	50-200	Low hills	3-7	Gently sloping
3	200-500	Hills	8-13	Sloping
4	500-1000	High hills	14-20	Moderately steep
5	>1000	Mountains	21-55	Steep
6			56-140	Very steep
7			>140	Extremely steep

Source (Surono, 2008)

Based on the map shown in Figure 4.4, there are few different region of the study area based on their elevation term. In terms of elevation, various regions in the study area. The red colour in the southern portion indicated that the hilly terrain was also covered with orange and yellow. A little hilly on the eastern side of the map. In comparison, the forest dominated much of the hilly region. In addition, about 60 percent of the elevation 50–100 metres, which shows undulating and hilly areas with orange colour, was filled in the other component of geomorphology in the topographical map. In comparison, the green colour is a rolling field 10 – 30 metres high. Then there are still several mountains with a gentle path from observation in the study field. It has a low gradient slope, which in turn specifies a sedimentary layer known as a soft rock. This sedimentary rock supports firmly in many geomorphology events for example mass wasting.

It was because water that can also be restored in a sedimentary rock. The fluid would then circulate before the force of gravity is transported. In the meantime, there is a lot of hill cutting on the other geomorphological occurrence that has provided new knowledge on the inner intensity of the hills. Furthermore the soil of the hill would be poor if the soil is disrupted.It would impact on the occuring of landslide and others geology structure such as faulting to occur. In addition, this field has long been used in the mining exploration of minerals as well.

Figure 4.5: A former mining site that is now a small ponds.

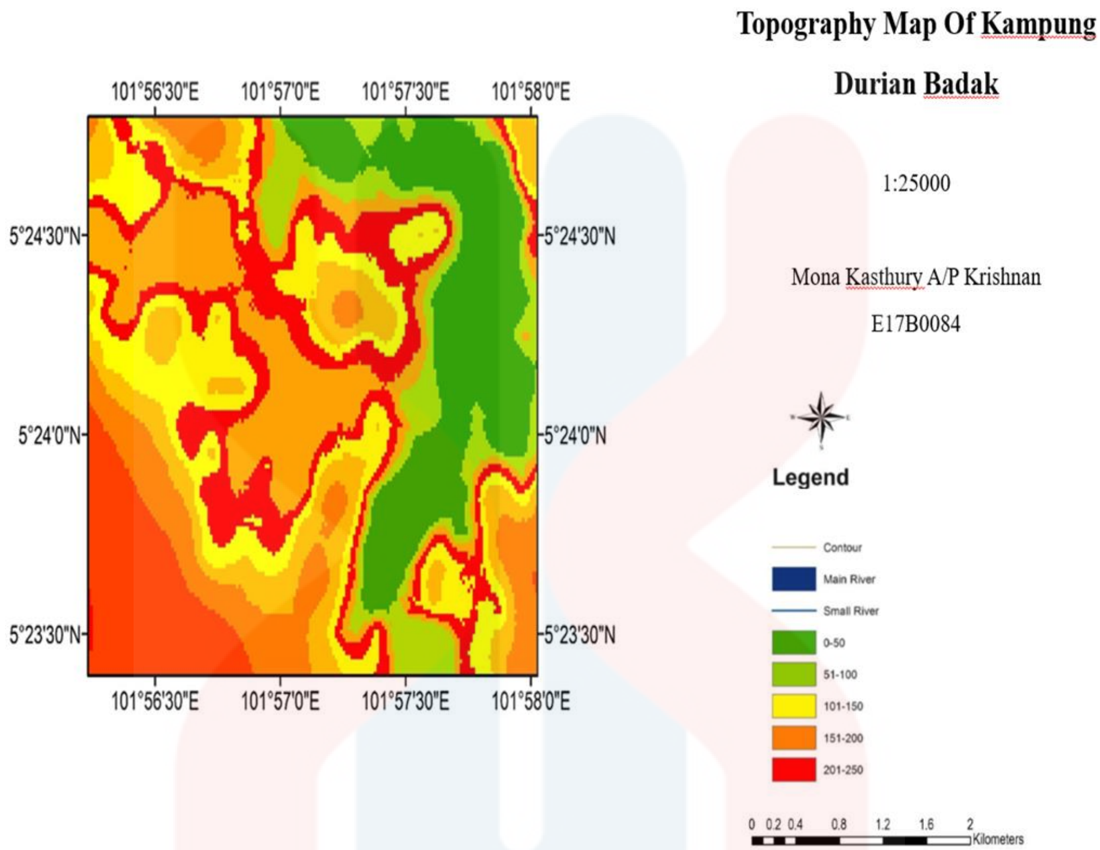


Figure 4.6: The Topography Map of study area.

b) Weathering

Weathering in this section is a very significant element in the change of environment the geomorphology of the field of research is closely interconnected. This is because the weathering and erosion process which took place in the atmosphere and hydrosphere contributes to the existence and origins of types of land with strong connections to the event of geomorphology (The Rock Cycle , n.d.). These procedures continuously deform the surface of the Earth and establish the sediment in the rock cycle. Land forms are the result of geospheric, environmental and hydrospheric interactions. Weathering is the decomposition of the substance in the area or decay into smaller parts influenced by several agents whose physical weathering will decrease, followed by chemical and biological.

It can alter the look of the earth's surface by physical weathering through variety of processes including pressure release, abrasion, wedging ice, hydraulic action, and thermal expansion. In other terms, by means of humidity or frost, temperature and friction, rocks are disintegrated. In the meanwhile it is the product of water that differs from a rock of mineral, where it can decompose by a dissolution that can respond to discontent of the rock mineral portion, influencing its composition as water molecules, such as hydrolysis, oxidation and carbonation process.

Furthermore, several physical and biological weathering materials occurred. Most of the outcrop in the study area underwent high weathering process. Therefore the outcrop on the surface of the earth is not good. In addition, due largely to the severe weathering process, some outcrops have been transformed into soil and sediments. This was also attributed to Malaysia's climate, which favours a high weather trend, considering its location on the equator and tropical climate with a hot and moist atmosphere over the years. Table 4:3 shows the characteristics of weathering.

Table 4.3: Characteristics of Weathering.

Class	Term	Description Of Rock
i.	Fresh rock	The content of rock material is in the original content. The point of geological pick scratch the surface which is difficult and it produces a ringing sound when it is struck with a geological hammer
ii.	Slightly weathered rock	Coloring is present at the joint surface of the rock. The original structure of the rock is well preserved. A ringing sound is produced when a hammer is directly been strucked on its surface.
iii.	Moderately weathered rock	The rock is slightly discoloured but somehow the original colour of the rock is present. The stucture in its original position is welly preserved. The point of the geological produced a scratch on the surface. An intermediate sound is produced when contact between the rock and hammer present.
iv.	Highly weathered rock	In this class, all of the material rock content had been discoloured. The original mass structure of the rock is still present eventough large intract on the rock surface. The point of geological pick is not easily indents. The rock material makes a dull sound when it is strucked by geological hammer.
v.	Completely weathered rock	In this class, all of the rock material is completely discoloured and the rock is converted into soil, but the original mass structure is slightly visible. The point in geological pick is easily indents. When the rock material is strucked by hammer, it then produces a emit dull sound.
vi.	Residual and colluvial soils	In this class, all of the rock material is fully converted into soil. The original structure of the rock is fully destroyed. At this point, the geological pick easily indents in the depth. When the rock is been strucked by the geological hammer, it doesn't produce sound as how other classes of rock produces sound.

Source (Agnese Kukela & Valdis Segliņš, Nov 2011)

During weathering processes, physical weathering and biological weathering would not affect rock mineral composition. In the study area, physical weathering is does not contain any excavation process and atmospheric exposure. This kind of weathering merely unsettles the rock dynamics. Granular disintegration, joint block splitting, exfoliation, for example. The fluctuation of temperature and pressure, the melting among other materials, is responsible for physical weathering. These two weathering types have often been identified in the area of study. Figure 4.8 briefs the types of weathering processes.

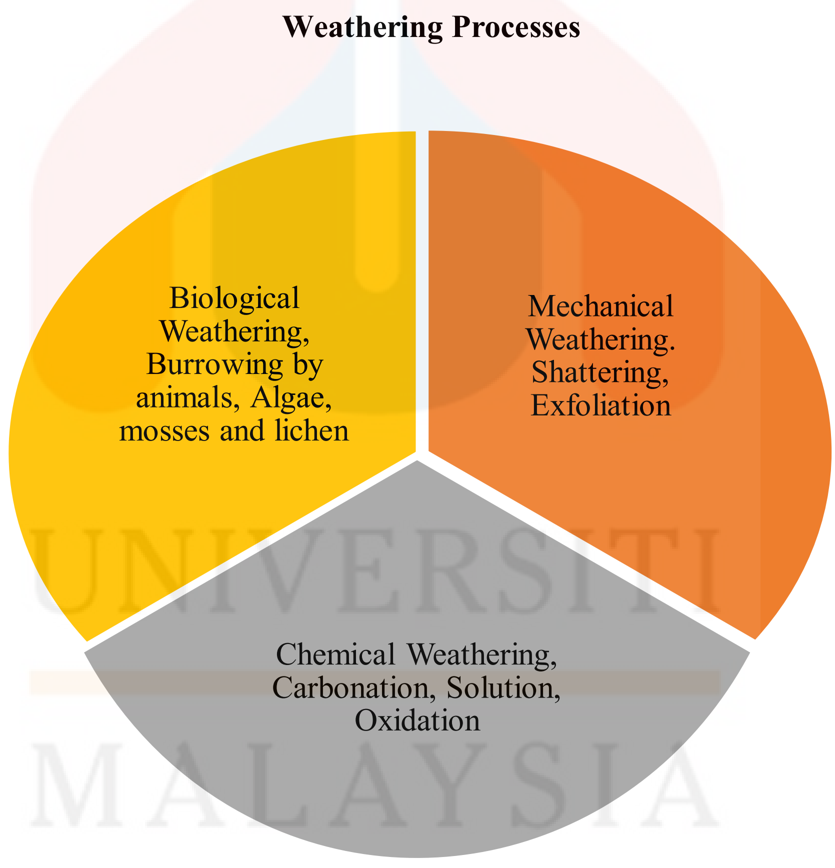


Figure 4.7: The weathering processes which causes weathering and erosion.

c) Drainage Pattern

Drainage pattern, developed over time by stream erosion that exposes the characteristics of rocks and geological formations that occur in a landscape area drained by streams. The drainage pattern of a given drainage basin consists of streams, rivers and lakes. They are influenced by the land's topography, whether the hard or soft rocks and the gradient of the land dominate a geographical area. A drainage basin is the topographical area from which runoff, flow and groundwater flow is obtained. Topographic barriers known as watersheds are segregated into drainage basins. (Sally L. Letsinger, Erin K. Hiatt, Allison Balberg, & Elias Hanna, 2020). Figure 4.8 shows Classification of drainage patterns.

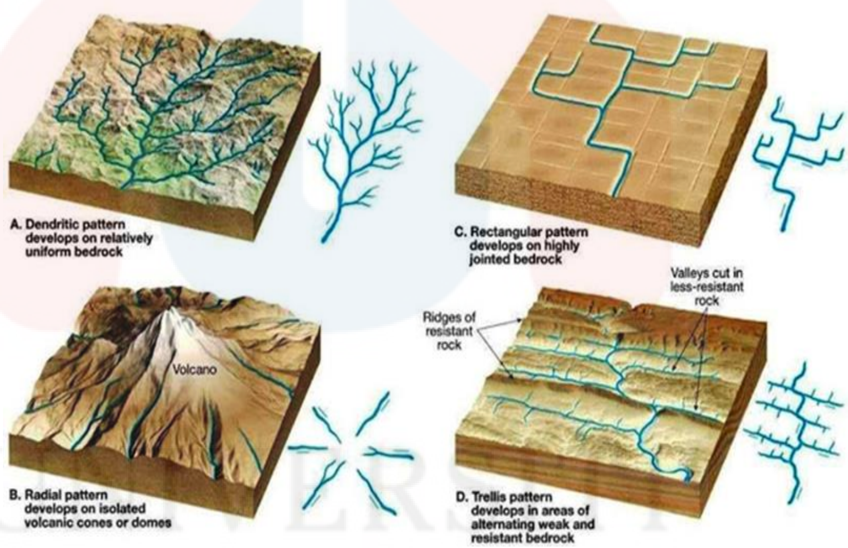


Figure 4.8: Classification of drainage patterns.

Source (Kaufmann.G, 2002)

In the study area, drainage pattern such as dendritic and parallel are observed and identified. Dendritic pattern developed and it is found in the east part of the study area. Areas where the rocks (or non-consolidated material) below the river have no specific structure and may also had been eroded to the same degree in all directions, dendritic patterns are by far the most frequent. Furthermore, rock such as limestone, gneiss, volcanic rock and unfolded sedimentary rock can be founded at dendritic pattern areas.

Meanwhile, Parallel drainage system is found in the west part of the study area. The parallel drainage system is a pattern of steep, relieved flows. Due to the steep slopes, the streams have very little affluence and are short and straight, with everything in the same direction. There is a prominent slope to the soil as parallel drainage trends arise. In regions with parallel elongated shapes such as outcropping of rock bands a parallel pattern often emerges.

At last, in the study area, a pattern of trellis drainage has been identified. A pattern of trellis drainage occurs in which subparallel streams erode a valley into less resistant systems. Typically, these beds dip steeply and may be part of a folding scheme. The tributaries sometimes meet in the right corners, where a knot known as a water gap will converge by more complicated forming. Figure 4.9 shows the drainage pattern in the study area.

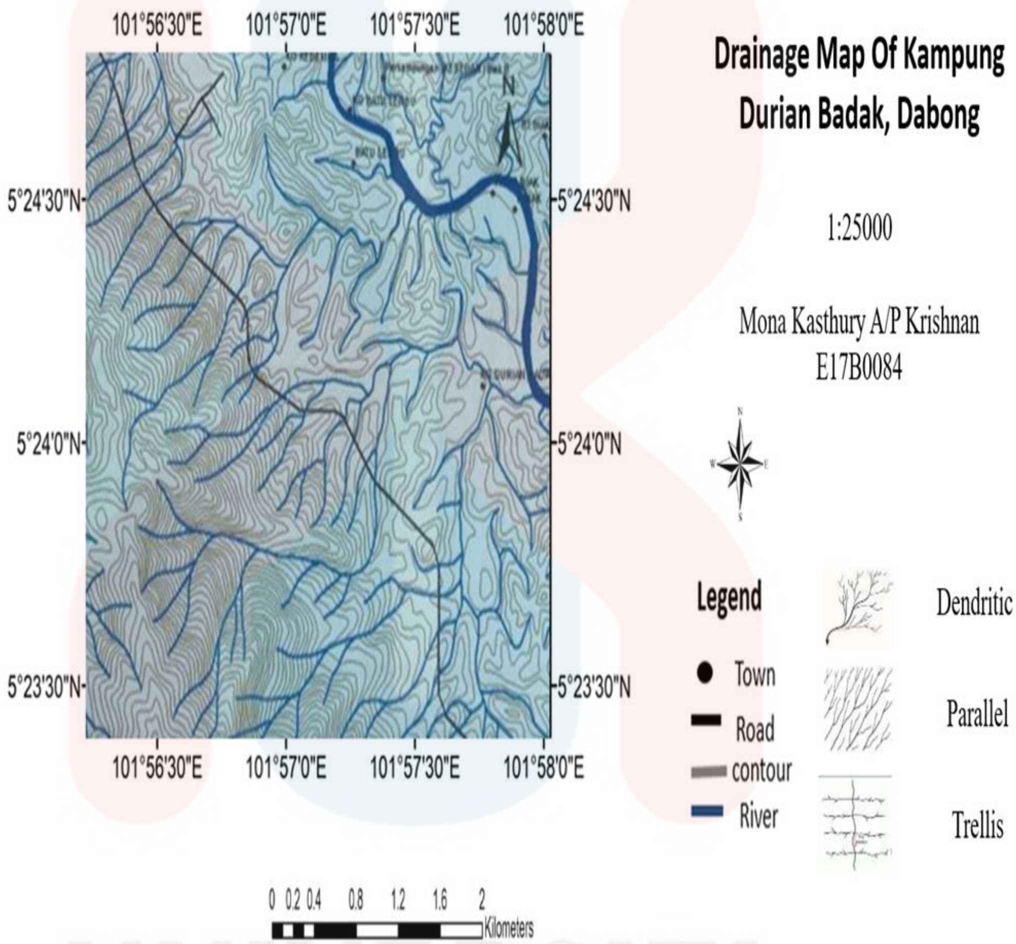


Figure 4.9: Drainage pattern in the study area.

