GEOLOGY OF KAMPUNG SUNGAI TUPAI, GUA MUSANG AND ASSESMENT OF GROUNDWATER QUALITY PARAMETERS IN THE COASTAL AQUIFERS OF BACHOK, KELANTAN

by

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

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DECLARATION

I declare that this thesis entitled “GEOLOGY OF KAMPUNG SUNGAI TUPAI, GUA MUSANG AND ASSESMENT OF GROUNDWATER QUALITY PARAMETERS IN THE COASTAL AQUIFERS OF BACHOK, KELANTAN” is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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APPROVAL

"I hereby declare that I have read this thesis and in our opinion this thesis is sufficient in term of scope and quality for the award of the degree of Bachelor of Applied Science (Geoscience) with Honors".

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Geology Of Kampung Sungai Tupai, Gua Musang And Assesment Of Groundwater Quality Parameters In The Coastal Aquifers Of Bachok, Kelantan

ABSTRACT

The present FYP research project focuses on geological mapping of Kampung Sungai Tupai, Gua Musang and the groundwater quality parameters at Bachok. Geological map was produced on 1:25,000 scale by using secondary data such as satellite imagery data). Based on geological mapping, the lithology is mainly comprised of limestone, tuff, slate, interbedded sandstone and alluvium and the age of this rocks are around Permian to Quarternary. Meanwhile, groundwater quality in coastal aquifers of Bachok can pose serious issue as it can cause contamination of groundwater. Therefore, groundwater quality parameters determine by using geochemical analysis with help of jabatan Mineral Geosains (JMG) Kelantan. Total four groundwater samples were collected from different location which were IBS UMK, Tangki Air UMK, SMKA Tok Bachok and SK Chantum with help of JMG Kelantan. The physic-chemical parameters which have been analysed in this research was pH, temperature, turbidity, conductivity, Total Dissolved Solids and Total Suspended Solids, Chloride, Fluoride, Nitrate, Sulphate, Bicarbonate, Magnesium, Calcium, Potassium, Sodium, Iron and Manganese. All the results of all parameters were compared with WHO and MOH guidelines for drinking quality of groundwater. Based on the result, the groundwater at IBS UMK, Tangki Air UMK and SMKA Tok Bachok are classified as fresh water and have good quality of water. Groundwater at SK Chantum is classify as slightly saline water, maybe because of seawater intrusion. Over all other physico-chemical parameters of all the groundwater samples are safe to use and within the permissible limit of the National Guideline of Raw Water Quality Standards by Ministry of Health Malaysia except location SK Chantum.

Keywords – Geological mapping, groundwater, quality, Bachok, Kelantan.

Geologi Kampung Sungai Tupai, Gua Musang Dan Penilaian Parameter Kualiti Air Bawah Tanah Di Perairan Pantai Bachok, Kelantan

ABSTRAK

Projek penyelidikan FYP pada masa ini memfokuskan pada pemetaan geologi Kampung Sungai Tupai, Gua Musang dan parameter kualiti air bawah tanah di Bachok. Peta geologi dihasilkan pada skala 1: 25,000 dengan melintasi, merakam pemerhatian lapangan dan kajian petrografi. Berdasarkan pemetaan geologi, litologi terutama terdiri dari batu kapur, tuf, batu sabak, batu pasir saling terlapis dan aluvium dan usia batuan ini sekitar usia Perm hingga Kuarterner. Sementara itu, kualiti air bawah tanah di perairan pesisir Bachok dapat menimbulkan masalah serius kerana boleh menyebabkan pencemaran air bawah tanah. Oleh itu, parameter kualiti air tanah ditentukan dengan menggunakan analisis geokimia dengan bantuan jabatan Mineral Geosains (JMG) Kelantan. Sebanyak empat sampel air bawah tanah dikumpulkan dari lokasi berbeza iaitu IBS UMK, Tangki Air UMK, SMKA Tok Bachok dan SK Chantum dengan bantuan JMG Kelantan. Parameter fizik-kimia yang telah dianalisis dalam penelitian ini adalah pH, suhu, kekeruhan, kekonduksian, Pepejal terlarut dan padatan terampai, klorida, fluorida, nitrat, sulfat, bikarbonat, magnesium, kalsium, kalium, natrium, besi dan mangan . Semua hasil dari semua parameter dibandingkan dengan pedoman WHO dan KKM untuk kualiti air tanah. Berdasarkan hasilnya, air bawah tanah di IBS UMK, Tangki Air UMK dan SMKA Tok Bachok diklasifikasikan sebagai air tawar dan mempunyai kualiti air yang baik. Air bawah tanah di SK Chantum diklasifikasikan sebagai air masin sedikit, mungkin kerana pencerobohan air laut. Lebih dari semua parameter fizik-kimia lain dari semua sampel air bawah tanah selamat digunakan dan berada dalam had yang dibenarkan dari Garis Panduan Nasional Piawaian Kualiti Air Mentah oleh Kementerian Kesihatan Malaysia kecuali SK Chantum.

Katakunci – pemetaan geologi, kualiti air bawah tanah, Bachok, Kelantan.

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LIST OF ABBREVIATIONS

GIS	Geographic Information System
GPS	Global Positioning System
IBS	Instant Building System
JMG	Jabatan Mineral dan Geosains
MOH	Ministry of Health
pH	Potential of Hydrogen
SMKA	Sekolah Menengah Kebangsaan Agama
SK	Sekolah Kebangsaan
TDS	Total Dissolved Solids
TSS	Total Suspended Solids
UMK	Universiti Malaysia Kelantan
WHO	World health Organization

LIST OF SYMBOLS

°	Degree
µ	Micro
°C	Degree calcius
m	meter
km	kilometer
Mg	Magnesium
Na	Sodium
K	Potassium
Ca	Calcium
Fe	Iron
Mn	Manganese
Cl	Chloride
F	Fluoride
NO_3	Nitrate
SO_4	Sulphate
HCO_3	Bicarbonate

CHAPTER 1

INTRODUCTION

1.1 General Background

Water is one of the most important basic needs of human life. Approximately 95% of the Earth freshwater is made up of groundwater which makes it essential for sustaining healthy life and dynamic economic growth. It is the major source of all fresh drinking supplies for some countries. Groundwater is defined as subsurface water that fills all the pore space of soils and geologic formations below the water table (Freeze and Cherry 1979). Groundwater is a water source origin from the earth which is at the space and cracks in rocks and soil. It moves through the rock or soil pore with slow movement. Groundwater stored underground in the aquifers. It is highly vulnerable to pollution because it comes from precipitation that been filter down through vadose zone to reach zone of saturation. Groundwater flows in the aquifer layer towards the point of discharge, which includes wells, springs, rivers, lakes, and the ocean.

Groundwater usually contains one or more naturally occurring chemicals that are formed from reaction between percolating water with soil and rocks. Overload consumption of major ions content and trace metals absorption through drinking water can cause health setback on human populations in many countryside areas that are relying on the groundwater resources as main water source. Contamination of groundwater can occur from several different causes, both natural and anthropogenic.

1.2 Study Area

1.2.1 Location

The geological mapping area is located at 102° 0'4.21''E, 4°48'26.49''N, 102° 2'49.78''E, 4°48'26.85''N, 102° 2'50.11''E, 4°45'45.57''N, 102° 0'4.55''E and 4°45'45.23''N. The area is near border of Pahang state. The area covers Kampung Sungai Tupai. The specification area is located in Bachok district. This district is located at 102° 4'0'' E, 6°24'0'' N. The size of Bachok is estimated 72 km^2 area and it was located approximately 20 km South East of Kota Bharu. Figure 1.1 refers to the base map of the study area.

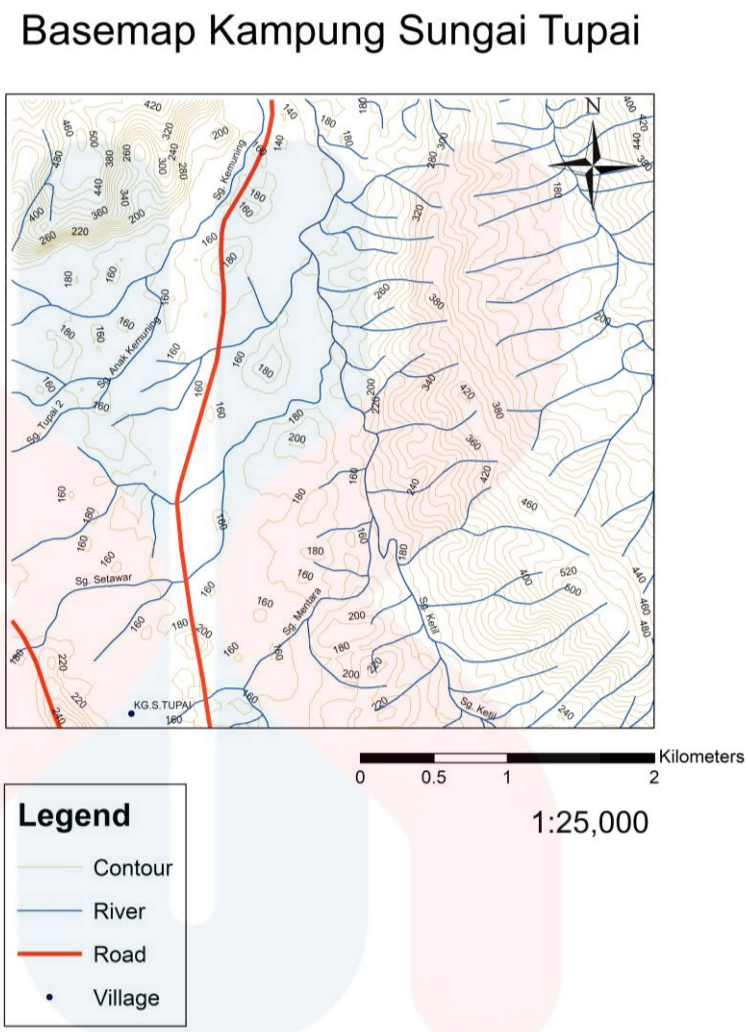

Figure 1.1: Basemap of Kampung Sungai Tupai

1.2.2 Road

A road is a route between two places that have been paved to allow human to travel to the desired destination. The routes that can be taken to reach the mapping area are the road that connects Jeli with Gua Musang. The road that can be taken are from Jeli > Dabong > Paloh > Gua Musang. It will take about three hours to reach the mapping area by car. For the specification area, the routes that can be taken to reach the area are the road that connects Jeli with Bachok. It will take about two hours to reach the research area by car.

1.2.3 Demography

Demography is the study of statistics of birth, migration, ageing, education, religion and other aspects that give effect to the population of an area. Table 1.1 shows the number of population of Kelantan and its district from 2010 to 2014.Most of the number of the population in districts of Kelantan showing increasing trend from 2011 to 2014. The number of population in Gua Musang increasing every year from 103,300 people in 2010 to 1114,500 people in 2014. The number of population in Bachok also increasing every year from 142,100 people in 2010 to 157,700 people in 2014.

Table 1.1: Population by district in Kelantan from 2011-2014

District/Year	2010	2011	2012	2013	2014
Bachok	142,100	146,000	149,900	153,800	157,700
Kota Bharu	509,600	522,00	534,500	547,000	560,100
Machang	101,300	103,900	106,400	109,000	111,700
Pasir Mas	212,000	217,300	222,800	228,300	233,800
Pasir Puteh	134,200	137,700	141,100	144,600	148,200
Tanah Merah	133,400	136,700	140,000	143,300	146,700
Tumpat	137,200	177,700	182,200	186,800	191,400
Gua Musang	103,300	106,000	108,800	111,700	114,500
Kuala Krai	120,800	123,700	136,500	129,500	132,400
Jeli	48,000	19,300	50,600	51,900	53,200
Kelantan	1,641,900	1,772,800	1,772,800	1,806,100	1,849,700

(Source: Jabatan Perangkaan Penduduk Negara Negeri Kelantan)

1.2.4 Land Use

The mapping area consists of one village which is Kampung Sungai Tupai. Based on the Figure 1.2, the mapping areas are covered by palm plantation and forest. Based on Figure 1.2, the specification area which is in Bachok district, are covered by built-up area, forest, paddy, mixed, agriculture, cleared land and river stream (Hashim, 2017).

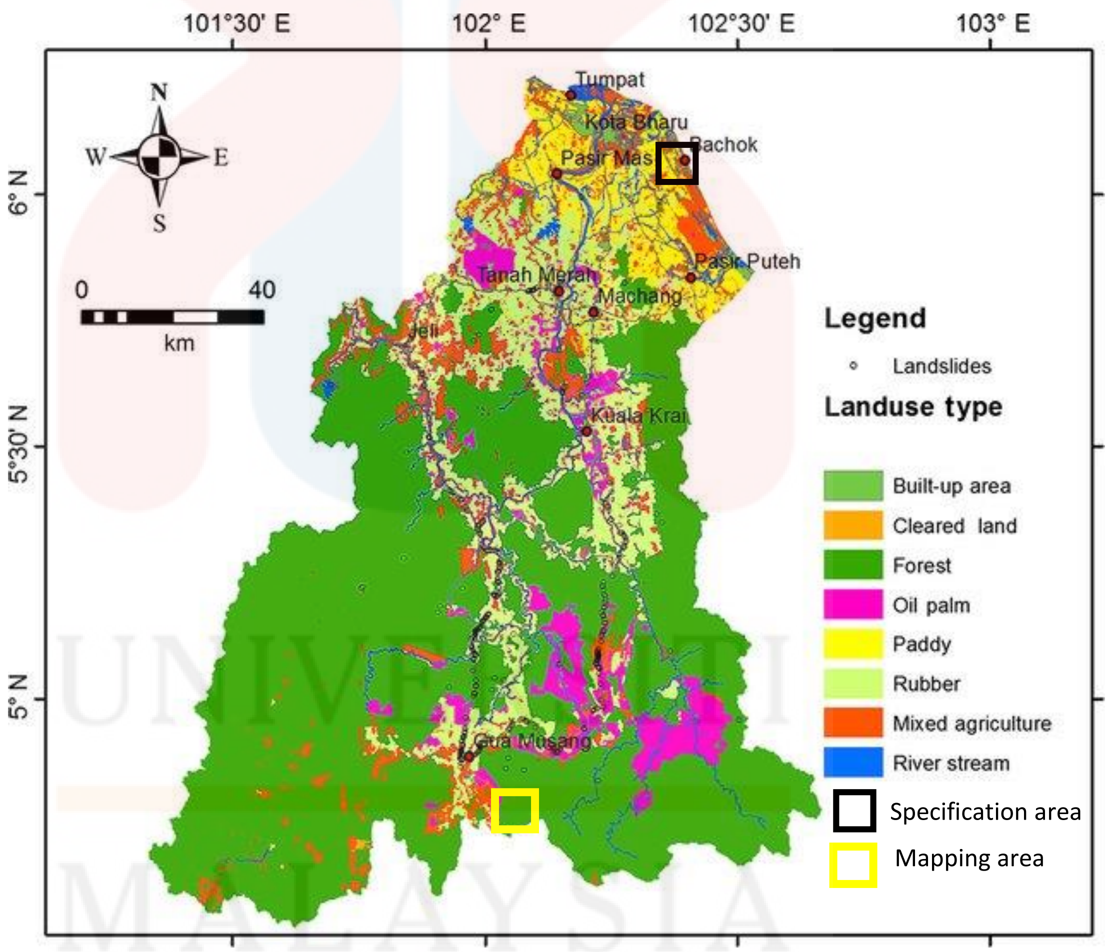

Figure 1.2: Land use in map of Kelantan (Hashim, 2017)

1.2.5 Social Economic

Most of the area in Gua Musang are been covered by rubber tree plantation, palm plantation, forest and agricultural area. Because of this, most of the people in Gua Musang work as rubber tappers, farmers and manufacturers of farm production. In Bachok area, the people work as farmers, rubber tappers and businessmen. They are also works as fisherman because Bachok district near sea. This kind of occupation had a good influence on the social economic of Gua Musang and Bachok, and these led to the developed of the two districts over the years.

1.3 Problem Statement

Although Kelantan geological map had already been produces by Department of Mineral and Geoscience Kelantan, the existed map produced in Kampung Sungai Tupai was in a large scale and not too focused in specific area. A geological map with a small scale need to be produced in order to obtain appropriate data of study area.

The importance of groundwater in supplying demand has increased drastically over the past years due to escalating challenges facing surface water resources. With the increasing demand for groundwater utilization, the quality of water in different aquifers becomes the only limiting factor. The deterioration of groundwater quality is becoming a widespread concern. Declination of groundwater quality in tube wells and boreholes is the most common phenomena. In dry season, few of the villagers faced the problem of contaminated well in the form of bad smell and also reddish colour of water. Contaminants such as pesticides, toxic chemicals, domestic waste and others also entering improperly constructed wells and causes the water quality get worse.

Assessment of groundwater quality in the aquifer has therefore become important to ensure the availability of safe water for human needs. However, describing the spatial variability of the overall water quality condition is difficult due to the lack of an effective monitoring system and the wide range of possible water quality indicators which is physical, biological and chemical to be considered.

1.4 Objective

1. To update the geological map of Kampung Sungai Tupai in Gua Musang.
2. To assess the groundwater quality parameters at Bachok.

1.5 Scope of Study

This study is focusing on the investigation of the groundwater quality at Bachok, Kelantan. This study were focusing on collecting data from different well that was drilled by Jabatan Mineral dan Geosains (JMG) at Bachok. The quality of the water were analyses on several essential parameters such as pH, Total dissolved solids (TDS), chloride, sodium and fluoride. The parameters were compared with WHO and National Standard for Drinking Water Quality, Malaysia.

Furthermore, the Geological mapping of this study were carried out at Gua Musang. Generally mapping based on fieldwork inputs including collection of samples from fresh outcrops, recording structural trends in rocks, and other field observations such as geomorphological features and drainage pattern but this time mapping mainly done based on images and previous researches due to COVID-19. All collected data was processed in GIS based platform including geological and other thematic maps.