4.3 Lithostratigraphy

a) Stratigraphic Position

Based on the figure 4.17, there are two formations within the study area that had been identified. There are Taku Schists formation and Gua Musang Formation. The oldest formation in the study area is the Taku Schist while the Gua Musang Formation is the youngest. The Taku Schist is composed primarily of metamorphosed argillacceous and arenaceous rocks, which interbedded by mafic components. The results of lithologies are dominantly in garnet-mica schists and quartz-mica-schist with assemblages of quartz, muscovite, feldspar and garnet (almandine) minerals (MacDonald, 1968)

The Taku Schists are dominantly consisting of quartz-rich mica schist, containing centimetre-sized tourmaline. Lenses of amphibolites are found within the Taku Schists as the result of metamorphism of mafic intrusions (C.S. Hutchison & D.N.K. Tan, 2009) The Taku Schists are located all throughout Central Belt. The schists are dominantly quartz-mica schists, though in lesser numbers quartz-mica-garnet schists. There are also small stripes of quartz and serpentinite. Biotite is connected with carbonate content, and calc-sillicate hornflets occasionally occur, and granitic gneiss is located on the south boundary of the Taku Schists (Ghani, A.A., Hutchison,, C.S., & and Tan, B.K.,, 2009)

Gua Musang Formation were formed between Middle Permians to Late Triassic and the Gua Musang formation was dominated by the interbedded Rhyolite. The formation Gua Musang consists of argillaceous and calcareous and it might be deposited in a region with a high degree of energy According to (Kamal Roslan Mohamed, Nelisa Ameera Mohamed Joehar, Mohd Shafeea Leman, & & Che Aziz Ali1, 2016), Gua Musang is found on a shallow marine shelf, at about 200m to 400m (C.S. Hutchison & D.N.K. Tan, 2009)

b) Geological Mapping

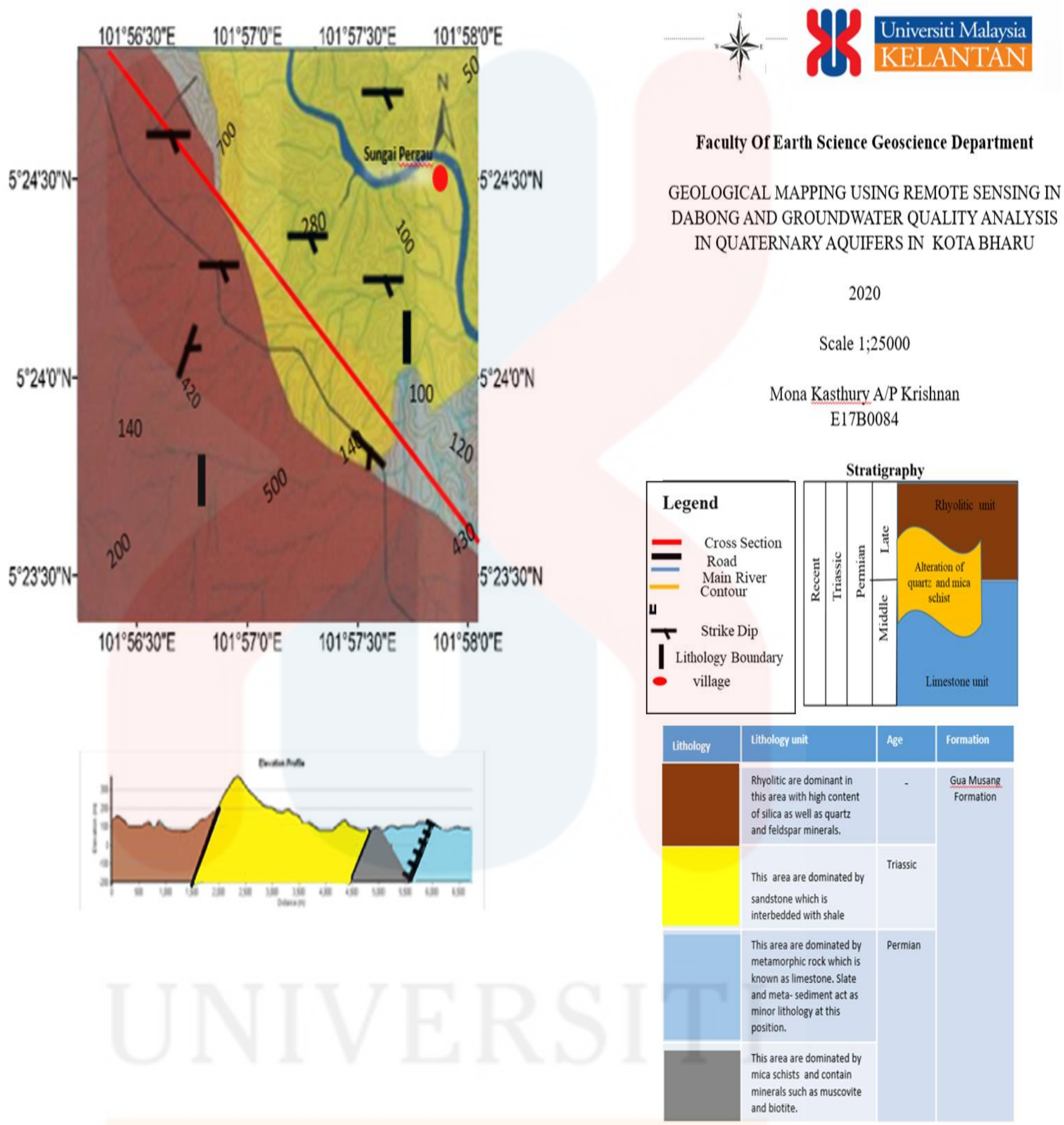


Figure 4.10: Geological Map of the study area

c) Stratigraphic Position.

Table 4:4 Stratigraphic position of the study area.

Lithology	Lithology Description	Age	Formation
	Rhyolitic are dominant in this area with high amount content of silica and as well as quartz and feldspar minerals.	Recent	
	This position are abundantly dominated by sandstone which is interbedded with shale.	Triassic	Gua Musang Formation
	This position mostly dominated by limestone. Slate and meta sediment act as a minor lithology at this position.	Permian	
	This position mainly stated as oldest position in the study area. This area is dominated by as mica schist. Minerals such as muscovite and biotite are present.		Taku Schist Formation

d) Unit Explanation

Unit 1 (Mica Schist)

Based on the observation in the study area, the outcrop are generated with shiny component which consists of thin layering in each rock. From the observation, schist rock had been identified which is a type of metamorphic rock. A rock is commonly classified under the metamorphic rock from their colour, material, its metamorphism and their texture as well. The colour of this grey rock, were generated due to metamorphism process which produces shale.

The metamorphic grade is an intermediate for this kind of rock which were schist. The rock of origin of Schist is essentially shale since it consists of minerals of clay. Besides from shale, phyllite, slate and gneiss may also be metamorphosed, however depending on temperature and pressure itself. As a result of the effects, foliated texture and coarse grains have been developed. Foliation shows the coarse grain which is so-called as schistosity. The definition of schistosity is cleaves from the Latin easily, but separate from slate because of its content. It has been graded as a schistosity because of parallel arrangement of muscovite and biotite minerals.

Dominantly, the present of mica consisting of the schist rock was seen by through our naked eyes. Focusing at the texture of the rock including foliation and folding pattern depends on the intense temperature and pressure of the pattern which had been found. Other than that, this transformation takes place along the converging boundary of the plates where it deformed from during the convergence and recrystallized at the subduction zone. This rock is indeed a process of regional metamorphism which had been induced and produces a tectonic plate collision by Increasing pressure and temperature.

Unit 2 (Phyllite)

The next unit that been found in the study area is phyllite followed by slate and sandstone which act as a minor lithology. Phyllite are metamorphic rock composed with a fine grain formed through the reconstitution of the sedimentary parental rocks such as mudstone and shale. Its size of grain is greater than the grain slate but lesser than the schist. In certain rocks, two phases of deformations, termed pre-crystalline and post-crystalline deformations, could well be differentiated based on two orientations of the specified rock surfaces, depending upon the directions used during metamorphism. phylite sheets can be parallel or crossed.

The colour of the phyllite is maroon from its observation. The effect of oxidation caused by climatic and environmental changes is the main reason for the weathering outcrop being strongly exposed. The phyllite seems to be a fine grain in its grain size. Phyllite is usually metamorphosed by a shale or mudstone rock. Meanwhile another minor, slate-interconnected lithology was discovered.Slate is a metamorphic rock, and is foliated in structure. The colour of the rock is grey from the analysis. The explanation is that the airs around this slate rock are very low in oxygen. There is therefore no oxidation process will occur that will turn the rock colour red.

Unit 3 (Rhyolitic)

Based on the previous study, the following is tuff lithology. Tuff evolves from the igneous volcano kind of rock. The rhyolitic tuff's colour is reddish brown based on the observation. Rhyolite is a strongly silica-rich, extrusive igneous rock. Normally it's pink or grey with such small grains that without a hand lens they are impossible to observe. Quartz, plagioclase and sanidine are made from rhyolite and contain small concentrations of hornblende and biotite. This is because temperature and climate impacts from oxidation are the primary reason the outcrop was particularly susceptible to weathering. Its texture consists in a very fine texture. Moreover, lithium-pyroclastic minerals are difficult to determine. Moreover, lithium-pyroclastic minerals are difficult to determine when the pyroclastics have been discarded and lithified under some conditions, the final product of tuff is.

4.4 Structural Geology

4.2.2 Lineament Analysis

Lineaments are initially described as mapping linear characteristics of the surface of the earth which differ distinctly and possibly represent sub-surface phenomena (Hamdi et al, 2018) Linear and curvilinear feature on the earth's surface were named as 'lineaments' by Hobbs (Hobbs, 1904). He even stated that a geological structure, including fractures, jointing and another kind of geological structure developed from the surface of the soil, is defined by the straight line from the terrain diagram. Figure 4. 11 shows the negative lineament of study area.

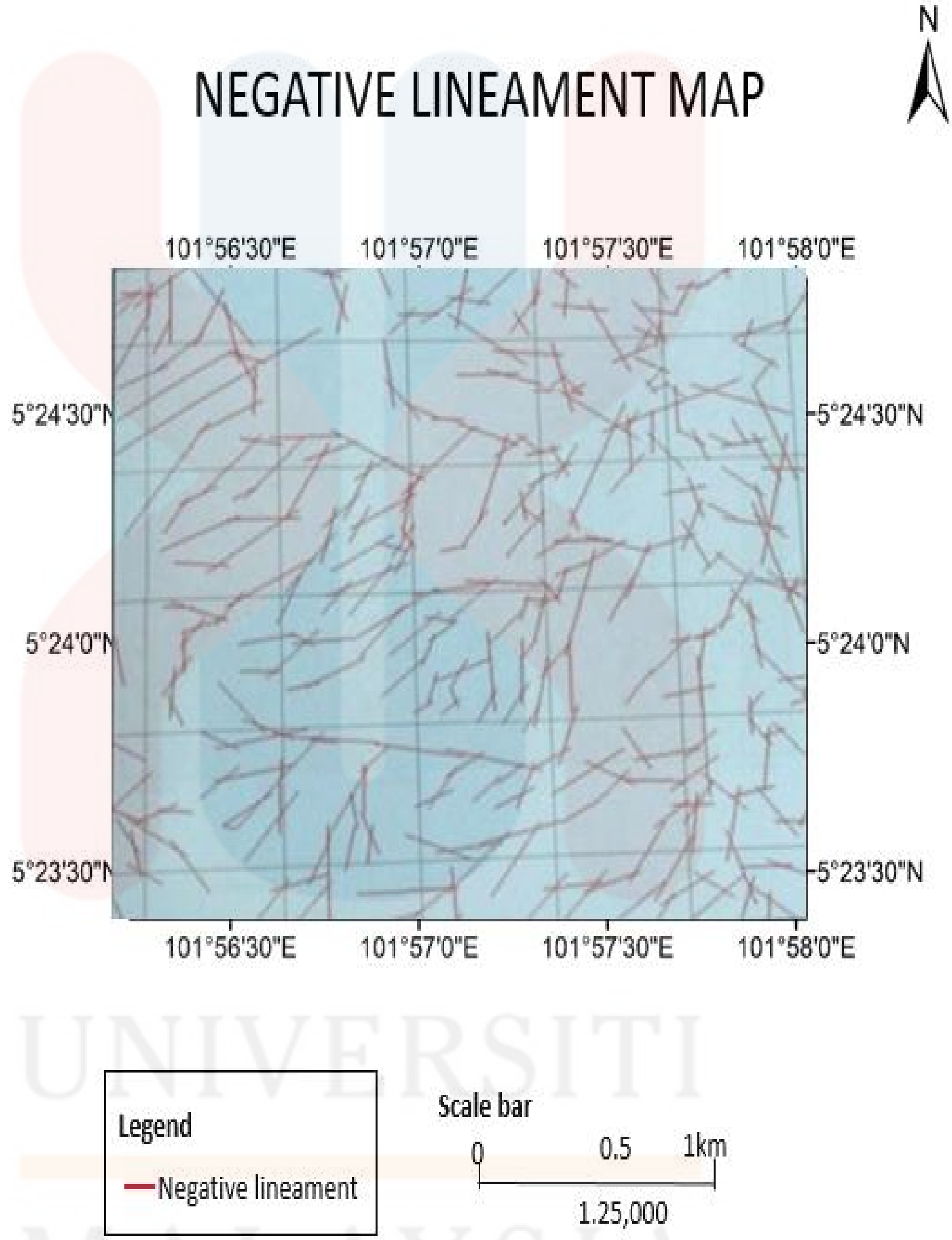


Figure 4.11: Lineament analysis of terrain map of study area

Table 4.5: Frequency of the linear analysis angle of strike.

Angle of Strike	Frequency
0˚- 10˚	-
11˚ - 20˚	2
21˚ - 30˚	3
31˚ - 40˚	7
41˚ - 50˚	3
51˚ - 60˚	4
61˚ - 70˚	4
71˚ - 80˚	3
81˚ - 90˚	7
91˚ - 100˚	2
111˚ - 120˚	5
121˚ - 130˚	8
131˚ - 140˚	7
141˚ - 150˚	5
151˚ - 160˚	4
161˚ - 170˚	6
171˚ - 180˚	5
181˚ - 190˚	2
191˚ - 200˚	1

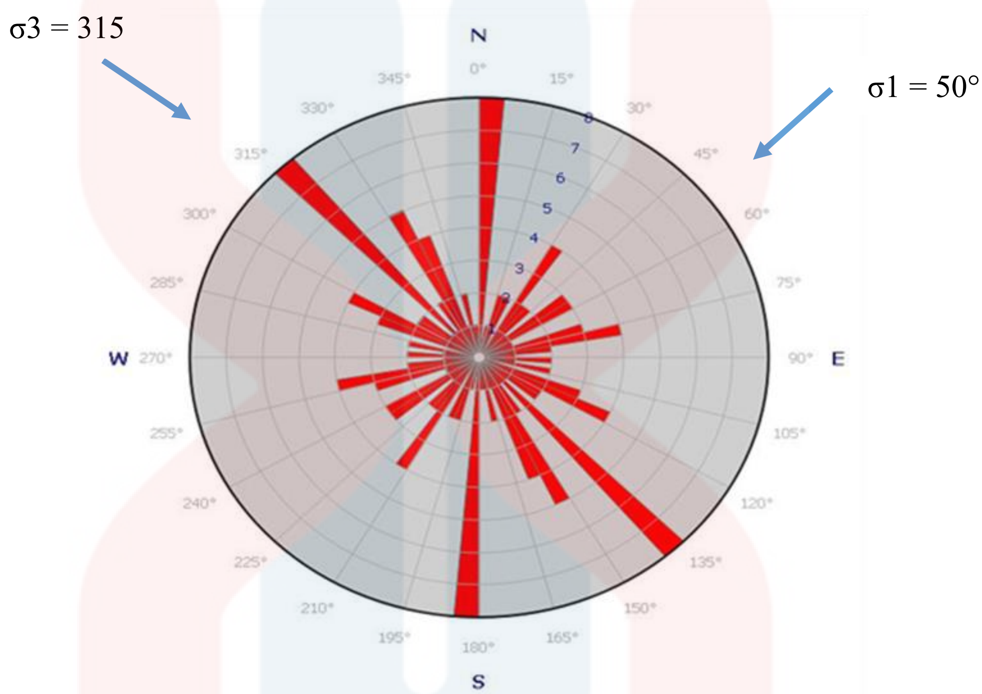


Figure 4.12: Rose diagram of lineament analysis of study area.