1.6 Significance of Study

The important of this study is to update the geological map for references when other people doing geology mapping in Kampung Sungai Tupai, Gua Musang, Kelantan. All data used from secondary data collection illustrated the geology of the study area. All the data are essential for future planning for mining, urbanization and others plan.

For specification part, the assessment of groundwater quality become useful for local people and agency that manage groundwater resources. High demand of groundwater in Bachok cause this research data become very crucial. This specification study can become a new plan for designing and developing groundwater well in the future. The result from this research can help the authorities to determine the quality of groundwater for the local people usage. This can help prevented the local people from consuming low quality of water.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter is the review of the general geology and groundwater to understand more detail of information regarding the mapping area and study area especially in term of groundwater quality assessment.

2.2 Regional Geology and Tectonic Setting

Malaysia contains various types of rock ranging from igneous, metamorphic and sedimentary rocks. Some are from granitic rocks of Titiwangsa Range (Cobbing et al., 1986). Generally, the Main Range or Banjaran Titiwangsa is the common term used to characterise and express the backbone situated along the Peninsular Malaysia. The Main Range covers long path extending from the border of Thailand and Malaysia and lengthens towards Negeri Sembilan state covering all the way until the southern part (Basir et al., 2004). The systems which occurred in the Peninsular Malaysia ranges from 570 million years to approximately 10000 years ago with major systems dated from Cambrian period until Quaternary ages. Figures 2.1 refer to the geological map of Kelantan.

The State of Kelantan is situated on the eastern side of the Malay Peninsula which lies between latitudes 4º 45" and 6º 25” north and longitudes 101º 30” and 102º 40” east. The central district is Kota Bharu. Kelantan has a coast line of 96 kilometers, and the total land border line is about 576 kilometers. The land area is about 15 000 kilometers2, the greatest length interval measured from north to south being 184 kilometers, and the longest width stretching from the eastern towards the western part is 96 kilometers (Metcalfe, 2000).

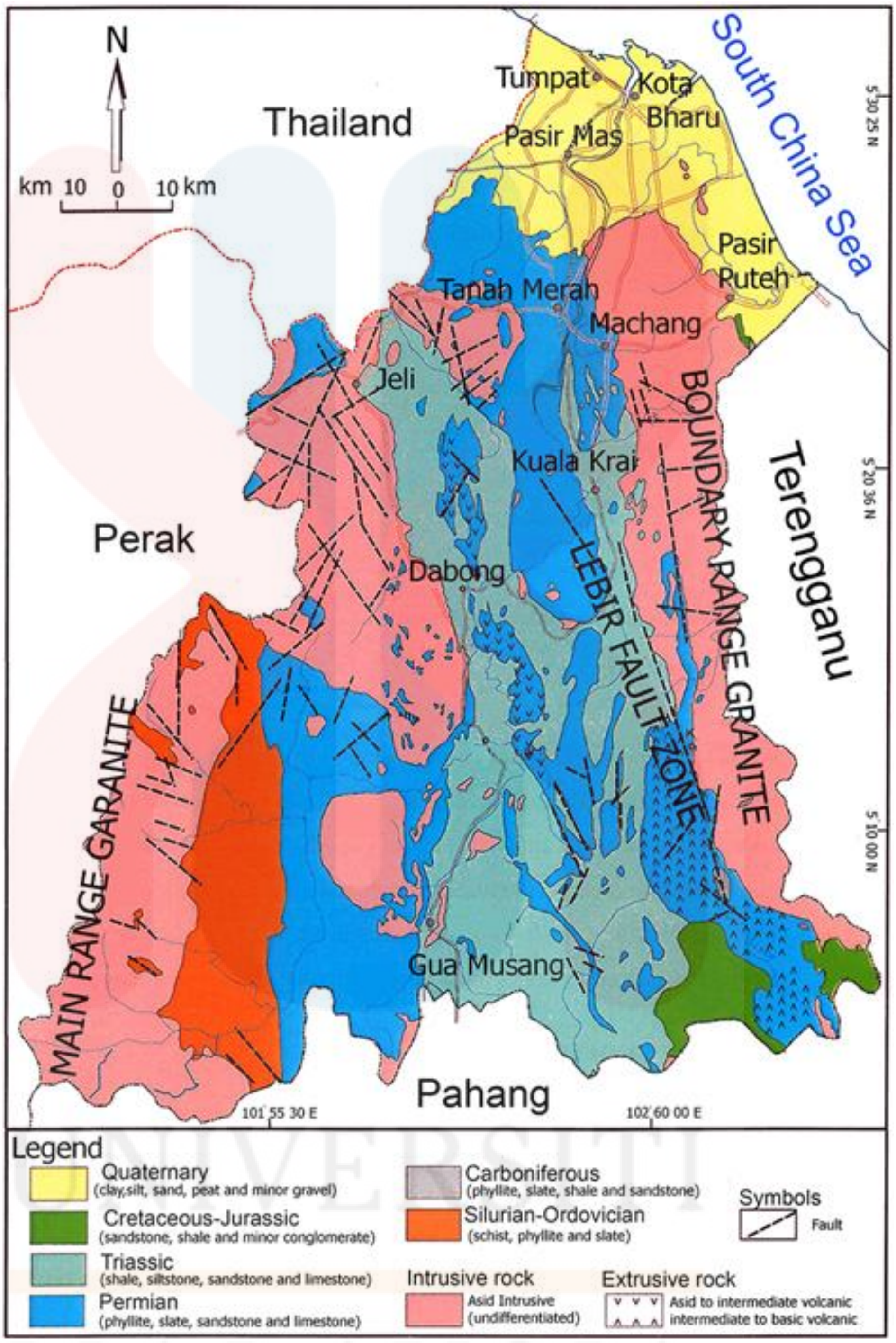

Figure 2.1: Geological Map of Kelantan (Hashim, 2017)

2.2.1 Stratigraphy

Stratigraphy is the branch of geology that deals with descripts, correlates and interpret the stratified rocks and stratified sediments on and in the Earth (Southard, 2007). As the environmental conditions changes slowly, the variation also in slow and continuous depositional processes with time. Most of the sediments are settle down by turbidity current. With the time passed, the sediments are compacted and cemented into sedimentary rock. The age of each layer can be explained by geological time scale.

Peninsular Malaysia are divided into three belt such as which are central, eastern and western. The boundary of eastern and western were demarcated by the Bentong-Raub Line which has been interpreted as the site of Lower Palaeozoic. The Central Basin occupies most of Kelantan, west Pahang, east Negeri Sembilan and west Johor are Permian and Mesozoic age. Most of the sediments in the Eastern Belt are Carboniferous-Permian age. Based on Khoo. (1983), the Mesozoic System in Peninsula Malaysia is distributed in two separate basins, one on each side of the Main Range. The larger of these occur in a continuous outcrop along the axial belt of the Peninsula running from the north in the state of Kelantan to the south in the state of Johor. The smaller one is at the extreme northeast, in three separate outcrops aligned north to south, 17 from Kedah to south Perak. This continues into southern Thailand. The geological formation of Kelantan can be separated into three major geological age which is Paleozoic, Mesozoic and Cenozoic.

For Paleozoic formation, it can be observed in the central of Peninsular Malaysia. The Gua Musang Formation and Aring Formation in the south of Kelantan consists of Upper Paleozoic rocks. The rocks consist of argillaceous, volcanic facies and calcareous and arenaceous facies. (Lee, 2004)

The middle belt that forms the north south trending belt extending away from the intercontinental boundaries with Thailand in the north and Singapore in the south is subjugated by the Mesozoic formation. The Telong formation which range from Late Permian to Late Triassic is the formation in the Mesozoic era. It consists of argillaceous and marble, and some tuff and andesite.

The Cenozoic formation is represented by the Quaternary sediment deposition. The Quarternary sediment depositions were envelop in the north Kelantan which consists of unconsolidated and semi consolidated boulders, sand, silt, gravel and clay. It lies beneath the coastal and inland plain. Figure 2.2 refers to the stratigraphy formation in Kelantan.

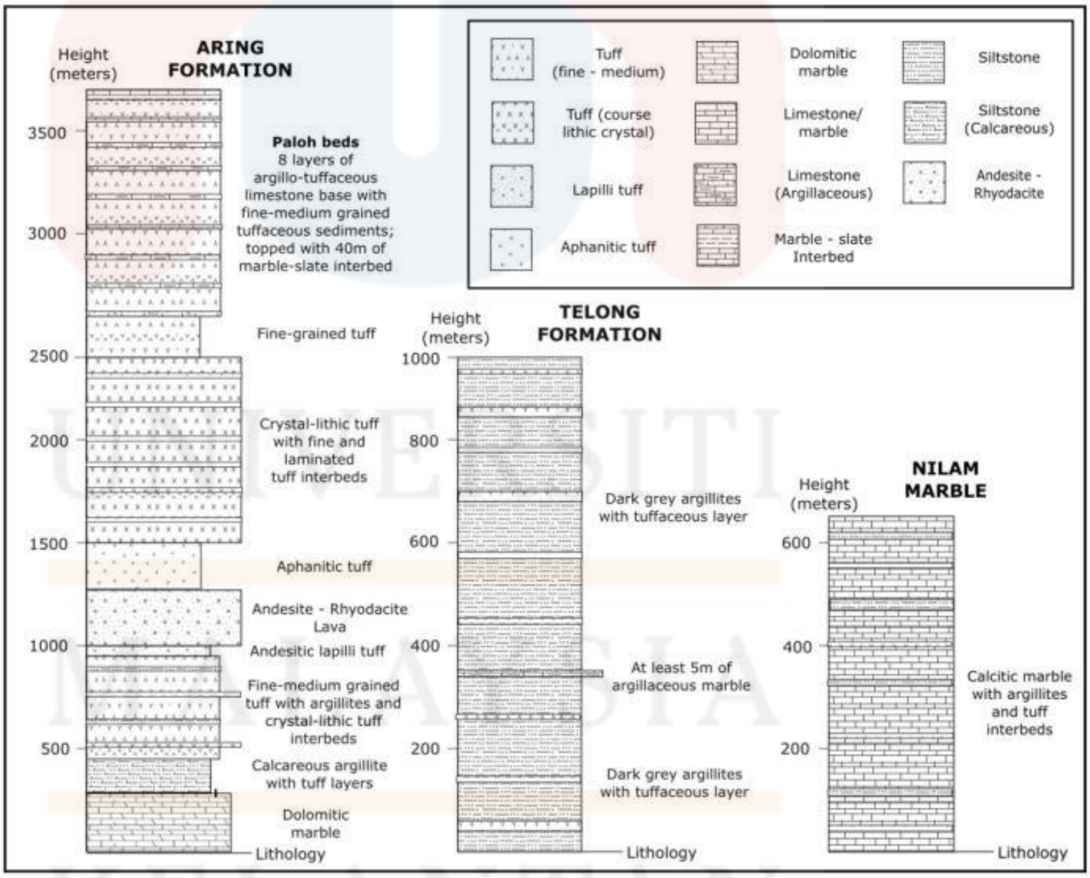

Figure 2.2: The stratigraphy formation in Kelantan (Aw, 1990)

2.2.2 Structural Geology

Structural geology is the study of structure that forms during tectonic process and about variation of structure that can form. In structural geology study, the information and data collection must gather throughout the field. In the north of the axial belt, the Telong Formation was correlated to the Gunung Rabong Formation and the top part of the Gua Musang Formation with the Aring Formation to the rest of the Gua Musang Formation (Aw, 1990). For Central Belt consist mainly of Permo-Triassic, a low meta-sediment grade, deep to shallow marine clastic sediment and limestone with abundant intermediate to acid volcanic and clastic volcanic were it deposited in paleo-arc basin. The Permo-Triassic deformation along the Betong-Raub Sature zone, was also recorded in the Upper Permian to Lower-Middle Triassic met sediment and limestone in the rest of central belt .the deformation style of these metasedimentary differs from that of the overlying Middle to Upper Triassic rock. The younger rocks are dominated by a single phase of upright folds with a spaced cleavage. Isoclinal fold, refolding, boundinage structure and schist facies metamorphism. The age of the Gua Musang formation consist of the thicker of it around 65m and is content of crystalline limestone and interbed with other sedimentary rock and volcanic rock. According to Aw(1974) said that the Kuala Betis area is located to the west of Gua Musang lithology similarities and identify as the Gua Musang Formation. The lithology of this area of Gua Musang major of limestone and volcanic rock. For the minor of the rock at Gua Musang are mudstone, chert, coal, conglomerate, granite, hornfel, sandstone, shale, and argillite.

2.2.3 Historical Geology

The Kelantan geological formations are range from Lower Paleozoic until Quaternary. It can be divided into three main ages which are Paleozoic, Mesozoic and Cenozoic. The Paleozoic formation in Kelantan was found in the central belt of Peninsular Malaysia. The bulk of the Upper Paleozoic sediments consist of marine Permian layer that exist as linear belt flanking Mesozoic sediment in the central belt. The depositional environment is typically shallow marine with active submarine volcanism starting in the Late Carboniferous and reaching its peak in the Permian and Triassic (Lee, 2004). According to Lee (2004), the Mesozoic formation consists of Permian-Triassic of Gua Musang, Aring and Gunung Rabong Formation, which made up mainly of shallow marine clastic and carbonates with interbedded volcanic, whereas in south part, Telong formation was dominated by deeper marine turbidite sediment.

2.2.4 Hydrogeology

Hydrogeology is the science of the occurrence, distribution, movement and chemistry of the water below the earth surface. (Fetter, 1988). The study deal with the relationship between the geological structure and water. Hydrogeology can be observer either quantitative or qualitative.

Groundwater is defined as subsurface water that fills all the pore space of soils and geologic formations below the water table (Freeze and Cherry 1979). Almost all groundwater can be thought of as a part of the hydrologic cycle, including surface and atmospheric waters (Todd, 1976). Groundwater usually stored in aquifer. An aquifer is a formation or a geological structure which has good permeability to supply sufficient quantity of water to a well or spring. Un-consolidated sedimentary formations like gravel and sand form excellent aquifers. Fractured igneous and metamorphic rocks and carbonate rocks with solution cavities also form good aquifers.

The water quality of the groundwater is very an important assessment in order to continue using it. In few parts of northern Kelantan especially in Kelantan River basin, the declinations of water table are well regarded effects of groundwater quality. In certain areas of Bachok districts where the aquifer are located nearby to the shore, problems such as seawater intrusion might poses serious concern as groundwater contaminated by seawater are not appropriate for domestic purposes especially for drinking supply.

Aquifer is a geological formation that capable store and yield water. It has different porosity and permeability depending on the type of rock of the aquifer. The volume of water of an aquifer that can transmit or absorb is determined by the porosity while the ability to pass through an aquifer is referred as permeability. There two type of aquifer which is confined aquifer and unconfined aquifer. Unconfined aquifer does not have underlain confining layer but have confining layer at the bottom of the aquifer. Confined aquifer is overlain and underlain by confining layer.

2.3 Water Quality

The water quality is a major factor that must be considered precisely when evaluating the water or groundwater of a given area. The water quality is defined using a set of physicochemical parameters of the water. The parameters should be divided into acceptable or unacceptable standard in which they have to be differentiated (Sundaram et al., 2009).

2.3.1 Factor Affecting Water Quality

The overwhelming of contaminants and pollutants in water especially freshwater seems to be the main issues concerning worldwide. Human activities are the main factors of the deterioration of the water quality. The improper dumping of toxic chemical waste which seep into aquifer, are one of the human activities that contaminate the groundwater. The other activities are including domestic waste and agricultural activities.

2.3.2 Safe Drinking Water

Water that obtained by the community in an area which serves as specific purpose can be described as drinking water. Several few standards need to be satisfied in order to be approved and the water can supplied to the people. The proper amount of ion concentration and others physicochemical parameters must be complied for the water to be supply through a safe distributions system in adequate quantity and pressure.

2.4 Drinking Water Quality Standard

A proper water quality standard is standard that have been issued by related organization that serves as guidelines for the adequate concentration of ion in water. This will ensure that the water supply is safe for drinking water and others domestic purposes.

The World Health Organization, WHO have emphasized the importance of conserving groundwater quality by following the guidelines for drinking water quality parameters and emphasis it on public health awareness (WHO, 2008). Table 2.1 refers the WHO Guidelines Parameters.

Table 2.1: Guidelines of Permissible limit for drinking groundwater by WHO (2011)

Parameters	Concentration (mg/l)
Chloride, Cl^-	250
Sodium, Na^+	200
Sulphate, SO_4^{2-}	200
Nitrate, NO_3^-	10
Fluoride, F^-	1.5
Hardness	500

(Source: World Health Organization)

2.5 Water Quality Parameter

In order to assess the quality of the groundwater, several physicochemical parameters need to be applied. A regular monitoring of this parameters can avoid diseases and contamination of the water source. Several analyses must be done in the field at the time sampling to measure how high or low the contamination of the groundwater in the research area. Table 2.2 refers the water quality parameter.

Table 2.2: Water quality parameter

Physical	Chemical	
Temperature	Bicarbonate	Fluoride
Turbidity	Sulphate	Iron
Conductivity	Chloride	Manganese
Total Suspended Solid (TSS)	Magnesium	Sodium
Total Dissolved Solid (TDS)	Calcium	Potassium
pH	Nitrate	

2.5.1 Groundwater Quality Parameter

Most of the groundwater quality assessment is conducted for research purpose and chemical quality monitoring (Boghici, 2003). Many factors influences groundwater quality parameters. These factors are related to each other in a complex manner and result. The physicochemical parameters are described as follow:

a) Temperature

The temperature acts as a catalyst in chemical reaction by reducing the solubility of gaseous and amplifies the tastes and the odors (Trivedy & Goel, 1984). The temperature is recorded using thermistor on the pH meter (Boghici, 2003)

b) Hardness

Water that rich in calcium or magnesium or both is defined as hardness. This characteristics of water substance increase the boiling point of the groundwater. Hard water prevent harmful process from happening in the pipelines structure by reducing the heavy metal from seeping into pipelines system (Trivedy & Goel, 1984)

c) pH

Water that have more free H+ ions than OH+ ions are classified as acidic water while water that have more free OH+ ions than H+ ions are classified as alkaline water. The pH of water can changes depending on the presence of air and temperature changes such as acid rain precipitating from cloud and seeping into subsurface toward aquifer (Trivedy & Goel, 1994). Carbonate system is the primary control in most potable groundwater.

d) Electrical Conductivity

Electrical conductivity is defined as the capacity of water to allow definite amount of electric current to pass through it. The salt that present as ionic form in water are very good at conducting electricity. The electrical conductivity is relate to total dissolved solids (TDS). The conductivity increases as the concentration of total dissolved solid increases and vice versa.

e) Total Dissolved Solids (TDS)

The total dissolved solids (TDS) are the measure of salt dissolved in a water sample after elimination of suspended solid. Total dissolved solids include bicarbonates, sulfates and chlorides of calcium, magnesium, sodium and silica (Trivedy & Goel, 1994). The limit of TDS in drinking water is 500 mg/l. If the concentration of TDS exceed this limit, the palatability of water decreases and may cause gastrointestinal irritation.

2.5.2 Concentration of major ions

The elements that present in Group 1, 2, 17 and 18 in Periodic Table are called major ion. Groundwater contains the major ions in it because the ions dissolve from sediment and soil particles as well as from infiltration process. The major ions that have been proposed are calcium, magnesium, sodium and potassium.

a) Calcium, Ca

Calcium, Ca2- is the most common cations in water. The presence of limestone, calcite and shells are the main factors of the existence of calcium in groundwater. Too much of concentration calcium intake can cause disease including heart problem.

b) Chloride, Cl

The concentration of chloride ion in water is presumably lesser compared to other cations such as sulphates. The major source of chloride contamination in aquifer is the industrial toxic chemicals. The rates of metal corrosion in the underground pipeline system in the groundwater supply will increase if there are too much concentration of chloride. This corrosion could be harmful if the water supply is being consumed without proper treatment system.

c) Magnesium, Mg

Magnesium is an important component in water system because it controls the hardness of water. Although magnesium is an important component, it can lead to disease if the drinking water have too much concentration of magnesium. There are several factors that influences the vast increases of magnesium in water beneath water table in aquifer. These factors are uncontrollable clearance of sewage into river and improper sewage treatment which cause some of harmful ion to seep into subsurface (Trivedy & Goel, 1984).

d) Sodium, Na

Sodium is a necessary ion especially in hard rock such as granites that exist in the form of plagioclase feldspar (Elango et al., 2007). The main constituent of the sodium ion in the natural environment is due to weathering process of rocks that contain sodium and other ion. Unlike other ion, sodium does not poses any serious effect when consumed excessively (Trivedy & Goel, 1984).

e) Potassium, K

Potassium is an alkali metal that lies in the Group 1 in the periodic table. The potassium exist in groundwater due to chemical reaction of mineral dissolution and other factors such as agricultural runoff (Fetter, 2000). Potassium is an essential element which should be consumed by animals and plants. It is beneficial in various ways as it aids in brain cells development and improve the digestive system in humans. Although it is beneficial to human, consuming large amount of potassium may be inappropriate (Trivedy & Geol, 1984).

f) Sulphate, SO_4

Sulphates anions are often found in natural water because of chemical dissolution process that dissolve sulphur content mineral. The main factors of existences of sulphates in groundwater are due to dispose of wastes such as sewage disposal, agricultural wastes and industrial toxic (Trivedy & Goel, 1984). However, the levels of sulphates that found in groundwater are originated from natural resources (WHO, 2008).

g) Carbonate, CO_3 and Bicarbonate, HCO_3

In natural water, some of the reason that bicarbonate ions exist is the dissociation of carbonic acid, H2CO3 that produced when carbon dioxide, CO2 from the atmosphere and from animal or bacterial respiration that dissolves in water. The concentration of carbonate and bicarbonate affect the suitability of groundwater as drinking water because it control both hardness and alkalinity of the water sources. Carbonate concentration in groundwater is usually low.

h) Nitrate, NO_3

Nitrogen is an element that lies in Group 15 in the periodic table and occurs as gaseous state in the atmosphere. The excess of nitrate concentration in groundwater is caused by several human activities. The waste discharge as well as biological oxidation of natural nitrogenous products and substances which come in sewage leads to considerable amount of nitrate accumulation in soil. The nitrate that accumulated in soil seep downward the soil and percolate into the groundwater in aquifers. Several groundwater may have nitrate concentration due to the leakage of natural vegetation (WHO, 2008).

i) Fluoride, F

The main source of fluoride in natural water sources may originates from various minerals and rocks in bedrock and sediments. The major problem in many parts of the world is the amount of fluoride that beyond the desirable amount which ranged from 0.6 mg/l to 1.5 mg/l. World Health Organization (WHO) suggested that the amount of fluoride ion content in drinking water must be in the ranged of 1.0 m/l to 1.5 mg/l. Excessive intake of fluoride can results in multidimensional health manifestations such as dental and skeletal fluorosis.

2.6 Previous Studies in Kelantan

There are a lot of studies have been conducted on groundwater quality in Malaysia especially Kelantan. Khan *et al*., (2017) had recently conducted study relating to groundwater quality in Bachok which is the study area. The study was conducted in the vicinity of Beris Lalang landfill, part of state Kelantan, Malaysia to determine the distribution of trace elements concentration in groundwater. A total of eleven groundwater samples and two surface water samples were analyzed for lead (Pb), manganese (Mn), copper (Cu), zinc (Zn), iron (Fe), chromium (Cr) and aluminium (Al) using Atomic Absorption Spectrophotometer (AAS). These probe elements were further categorized as toxic metals (i.e. Pb), transition metals (i.e. Mn), metallic elements (i.e. Cu, Fe, Zn, Cr), and non-metallic elements (i.e. Al). This study shows that few groundwater samples have marginally high concentration of Mn, Pb, Fe and Cr as per W.H.O. standard for potable water.

Khan *et al*., (2018) conducted a study on the suitability of shallow aquifer for irrigational purposes in some parts of Kelantan, Malaysia. This study was aimed at assessing the suitability of groundwater for irrigational purposes in some selected communities of Kelantan where farming activities are very intensive. Thirty-two (29 groundwater and 3 surface water) samples were collected and analysed for major anions and cations. Physicochemical parameters such as electrical conductivity (EC) and total dissolved solids (TDS) were also measured. From the results of the analyses and measurements, the suitability of the groundwater for irrigation were evaluated based on the TDS, EC, percentage sodium (%Na), sodium adsorption ratio (SAR), residual sodium carbonate (RSC), Boron classification, fluoride and Nitrate. US salinity laboratory (USSL) diagram and distribution maps of different parameters were also applied in the present investigation. SAR plot indicates that the groundwater falls within the excellent class for irrigation. In terms of sodium percentage, most of the samples fall within the doubtful class with few samples in permissible class. With respect to residual sodium carbonate, majority of the samples exhibit doubtful class with only few samples in permissible limit. Other samples recorded are not suitable for irrigation. Based on the boron classification, the samples fall within the excellent water class.

CHAPTER 3

MATERIALS AND METHODS

3.1 Introduction

This chapter discuss about the materials and equipment that were used in this study to achieve all the objectives. The application of GIS and Aquachem was the main tools for the interpretation of data in assessment of the groundwater quality parameter.

3.2 Materials/Equipment

All the materials and equipment are given in details in Table 3.1

Table 3.1: Equipment and material

Equipment/material	Use	Pics
Geological Hammer	Geological Hammer is used to break fresh rock from the outcrop for sampling purposes. There are two types of geological hammer that	

	being used which are pointed and chisel hammer.	
Compass	The compass is used for navigation and orientation purposes. Compass will aids in map interpretation and to measure strike and dip reading.	
Global Positioning System (GPS)	A GPS (Geographic Positioning System) is a satellite based navigation system. GPS will be used to mark sampling location and record the traverse map in study area.	
YSI 556 MPS Multi-parameter	This device can simultaneously measures dissolved oxygen, pH, conductivity and temperature.	

Measuring Tape	Measuring Tape is used to measure bed thickness, outcrop height and width as well as drainage width.	

These are the application that are used in this study (mapping and specification)

- Arc GIS software

Arc GIS software is software used to digitize map of our study area and produce topographic map of the study area. Based from the map generate from the software we can carry out reconnaissance study to interpret the lithology, landform and water shed of the study area.

- AquaChem

This software is groundwater software that suitable for analysis, management and reporting of water quality data. AquaChem have many functions and calculations. This software can analyze and report aqueous geochemistry of municipal groundwater supply wells. This software also have automatic geochemical calculations of water type, sum of anion and cations, ion balance, hardness and TDS.

3.3 Methodology

3.3.1 Research flowchart

The research flowchart is the overall process of method that were used to completing this study. Figure 3.1 refer to the research flowchart.

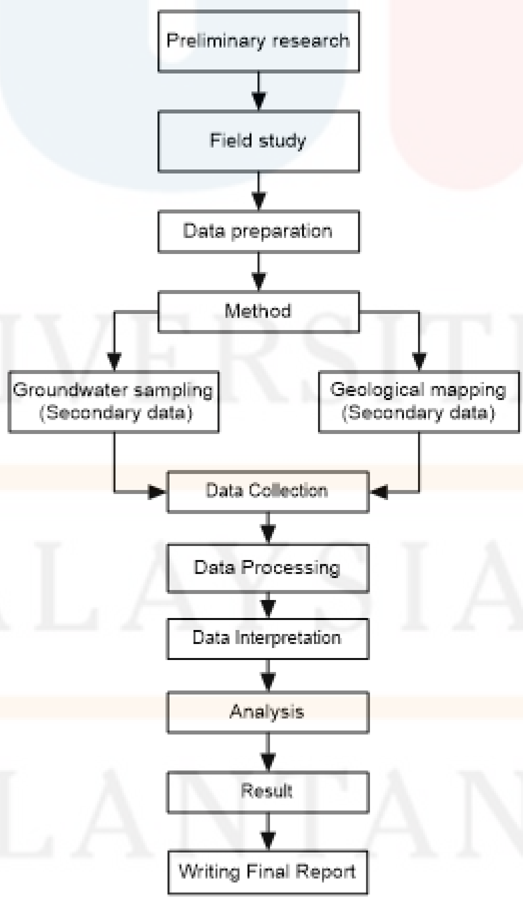

Figure 3.1: Research flowchart

3.3.2 Preliminary studies

Preliminary studies were made by searching on the library book source and internet source. The information that needs to be collected such as general geology and the general hydrogeology information of the study area (mapping and specification).

3.3.3 Field Studies

a) Geological mapping

In this research, the geological mapping were be made based on the interpretation of secondary data using previous research, satellite imaging and GIS. Terrain and base map are important in finding accurate information as well as updating. In addition, software like ArcGIS is useful for geological map production. The geological map is important to map the structure, lithology and so on that related to geology within the chosen mapping area.

The geological mapping supposedly need to be conducted using field activities. The activities that need to be done during geological mapping are traversing, sampling and observation at the mapping area. Traversing is essential in order to mark the pathway during mapping and act as evidence that the mapping has been done. Sampling is method to take sample from outcrop using geological hammer. Only fresh sample of outcrop need to be taken for the mapping. The observations are written in the field notebook regarding the information related to the geological mapping. The base map are also important to use during geological mapping. All of the outcrop location will be mark in GPS and base map. After the collection of data, the geological map will be produced.

b) Water sampling

The groundwater samples were collected and poured into polyethylene bottles that covered with aluminums foil. Then, the bottles preserved in a cool box and covered by ice. For the preservation of groundwater, the samples should be stored in a cold temperature which is approximately below 4°C. A cold temperature for preservation is very important in order to avoid any chemical reactions from occurring during transportation process. Approximately 15 samples of water need to be collected in the specification area.

3.3.4 Laboratory work

The laboratory work was make based on secondary data. It is only make by interpretation of secondary data from previous research, satellite imaging and GIS.

3.3.5 Data processing

a) Geology mapping

The interpretation of the secondary data were included all aspect of geology part such as lithology, structure, geomorphology, mineral and petrology, stratigraphy, sedimentology and depositional environment, paleontology and others. The map will be processed using ArcMap according the interpretation of secondary data.

b) Research specification

The secondary data of the sampling were interpret using the Aquachem software and the parameter will be assess by comparing the result with World Health Organization (WHO) and national standard for drinking water quality in Malaysia.

3.3.6 Data analysis and interpretation

a) Geology mapping

Each of the structure were analyzed using software such as Georose and ArcMap to create new map. This is important in order to determine the structure of plate tectonic movement or changing of structure cause by weathering and erosion process as well as to determine the depositional environment.

b) Groundwater

For the groundwater analysis and interpretation, Aquachem application were used to analyze the sample secondary data. The Aquachem application was used to generate varies type of plotting for geochemical plots such as piper and stiff and also to generate statistical plots such as histogram, probability and quantile. Apart from generate varies plotting, Aquachem also can perform quick water quality calculations and conservations such as unit conversion and ionic functions. After the data have been analyse using Aquachem, graph of the parameter were made to show the result.

CHAPTER 4

GENERAL GEOLOGY

4.1 Introduction

The general geology of study area which is in Kampung Sungai Tupai were discussed in this chapter. There are several components in general geology that were described and explained such as accessibility, settlement, forestry, geomorphology with classification and drainage pattern, lithostratigraphy, structural geology and historical geology. This components were discussed using secondary data and previous study.

4.1.1 Accessibility

Accessibility is the ability to access. In order to reach the study area, access road must been identify. Without access road, the research cannot be done smoothly because it is difficult to reach the study area. Access road that can be used to reach study area is using highway which is Lebuhraya Gua Musang-Kuala Lumpur. There are also unpaved road that can be used to access to oil palm and rubber plantation area.

4.1.2 Settlement

Settlement is the place where people live. It is includes the people who live there, the buildings, the streets, the roads and pathways which link up the buildings in the settlement. Every settlement must have a site and a location that can be described. The site of a settlement is the land area which the settlement is built. The site can be by a riverside, plain or at the base of a hill. The location of a settlement is the position of settlement in relation to other cultural features. Settlements can be classified using their pattern which is isolated, dispersed, nucleated and linear.

There are a several settlement that can be identify in the study area. The first settlement is Kampung Sungai Tupai. The pattern of this settlement is linear because the houses in the area form a straight line that follow the line of road. Next, there are also building that belong to plantation worker. This settlement has an isolated pattern because it is located in plantation area and very remote from others building.

4.1.3 Forestry

Most of the land in the study area is used for agriculture. High elevation land is used for palm plantation while low elevation land is used for rubber plantation. The palm plantation is situated at western part in the study area. The rubber plantation is situated at southern and north-eastern part in the study area. The study area is also covered by forest.

4.2 Geomorphology

4.2.1 Geomorphologic classification

Geomorphology is the study of landforms that involving the processes and evolution of landscape at the surface of the earth. A method called geomorphologic classification is made to identify and classify landform of an area. The geomorphology of this study area have been identify and classify based on landform and topography. Topography is the study of shape and features of the Earth surface. According to Raj (2009), topographic unit can be classified into five type based on the elevations which is low lying, rolling, undulating, hilly and mountains. The low lying have elevation less than 15 meter above sea level. The rolling have elevation from 16 meter to 30 meter above sea level. The undulating have elevation from 31 meter to 75 meter above sea level. The hilly have elevation from 76 meter to 300 meter above sea level. The mountains have elevation more than 301 meter above sea level.

The lowest elevation in the study area is 140 meter above sea level while the highest elevation is 520 meter above sea level. This means that there are two topographic units that found in study area which is hilly that have range from 140 meter until 300 meter and mountains that have range from 301 meter until 520 meter. More than 50% of the study area are hilly. Figure 4.1 shows the topographic map of the study area.