The rose diagram of the research sample area is shown in Figure 4.12. Sigma 1(σ 1). The direction of the (σ 1) is at northwest where the reading is N315 ˚ W. This maximum strength is the strength that tends to make the rocks slightly break or fracture. This maximum strength is the strength that tends to make the rocks slightly break or fracture. It reveals that on the base of Figure 4.12, the joint distribution in the study area is dominant by 315° and 5°. Thus, it indicates that when the shear stress acts on the body of rocks, the maximum stress caused the rock to slide in 315° and 5°. Eventually, the minimal stress that Sigma 3 (σ 3) has a reading about N75 ˚ E.

CHAPTER 5

RESULTS AND DISCUSSION

5.1 Introduction

The Earth is primarily liquid freshwater. It is not present in lakes and rivers but contained underground in aquifers. In fact, during the cycles of non-rainfall, these aquifers provide useful water base flow. They are therefore a vital resource that needs preservation so that freshwater can support the human race and its reliant habitats. The groundwater contribution is vital; probably up to 2 billion people are directly dependent on aquifers, and 40 percent of the world's food is derived from irrigated, groundwater-based agriculture. In future, aquifer production will remain necessary for economic development, and reliable supplies of water for domestic, industrial and irrigation purposes will be needed. (Soltan & M, 1997)

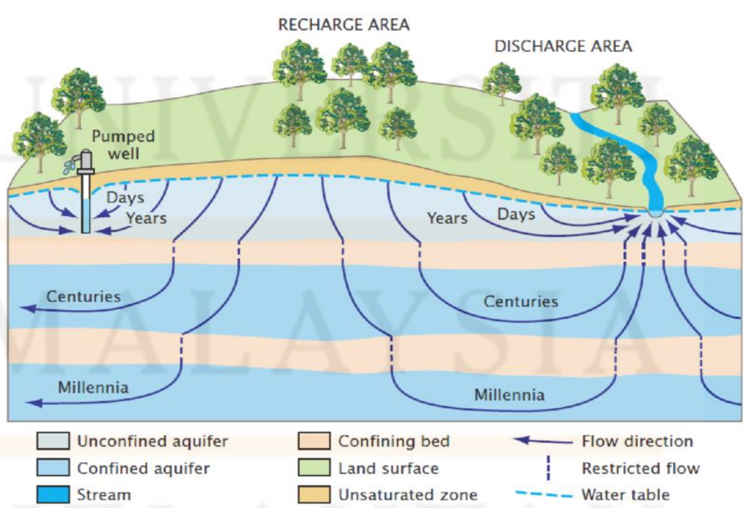


Figure 5.1. Groundwater in the hydrological cycle

All freshwater will need to provide a recharge source. It is usually rainfall/snowmelt but often may also be drains from rivers, lakes or canals. Usually, the recharge goes downstream into the unsaturated area and the aquifer fills up to the ground surface from where the water falls. Ground like springs, supplying the lowland river with a dry-weather flood (or baseflow). This saturates the aquifer to a level where the outflow stops. In recharge zones, semi-smooth aquifers are typically unconfined, but in other areas in broader depth groundwater is often partly limited to low permeability strata or entirely contained by impermeable strata (an air louds). Water can be found under pressure under restricted environment and after the wells have been dug, it can reach a degree called a potentiometric surface above, even to the ground surface.

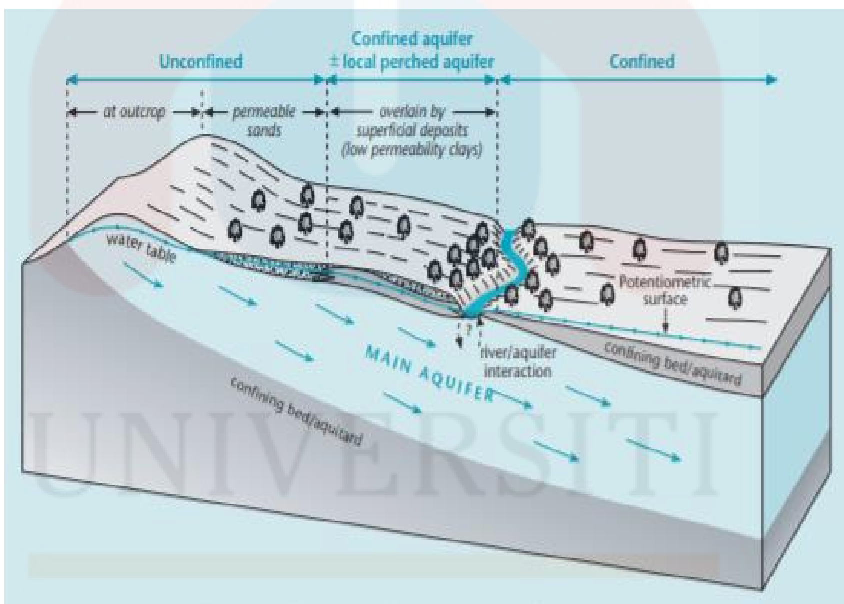


Figure 5.2. Schematic of a common aquifer situation.

Therefore the key considerations are the origins and chemical composition of refueling water, lithological and hydrological properties of the geological unit, the different chemical processes taking place within the geological unit, and how long it has been in contact with the geological unit (residence time). These considerations will all influence dissolved ingredients in ground water forms and amounts. The most abundant dissolved elements are the major ions, both charged positive (cations) and charged negatively (anions). Due to electron neutrality specifications, cations and anions are found in the water in equivalent proportions and constitute the bulk of solids dissolved in groundwater.

Table 5:1 :Drinking water quality as per EQS, WHO and EC standard.

Parameter	Drinking water quality as per		
	Environmental Quality Standard	World Health Organization standard	Electrical Conductivity standard
pH	6.0-8.5	6.8-8.5	6.5-8.5
TDS (mg/L)	1000	1000	1000
Iron (mg/L)	0.3-1.0	0.3	0.20
Sodium (mg/L)	200	200	175
Chloride (mg/L)	150-600	250	250
Sulphate (mg/L)	400	400	25
Fluoride (mg/L)	1.0	1.5	1.5
Arsenic (mg/L)	0.05	0.05	0.05
Ammonium (mg/L)	0.5	1.5	0.5
Nitrate (mg/L)	10	10	10
Phosphate (mg/L)	6.0	-	5.0
Potassium (mg/L)	12.0	-	10
Endrin (mg/L)	0	0.2	0.2
Heptachlor (µG/l)	0	0.0	0.1
DDT (µG/l)	0	1.0	0.1

Effects of drink water of environmental pollutants has been linked to a wide variety of harmful effects on human wellbeing, including elevated cancer risk (e.g. exposure to trichloroethylene and trihalomethane (THM)); adverse effects in neurodevelopment (e.g. lead exposure) (for example, from exposure to atrazine) (for example, from exposure to atrazine). Although chemical parameters in drinking water have been based on the possible toxic effects of chemicals in the past, there is growing evidence of positive public health effects of certain parameters such as minerals in drinking water. There is evidence that low amounts of magnesium in drinking water are linked to an elevated risk of cardiovascular disease and a higher risk of fracture in kids, some neurodegenerative conditions, premature birth and birth weight and some forms of babies are associated with low calcium content and may types of cancer.

In the study area, Kota Bharu are selected as the study range for this quality analysis as a groundwater source as for drinking and domestic use of water. In this study, the focus is on the concentration of the major ions, which is in pH, Sodium, chloride, suplhate, Ammonia, nitrate, potassium and magnesium in domestic wells of at Kota Bharu. Cation, anion, and different drinking water quality criteria are defined in this report. In a 1.5-liter sanitised container of polyethylene, 20 water collections were assembled from nearby wells. For real particle testing, water samples are once again examined.

The use of a titrimetric approach is tested for the chloride, carbonate and bicarbonate particles. As to molecule, atomic absorption Spectrophotometer (AAS) is used for sodium, potassium, magnesium and calcium ions to analyse concentrations of ions. During the analysis, sulphate using gravimetric methods was investigated. Colorimetric approach is used with regard to nitrate and fluoride particles.Management of drinking water quality has evolved into a crucial factor of waterborne disease prevention and control. Water is essential. .

However, illness will and does move from the poorest to the richest in all nations of the world. Healthy drinking water is thus an immediate need and therefore a fundamental human right (Khan & M.M.A, 2006). The pollution of ground water becomes unavoidably from product of human activity. In areas that have high population levels and heavy human land use are highly vulnerable to soil water. Virtually any activity either deliberately or unintentionally, in which chemical or waste is released into the atmosphere will pollute groundwater. It is impossible and costly to purify groundwater when it is polluted. We ought to see how surface waters and earth waters interrelate in order to continue approaching pollution reduction or remediation. Where a source of contamination is well near a water supply, there is a chance of contamination. If the river or stream in the vicinity remains, it may even be poisoned by ground water.

5.2 Investigation Techniques

Before the field investigation, applied existing knowledge were gathered for the purpose of generating well-organized hydrogeological research involving both mappings of hydro-stratigraphic units, geological formations and hydro-chemical of water sampling. The analysis utilized both primary and secondary chemical data. The secondary data is primarily obtained from results of previous study chemical analyses. In the description and analysis of chemical features of groundwater, quantitative data for large ions, cumulative solved solids (TDS) and conductivity have been used. Diagram and geochemical maps of Trilinear Piper were used to evaluate both the chemical forms and components of groundwater. The current data have helped to design water flow patterns.

In summary, current data on geo-resistivity and seismic reflection were given to define characteristics of the surface in the hydro-geochemical investigation. Figure 5.3 shows groundwater aquifers using hydro geochemical and geophysical methods (A. R. Samsudin, A. Haryono,, U. Hamzah , & A. G. Rafek , 2017) Current borehole knowledge gathered data on soil stratification and watering locations below the ground level (Ismail 1992). Figure 5.2 indicates a common cross-sectional location in the Southeast part of the sample area. In the Quaternary sediments there are up to four aquifers. The semi-permeable clay layers discern all aquifers. The largest aquifer is made up of fine, light brownish sand and grey clay and coats about two meters and a height of 15 m below the surface of the earth.

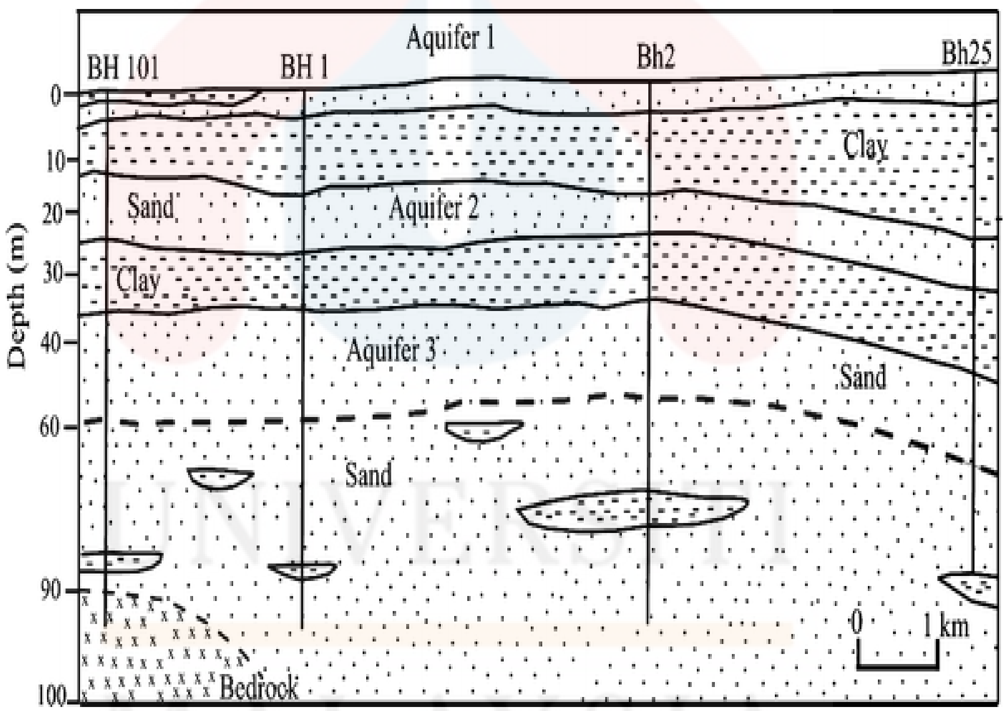


Figure 5.3: Subsurface of Bachok part of study area.

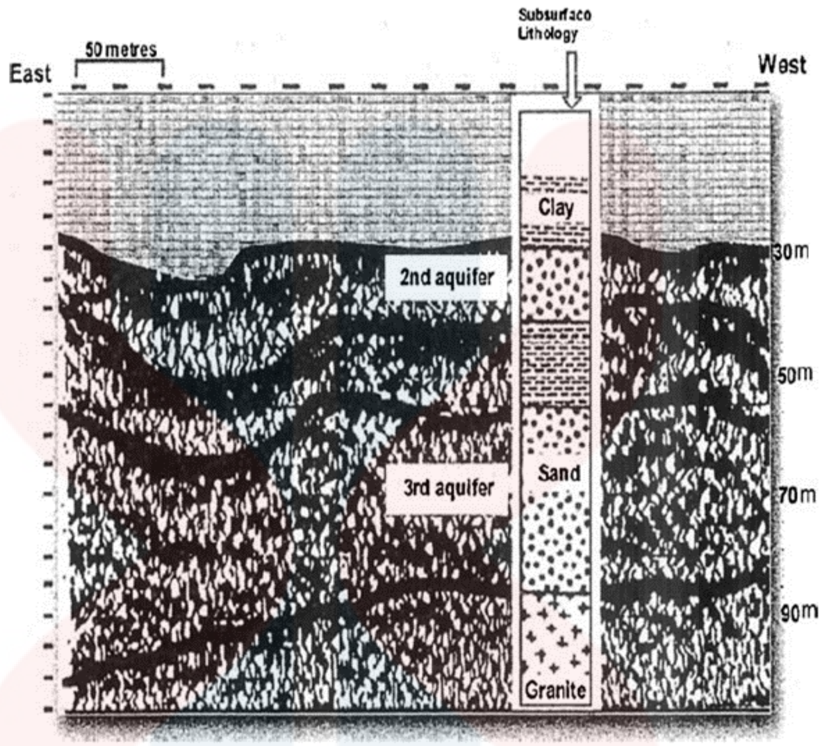


Figure 5.4: Interpretation of seismic section and lithology in Bachok, Kelantan

5.3 Factors Affecting Groundwater Composition

Numerous characteristic variables can determine ground-water quality; then again, the essential components incorporate the source and chemical structure of recharge water, the lithological and hydrological features of the geologic unit, the different processes happening inside the geologic unit, and the measure of time the water has remained in contact with the geologic unit. These elements can influence the sort and amounts of broke up constituents in ground water.