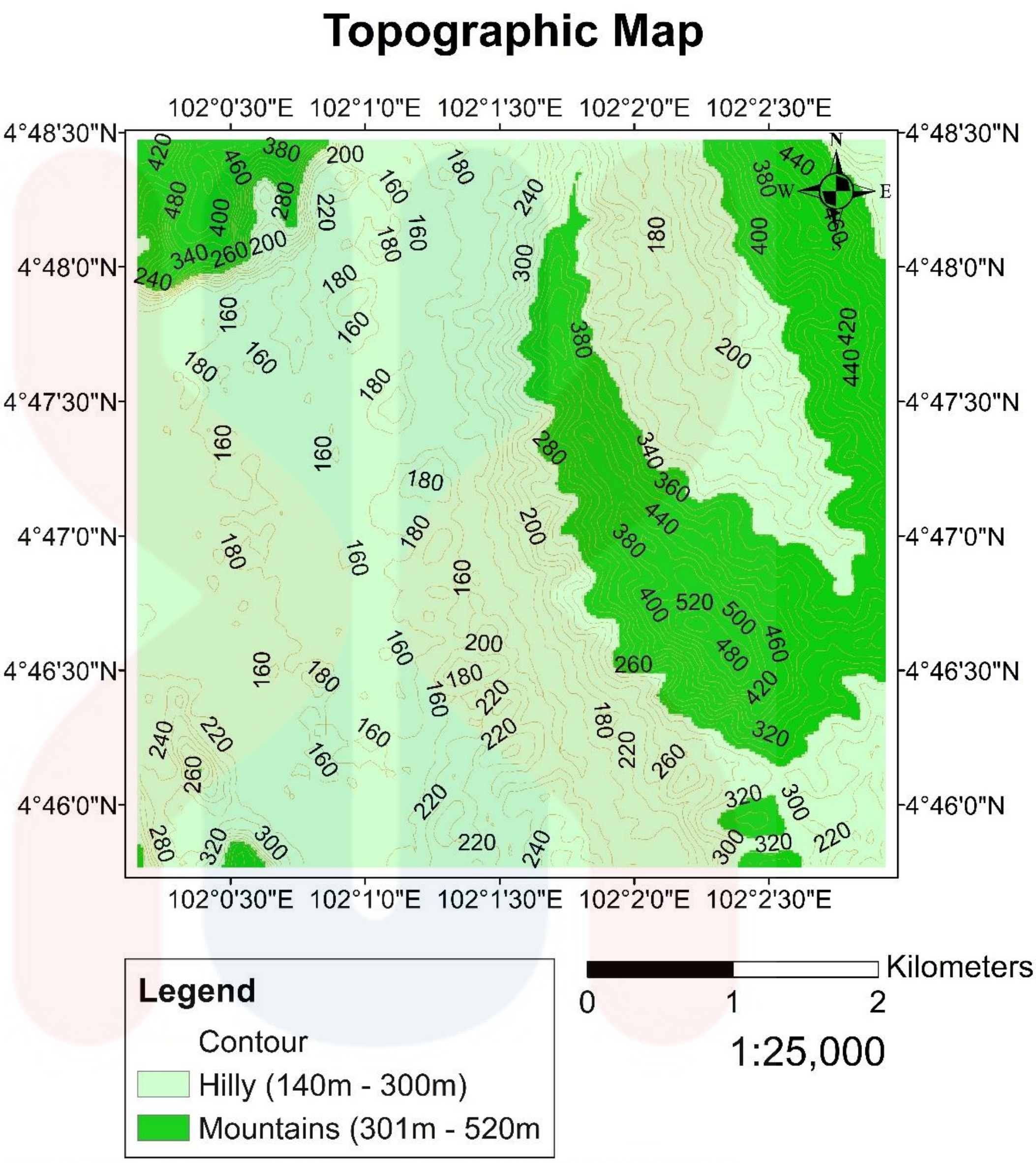

Figure 4.1: Topographic map of study area

4.2.2 Drainage pattern

Drainage pattern is the pattern that shows the flow of water that formed by streams, rivers or lakes. The drainage pattern is formed of aggregation of natural drainage ways (Argialas et al., 1988). It is influenced by the types of rocks and the gradient of the land. Different lithology and topography shows different drainage pattern. The drainage pattern can be study using a topographic maps or an aerial photograph. The shape of the branches river flow will be used to determine the drainage pattern.

In the study area, there are two types of drainage pattern that can be identified which is dendritic and trellis. Dendritic patterns is the most common pattern that develop in area where rock beneath the river flow has no particular structure and easily eroded in all directions. It is usually associated with horizontal strata. Trellis pattern is a patterns that usually develop in an area that have folded or tilted sedimentary rocks. The sedimentary rocks eroded to varying degrees depending on their strength. It is associated with folded strata. Figure 4.2 shows the drainage pattern of dendritic (blue) and trellis (red) in study area. Most of the study area are covered by dendritic pattern which exist on the limestone lithology. The trellis pattern are mostly covered in the sandstone lithology.

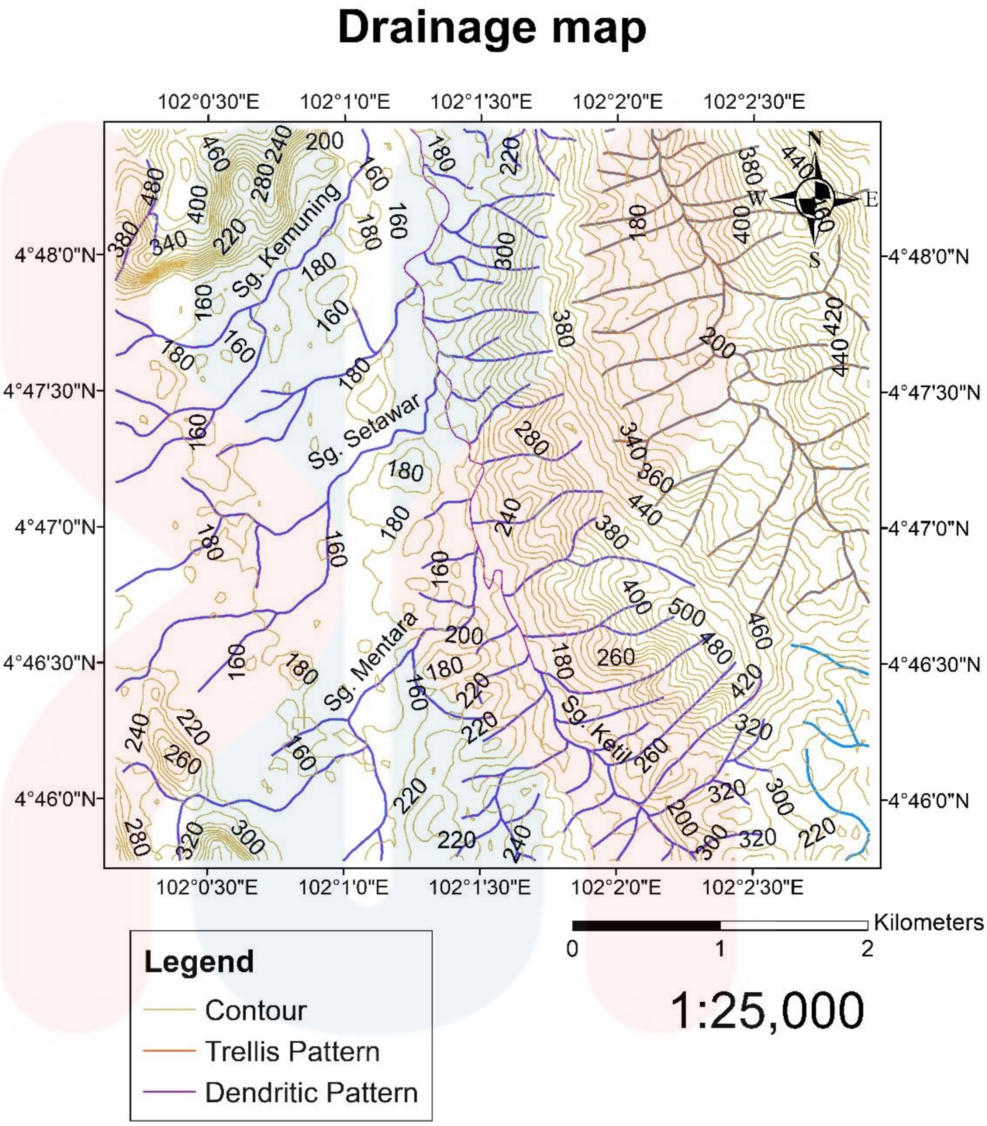

Figure 4.2: Drainage pattern in study area

4.3 Lithostratigraphy

4.3.1 Stratigraphic position

Stratigraphic position is a rock layer that shows their position according to the age. According to previous study conducted at the study area, the sequence of the rock from oldest to youngest are limestone, tuff, slate, sandstone and alluvium. Figure 4.3 shows the stratigraphy column of the study area. Sandstone, slate, tuff and limestone are all from the same formation which is Gua Musang Formation. Figure 4.3 refers to the stratigraphic column of study area. Figure 4.4 refers to the geological map of Kampung Sungai Tupai.

Era	Period	Formation	Lithology	Description
Cenozoic	Quaternary			Alluvium located at main river and composed of graved sand and silt.
Palaeozoic	Permian	Gua Musang Formation		This sandstone is Quartz Arenite Sandstone which have abundance of quartz and also composed of lithic and feldspar.
				Slate with a fine-grained size, composed of clay and it is foliated resulted from metamorphism of mudstone.
				Tuff is a pyroclastic composed of volcanic ash with a fine-grained, contain mainly of quartz and brown in colour.
				The type of limestone rock is micrite limestone which dominate by fine-grained calcite

Figure 4.3: Stratigraphic column of study area

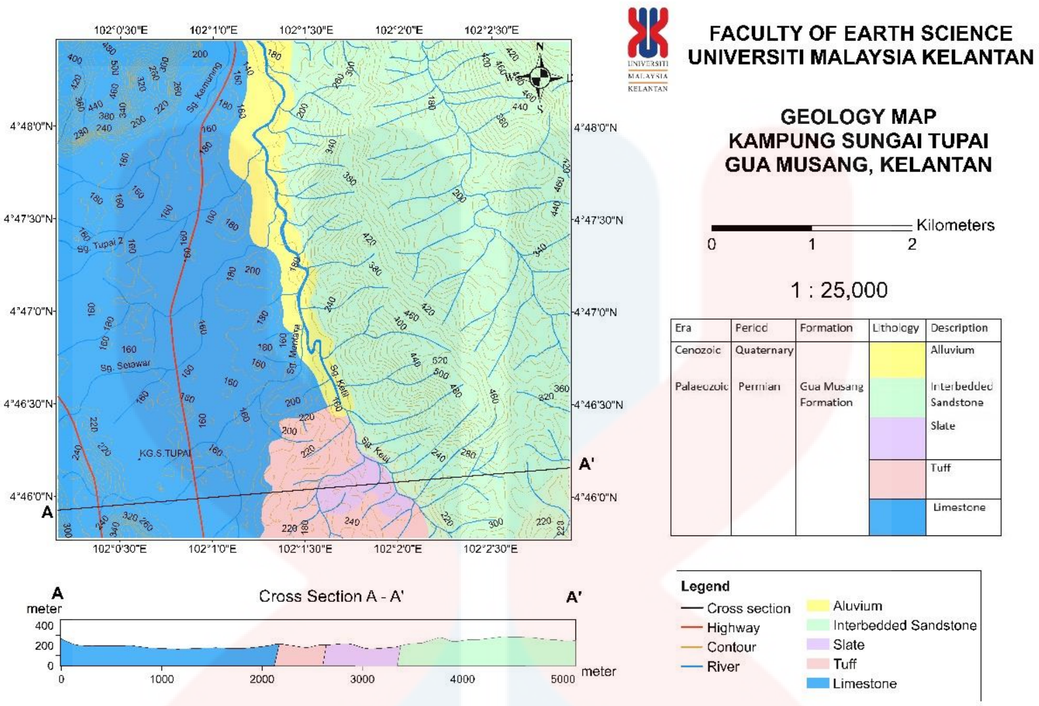

Figure 4.4: Geological map Kampung Sungai Tupai

4.3.2 Unit explanation

Lithologic class definitions are based on descriptions of observable features in an Earth material. Lithologic classification for a geoscience database system is designed to classify the lithologic constituents used to define rock volume units. In this research, the rock unit have been identify based on the recent study by Salimah (2018). There are five rock unit in the study area which are alluvium, interbedded sandstone, slate, tuff and limestone.

a) Limestone

Based on previous study, the limestone is classified as micrite limestone. The limestone is classified according to Folk's texture classification of carbonate sediment. Micrite limestones are mud limestone that abundance with lime mud matrix and not contain organic materials. The micrite limestone in study area is dark grey and has fine grain texture. The compositions of mineral in the limestone at study area are calcite, aragonite and dolomite.

b) Slate

Slate is a metamorphic rock that has foliation. Slate has low grade metamorphism. It is composed of clay and mica mineral. Slate is dark coloured and has fine grain texture. The composition of mineral in slate is quartz, chlorite, muscovite, graphite and calcite.

c) Tuff

Tuff is a product of the volcanic eruption that contains ash. Tuff contain fine ash that has clast size less than 0.063mm. In the study area, the colour of the tuff is dark brown. The tuff has mineral composition of augite, olivine, hornblende, quartz and volcanic glass.

d) Sandstone

Sandstone is a sedimentary rock that composed mainly of sand-sized minerals particles that dominantly by feldspar or quartz. The sandstone in study area is identified as quartz arenite sandstone. Quartz arenite sandstone is different than other types of sandstone because it has more quartz mineral content than feldspar mineral and lithic fragments contents. The colour of the sandstone is dark brown. The mineral compositions of the sandstone are quartz, feldspar, lithic fragment, biotite and opaque.

e) Alluvium

Alluvium is the loose and unconsolidated materials. In the study area, alluvium is located along the main river, Sungai Ketil. The erosion and weathering of rock maybe deposited along the river that cause alluvium to form.

4.4 Structural geology

4.4.1 Lineament analysis

Lineament is features that indicate the geological structure in an area. The lineament also can indicated weak zone in the area. Lineament can be determined by analyse line that comprise of aligned valley, straight river or hills. Figure 4.5 shows the lineament in the study area. Most of the lineaments have the same direction which can indicate that the forces that occur in study area are same. Figure 4.5 refers to the lineament map of study area. Figure 4.6 refers to the Google Earth picture of lineament in study area.

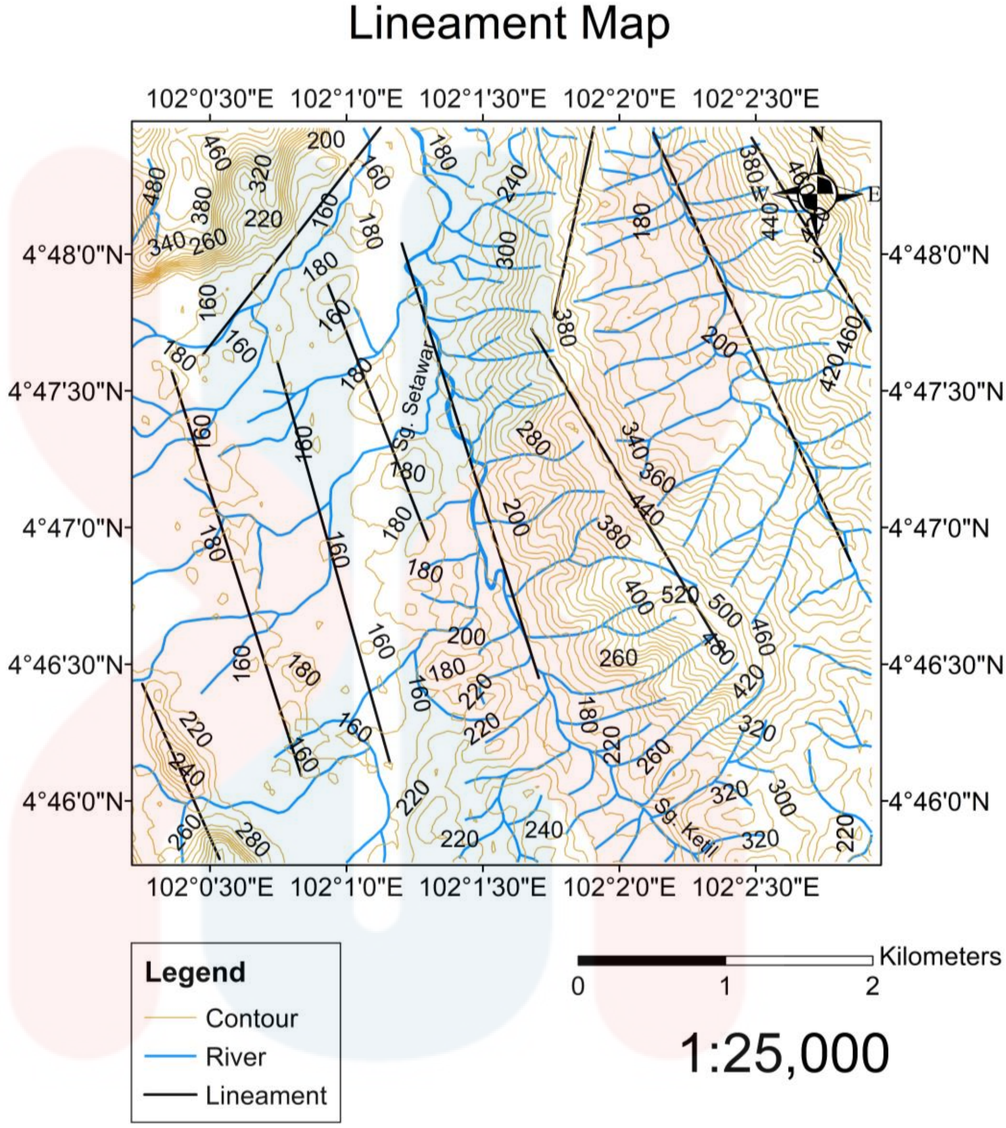

Figure 4.5: Lineament map of study area

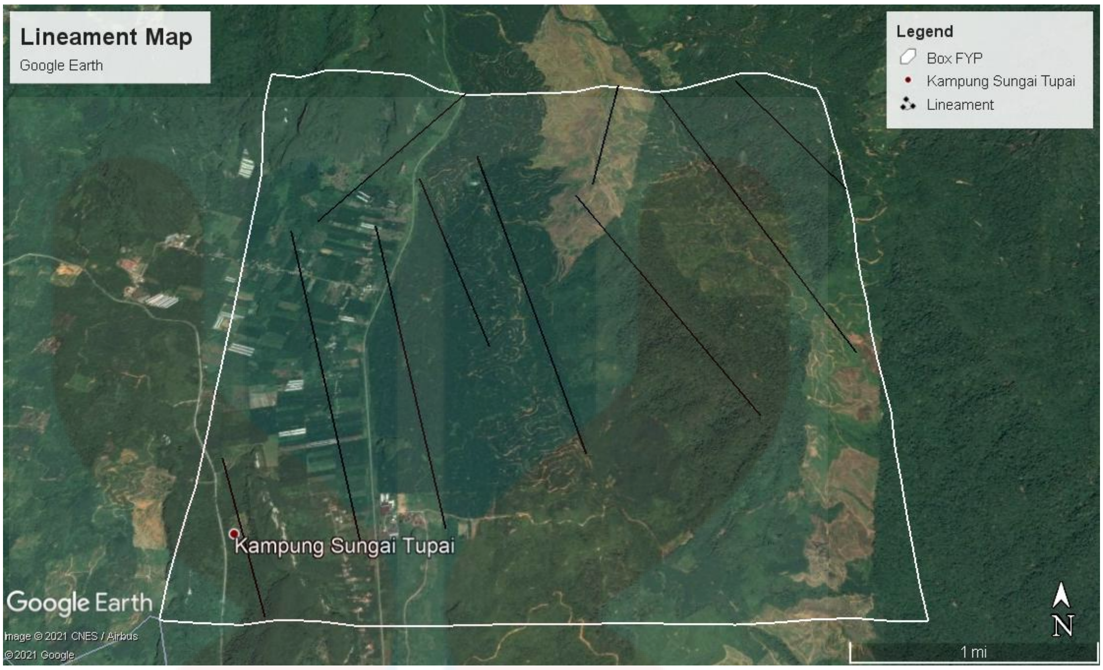

Figure 4.6: Google Earth Images of lineament map

4.5 Historical geology

The Kelantan geological formations are range from Lower Palaeozoic until Quaternary. It can be divided into three main ages which are Palaeozoic, Mesozoic and Cenozoic. The age of the study area is Palaeozoic. The Palaeozoic formation in Kelantan was found in the central belt of Peninsular Malaysia. The bulk of the Upper Paleozoic sediments consist of marine Permian layer that exist as linear belt flanking Mesozoic sediment in the central belt. The depositional environment is typically shallow marine with active submarine volcanism starting in the Late Carboniferous and reaching its peak in the Permian and Triassic.

CHAPTER 5

ASSESMENT OF GROUNDWATER QUALITY PARAMETERS IN BACHOK

5.1 Introduction

Groundwater quality is an important aspect that need to be assess periodically in order to ensure the groundwater supply that will be used for daily usage are in good quality. In this chapter, groundwater quality is discussed based on different parameters using the data acquired from JMG Kelantan. The results and interpretations of groundwater samples data from four different places in Bachok are discussed in detail.

5.2 Hydrogeology of Kelantan

The northern part of Kelantan is consist of Quaternary deposit. The Quaternary alluvium plain underlain is the reason that northern Kelantan have the major groundwater potential. The Quaternary deposit is distributed with sand, silt, clay, peat and minor size gravel (Dony et al., 2014). The Quaternary sediments which is consist of semi-consolidated and unconsolidated are deposited in the early Pleistocene (Fontaine, 2002). The sources of the groundwater potential are deposited in the Lower Kelantan River Basin. The groundwater resources can be extracted from the aquifer body reservoir in deeper settings (Daud et al., 1985). The depth of the groundwater is around 10 meter to 30 meter depending on the depth of the aquifer. Simpang Formation can be found in the Kelantan River valley and delta (Hutchison & Tan, 2009). The age of Simpang Formation is Pleistocene. The lithology and rock unit of Simpang Formation is consist of clay, sand and silt associate with gravel. The clay and sand are found intercalated with one another. The environment of deposition Simpang Formation is fluvial.

There are four aquifers exist in the Quaternary deposit which consist of alternating layers of coarse gravels to silt or a mixture of these two materials. (Nasiman et al., 2011). The first aquifer is recharged by percolation from precipitation. The first aquifer is suitable for abstraction. This is because it exhibiting significant recharge rate. The second aquifer has low thickness and only store limited groundwater amount. This aquifer is not quite suitable for large scale of groundwater exploitations. The third aquifer has a thickness varying from one place to another place and generally increases towards the coast. This aquifer is the most suitable aquifer for groundwater abstractions because it yields significant volume of groundwater and protected from contaminant. The fourth aquifer is not dispersed entirely in the northern Kelantan basin because it develops interaction with underlying granitic structure (Nasiman et al., 2011). Figure 5.1 refer to the geological fence diagram of lower Kelantan basin. Figure 5.2 refer to the geology map of northern Kelantan.

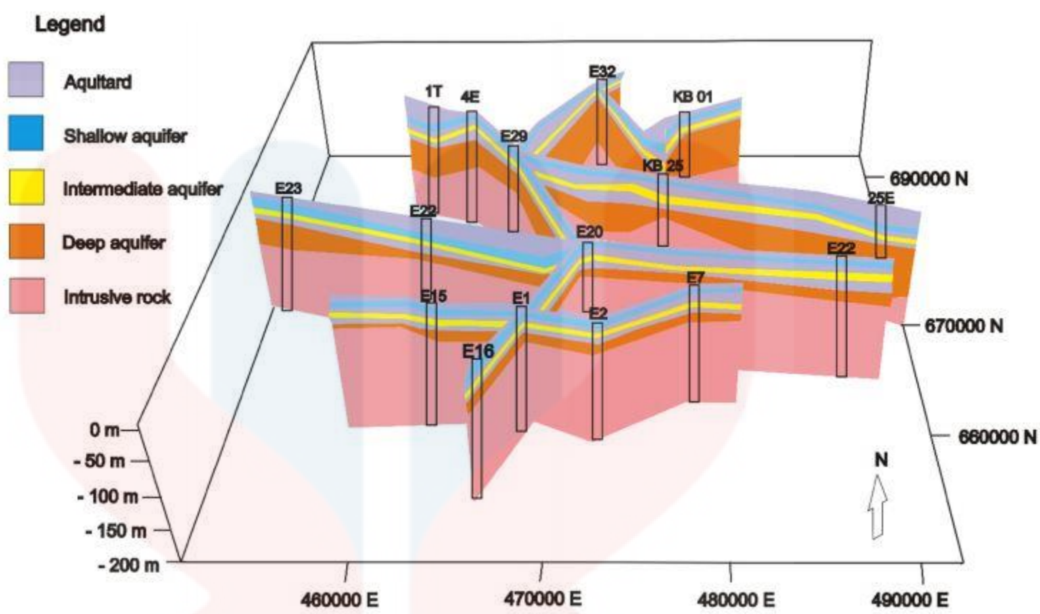

Figure 5.1: Geological fence diagram of lower Kelantan basin (Sefie *et al*., 2018)

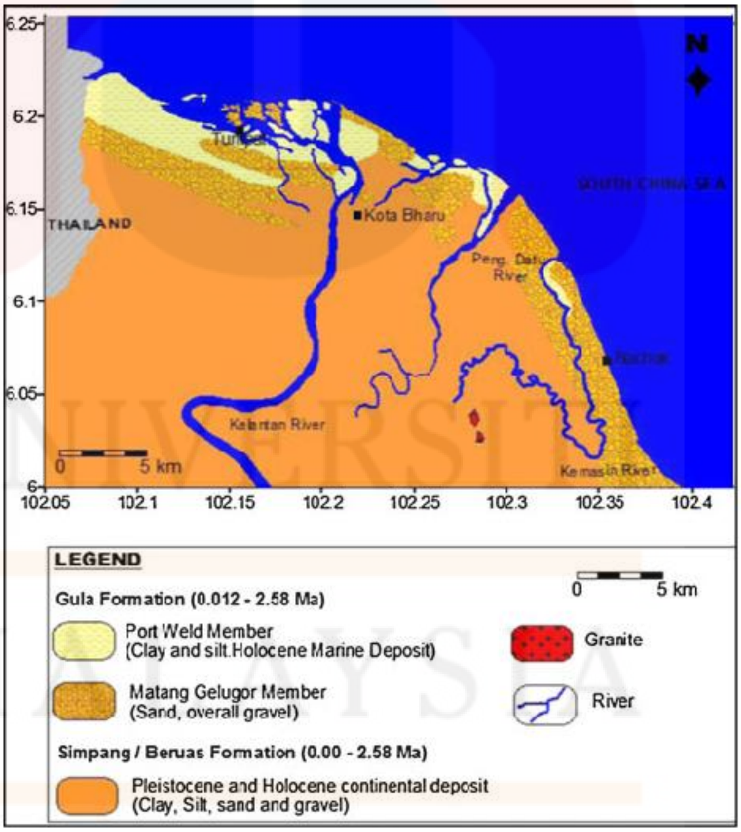

Figure 5.2: Geology map of northern Kelantan (Hussin et al, 2013)

5.3 Data Acquisition

The data that have been used for this study was obtained from JMG Kelantan. This data have essential information that helps this study carry on smoothly. This data sampling was taken from four different well by JMG Kelantan. This data includes four water sampling data from 3 different locations in Bachok which is Universiti Malaysia Kelantan, Sekolah Menengah Kebangsaan Agama Tok Bachok and SK Chantum. Figure 5.3 shows the location of groundwater sampling. Table 5.1 shows the information about all the four well.

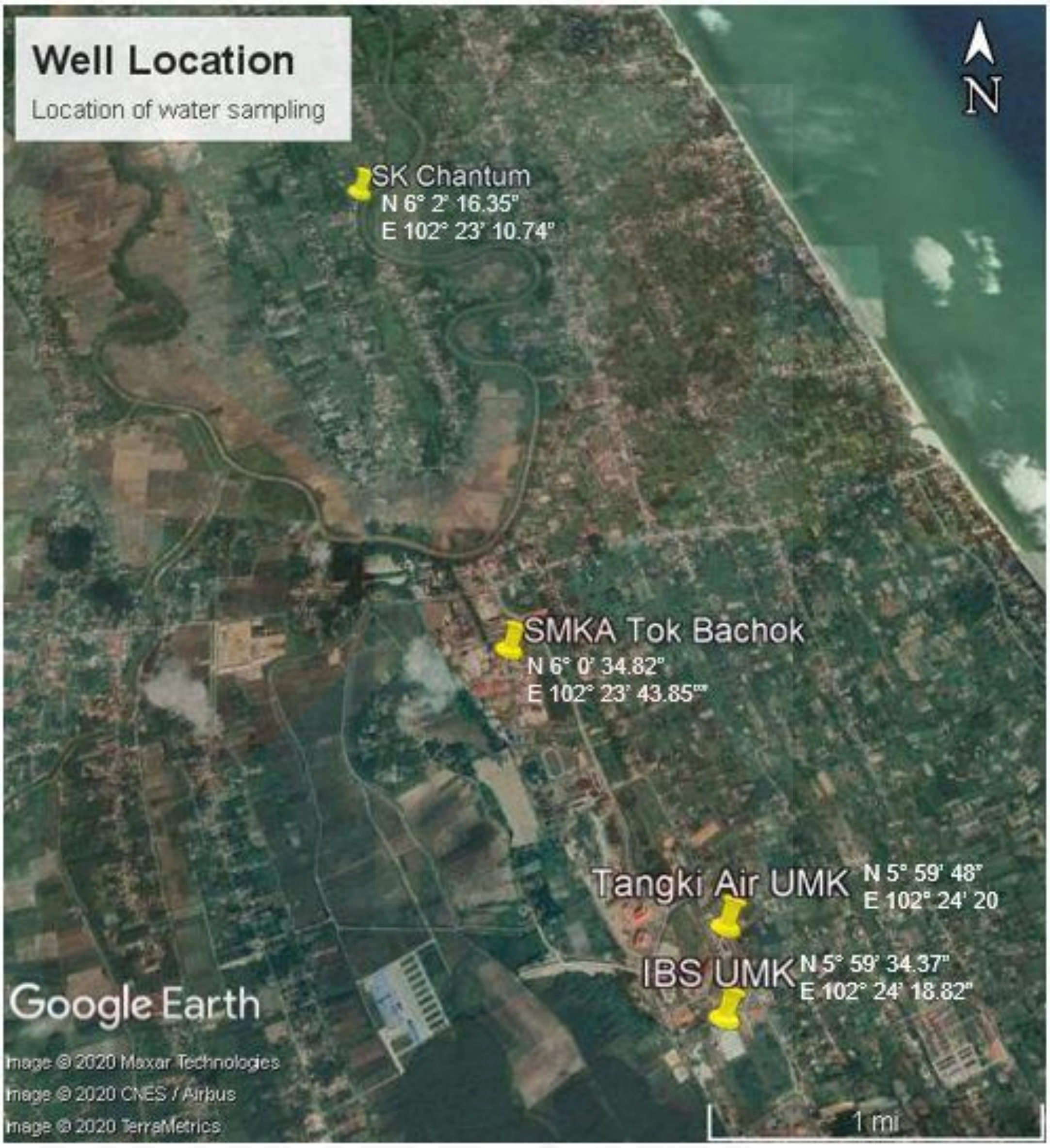

Figure 5.3: Location of groundwater samples in Bachok

Table 5.1: Groundwater samples location

No	Location	Coordinate	Depth	Elevation	Distance from shoreline
1	IBS UMK	N 5° 59’ 34.37” E 102° 24’ 18.82”	50 meter	7 meter	2.87 kilometer
2	Tangki Air UMK	N 5° 59’ 48” E 102° 24’ 20”	36 meter	8 meter	2.67 kilometer
3	SMKA Tok Bachok	N 6° 0’ 34.82” E 102° 23’ 43.85”	48 meter	9 meter	3.01 kilometer
4	SK Chantum	N 6° 2’ 16.35” E 102° 23’ 10.74”	32 meter	11 meter	2.68 kilometer

The water sampling data that are obtained from JGM Kelantan are physical parameters and chemical parameters. The physical parameters used in this study are pH, temperature, turbidity, conductivity, Total Dissolved Solids (TDS) and Total Suspended Solids (TSS). The chemical parameters which is major ions are divided into two, anion and cation. The anions used in this study are Chloride, Fluoride, Nitrate, Sulphate and Bicarbonate. The cations used in this study are Magnesium, Sodium, Potassium, Calcium, Iron and Manganese. Table 5.2, Table 5.3 and Table 5.4 refers to the data of the physical parameter and chemical parameter (major cation and major anion) of the groundwater sample in four location at Bachok. Table 5.5 refers to the guidelines for drinking water quality by Ministry of Health Malaysia and World Health Organization.

Table 5.2: Physical parameters of groundwater samples

No	Location	Parameter						
		pH	Temperature, °C	Turbidity, NTU	Conductivity, µs/cm	Total Solids(TS), mg/L	Total Dissolved Solids(TDS), mg/L	Total Suspended Solids(TSS), mg/l
1	IBS UMK	6.8	27	27	177.3	290	224	66
2	Tangki Air UMK	6.6	28	11	217.3	328	284	44
3	SMKA Tok Bachok	6.7	26	22	75.9	140	124	16
4	SK Chantum	6.9	27	66	1520	2228	2188	40

(Red coloured number means exceed the limit by WHO and MOH)

Table 5.3: Major cation parameters of groundwater samples

No	Location	Parameter					
		Cations					
		Magnesium(Mg), mg/L	Sodium(Na), mg/L	Potassium(K), mg/L	Calcium(Ca), mg/L	Iron(Fe), mg/L	Manganese(Mn), mg/L
1	IBS UMK	6.22	5.69	5.78	5.81	0.20	ND(<0.0002)
2	Tangki Air UMK	3.09	0.51	4.10	0.03	1.92	ND(<0.03)
3	SMKA Tok Bachok	ND(<0.03)	1.68	3.63	5.72	1.92	ND(<0.03)
4	SK Chantum	2.97	ND(<0.02)	2.76	3.47	ND(<0.02)	0.03

(ND = Not Detected)

Table 5.4: Major anion parameters of groundwater samples

No	Location	Parameter				
		Anions				
		Chloride,(Cl^-), mg/L	Fluoride(F^-), mg/L	Nitrate(NO_3^-), mg/L	Sulphate(SO_4^{2-}), mg/L	Bicarbonate(HCO_3^-), mg/L
1	IBS UMK	48	0.18	0.34	3	78
2	Tangki Air UMK	38	0.26	0.48	1	143
3	SMKA Tok Bachok	8.1	0.19	0.37	ND(<3)	74
4	SK Chantum	680	0.19	0.30	ND(<3)	271

(ND = Not Detected)

(Red coloured number means exceed the limit by WHO and MOH)

Table 5.5: Guidelines for Drinking Water Quality by Ministry of Health Malaysia and World Health Organization

Parameter	Unit	MOH (2004)	WHO (2011)	The value in study area
pH	-	6.5-9.0	6.5-8.5	6.6 – 6.9
Temperature	°C	NA	NA	26 – 28
Turbidity	NTU	5	NA	11 – 66
Conductivity	µs/cm	NA	1500	75.9 – 1520
Total Dissolved Solid	mg/L	1000	1000	140 – 2228
Total Suspended Solid	mg/L	50	50	16 – 66
Chloride	mg/L	250	250	8.1 – 680
Fluoride	mg/L	0.9	1.5	0.18 – 0.26
Nitrate	mg/L	10	50	0.30 – 0.48
Sulphate	mg/L	250	250	0 - 3
Bicarbonate	mg/L	NA	500	74 – 271
Magnesium	mg/L	150	100	0 – 6.22
Sodium	mg/L	200	200	0 – 5.69
Potassium	mg/L	NA	200	2.76 – 5.78
Calcium	mg/L	NA	300	0.03 - 5.81
Iron	mg/L	0.3	0.3	0 – 1.92
Manganese	mg/L	0.1	0.4	0 – 0.03

(NA = not available)

5.4 Result and analysis

Result is the item of information obtained by experiment or some other scientific method. The result in this research was presented by using the graph. Analysis is the detailed examination of the elements of structure of something. The analysis of this research were done by analyzed the graph which is represent the result.

5.4.1 Physical parameters

a. pH

A pH value is used to determine acidity or basic of a solution. The range of pH value is 1 until 14. The range of acidic solution is 1 until 6.9 while the range of basic solution is 7.1 until 14. The value of 7 is natural. Figure 5.4 below shows the pH value of all water sampling location. The highest value of pH recorded is 6.9 at SK Chantum. The lowest recorded pH value is 6.6 at Tangki Air UMK Bachok. The pH value of IBS UMK and SMKA Tok Bachok are 6.6 and 6.7 respectively. All this pH value indicate that the groundwater at IBS, Tangki Air, SMKA Tok Bachok and SK Chantum are acidic. Based on table 5.5, all groundwater sample pH value are within the range that allow by MOH and WHO. All the groundwater at the locations are suitable for domestic use.