The most abundant components measured are the significant particles, which can be both positively charged (cations) and negatively charged (anions). As an outcome of the requirement of electro neutrality, cations and anions are available at equivalent fixations in water and involve the greater part of the total dissolved solid (TDS) in groundwater. The most extensive cations introduce in water are sodium (Na+), potassium (K^+); calcium (CA^{2+}) and magnesium (MG^{2+}), the most inexhaustible anions are bicarbonate (HCO_3), chloride (Cl-), and sulphate ($SO4_{-2}$). By calculating the concentration of these ions in groundwater inspects, chemical quality of water is determined, and the type of water can be portrayed and depicted. A variety of physical and chemical factors may play a major role in influencing the chemical composition of groundwater (such as oxidation – reduction, evaporation, precipitation, weathering, sorption, and exchange reaction). The importance of these variables varies though depending on the change in geological and hydrogeological conditions. (Dazy J & Razack M, 1990)

Mineral dissolution and weathering are significant considerations in the management of water chemistry in small to medium-size ground water basins with reasonably uniform lithology. In regional groundwater basins with variable lithology, the effect of lithology on physiochemical parameters was therefore not adequately discussed. In arid regions, where these regional basins provide only water to large areas, this becomes more significant. Different rock types would have different mineralogical concentrations and thus different element accumulation in geographic basement basins with significant geological differences. (MT, 2004)

The ionic ratio of water is used to sort it according to the ionic cation and anion, measured by milliequivalents per litre. A milliequivalent (meq/L) is a molar strength determination of the ion, normalized via the ion's load. The ion which has mostly been dissolved must be above 50% of the total. For example, where the water consists of more than 50% of the total anion milliequivalents as bicarbonate and more than 50% of the total cation milliequivalents as sodium, it is classified as water of the sodium bicarbonate form. If neither a cation nor an anion is dominant (over 50%), water is classified as mixture nor the two most common cations or anions are classified in decreasing order. (Yidana MS, Ophori D,, & Yakubo BB, 2007)

5.4 Results and Discussion

The research results obtained from the analysis are based on the physical and chemical parameter concentration of the hydrochemical data from the 12 groundwater samples. Temperature, pH, dissolved oxygen (DO), conductivity, gross solid dissolved (TSD), salinity and turbidity are also physical parameters. In the chemical parameters of domestic groundwater wells including Na^{+},K^{+},Ca^{2+} ,Mg^{2+}, HCO_{-3} ,Cl-, $SO2_{-4}$, NO_{-3} and F- large ion concentration have been analysed.

The location of the water sampling in the sample area is shown in Figure 5.5. Table 5.2 shows the sample points coordinates, while Table 5.2 indicates water depth, ground level well height, water height below ground level and above sea level elevation and contour. In relation towards table 5.3, all physical parameters measured are measured with a concentration shown throughout the whole main ion evaluated in table 5.4. Finally, the WHO and MOH drinking water standards distinction is seen in Table 5.5.

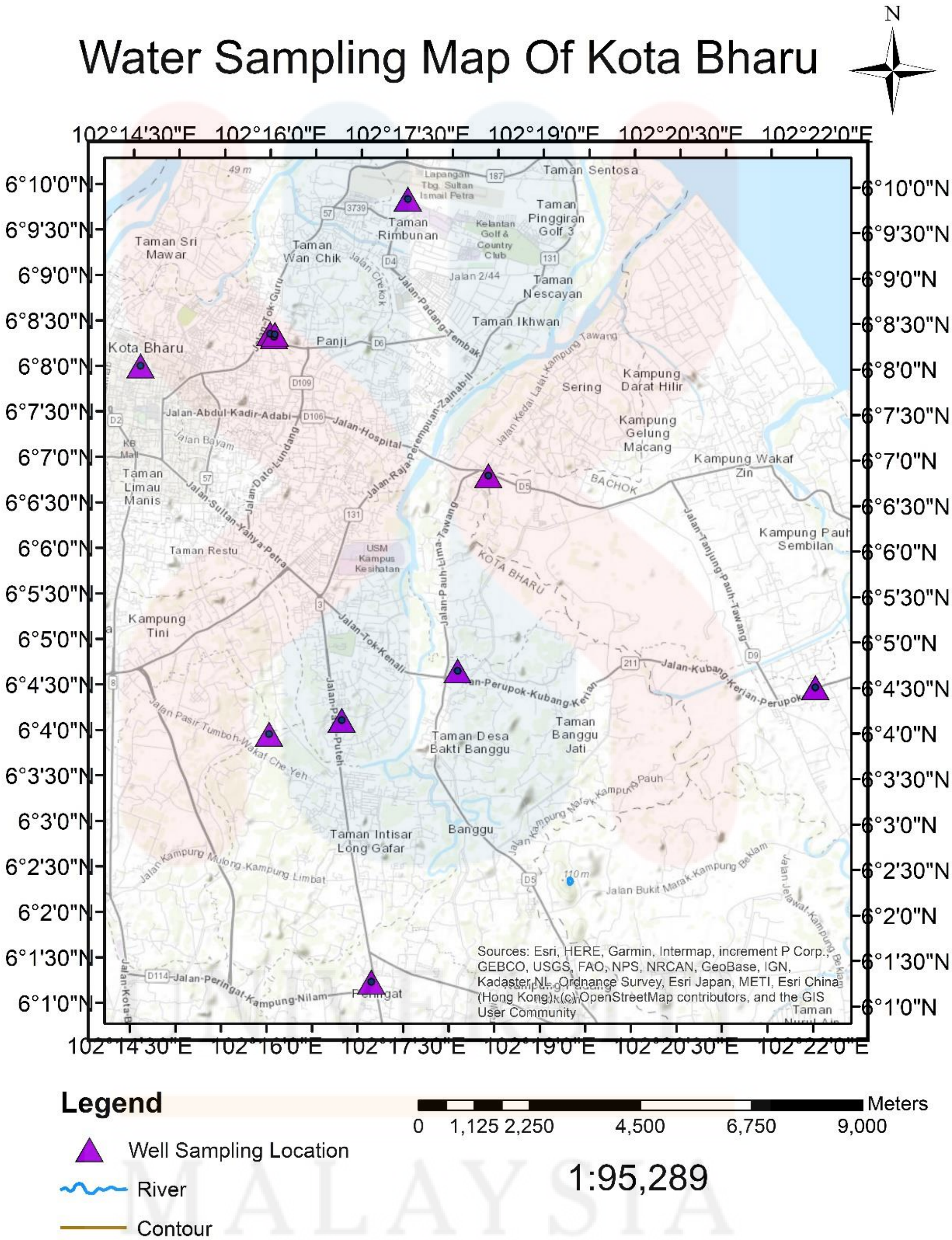


Figure 5:5: Water sampling location map in the study area.

Table 5.2 show the sample points coordinates

Location	Station ID	Latitude	Longitude
Sek.Keb. Kota Jembal	PD105	N 47 ° 95’50.4’’	E 67 ° 61’05.7’’
Kg. Binjai (Amarda Tractor)	PD104	N 47 ° 89’43.5’’	E 67 ° 21’45.6’’
Pusat Kesihatan Beris Kubur Besar	PD96	N 48 ° 61’88.3’’	E 67 ° 18’36.4’’
	PD98	N 48 ° 61’88.5’’	E 67 ° 18’34.9’’
	PD100	N 48 ° 61’90.4’’	E 67 ° 18’36.1’’
Pusat Kesihatan Peringat	PD101	N 48 ° 61’88.5’’	E 67 ° 18’34.5’’
Sek.Keb.Seribong	PD108	N 48 ° 61’90.4’’	E 67 ° 18’36.6’’
Lundang	PD109	N 47 ° 72’14.6’’	E 66 ° 58’40.1’’
Logi Air Pengkalan Chepa	PD66	N 47 ° 790’0.7’’	E 68 ° 17’00.8’’
	PD67	N 47 ° 79’00.0’’	E 68 ° 17’00.7’’
	PD68	N 47 ° 79’00.1’’	E 68 ° 17’00.5’’
	PD69	N 47 ° 79’00.5’’	E 68 ° 17’00.4’’
	PD70	N 47 ° 79’00.4’’	E 68 ° 17’00.1’’
Logi Air Tg Mas	PD74	N 47 ° 52’00.9’’	E 67 ° 89’00.4’’
	PD76	N 47 ° 51’22.8’’	E 67 ° 89’59.5’’
	PD77	N 47 ° 52’15.6’’	E 67 ° 89’49.4’’
Tangki Air Jalan Merbau	PD80	N 47 ° 25’00.4’’	E 67 ° 83’00.6’’
	PD81	N 47 ° 25’00.2’’	E 67 ° 83’00.5’’
	PD82	N 47 ° 25’00.7’’	E 67 ° 83’00.1’’
	PD83	N 47 ° 25’00.1’’	E 67 ° 83’00.9’’
	PD84	N 47 ° 25’00.6’’	E 67 ° 83’00.0’’

Table 5.3: Location, Well ID, Elevation, Date of sampling, Water level and Water depth of groundwater

Location	Well ID	Elevation	Date	Water Level (m)	Water depth (m)
Sek.Keb. Kota Jembal	PD000105	18	20/10/2020		6.36
Kg. Binjai (Amarda Tractor)	PD000104	5.88	20/10/2020	2.1	
Pusat Kesihatan Beris Kubur Besar	PD000096		20/10/2020	3.21	
	PD000097		20/10/2020	3.15	
	PD000098		20/10/2020	3.2	
	PD000099		20/10/2020	3.79	
	PD000100		20/10/2020	3.4	
Pusat Kesihatan Peringat	PD000101	5.87	20/10/2020	3.92	6.21
Sek.Keb.Seribong	PD000108	6.26	20/10/2020	5.44	5.54
Lundang	PD000109	5.67	20/10/2020	5.51	6.03
Logi Air Pengkalan Chepa	PD000066	5.87	21/10/2020	5.75	
	PD000067		21/10/2020	5.7	
	PD000068		21/10/2020	5.51	
	PD000069		21/10/2020	5.71	
	PD000070		21/10/2020	5.25	
Loji Air Tanjung Mas	PD000072		21/10/2020	10.39	
	PD000073	4.49	21/10/2020	9.77	
	PD000074		21/10/2020	6.97	
	PD000076		21/10/2020	6.68	
	PD000077		21/10/2020	6.4	
	PD000078		21/10/2020	7.56	
Tangki Air Jalan Merbau	PD000080		21/10/2020	6.63	
	PD000081	6.55	21/10/2020	6.6	
	PD000082		21/10/2020	6.58	
	PD000083		21/10/2020	6.54	
	PD000084		21/10/2020	6.61	

5.4.1 Depth to Water Level

The topmost layer of the saturation areas at which hydrostatic stress correlates to atmospheric pressure and is the water column which is entered in well is called the water table. Typically, this can be found with an open aquifer. It is determined that the water level in the wells is adequate to explain the level of water in the studying region. The water table is the surface of the water pressure head (when the pressure gauge is 0) relative to the atmospheric pressure. It can be seen as the "surface" of the materials on the floor saturated in a specific area by ground water. (Winter, , Thomas C, & Judson W, 2018)

Groundwater could be precipitated by drainage to the aquifer or from groundwater. Water penetrates through pores in the soil in areas with appropriate precipitation and flows through the unsaturated region. Water covers more pores in the soles at ever lower depths, until there is a saturation zone. Underneath the water table, layers of permeable rock called aquifers are called in the phreatic region (saturation zone). The water table can be more difficult to define in less permeable soils, such as near basement formations and historical reservoirs. ("Ground Water and Surface Water A Single Resource, H.J, & S. El Guindy, 1984)

The table of water should not even be misunderstood for a deeper well with the amount of water. If a lower permeable unit in a deeper aquifer is used, and hold the upward surge, so the water level in this aquifer can raise to a higher or less than the real water table elevation. The water elevation in the depth well depends on the water pressure in the deeper water which is not called the water table but the potentiometric surface.

5.4.2 Water Table Contours and Groundwater Movement

The water of the 21 domestic wells are measured and the water level altitude has been generated based on the average sea level. Significantly reduced amounts of the water table were identified and water table contour charts were produced in reference to the intermediate sea level. These maps show the direction of groundwater flow, including recharge and discharge zones. These maps were helpful. Contours of convex show the soil-water recharge region while concave contours show the soil-water direction (Todd, 1980). In addition, the flow line divergence indicates a recharging region, while the flow line convergence is a discharging area (Fetter, 1988). The direction of groundwater movement observed from the contour of the water table is usually from the south east to the north east. The flow path clearly indicates that rivers in the research region collect water from the groundwater system.

Table 5:4 Physical Water Quality Parameters

Location Code	Temp (˚C)	pH	DO (mg/L)	Conductivity (mg/L)	TDS (mg/L)	Hardness (mg/L)	Salinity (mg/L)	Turbidity (NTU)
1	30.2	6.36		232	116	29.96	0.2	13.5
2	29.9	5.8	6.75	32.5	163	17.28	0.2	3.91
3	29.8	3.91	4.32	1186	696	43.60	0.8	4.35
4	29.8	6.1	3.95	8.19	409	157.16	0.2	44.2
5	29.7	3.96	3.35	1592	487	17.26	0.6	2.36
6	29.1	6.21	4.97	133	67	5.05	0.04	65
7	29.8	5.57	2.67	147	73	8.80	0.3	0.82
8	29.9	6.03	2.60	1.48	74	542.84	0.1	3.44
9	30	6.77	4.10	1095	650	51.76	0.49	60.5
10	29.9	6.71	6.15	308.5	183.3	14.37	0.13	19.4
11	30	6.61	5.07	1126	669.5	15.26	0.5	20.1
12	30	6.58	4.39	1148	682.5	25.97	0.51	48.5
13	29.9	6.84	4.40	5895	3503.3	23.80	2.89	18.9
14	29.4	6.29	4.38	241.6	144.95	15.57	0.1	30.1
15	29.7	6.81	6.67	682	409.5	29.67	0.3	62.1
16	29.4	6.67	4.05	671	403	5.08	0.3	50.3
17	29.5	6.46	3.98	159.1	95.55	16.67	0.07	3.87
18	29.5	6.37	2.60	142	85.15	17.89	6.38	1.06
19	30.1	6.84	2.55	117.9	69.55	189.97	0.05	1.49
20	30	6.95	5.11	173.6	102.7	51.87	0.07	0.64
21	30.4	6.8	4.09	417.1	245.7	55.97	0.18	96.5

Exceeds standard limit of WHO and MOH

Table 5.5: Major ion concentrations in the wells

Location Code	Na^{+}	K^{+}	Ca^{2+}	Mg^{2+}	$HCO_{\_3}$	CI	$SO4$	NO_3	AI
1	20	6.75	15	9.0	5.5	52	3	<0.5	<0.01
2	59	4.88	41	27	0	42.6	3	<2.1	<0.01
3	12	7.10	9.2	6.2	35.7	54	3	<0.5	<0.01
4	1.9	8.89	4.5	0.9	44	273	3	<1.8	<0.01
5	73	4.18	11	9.2	2.5	7.10	1.75	<0.5	<0.01
6	85	33.01	1.5	17	20	1	1.65	<1.5	<0.01
7	24	2.2	3.6	2.8	41	6.9	0.33	<14	<0.01
8	13	5.4	7.5	1.3	2.5	25	0.47	<7.1	<0.01
9	46	4.75	6.8	26	20	57	0.81	<3.5	<0.01
10	2.67	6.5	5.0	25	41	241	9.05	<0.9	<0.01
11	13	4.3	15	1.75	32	14.50	12.55	<0.5	<0.01
12	20	12	23	0.75	10	52.57	3	<0.5	<0.01
13	11	4.75	94	1.20	0	21.35	3	<0.5	<0.01
14	14.18	4.3	2.7	5.55	8.9	15	3	<0.5	<0.01
15	12	1.7	4.3	4.47	78.3	1.0	3	<0.5	<0.01
16	17	6.3	1.3	2.03	59.5	153	3	<1.0	<0.01
17	21	6.7	1.5	6.08	14	23	1.77	<0.90	<0.01
18	23.2	5.0	6.0	1.81	18.7	12	1.50	<4.67	<0.01
19	16	16	5.0	1.55	1	29	0.45	<1.93	<0.01
20	3.8	3.8	24	2.75	46	1	9.60	<0.87	<0.01
21	23.25	20.50	5.37	2.03	6.4	28.67	8.05	<1.5	<0.01

Exceeds standard limit of WHO and MOH

Table 5.6 Comparison between WHO and MOH drinking standards

Constituents	Unit	WHO 2011	WHO 2006	MOH 2010	Concentration in study area
Temperature	˚C	Variable			29.1-30.4
pH	mg/L	6.5 – 9.5		5.5 – 9	3.96-6.84
Dissolved Oxygen	mg/L	NA		NA	2.60- 6.75
Conductivity	µS/cm	1000		NA	117.9-5895
TDS	mg/L	500-1500		1000	73-542.84
Hardness	mg/L	500		500	5.60 – 834.74
Salinity	mg/L				0.04-2.89
Turbidity	NTU	5		0	0.82-96.5
Na^{+}	mg/L	200		200	1.9-59
K^{+}	mg/L	20	12		2.22-33.01
Ca^{2+}	mg/L	200	75		1.3-94
Mg^{2+}	mg/L	50	50	150	0.75-26
$HCO_{\_3}$	mg/L	10	300		0.78.3
CI	mg/L	250		250	1-273
SO_4^{2-}	mg/L	500		250	0.45-12.55
NO_3	mg/L	50		10	0.5-7.1
AI	mg/L	1.5		1.5	0.01

Exceeds standard limit of WHO and MOH

5.4.3 Temperature

The groundwater temperature in the study area varies from 29.1 ˚C to 30.4˚ C per human. The groundwater has a normal spectrum of temperature values in Malaysia in terms of aquifer layers for the tropical monsoon weather. The temperature can affect the acceptability of a variety of other inorganic elements and chemical pollutants that can alter the taste. The higher water temperature increases microorganism development and can produce taste, odour, colour and corrosion issues. The map indicating temperature levels in the wells sampled as seen in Figure 5.9 below.