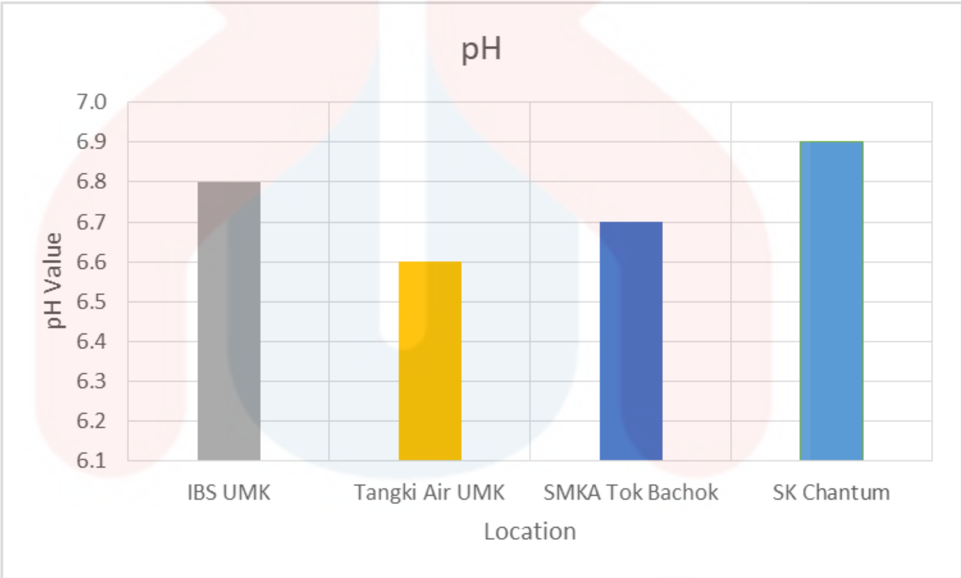

Figure 5.4: pH value of groundwater samples

b. Temperature

Temperature is the measurement for determine whether the solution is hot or cold. Figure 5.5 shows the temperature of all the groundwater sample. The highest temperature recorded is 28°C at Tangki Air while the lowest temperature is 26°C at SMKA Tok Bachok.

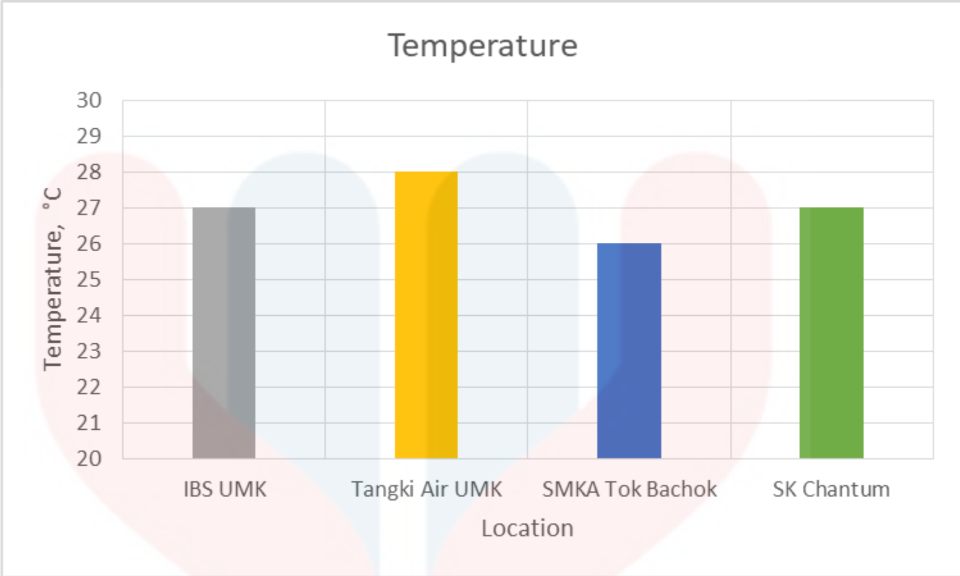

Figure 5.5: Temperature reading of groundwater samples

c. Turbidity

Turbidity is the measurement of the relative clarity of water. The presence of suspended particles can cause the turbidity of water increase. Water that have high cloudiness will have high turbidity. Figure 5.6 shows the turbidity of all the groundwater sample. The highest turbidity recorded is 66 NTU at SK Chantum while the lowest turbidity recorded is 21 NTU at Tangki Air. The turbidity for IBS and SMKA Tok Bachok are 27 NTU and 22 NTU respectively. Based on the table 5.5, all the groundwater samples turbidity value are above the permitted value by MOH and WHO which is 5. Although the groundwater samples has high turbidity, it can be used for daily used other than drinking. The groundwater must be filter carefully for drinking purpose.

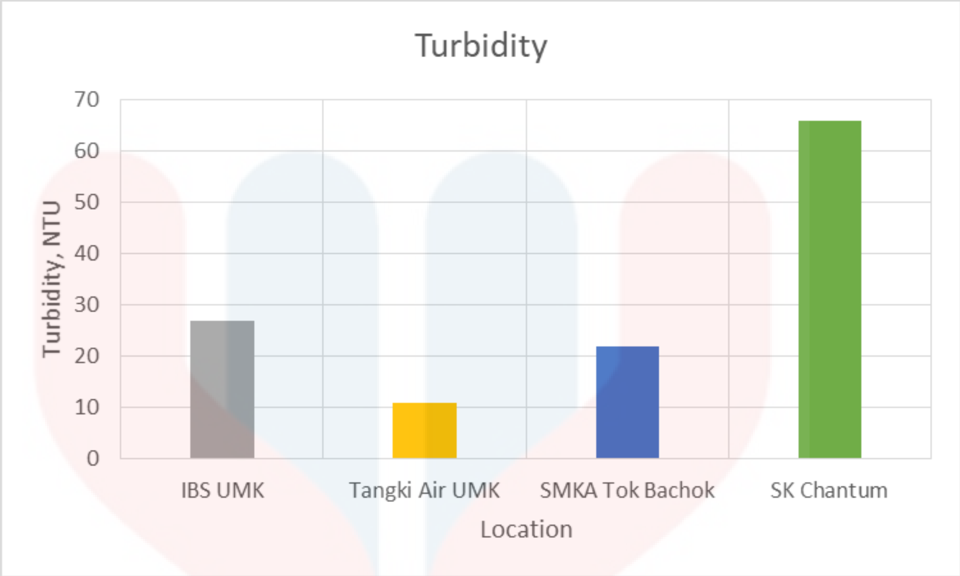

Figure 5.6: Turbidity value of groundwater samples

d. Conductivity

The conductivity is the measure of water capability to pass electrical flow. The conductivity of water is related to the concentration of ions in the water. High conductivity indicated high concentrations of ions. Figure 5.7 below shows the conductivity value of all the groundwater samples. The highest recorded value of conductivity is 1520 at SK Chantum while the lowest recorded value is 75.9 at SMKA Tok Bachok. Based on the table 5.5, only groundwater sample at SK Chantum have conductivity value that exceed the permitted value by MOH and WHO.

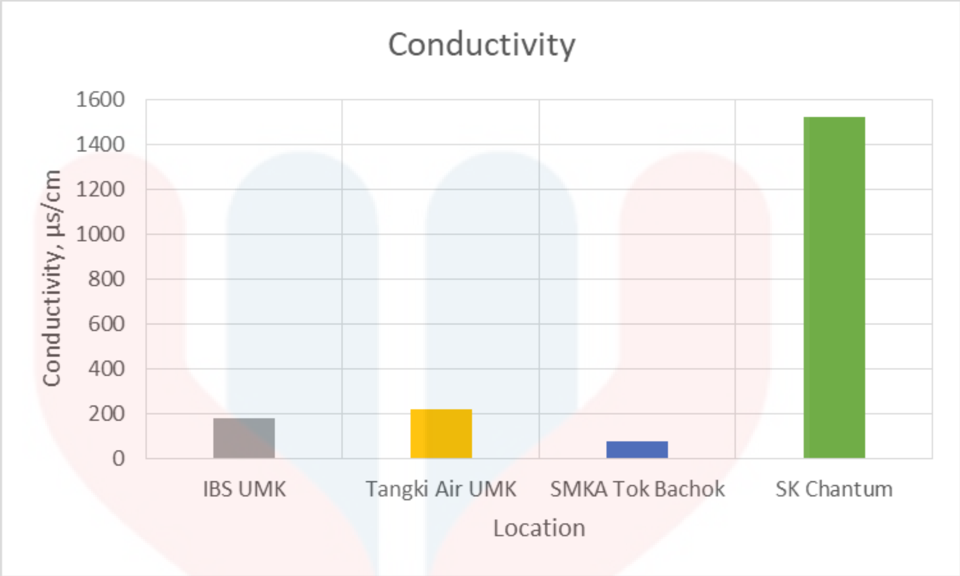

Figure 5.7: Conductivity value of groundwater samples

e. Total Suspended Solids (TSS)

Total Suspended Solids is the measurement of the filterable solids in the groundwater sample. Figure 5.8 shows the value of Total Suspended Solids in the groundwater samples at four different location in Bachok. The highest value of Total Suspended Solids in groundwater samples is 66 mg/l at IBS UMK. Groundwater sample at SMKA Tok Bachok has the lowest Total Suspended Solids which is 14 mg/l. The permitted limit of Total Suspended Solids by WHO and MOH is not more than 50 mg/l. Only groundwater at IBS UMK has the value of Total Dissolved Solids that exceed the permitted limit.

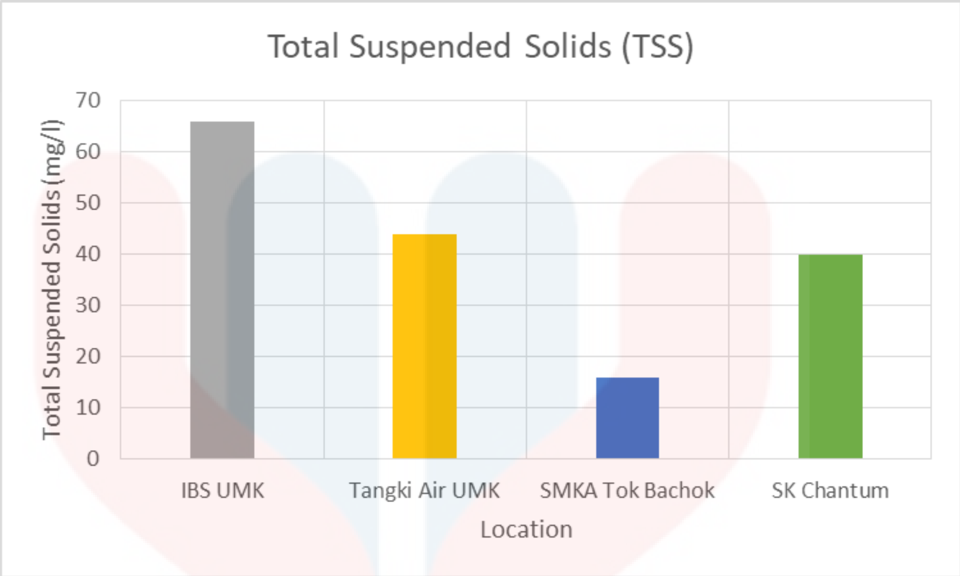

Figure 5.8: Total Suspended Solids of groundwater samples

f. Total Dissolved Solids (TDS)

Total Dissolved Solids is the measurement of organic and inorganic substances that dissolved in a solution. The substances are usually smaller than 2.0 µm. Figure 5.9 shows the value of Total Dissolved Solids in four different sampling location. The groundwater sample at SK Chantum has the highest value of Total Dissolved Solids which is 2188 mg/l. The groundwater sample at SMKA Tok Bachok has the lowest Total Dissolved Solids which is 124 mg/l. Based on table 5.5, only groundwater sample at SK Chantum has the amount of Total Dissolved Solid that exceed amount that permitted by MOH and WHO. The groundwater samples at IBS, Tangki Air and SMKA Tok Bachok are suitable for drinking.

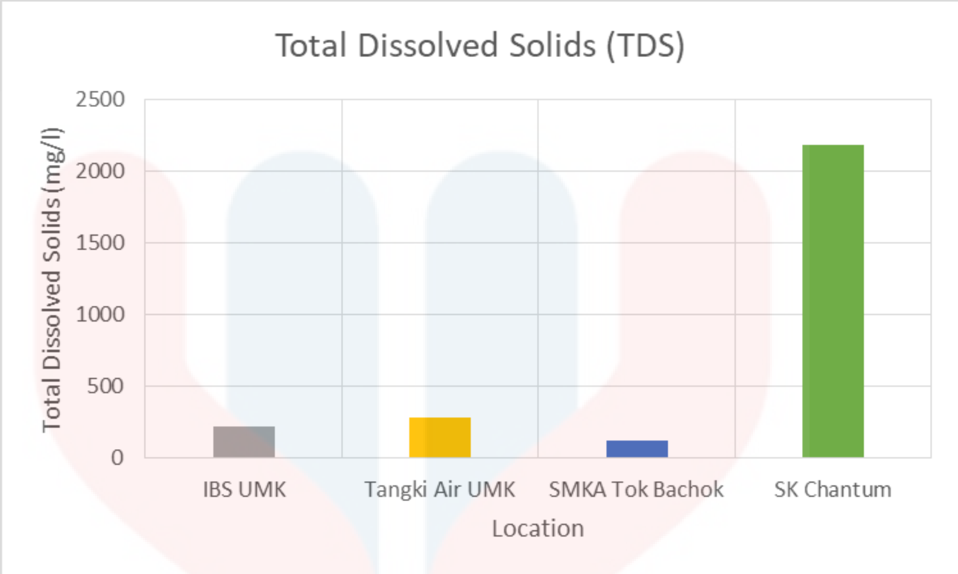

Figure 5.9: Total Dissolved Solids of groundwater samples.

Table 5.6 shows the classification of water based on Total Dissolved Solids (Shahida, Ummatul, 2015). Groundwater sample at IBS, Tangki Air and SMKA Tok Bachok can be categorized as freshwater because the amount of Total Dissolved Solid are less than 1000 mg/l. The groundwater sample at SK Chantum can be categorized as slightly saline water because the amount of Total Dissolved Solids is within 1000 mg/l to 3000 mg/l.

Table 5.6: Classification of water based on Total Dissolved Solids

Categorize	TDS (mg/l)
Freshwater/Non-saline	< 1000
Slightly saline	1000 – 3000
Moderately saline	3000 – 10000
Very saline	>10000

5.4.2 Major anions concentration

a. Chloride

Figure 5.10 shows the concentration of chloride ion in all groundwater sampling location. SK Chantum have the highest concentration of chloride ion which is 680 mg/l. SMKA Tok Bachok have the lowest concentration of chloride which is 8.1 mg/l. The concentration of chloride at IBS UMK and Tangki Air UMK are 48 mg/l and 38 mg/l respectively. The permitted limit concentration of chloride for drinking water supply by MOH and WHO is 250 mg/l. The groundwater samples at SK Chantum is not suitable for drinking water supply because the chloride concentration exceed 250 mg/l. The concentration of chloride at SK Chantum is too high maybe because of anthropogenic process or sea water intrusion. Groundwater at IBS UMK, Tangki Air UMK and SMKA Tok Bachok is suitable for drinking water supply.

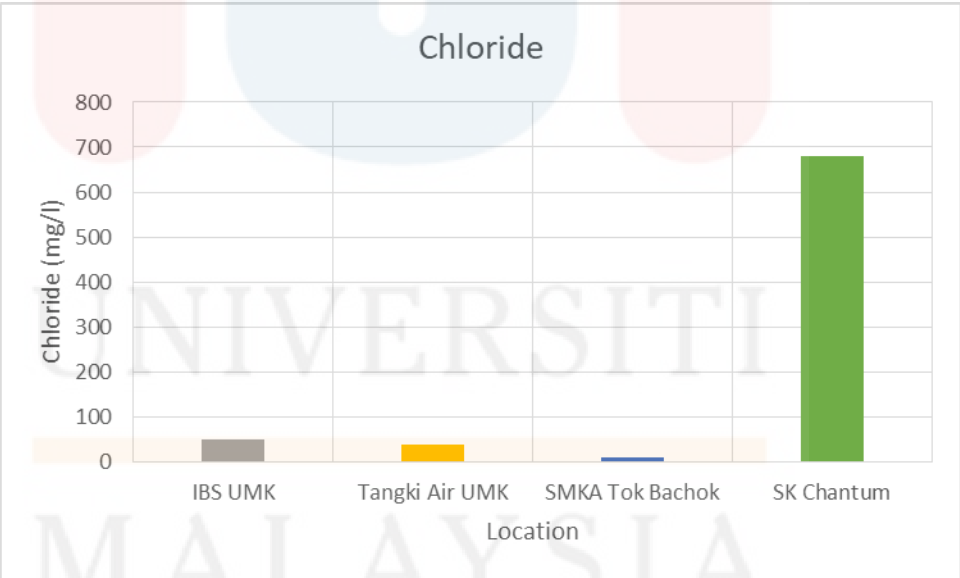

Figure 5.10: Chloride concentration in groundwater sample

b. Fluoride

Figure 5.11 shows the concentration of fluoride in four different location of groundwater samples. Tangki Air UMK has the highest concentration of fluoride which is 0.26 mg/l while IBS UMK has the lowest concentration of fluoride which is 0.18 mg/l. SMKA Tok Bachok and SK Chantum have the same concentration of fluoride which is 0.19 mg/l. All of the groundwater samples have the concentration of fluoride that are below that permitted limit by MOH and WHO which is 0.9 mg/l and 1.5 mg/l respectively.

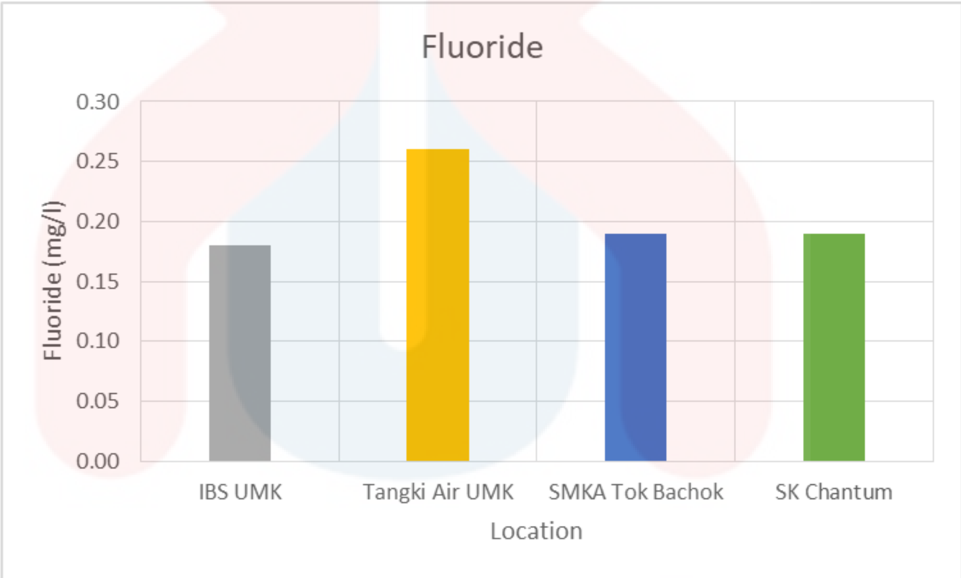

Figure 5.11: Fluoride concentration in groundwater samples

c. Nitrate

Figure 5.12 shows the concentration of nitrate in all groundwater samples at different location. The highest concentration of nitrate is 0.48 mg/l at Tangki Air UMK while the lowest concentration of nitrate is 0.30 mg/l at SK Chantum. The nitrate concentration of all groundwater samples showing a safe level of nitrate based on the limit amount of concentration that are permitted by MOH and WHO which is 10 mg/l and 50mg/l respectively.

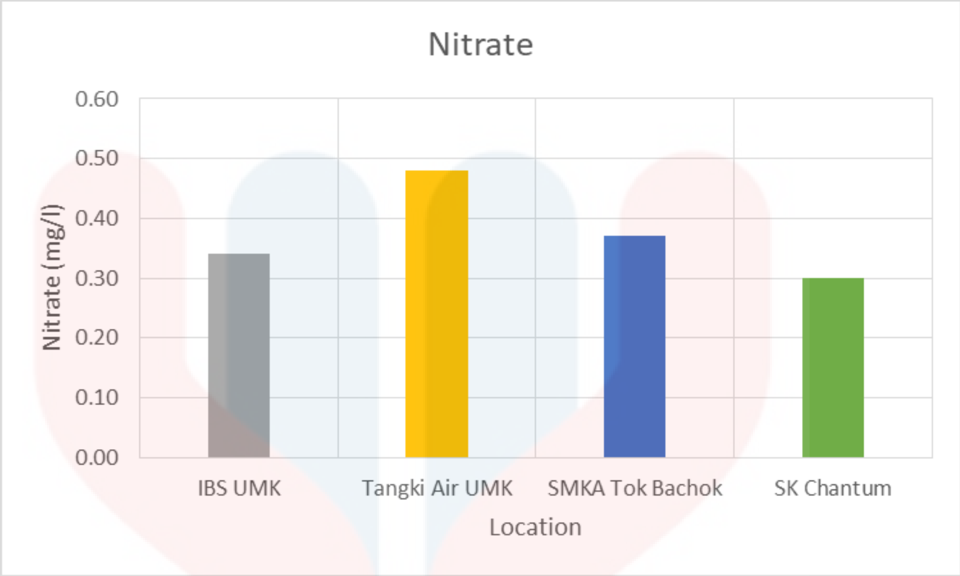

Figure 5.12: Nitrate concentration of groundwater samples

d. Sulphate

Figure 5.13 shows the concentration of sulphate at different location of groundwater samples. The highest concentration of sulphate is 3 mg/l at IBS UMK. The concentration of sulphate at SMKA Tok Bachok and SK Chantum are not detected. The permitted limit of sulphate concentration by MOH and WHO is 250 mg/l.

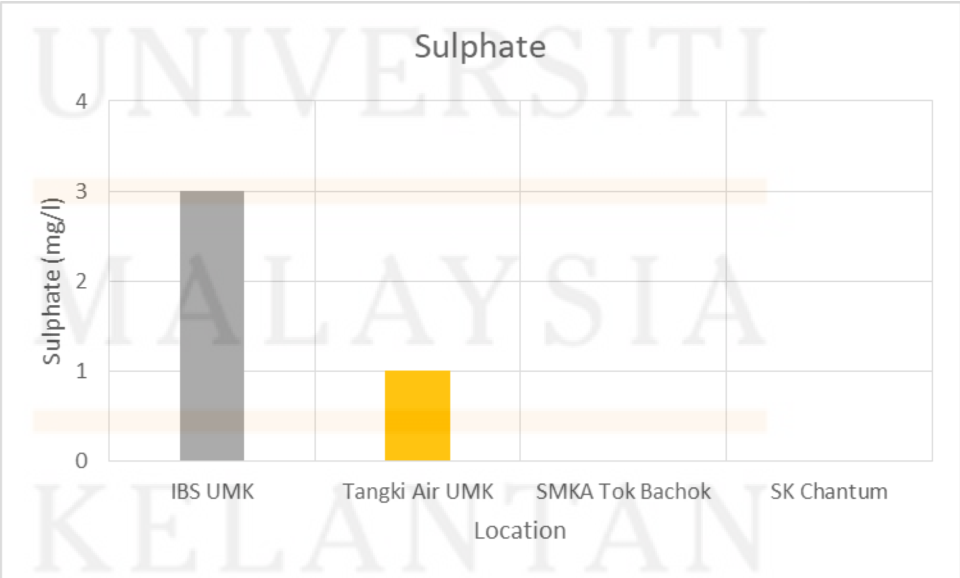

Figure 5.13: Sulphate concentration in groundwater samples

e. Bicarbonate

Figure 5.14 shows the bicarbonate concentration at four groundwater sampling locations. The lowest concentration of bicarbonate is 74 mg/l while the highest concentration of bicarbonate is 271 mg/l. The limit permitted of bicarbonate concentration by WHO is 500 mg/l. So all the bicarbonate concentration of the four different location is within the limit permitted.

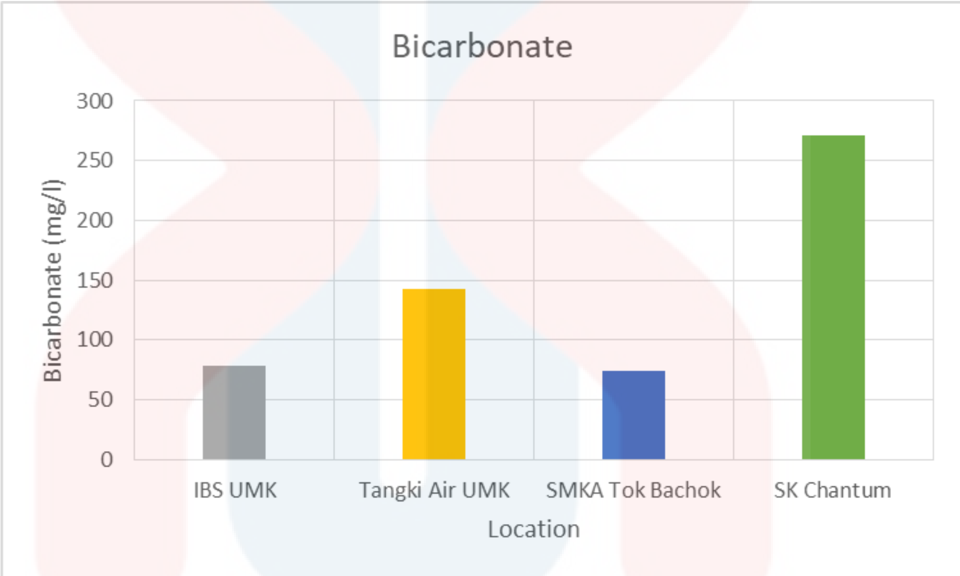

Figure 5.14: Bicarbonate concentration in groundwater samples

5.4.3 Major Cations Concentrations

a. Magnesium

The magnesium concentration of different groundwater samples is shown at Figure 5.15. IBS UMK has the highest concentration of magnesium which is 6.22 mg/l. SMKA Tok Bachok do not has any detected concentration of magnesium. All the groundwater samples have a concentration of magnesium within the permitted limit by MOH and WHO.

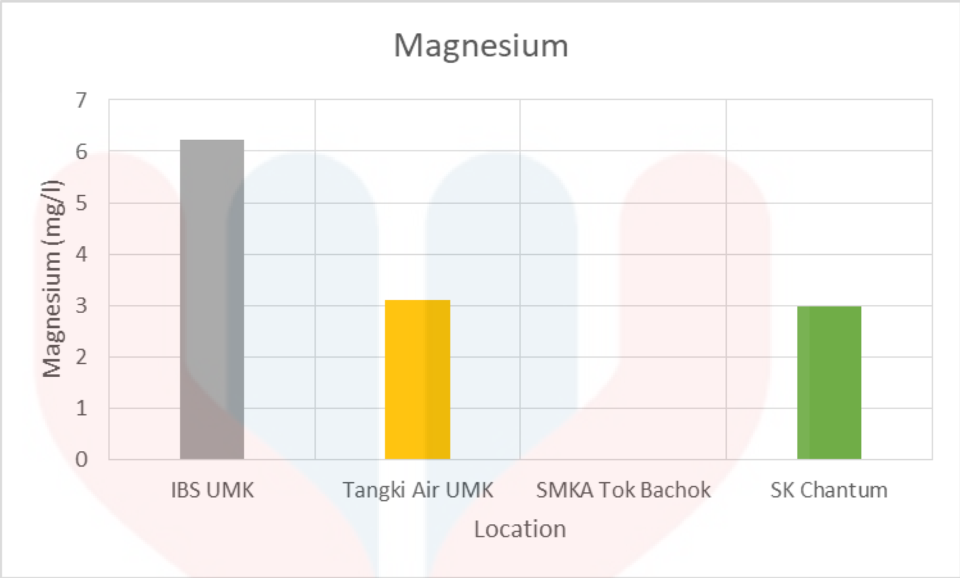

Figure 5.15: Magnesium Concentration in groundwater samples

b. Sodium

Figure 5.16 shows the concentration of sodium in groundwater samples at four different sampling location. SK Chantum do not have any detectable amount of sodium concentration. IBS UMK has the highest concentration of sodium which is 5.69 mg/l. All the groundwater samples has low concentration of sodium than the permitted limit by MOH and WHO which is 200 mg/l.

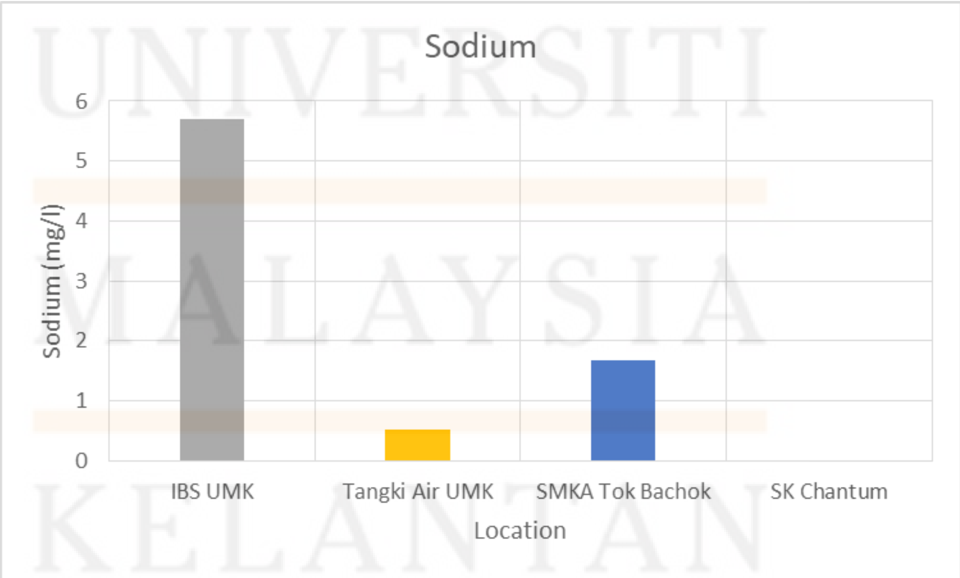

Figure 5.16: Sodium concentration in groundwater samples

c. Potassium

Figure 5.17 shows the different of potassium concentration of groundwater samples at four different location. The highest concentration of potassium is 5.78 mg/l at IBS UMK while the lowest concentration of potassium is 2.76 mg/l at SK Chantum. The permitted limit of potassium concentration by WHO is 200 mg/l, so all the groundwater concentration of sodium is within the permitted limit.

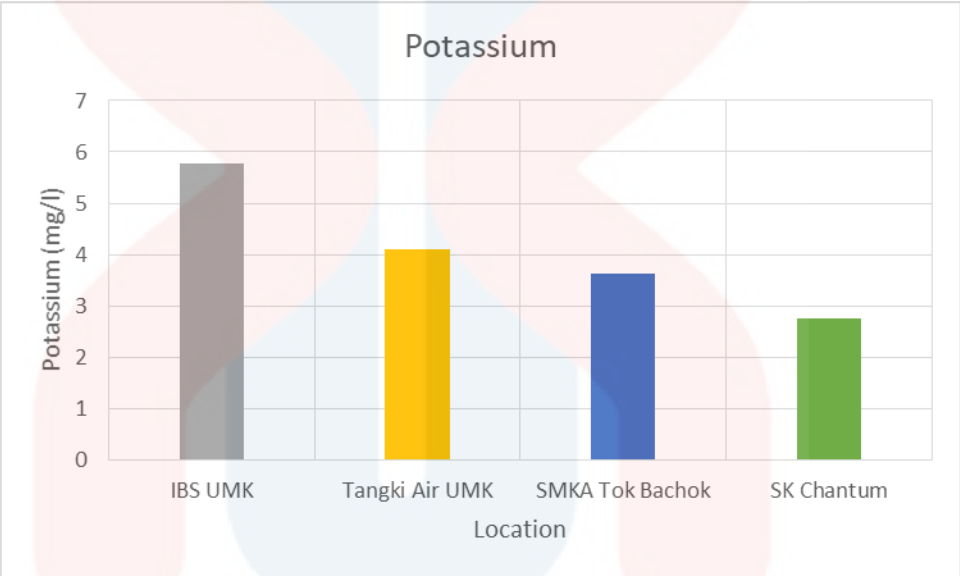

Figure 5.17: Potassium concentration in groundwater samples

d. Calcium

Figure 5.18 shows the concentration of calcium in groundwater samples at four different locations. The highest calcium concentration in groundwater samples at IBS UMK which is 5.81 mg/l. Groundwater sample at Tangki Air UMK has the lowest concentration of sodium which is 0.51 mg/l. The permitted limit by WHO is 200 mg/l, so the groundwater at all locations have concentration of sodium within the permitted limit.

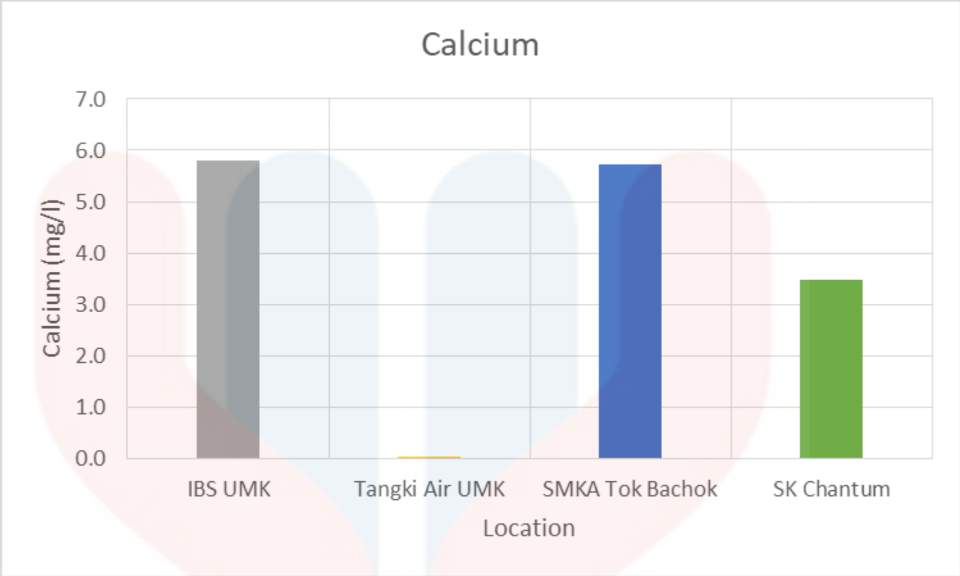

Figure 5.18: Calcium concentration in groundwater samples

e. Iron

Figure 5.19 shows the iron concentration in groundwater samples at different locations. The highest concentration of iron is 1.92 mg/l at Tangki Air UMK and SMKA Tok Bachok. SK Chantum do not have detectable concentration of iron. The permitted limit of iron concentration by MOH and WHO is 0.3 mg/l. The iron concentrations of groundwater samples at Tangki Air UMK and SMKA Tok Bachok are exceed the permitted limit for drinking water supply.