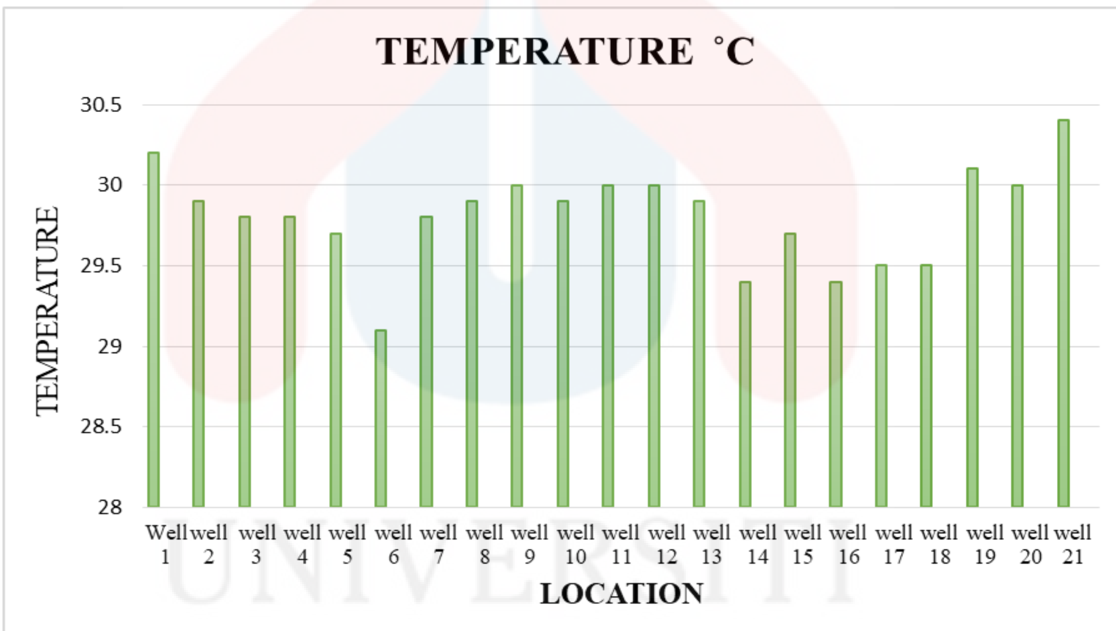


Figure 5.9: Graph for range of temperature in the sample

5.4.4 pH

The pH indicator is groundwater acidity or alkalinity. Groundwater with a pH of 7 has hydrogen (H^{+}) and hydronium particles equal amounts and is known to be neutral. PH is slightly acidic at 5.7 and appears to grow more environmentally neutral conditions. pH is critical provided that it controls much of the chemical reactions, including ground water, which therefore has a firm effect on arsenic, copper, manganese or nitrogen in the region or non-appearance. Acidic ground water is destructive in nature, whereas alkaline ground water appears to encrust.

The pH of the field of study is between 3.96 and 6.84. The pH of the ground water obtained in most wells, except for a few wells, such as Well 3, Well 5 and Well 7, is usually mildly acidic. They are alkaline in nature. They are alkaline in nature. Acidity can be due to the association of natural soil and air processes with the chemical reaction occurring within a groundwater system. Although pH values vary from 7 to 8 for older groundwater in confined water supplies are causing alkalinity. Increased bicarbonate produces a higher pH; the by-product of these confined aquifers is the normal decrease reaction. The pH values for all wells in the sample region are shown in Figure 5.10 below.

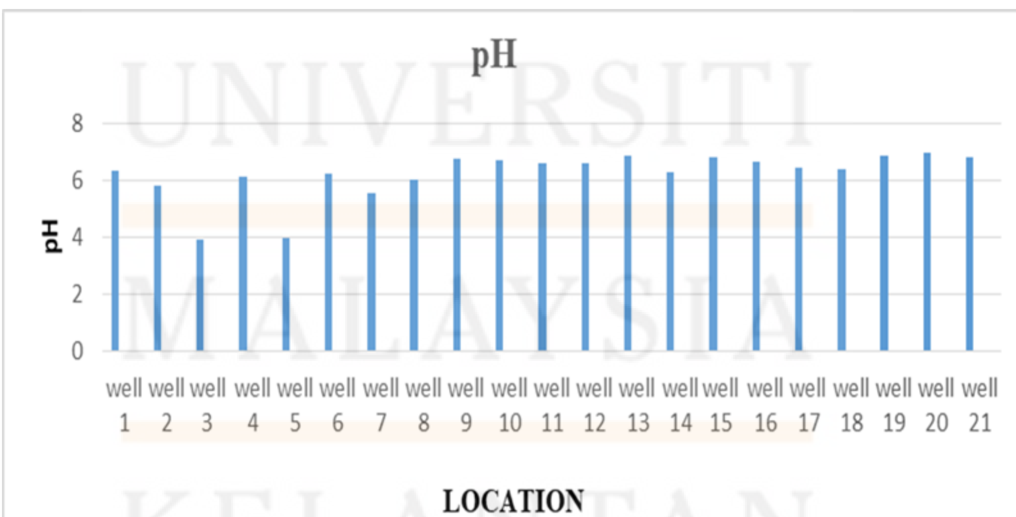


Figure 5.10: The concentration pH from the sampled well

5.4.5 Dissolved Oxygen (DO)

A direct water temperature, treatment, and biological, or chemical processes within the dispersal frame affect the dissolved oxygen substance in water. The use of dissolved water oxygen may lead to microbial nitrite and sulphate nitrate transition to supply. The convergence of ferrous iron can also be enhanced by the subsequent staining of the tap as water flows in. Significant quantities of oxygen that has been dissolved could corrode the channel. The dissolved oxygen content in water is used to denote the toxicity and the portability thereof. This then represents a key test of water pollution management and sewage disposal and waste treatment process control practises. The proposed recommendation value is not less than 8 mg/l for drinking water (WHO, International Standards for Drinking Water., 1984). Lower levels mean microbial or corrosive pollution.

The analysis indicates a dissolved oxygen concentration between 2.0 mg/L and 6.75 mg/L in the collected groundwater samples. The values are below the prescribed WHO 1984 guideline rating. However, for drinking purposes, the concentration is expected to be healthy. Well 2, which amounts to 6.75mg/L, is the maximum concentration of dissolved oxygen. Perhaps this is due to the mixed planting undertaken in the entire field. Vegetation directly changes the dissolved oxygen by photosynthesis by discharging oxygen into the groundwater. It affects dissolves oxygen levels indirectly as vegetation shading can decrease water temperatures and dissolves oxygen increases as temperatures drop. (WHO, International Standards for Drinking Water., 1984)Throughout the water sample from well 8 that indicates a value of 2.6 mg/ L the lowest oxygen dissolved is detected.

Coca crops and farms, including chickens, ducks and cows, lie around this field. Oxygen levels could be decreased by fertilizing plants by adding phosphates and nitrates into the groundwaters, the components of fertiliser. The waste organic matter from animals that could spill into the field may also be another alternative. Micro-organisms break down organic matter. The dissolved oxygen in the groundwater is utilized by the micro-organism. The dissolved oxygen content in all 21 wells as seen in Figure 5.11 below.

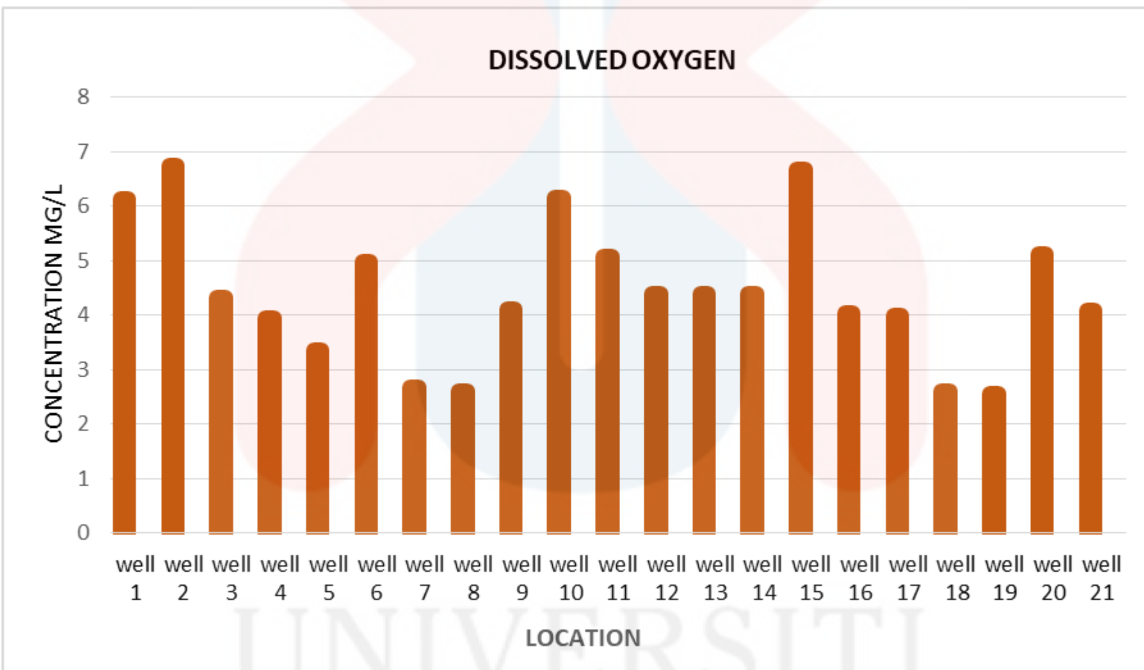


Figure 5.11: Dissolved oxygen content at the sampled well

5.4.6 Electrical Conductivity

The potential to conduct electric current is conductivity. Groundwater conduction depends on the temperature, ion forms and the concentration of different ions. Pure water has a poor conductance in chemically pure water. It's a strong isolator, thus. On the other side, the water is conductive from a miniscule measure of ionized mineral salt. Dissolved ion in the groundwater influences the conductivity the greater the presence of ions, the greater the value of the action of the solution. A rise of 11˚C increases the conductivity by roughly two percent. The power supply system is µs/cm. (Dieter, et al., 2018)

Groundwater conductivity in the alluvium aquifer increases with a depth and groundwater flux Groundwater can be sorted according to on the electric conductance guideline. Since different chemicals and salts dissolve into water, they become negative charged ions. Potassium, magnesium and sodium are the positive charged ions that can influence water. Negative ions, on the other hand, are carbonate, chloride and sulphate. A larger quantity of a material such as sulphate will result in a rise in scale, which can affect boilers and other industrial machinery. Measuring the electrical conductance of water is a very simple and cost efficient way to identify how many ions are present in water for environmental and industrial applications. The water will be correctly handled after these samples have been taken.

The conductivity of the sampled areas varies from 1.48 – 5895 µs/cm. The electric conductivity is considered ideal for human use, with a range of around 1000 µs/cm (WHO, 2011), while iron structures are more corrosive than that. All samples show low conductivity with the exception of 5 wells, well 3, well 9, well 11, well 12 and well 13, listed as improperly conductive (Class 5). (WHO, International Standards for Drinking Water., 1984)

The conductivity of the ions is in water. This means that the more energy is generated and the greater the amount of Na+ and Cl-ion present in the groundwater. The Na+ ions and Cl ions concentration in Well 11 and 13 are the highest. For well 2 and well 8, the equivalent values are 32.5/L and 1.48 mg/L.

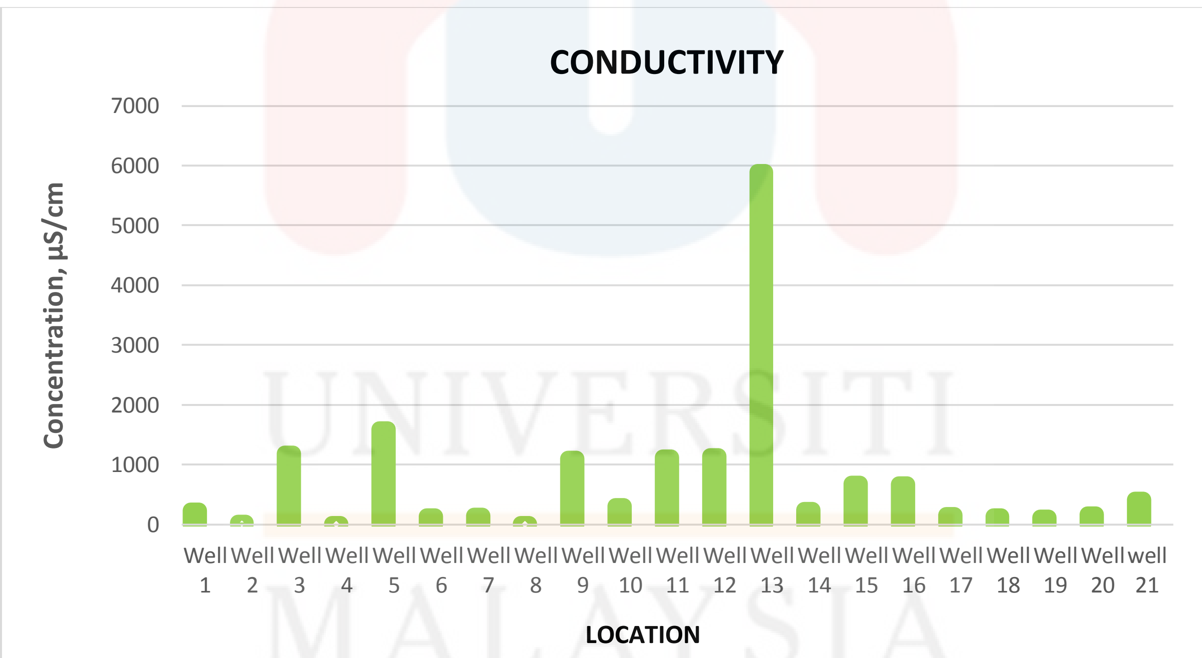


Figure 5.12: a clear view of the conductivity in the study area.

5.5.7 Total Dissolved Solid

The dissolve of both inorganic and organic compounds in a solvent in molecular, ionized or suspended form (colloidal soil) is determined by the dissolved aggregate composition of all dissolved solids. (TDS) amounts are commonly recorded in parts per million (ppm). (Salinity and drinking water, 2020)Concentrations of Water TDS may be measured by means of a digital detector. The operational definition is typically that solids must be sufficiently small to stay filtrated by a 2-micrometer (nominal or smaller) pore filter. In the case of freshwater environments only total dissolved solids is generally discussed as salinity contains some of the ions that are the definition of TDS. TDS is primarily used to research quality water for rivers, lakes and streams.