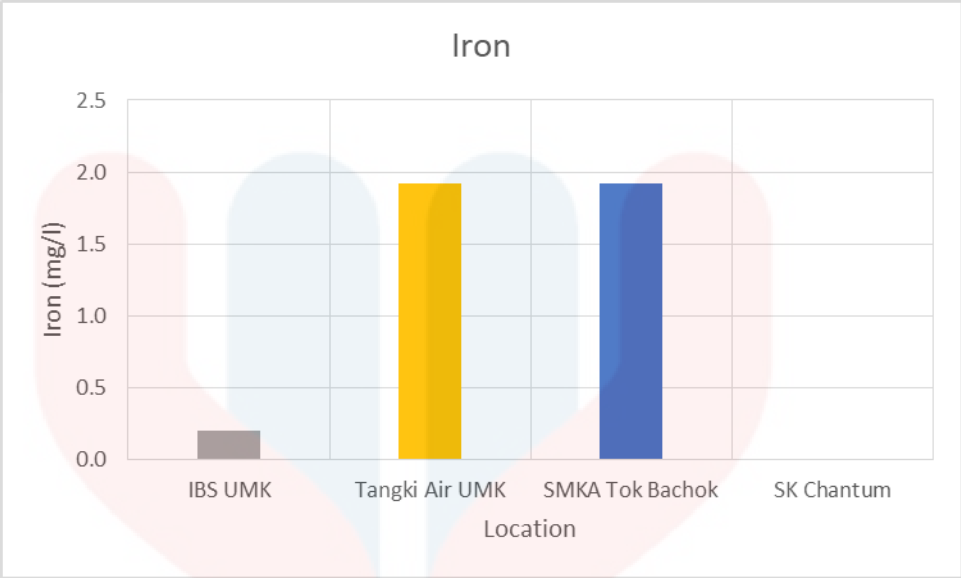

Figure 5.19: Iron concentration in groundwater samples

f. Manganese

The manganese concentration of groundwater samples at different location is shown by Figure 5.20. Only SK Chantum have detectable concentration of manganese in the groundwater samples. IBS UMK, Tangki Air UMK and SMK Tok Bachok does not have detectable manganese concentration. The permitted limit of manganese concentration by MOH and WHO are 0.1 mg/l and 0.4 mg/l respectively. All the groundwater samples are within the permitted limit.

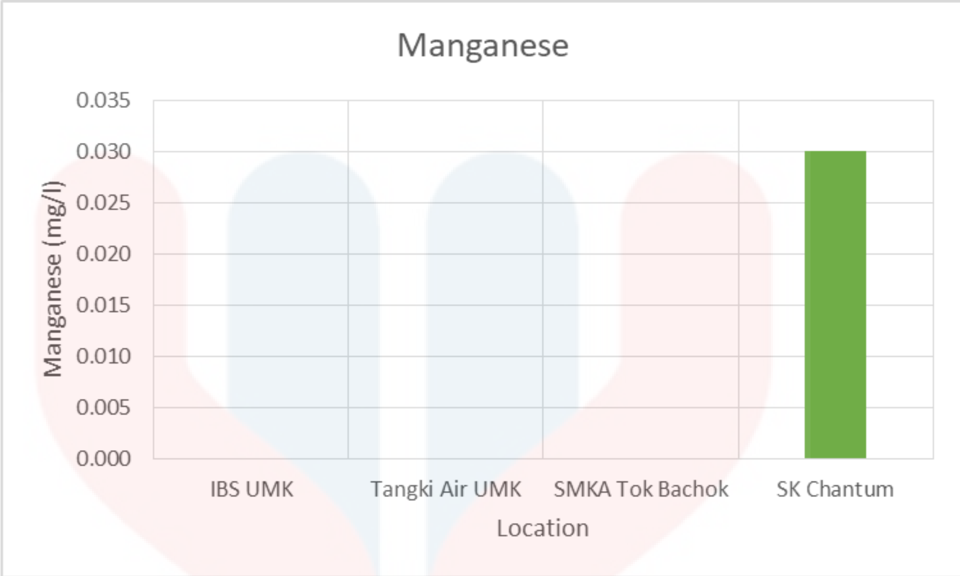

Figure 5.20: Manganese concentration in groundwater samples

5.4.4 Water chemistry analysis

a. Hydrochemical Facies

A piper trilinear diagram is used to show the percentage composition of ions (Fetter, 1988). Mostly all of the natural waters contain cations and anions in chemical equilibrium. The right triangle represent the anions and the left triangle represent cations. The diamond shape is used to summarize the cations and anions triangles. The hydrochemical facies is used to describe the groundwater bodies that have different chemical composition.

Figure 5.21 shows the piper trilinear diagram for groundwater samples at different locations in Bachok. For IBS UMK, the groundwater samples have no dominant cations type and have bicarbonate anions type. The groundwater samples at IBS UMK is a mixed type class. For Tangki Air UMK, the groundwater samples have magnesium cations type and no dominant anions type. The groundwater samples also is a mixed type class. For SMKA Tok Bachok, the groundwater samples have calcium cations type and have bicarbonate anions types. The groundwater samples is a magnesium bicarbonate type class. For SK Chantum, the groundwater samples have no dominant cations type and have chloride anions type. The groundwater samples is a calcium chloride type class.

Table 5.7: The percentage of ion in milliequivalents per liter (meq/l)

Location	Percentage of ion in meq/l (%)					
	Ca	Mg	Na + K	Cl	SO_4	CO_3 + $HC0_3$
IBS UMK	38.66	50.65	68.23	6.20	75.00	13.78
Tangki Air UMK	0.20	25.16	8.50	4.91	25.00	25.27
SMKA Tok Bachok	38.06	0.00	21.43	1.05	0.00	13.07
SK Chantum	23.08	24.19	1.84	87.84	0.00	47.88

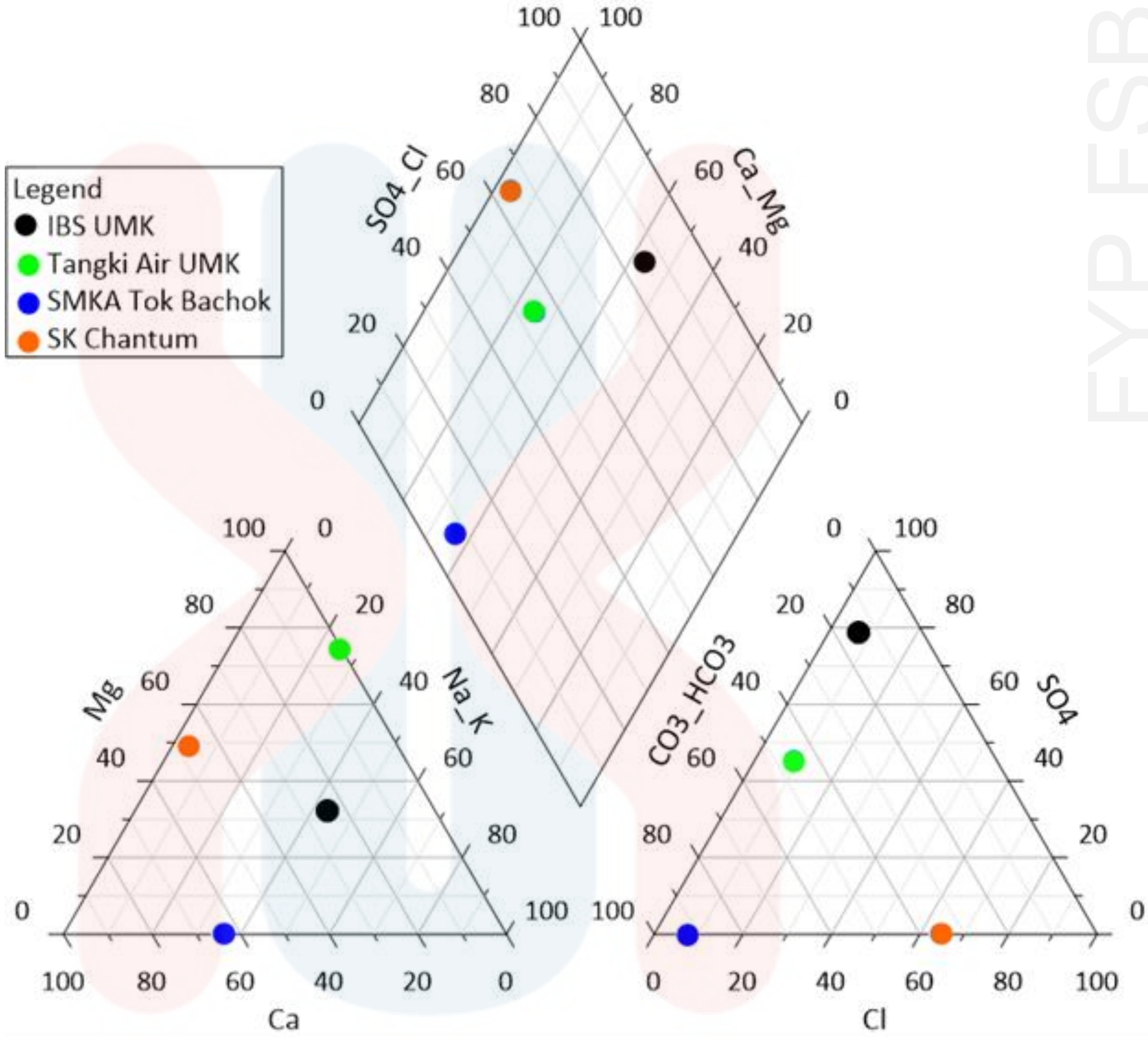

Figure 5.21: Piper trilinear diagram for groundwater samples at different location.

b. Stiff diagram

Stiff diagram is a polygonal shape diagram that created using four or three parallel horizontal axes that is extending on the vertical axis. This graphical presentation of chemical analyses is used to show major ions composition of water and its concentration. It also can be used to make a comparison of water from different sources. The larger the polygonal shape area, the greater the major ions concentration.

Figure 5.22 shows the stiff diagram for all groundwater samples from IBS UMK, Tangki Air UMK, SMKA Tok Bachok and SK Chantum. From the stiff diagram, SK

Chantum has the highest concentration of major ions because SK Chantum stiff diagram have the largest area of polygonal shape. SMKA Tok Bachok has the lowest concentration of major ions as it has the smallest area of the polygonal shape. The different in concentration of major ions in groundwater samples can be seen clearly using all four stiff diagram in Figure 5.21.

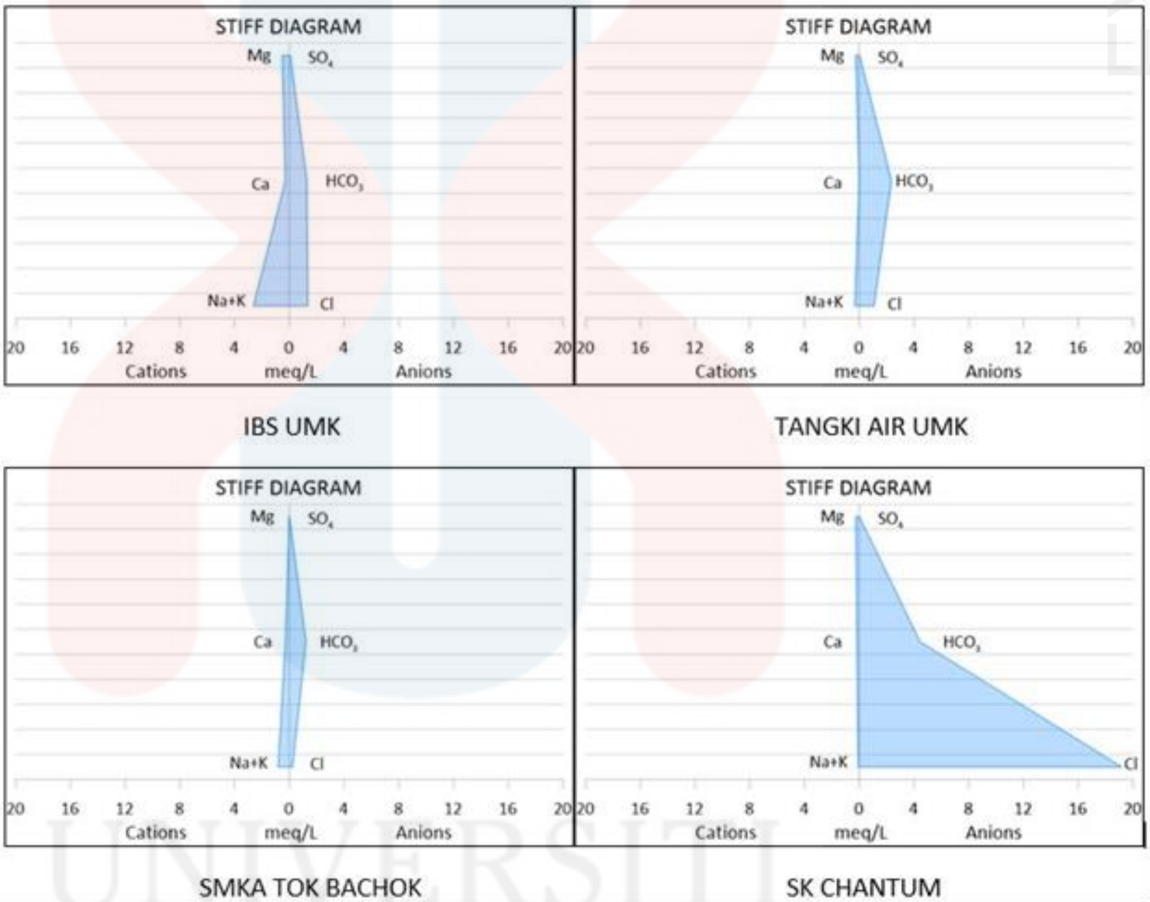

Figure 5.22: Stiff diagram for all groundwater samples at different location

5.4 Discussion

Based on results and analysis of the groundwater samples, the water quality of each location was interpreted. All the wells have good quality water except SK Cantum. The groundwater at IBS UMK have good quality water and can be used for domestic usage. However, the water must be treat carefully because the turbidity and Total dissolved solids concentration are exceed the limit by WHO and MOH. The water can be treated using setting and decanting method.

The groundwater at Tangki Air UMK and SMKA Tok Bachok also has good quality of water and can be used for domestic usage except drinking. The groundwater at both locations have turbidity and iron concentration that exceed the limit by WHO and MOH. The high turbidity can be solve using setting and decanting method. The high iron concentration can be solve using aeration which injecting air followed by filtration. After carefully treat, the water can be used as water drinking supply. Based on the concentration of Total Dissolved Solids, the groundwater at IBS UMK, Tangki Air UMK and SMKA Tok Bachok are classify as fresh water.

The groundwater at SK Chantum have a low quality of water. The groundwater at SK Chantum is considered as slightly saline water because it has Total Dissolved Solids value within 1000 mg/l to 3000 mg/l. The groundwater also have high concentration of chloride. This also indicate that the water maybe has intrusion of seawater. The location of the well at SK Chantum is near a river that flows towards the sea. This can be a reason for the water in the well to be intrude by seawater. The high concentration of Total Dissolved Solids and chloride can be reduce using reverse osmosis method. Reverse osmosis also can reduce the high conductivity value of the groundwater at SK Chantum.

CHAPTER 6

CONCLUSION AND RECOMMENDATION

6.1 Conclusion

In the nutshell, Kampung Sungai Tupai which is the study area are covered by limestone, tuff, slate, sandstone and alluvium. All these rock except alluvium are from Gua Musang Formation. The age of the rocks are Palaeozoic. The topographic units of this study area are hilly and mountains. Dendritic and trellis of drainage pattern are identified in the study area.

For the specification research in Bachok, the groundwater at IBS UMK, Tangki Air UMK and SMKA Tok Bachok has good water quality. Most of the parameters value of the locations are within the value permitted by WHO and MOH. The water at these locations are classify as fresh water based on the concentration of Total Dissolved Solids (TDS). The groundwater at SK Chantum has a slightly low quality water. This is because the groundwater has high concentration of chloride and TDS. The water at SK Chantum is classify as slightly saline water.

From the interpretation of the groundwater quality parameters of all well, there are few findings that can be highlighted in this research. The high value of TDS in SK Chantum was one of the findings. This high value of TDS maybe caused by the seawater intrusion. Although all the well have almost the same distance from shoreline, only well at SK Chantum have significantly high concentration of TDS. The seawater intrusion maybe not caused directly from the sea, but caused by the river that are near SK Chantum. The river maybe become the source of seawater intrusion because it is connected to the sea. The depth of the well maybe can become one of the source for the seawater intrusion too. Well at SK Chantum have the lowest depth compared to others well. The high amount of chloride in well at SK Chantum also can be indicator for the presence of the seawater intrusion. Only SK Chantum have significantly higher concentration of chloride compared to other well.

6.2 Recommendation

This research can be improved significantly if the fieldwork is allowed. If the fieldwork is allowed, more accurate data can be acquired and the result can be improved. For general geology part, mapping is very important for determining the exact rock units in study area. Thin section from rock sample must be made to get the composition of the rock mineral. This will help for determine the rock type in study area.

The groundwater quality of all four locations have been assess according to WHO and MOH parameters. Water samples from three locations shows good quality of water while water samples from one location shows a slightly low quality of water. All of this groundwater source must be protected against pollution to ensure the quality of groundwater does not decreased. The groundwater quality must be monitoring.

There are two activities that can be done for monitoring this groundwater quality in all location. First, planning a groundwater monitoring program. The purposes are to determine the water quality and chemistry of a specific water supply well, to determine the extent of groundwater contamination from a known source and to monitor a potential source of contamination. There are 6 steps for prepare the groundwater monitoring plan (Todd, 1976). Step 1 is understand hydrogeological setting. Step 2 is evaluate background conditions. Step 3 is design groundwater monitoring system. Step 4 is establish sampling and analysis. Step 5 is establish data evaluation methods. Step 6 is develop response criteria.

The second activity for monitoring groundwater quality is installing groundwater monitoring wells. Groundwater monitoring wells are installed for the specific purpose of determining the quality for the groundwater quality in the aquifer and at the location. There are 4 specific steps must be taken to properly install a groundwater monitoring well (Fetter, 1998). First, the boring is advanced into the ground by means of drilling rig. The drilling methods need to be selected based on the local geology, size and depth of the monitoring well to be installed. Second, samples of the geologic are collected to make a geologic log. Third, once the auger is at the desired final depth of the bottom of the monitoring well, the plug at the end is removed. Lastly, the well consist of a casing and a screen. The purpose of the screen is to allow water to enter the well but in the same time it keep out the soil.

The two activities mentioned above can be used for monitoring the water quality in the well. The groundwater well in all location must be continuously monitor in order to ensure the water quality is always good. This can help the people who are using it will always get a good resource of water.

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