Agricultural runoff and industrial (urban) runoff, clay-rich mountain waters, soil erosion liquidation and the point source of water degradation are the main causes of TDS in the receive water. In nutrient runoff, general wastewater fluids, and snow-capped runoff where road deice salts are added, the most important chemical components of the plant are calcium, phosphates, nitrate, sodium, potassium, and chloride. The chemicals may be of the order of 1,000 or less molecules cations, anions, molecules or agglomerations, so long as the micro-granula is soluble. Pesticides derived from surface runoff are more exotic and dangerous components of TDS. Certain dissolved solids naturally occur as a result of rock and soil weathering and dissolution. The USA has developed a secondary water quality standard for drinking water of 500 mg/l. (DeZuane & John , 1997)

Table 5.7: Classification of Total Dissolved Solid

Water class	(Goorel.1958)	(Altoviski,1962)	(Drever. 1997)	(Todd.2005)
Freshwater	0-1000	0-1000	< 1000	10-1000
Slightly water	------	1000-3000	1000-2000	-----
Highly-brackish water	1000-10000	3000-10000	2000-20000	1000-10000
Brackish water	10000-100000	10000-100000	-----	10000-100000
Saline water	-----	-----	35000	
Brine water	>100000	>100000	>35000	>100000

Source (Aldahaan, Saadi, Hussain, Hussain, Al-Ansari, Nadhir, & Knutsson, Sven, 2015)

TDS is between 73 – 3503, 3 mg/L in the area undergoing study. There are 20 samples in the fresh water category, while 1 sample is over the limit of freshwater. TDS values under 600 mg/l are known to be good for human consumption ((WHO, International Standards for Drinking Water., 1984)). The TDS value over 1000 mg/l makes drinking water dramatically unpleasant ((WHO, International Standards for Drinking Water., 1984)). At 12 wells 13, 682.5mg/L and 3503.3mg/L respectively, the maximum value of TDS is seen. The cumulative key ions in the wells can be attributed to this. For most critical ions, these two wells have the highest reading examined. Whilst at Well 6 the lowest value is 67 mg/L, this value makes sense because compared with the other sampled wells the lowest value exhibits for the main ions. The TDS values of all the sampled wells are presented in Figure 5.13 below.

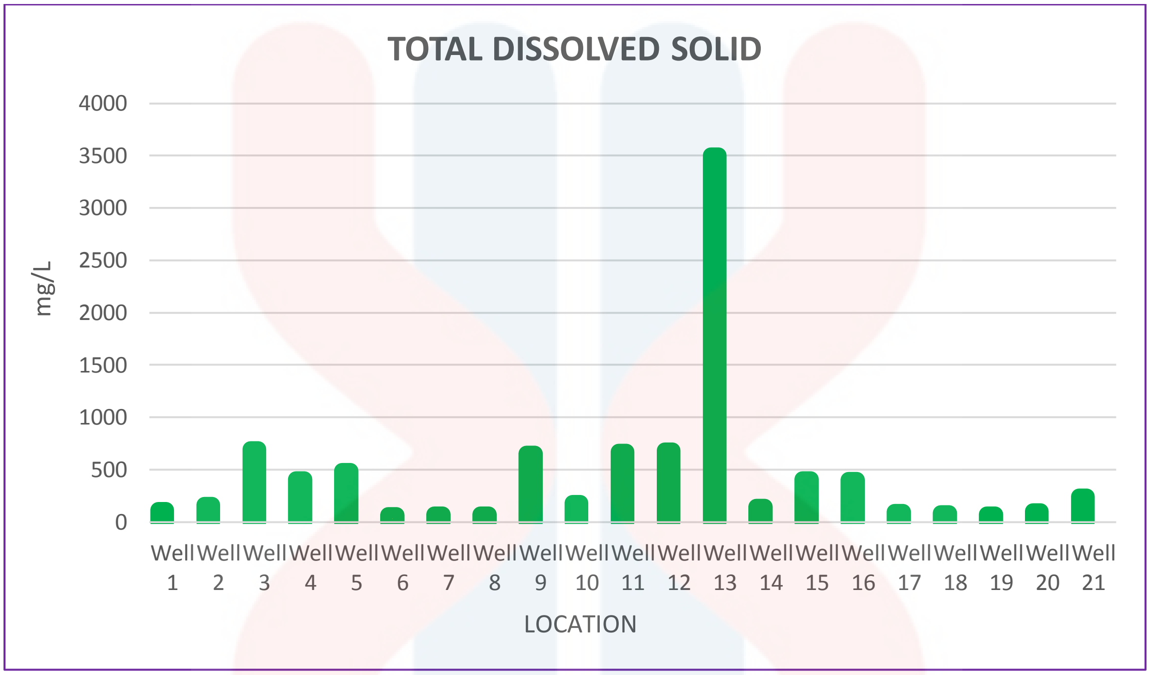


Figure 5.13: TDS measured the in the sampled wells

5.4.8 Hardness

The hardness of the water is mainly the proportion of calcium and magnesium, while iron in the water is less possible. Water hardness is calculated by adding calcium, magnesium concentrations and translating this value into equal Calcium carbonate (CaCO3) concentration per litre of water per milligrams (mg/L). The weather of calcareous, sedimentary rock and calcium bearing minerals naturally induces water hardness in most groundwaters. In reservoirs from the effluent of chemicals and mines or improper application of lime to soil in agricultural fields, hardness may also occur locally. High amounts of calcium and other ions make water more of an aesthetic problem, primarily because of their acidic taste. It also limits the soap's ability to generate the lather and induces the creation of scales in pipes and plumbing equipment.

People could also accustom themselves to high drinking water hardness. If the water is overly difficult, use water bottled or get water from an alternative outlet, such as a municipal system or a local well which has been checked and found to be less challenging. You will eliminate those forms of hardness by boiling. Water treatment techniques may be used for reducing other forms of water hardness, such as reverse osmosis, ion exchange, or oxidation filters. (Canada). Water is being pumped by a resin tank that induces calcium and by the ion exchange process. Magnesium ions with sodium or potassium ions to be substituted. As the sodium swap raises sodium levels in water, it is recommended in the Standards for Canadian Drinking Water Safety that a separate, non-soft water source be retained for drinking and cooking purposes if used for treatment.

Table 5:8 Water hardness classification (RAS HS & GHIZELLAOUI S, 2012)

Degree of water hardness	Dissolved concentration of calcium and magnesium (mg/L) as CaCO3
Soft	<60
Moderately hard	61 to 120
Hard	121 to 180
Very hard	>180

The hardness value obtained in my area of study ranges from 5.05 to 542.84 mg/L depending on the water sample. There have been several water grades based on water hardness, which may include soft water, relatively hard water, hard water and extremely hard water. Out of the 21 samples analysed, 18 samples were under the allowable limits of the WHO (Well 4, Well 5), Well 8 and Well 19 samples, with a cumulative allowable limits of 157, 16 mg/L, 542, 84 mg/L, 189, 97 mg/L and well 19, with the exception of well 4, Well 8, Well 19 ((WHO, International Standards for Drinking Water., 1984) The distribution hardness for the 21 sampled wells is seen in Figure 5.14 below.

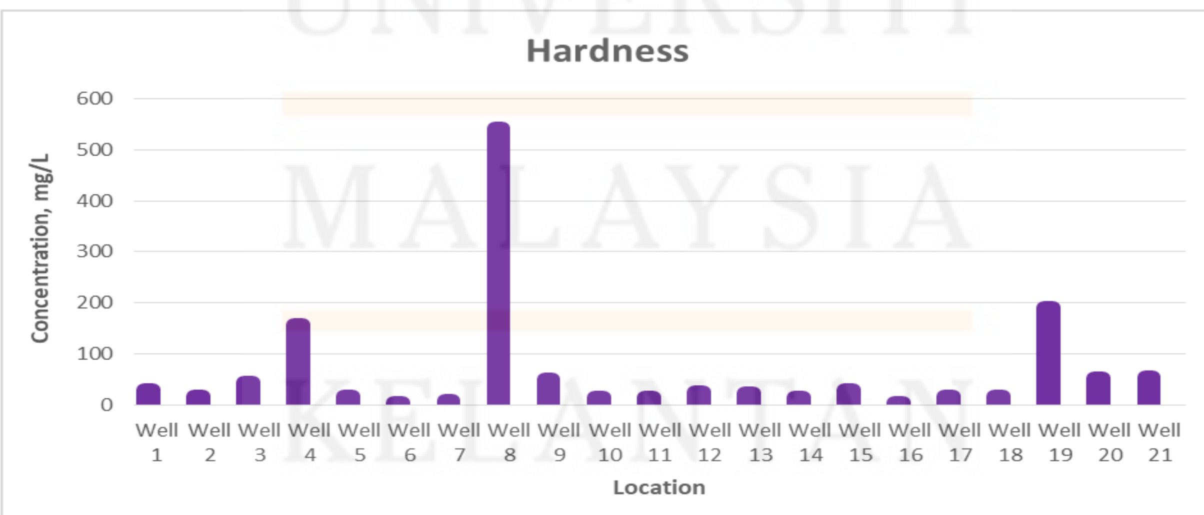


Figure 5.14: Hardness measured the in the sampled wells

5.4.9 Turbidity

Water turbidity results from dissolved particles, which obstruct the absorption of light into the water. It may either be caused by or mixed with inorganic or organic matter. Microorganisms are normally associated with particles, and filtration reduction of turbidity can minimize microbial contamination of handled water substantially. Inert argil or crawl particles or non-soluble reduced iron and other oxides are caused by turbidity in some groundwater supplies when anaerobia water is injected in the water. Distribution system turbidity can be caused by sediment disturbance, but also by the input of polluted water out of the system. Due to noticeable cloudiness Turbidity may even impact the consumer's acceptability of water. (Batch LF, Schulz CR, & Linden KG, 2004)

Turbidity is influenced by water particles that are suspended or dissolved such that water appears cloudy or turbulent. Sediments in particular clay and silt, fine organic or inorganic matter, soluble organic compounds, alga's and other macroscopically species may include particular particulate matter. (WHO, Turbidity measurement: the importance of measuring turbidity:, 2008)

The aesthetics of the lakes and streams are greatly reduced by high turbidity and have a negative effect on leisure and tourism. The costs of drinking water and food production can be raised. The loss of food sources, breeding grounds and the impact of Gills will destroy fish and other aquatic life. Sediment also ranks on the list of turbidity inducing compounds or contaminants. However, any water bath has many pollutant sources or physical properties that can influence the purity of the water.

In the study area, the turbidity level ranges from 0.64 – 50.3 NTU. Groundwater samples from 9 wells out of the 21 wells sampled records value of turbidity less than 5 NTU. Nevertheless, Well 1, Well 4, Well 9 Well 10 Well 11, Well 12, Well 13, Well 14, Well 15, Well 16 and Well 21 gives a turbidity value of 13.5 NTU, 12.57 NTU, 6.65 NTU, 9.77 NTU, 19.4 NTU, 20.1 NTU, 11.95 NTU, 18.9 NTU, 30.1 NTU, 12.75 NTU, 50.3 NTU and 11.35 NTU respectively. The colour of the water sample also manifests cloudiness and yellowish colour. The Figure 5.15 will show the corresponding values for turbidity in all the 21 wells.

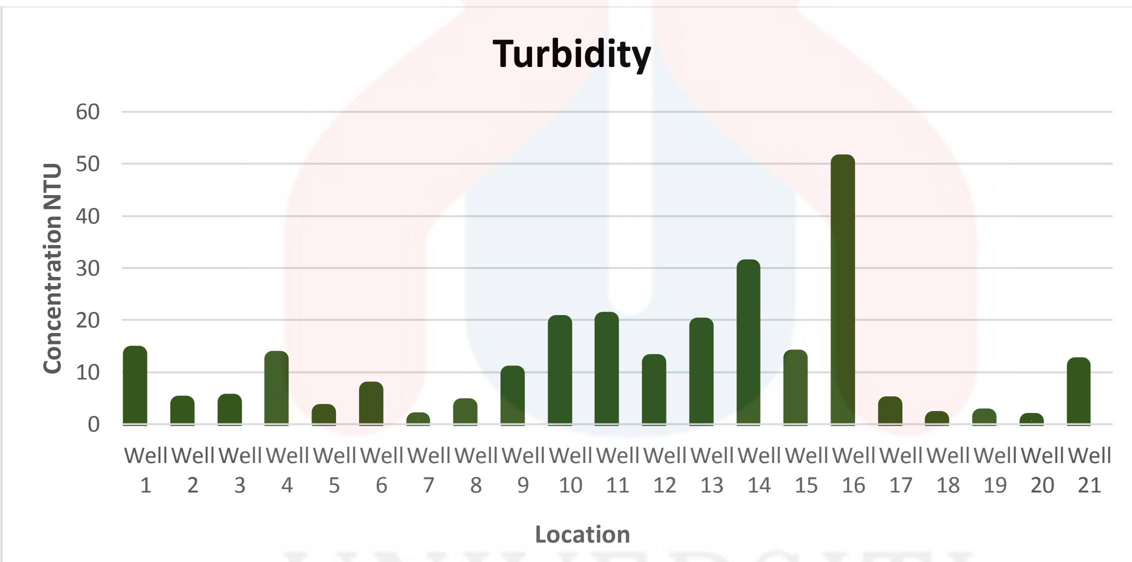


Figure 5.15: Turbidity level in all the sampled wells

5.5 Major Cations

5.5.1 Sodium (Na^+)

In drinking water, sodium ions are produced mainly. However in general, sodium centralizations in consumable water are fewer than 20 mg/l and in any area will significantly surpass this. It should be specified that the sodium ion in drinking water may be replaced by certain water softeners. The conceivable connection between sodium and sodium in drinking water cannot be thoroughly concluded. This does not indicate a consistency of the well-being based law. However, the excess of 200 mg/L can contribute to an improper taste. (Kshitindra Kr. Singh, Geeta Tewari, & Suresh Kumar)

The concentration range is between 1.90 mg/L and 85.27 mg/L in the area of study. At Well 7, 85.27 mg/L, the maximum concentration was determined, with Well 5 at the lowest concentration. The sodium ion concentration in all 21 wells as seen in Figure 5.16 below.

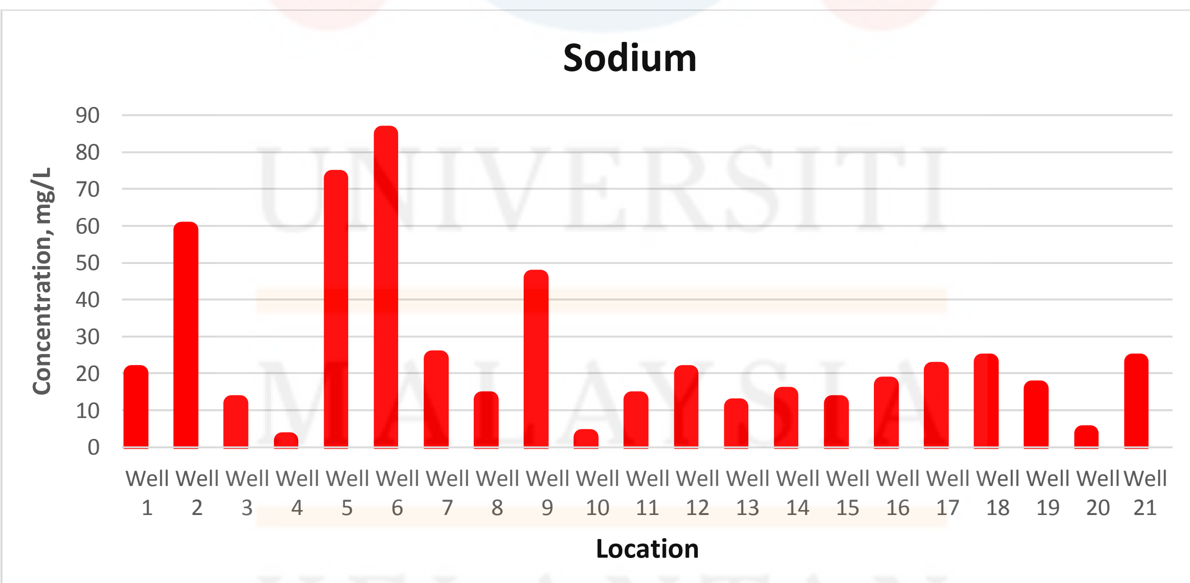


Figure 5.16: Sodium concentration in all the sampled wells

5.5.2 Potassium

Potassium is a primary parameter. In regardless of the reality that the human chance of continuing intake isn't really potassium. Its efficiency will indicate a decaying nature of the groundwater and numerous problems with well water quality which can have undesirable well-being effects. Potassium softeners using potassium chloride are the most common potassium content in drinking water. Potassium accumulation in igneous, metamorphic rock is most likely due to silica, orthoclase, microcline, hornblende, muscovite and biotite. A considerable amount of potassium is absorbed into groundwater from the evaporation deposit, such as gypsum and sulphate. For human consumption, the allowable dose is 200 mg/L. (Gennar, 2002)

Although potassium can cause certain health effects for certain persons, it is well under the scale of which adverse health effects exist in the ingestion of potassium from drinking water. Health risks apply to the ingestion of potassium-based water-treated drinking water (mainly potassium chloride to regenerate ion exchange water supplants), which only impacts individuals within high-risk categories (coronary heart disease, coronary artery disease, asthma, diabetes, Adriatic insufficiency)

In the study area, the potassium concentration is within the permitted limit allowed by WHO 2011 and MOH 2010. Thus, the water used from the domestic wells is reliable for consumption. The highest level for the potassium ion is seen in Well 7, which is about 33.01 mg/L and the lowest is recorded at Well 16. High amount of potassium in groundwater near Well 7 is expected due to the agricultural activities done nearby the area that contribute to leaching of the fertilizers used. The Figure 5.17 underneath shows the concentration distribution in all 21wells in the study area.

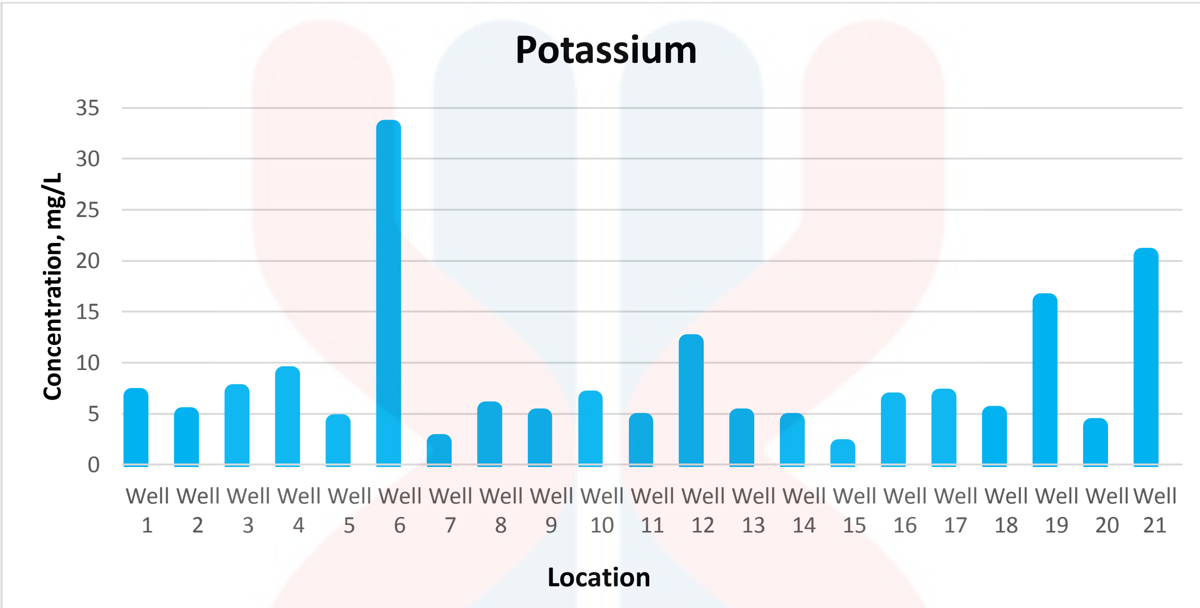


Figure 5.17: Potassium concentration distribution in all 21wells in the study area

5.5.3 Calcium

One of the natural, abundant natural elements is calcium ion. During the weathering of rocks, primarily calcareous, the soil goes by water drained, watered and watered. It also joins the irrigation system. Calcium leaching from the earth has been shown to increase considerably with rainwater acidity. Calcium levels of water depend on the residence time of the water in a geological deposit rich in calcium.

Except Well 14 which contains 94 mg/L, the calcium concentration is more than 75 mg/L. The calcium content in the sample area does achieve the approved amount by the 2006 WHO. The dissolution of $CaCO_3$and CaMg (CO_3) precipitates during groundwater recharging may have induced a large number of calcium ion present in the groundwater of the study area. The calcium ion level in all 21 wells is seen in In Well 17 the lowest calcium ion concentration are shown.

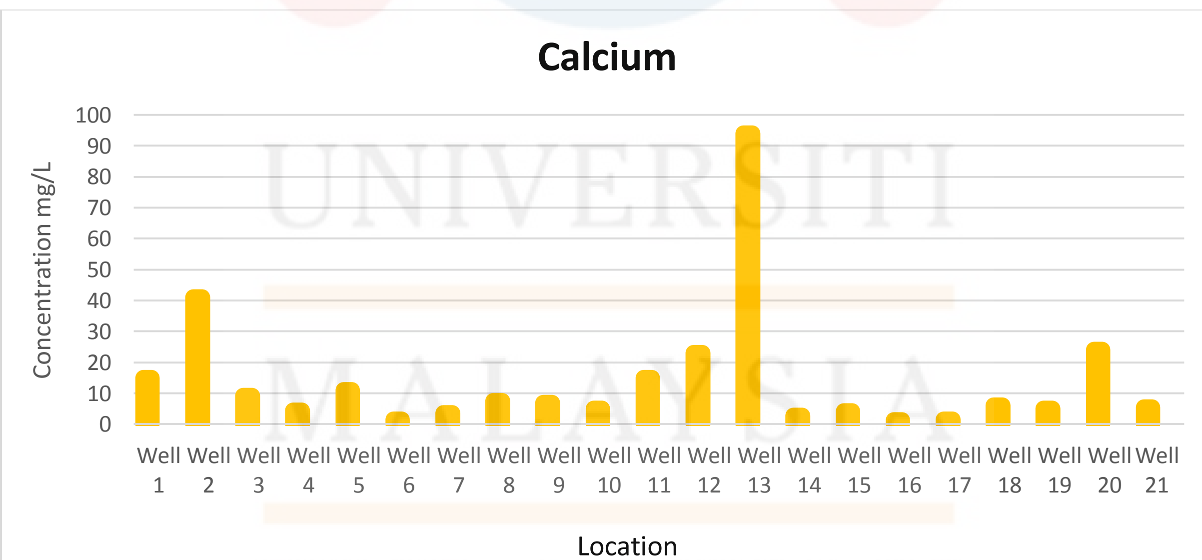


Figure 5.18: Calcium concentration in all the sampled wells

5.5.4 Magnesium Mg^{2+}

Magnesium ion is available throughout all freshwater and is an actual water hardness donor. The main sources of magnesium in natural waters are thought to be ferromagnesian mineral present in igneous rocks and magnesium carbonates in sedimentary rocks. Magnesium, which is listed in a particular survey, is one of the real gain factors of water hardness. If it goes beyond 500mg/L, magnesium can lead to the unwanted taste of drinking water. The permissible limit is 50 mg/L based on WHO in 2006, while the total human intake was about 150 mg/L based on (WHO, International Standards for Drinking Water., 1984). The laxative effect of magnesium on the sulphate ion can cause adverse effects in an indirect way.

The concentration of magnesium ion in the study area sampled varies between 0.75 mg/L and 27 mg/L. All well water for the magnesium ion based on the 2006 WHO is below the acceptable consumption amount. Magnesium can be present in considerable concentrations in sea water, and this phenomenon may be caused by surrounding seawater. The following diagram 5.19 indicates a direct magnesium ion distribution in the area analysed.

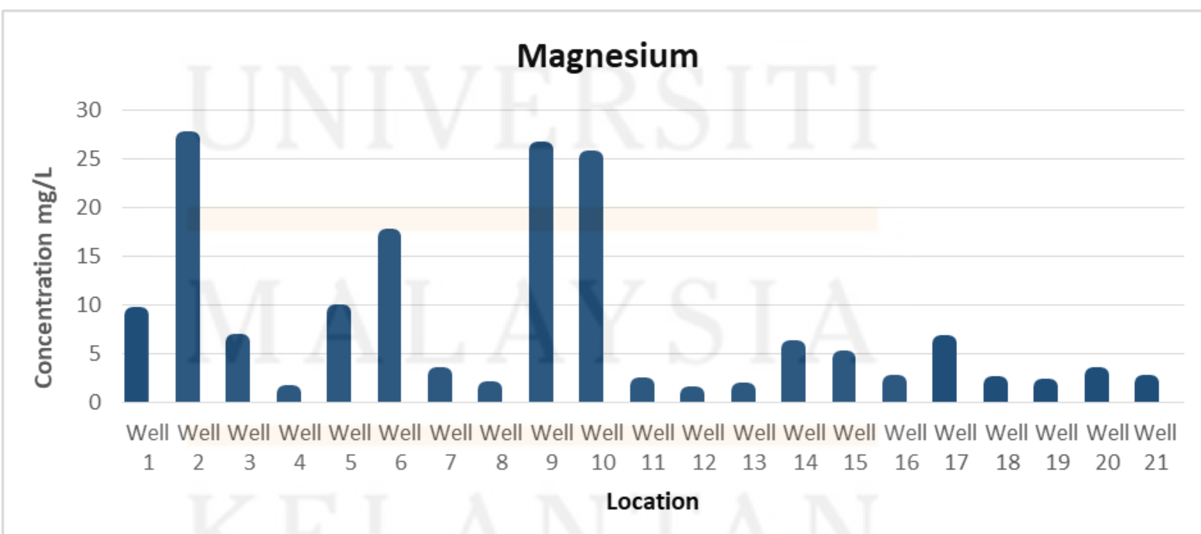


Figure 5.19 : Magnesium concentration in all the sampled well Major Anions

5.6 Major Anions

5.6.1 Bicarbonate

The movement of carbon dioxide into water on carbonate rocks creates bicarbonates. For example, limestone and dolomite, bicarbonate and carbonate produce an atmosphere that is soluble. In steam boilers and in the boiling point, calcium and magnesium bicarbonates form a scale and discharge destructive carbonic corrosive gas. They shape carbonate hardness in a combination of calcium and magnesium. The appearance is altered or the alkalinity affects the destruction of water; bicarbonate is of no importance in the general supply but in large quantities.

The study area contains bicarbonate ions from 0 to 78.3. The study indicates that in all the well water obtained, bicarbonate ions are in a sufficient concentration to be consumed by villagers in 2006 at a concentration that makes drinking water of up to 300 mg/L. In Well 16, which has a concentration of 78.3 mg/L and in Well 3 and Well 14, which is about 0 mg/L, the lowest concentration can be found. The bicarbonate content in all 21 wells is seen in figure 5.20 below.

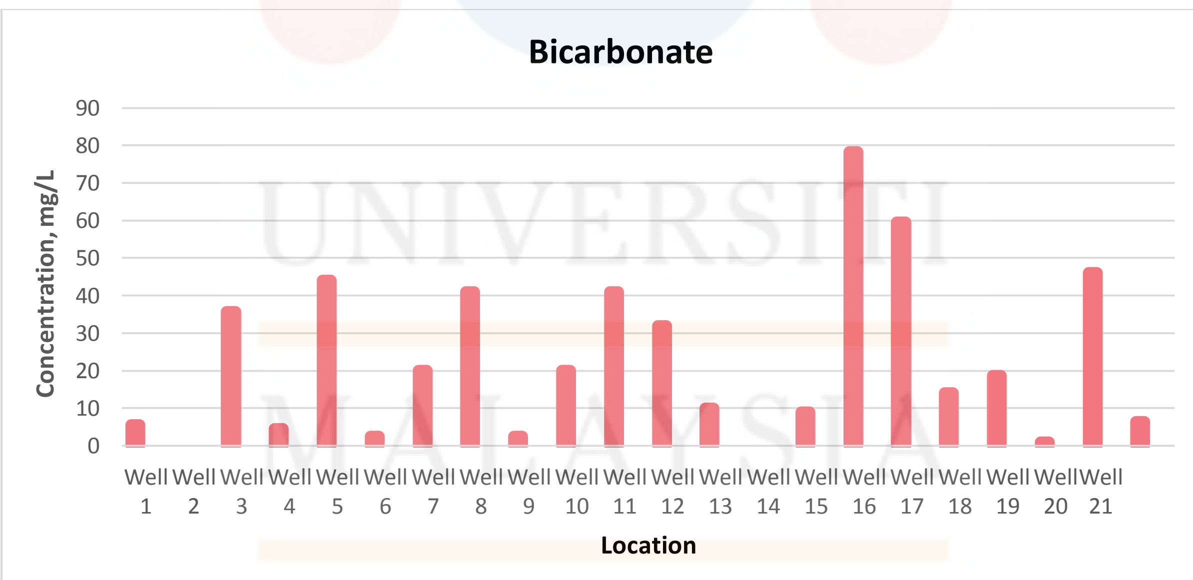


Figure: 5.20: Bicarbonate concentration in all the sampled wells

5.6.2 Chloride (Cl-)

The dissolution of salt precipitation, chemical industries waste products, oil well systems, sewerage, water purification, neglected fluids, volcanic vapors, and sea splash and sea water interference in coastal area can be related to the residence of chloride from potable water supplies. Both these sources can contribute to regional surface water and groundwater pollution. The chloride ion is highly mobile and gradually transferred to enclosed or peatland basins. There is a concentration of less than 250 mg/l of chloride ions for human use.

Few well have elevated chloride levels, with concentration values of 273 respectively, along with others like Well 5. The chloride concentration of Well 7 Well 16 and Well 21 is 1.0 mg/L and is the lowest. Figure 5.21 indicates the distribution of chloride levels.

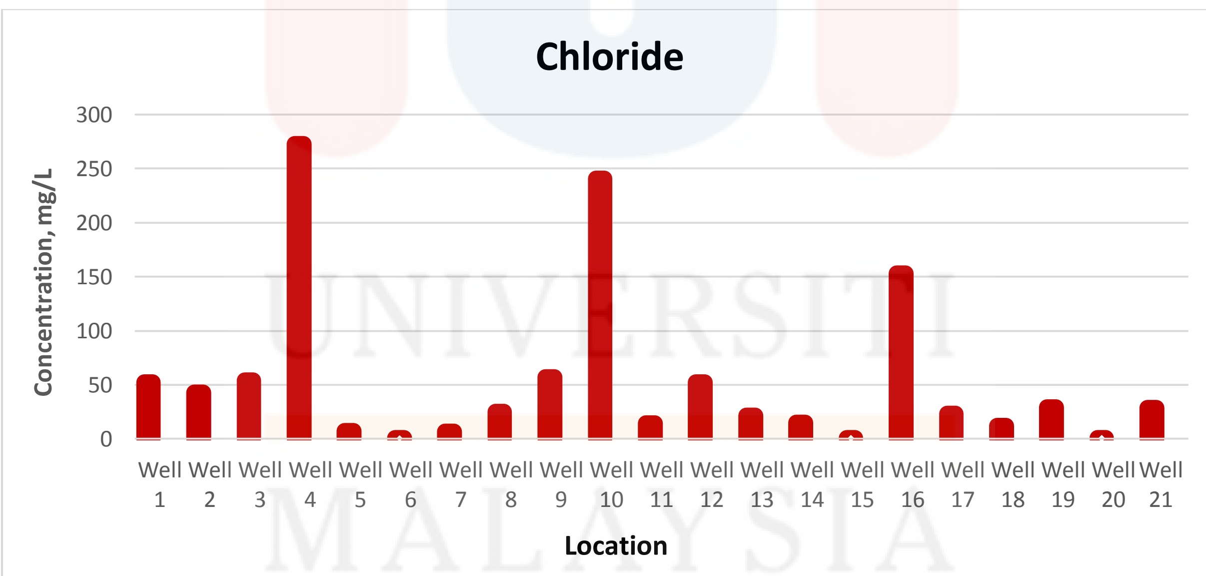


Figure 5.21 Indicates the distribution of chloride levels

5.6.3 Sulphate

Rocks which mostly contain gypsum, iron sulphides and other Sulphur aggregates are diffused by sulphate ions. In addition, the diuretic effect in combination with other ions is common in mine water and all industrial excesses, which in significant quantities, have a bitter flavour. Water sulphate consisting of calcium reports in steam boilers to a thick scale. The approved concentration of sulphate ions in drinking water is 500 mg/L and 250 mg/L in compliance with WHO, 2011 and MOH 2010. Based on the research sulphate concentration, the range 0.33 mg/L to 12.55 mg/L is appropriate for use. Background: Well 12, 12,55mg/L and Well 8 is the lowest dose at the concentration of 0, 33 mg/L, the highest is shown. Figure 5.22 indicates the distribution of sulphate concentration. (WHO, International Standards for Drinking Water., 1984)

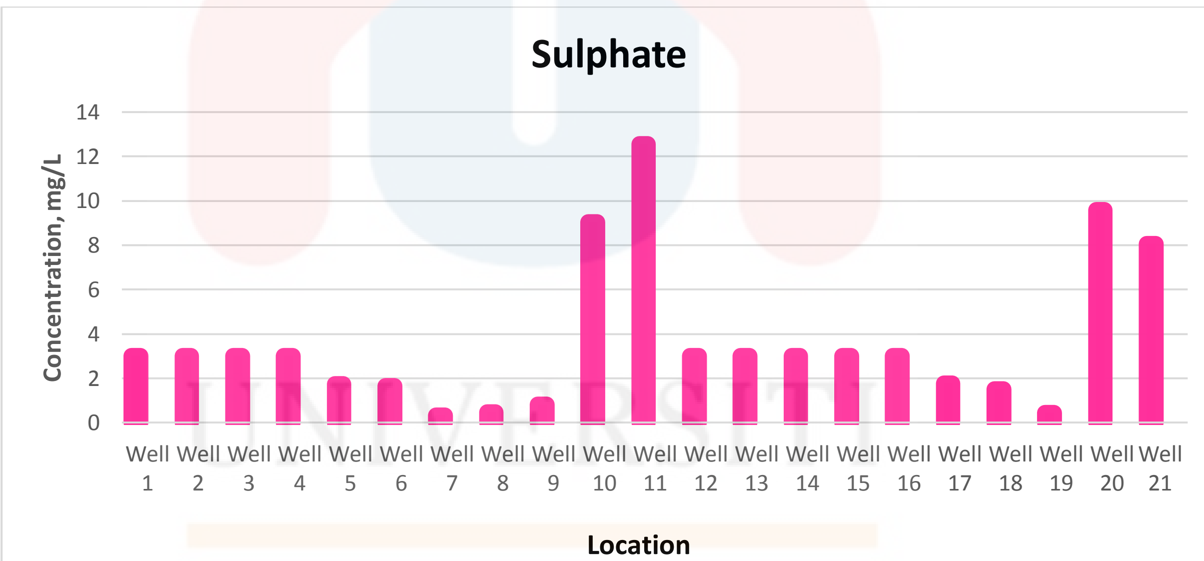


Figure 5:22 indicates the distribution of sulphate concentration

5.6.4 Nitrate

In inorganic fertilizers, nitrate is used mostly. It is also used in the manufacture of explosives as an oxidizing agent. For glass manufacturing, purified potassium nitrate is used. The food preservative, in particular in cured meats, uses sodium nitrite. The food often contains nitrate often to act as a nitrite buffer. In plants for which it is a main nutrient, nitrates occur naturally. In animals, including humans, nitrate and nitrite are also produced endogenously. Nitrate in saliva is secreted and processed in the oral microflora into nitrite. As a result of farming operation (including over-use of non-organic nitrogen fertilizers and manures), the handling of waste water and of oxidizing nitrogen waste products in human and animal excess, including septic tanks managed, may even enter nitrate surface water and groundwater. (Walker R, 1995).

Nitrate ion concentration in the study area ranges from 0.50 mg/L to 14 mg/L. This range of values falls in the allowed concentration of nitrate in drinking water as proposed by WHO, 2011 (50 mg/L). Thus it is suitable for domestic purpose. The figure 5.23 shows a clear view of the concentration in the study area.

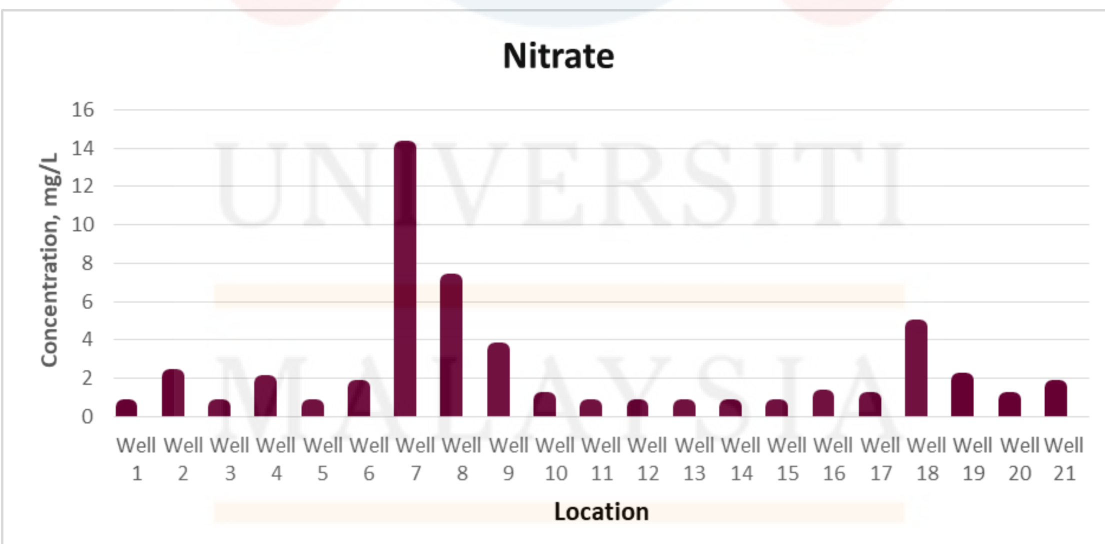


Figure 5.23: Nitrate concentration in all the sampled wells

Classification of Groundwater

5.7.1 Piper Trilinear Diagram

Through plotting them on the Piper-trilinear diagram, chemical data from the respective samples were applied (Piper, 1944). H (Piper, 1944). Hydro geochemical faces so as to distinguish and discriminate between suitability of the water structure for different groups. Instead of other potential plotting methods, it is often important to define chemical interactions more specifically. The analogy, dissimilarities and separate water forms in the sample region is seen in these diagrams. The well waters were likewise divided into the waters displaying water types according to the subdivisions of (Vinod K Singh, Devendra Singh Bikundia, Ankur Sarswat, & Dinesh Mohan, 2011)of the Piper trilinear graph shown in figure 5.25

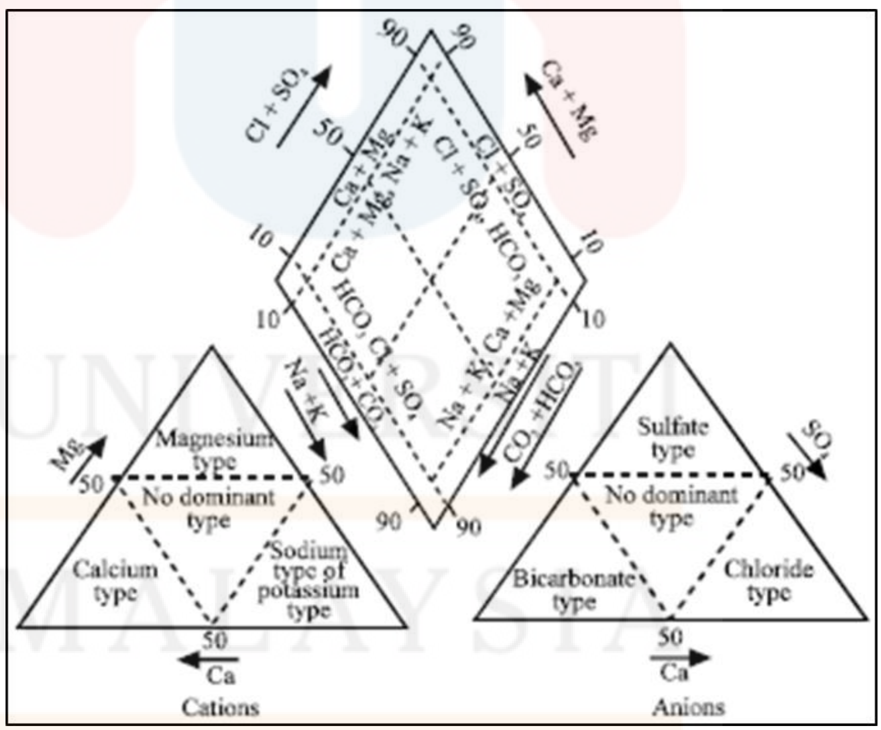


Figure 5.24: Classification diagram for anion and cation facies in the form of major-ion percentages.

A considerable amount of water analysis is checked for analytical research to assess the excellent quality of a trilinear diagram. Therefore, the easiest way to analyse the continual variations in the geochemical composition of water samples is to plot collected aspects. The diagram is divided into three fields, two triangle fields and one diamond field. The Meq/L percentage values of cations and anions are separately traced in the triangular fields. Cations on the left and anions on the right triangle are labelled. In diamond shaped regions, the overall characteristics of the water are seen. The diagram is also helpful in visual description of changes in key ion chemistry in the soil flow mechanism (Nabil Darwesh, Mona Allam, Qingyan Meng, & Hefdhallah Alaizari, 2019) Figure 5.26 shows Piper-trilinear diagram for major groundwater analysis from the study area.

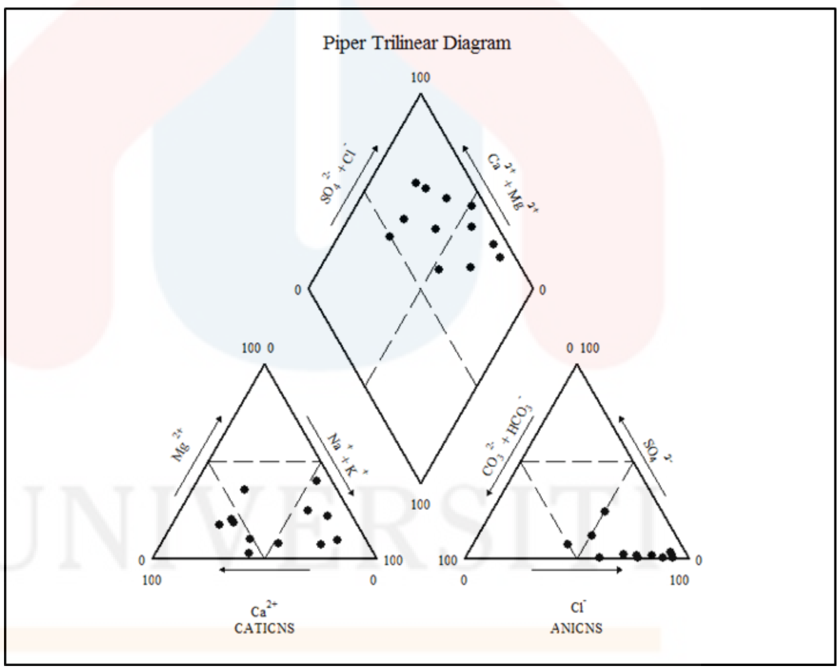


Figure 5.25: Piper-trilinear diagram for major groundwater analysis from the study area.

It is noticeable that most wells in the group are often located in the calcium and sodium type – potassium type, although only one well is found in the predominant type. The anionic group observes that most water samples are of the form of chloride and the sample from well 9 is of the type of bicarbonate. The intersection on the four-sided map indicates that the waters of the research area is listed as water types of Na as data points on both triangles are mapped onto the adjacent grid (K). Cl (SO_4), Ca (Mg) (SO_4). This form of water has alkalin earth water with an elevated level of chloride and sulphate in the alkali. In this field of the sample it is apparent that the chloride and sulphate ions are the dominant anions. Hence, virtually no bicarbonate water is available. The chemistry of the lateral groundwater refuel can be required to do this.

5.72 Langeliar – Ludwig Diagram

The research indicates that most groundwater samples are similarly dependent on Na water type Na (K). Cl (SO_4) and Ca (Mg).Cl (SO_4). The Ca-Na-Cl-SO is a significant component of precipitation in the atmosphere. Consequently, precipitation is affecting the chemistry of this physicochemical parameters.

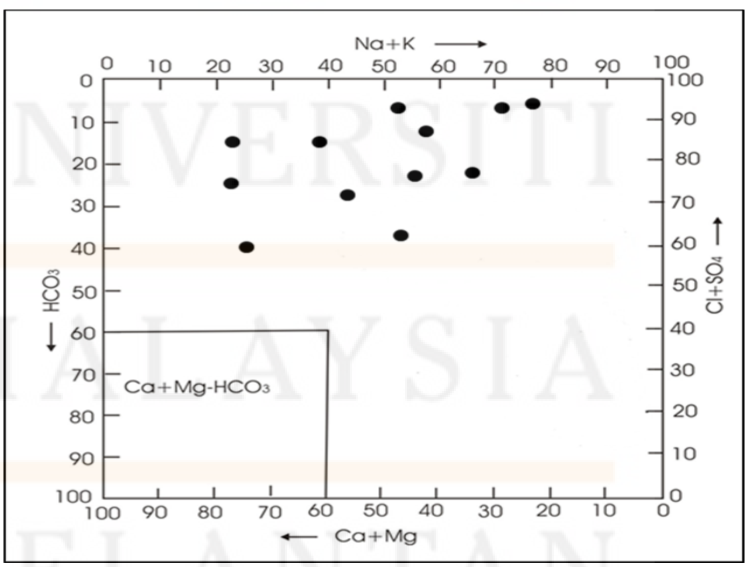


Figure 5.26: Langeliar – Ludwig Diagram

CHAPTER 6

CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

An updated geological map of the study area has been provided showing the identifiable rhyolitic, sandstone, limestones and Mica schists of four forms of lithology. The petrographic research was carried out to classify the descriptions and properties of the rocks. The research area was updated by secondary data and interpretation via Google View and Google Earth throughout the road networks, drainage flow and soil.

This resulted in the processing of an updated geological map of the study area. Geological mapping studies are structured to provide students with different Kelantan and Malaysian knowledge. It clarifies geological knowledge of earth processes and ecosystems. By looking at the geographical aspects during field observation, we could see information from the previous map.

In the hydrogeology research, large concentrations of ions were observed and analysed in domestic wells, along with groundwater level and movement activity in parts of Kota Bharu. The choosing was taken of 21 domestic wells for sampling and analysis later on. The amount of water in the field of research seems to be shallow, varying from 2.1 to 10, 39 metres. This means that in the first aquifer there is water from the household wells. The water content of the environment analysed also affects the dissolved solids or the concentration of main ions. The high water level environment displays low ion dilution levels and higher ion concentrations at low water levels. In the sample field, the flow of groundwater moves from a high gradient to a lower gradient. The presence of the river also affects water flow.

Based on this finding and discussion, the majority of domestic well criteria are still acceptable and safe for drinking according to WHO 2011 and MOH 2010 guidelines. For potassium ion, with the exception. Well 7 consists of 33.01mg/L concentrations respectively. The overall quality of groundwater for drinking and for home use is nevertheless reliable in the research region.

The facies of groundwater are grouped with the diagram of Piper Trilinear and Ludwig Langeliar. The water of the sample area was divided into water forms of Na based on the classification for these classifications (K). Cl (SO_4) Ca (Mg) (SO_4). This implies that the area's groundwater comprises primarily of alkaline and alkaline Earth metals mixtures and mostly of water type Cl -SO_4^{2-} Many samples of water consist of two kinds of water mixtures.

6.2 Recommendations

Every method for its effective utilization must be thoroughly understood by the groundwater system, the characteristic of recharge and discharge. Restoration is a major source of variation in the composition of groundwater. Accurate estimation of groundwater supply quantities and quality is also important to the sustainability of the resource. In addition, it will develop excellent aquifer management through continuous monitoring of groundwater movement and efficiency. The level of groundwater should be frequently checked in the first place so that water is really safe for community consumption. Significant harmful impacts will occur in the study area because of the depletion of ground water, largely due to the lowering of groundwater, the transmit of saline water from the shore or movement to deeper fresh water.

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