GEOLOGY AND GROUNDWATER QUALITY STUDIES OF DOMESTIC WELL AT TANAH MERAH, KELANTAN

by

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ABSTRACT

Groundwater is one of the alternative source during the dry season or during flood season. To fulfil the demand of the groundwater sources, the water quality is one of the important factor that should be measure. The contaminated groundwater can cause adverse effect to humans. Domestic well water sample is collected from 15 well located at different locations covering the area of study area in Tanah Merah town. The well water samples is analyzed for their physico-chemical parameter. This physical parameter such as water level, temperature, pH, Electrical Conductivity (EC), Turbidity, Total Dissolved Solids (TDS), and Total Suspended Solids (TSS) is measured by using some intruments such as Multiparameter probe, Portable TSS probe, portable Turbidimeter and dip meter. The chemical parameter such as hardness, Calcium, Magnesium, Ferum, Potasssium,Sodium, Bicarbonates, Sulphate, Nitrate, Chloride, Silica, and Fluoride is measured in laboratory by using the Atomic Absorption Spectroscopy (AAS), titration method and also gravimetric method. The hydrochemical facies of the well water at the study area is determined by using piper diagram.The result of the analysis is compared with the standardize value by World Health Organization (WHO) and Ministry of Health (MoH). Water Quality Index (WQI) is also applied to identify the overall water quality at Tanah Merah. From the analysis carried on these sample, 8 well out of 15 well is contaminated and the WQI result stated the overall well water is in poor quality status. From the piper diagram, the dominant group is bicarbonate-sodium-potassium.There is two types of rock at study area, which is sedimentary rock and volcanic igneous rock. The volcanic igneous rocks consist of andesite and tuff.

ABSTRAK

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Air bawah tanah merupakan sumber alternatif ketika musim kemarau atau musim banjir. Bagi memenuhi syarat sebagai sumber air bawah tanah, kualiti air adalah salah satu faktor yang penting untuk di ukur. Air bawah tanah yang telah tercemar akan mendatangkan kesan yang boleh memudaratkan bagi manusia. Sampel air di ambil dari 15 telaga dari kawasan yang berbeza dan masih berada di dalam kawasan kajian; Bandar Tanah Merah. Sampel air yang di ambil dianalisa bagi bacaan physico-chemical. Parameter fizikal yang diambil adalah seperti suhu air, nilai pH air, kekonduksian elektrik (EC), paras air, kekeruhan, jumlah pepejal larut (TDS) dan jumlah pepejal terampai (TSS) yang diukur menggunakan alat – alat yang tertentu seperti siasatan multiparameter, siasatan mudah alih TSS, siasatan turbidimeter, dan meter berenang. Bagi parameter kimia, kekerasan, Kalsium, Magnesium, Ferum, Potasium, Sodium, Bikarbonat, Sulfat, Nitrat, Klorida, Florida dan Silika, dikaji di dalam makmal menggunakan spektroskopi penyerapan atom (AAS), kaedah pentitratan dan kaedah gravimetric. Fasies Hidrokimia telaga di kawasan kajian, ditentukan menggunakan rajah piper. Keputusan daripada analisa tersebut dibandingkan dengan nilai yang telah ditetapkan oleh Organisasi Kesuhatan Dunia (WHO) dan Kementerian Kesihatan (MoH). Indeks Kualiti Air (WQI) turut dilaksanakan untuk mengenalpasti kesemua kualiti air di Tanah Merah. Daripada analisa yang dilakukan, 8 daripada 15 telaga telah tercemar dan WQI menunjukkan keseluruhan air telaga berada dalam keadaan yang tidak bagus. Daripada rajah piper, kumpulan dominan ialah bikarbonat-sodium-potasium. Terdapat dua jenis batuan yang berada dia kawasan kajian iaitu dari kumpulan batuan enapan dan batuan igneus gunung berapi. Batuan igneus gunung berapi tersebut terdiri daripada andesit dan tuff.

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LIST OF ABBREVIATION

AAS	Atomic Absorption Spectroscopy
EC	Electrical Conductivity
GPS	Global Positioning System
MoH	Ministry of Health
TSS	Total Suspended Solids
TDS	Total Dissolved Solids
WHO	World Health Organization
WQI	Water Quality Index
Ca	Calcium (Ca^{2+})
Fe	Ferum (Fe)
Na	Sodium (Na^{+})
Mg	Magnesium (Mg^{2+})
K	Potassium (K^{+})

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CHAPTER 1

INTRODUCTION

1.1 General Background

The general geology of Tanah Merah is always changed due to development activity and also due to involvement of geological process that caused changes in the earth surface. The earth movement caused the occurrence of geological structure such as folding, fracture, and faulting on the earth surface and subsurface. This study also covered the geomorphology and type of outcrop distribution on the study area.

This research study entitled is “Geological and the groundwater quality studies in domestic wells at Tanah, Merah, Kelantan”. Groundwater is the natural resources that have been utilized by the human for the use in everyday life (Thamer, 2009). Groundwater provides daily usage for urban and rural communities, support agriculture irrigation, rural industries, maintain ecosystems, sustains the flow of rivers and streams by discharging the groundwater into the river. (Islami, 2015). Groundwater quality studies involve the aspect physical, chemical and biological characteristic. The physical characteristic include the water pH, temperature, electric conductivity, Total Dissolve Solid (TDS), turbidity, water salinity, color, taste and also water odor. The physico-chemical characteristic of groundwater reflect the input from the atmosphere, soil and water-rock reactions as well as pollutant sources such as mining, land clearance, agriculture, acid precipitation, domestic and industrial waste (Appelo and Postma, 1993). The groundwater pollution and management is the crucial issues that should be taken into serious measure. The pollution of groundwater can affect the exploitation and limit the usage of groundwater.

Malaysia is blessed with the extensive amount of groundwater. There is no serious issues of water shortage except during the seasonal weather change that can caused drought to some area. In Malaysia, Kelantan and Perlis state fully utilized the groundwater for public water supply. The others state, such as Terengganu, Pahang, Sarawak and Sabah dominantly use surface water and also small amount of groundwater as a water supply system. In Kelantan, about 70% of the total water supply in the state is derived from groundwater, primarily in Kota Bharu areas and also at Pasir Mas, Pasir Putih, Tanah Merah and Kuala Krai (Thamer, 2009). In north Kelantan area the groundwater is fully exploit by the rural area communities for their daily usage. The groundwater sources are obtain from the shallow aquifer area, they build a conventional wells that are less than 10 m deep to withdraw the groundwater (Islami, 2015). Since the groundwater is the main water resources for the communities, thus the groundwater drainage must be preciously preserve from any possible contamination. This is because, groundwater are very vulnerable to pollution, the polluted water restricted the consumption and usage of the water. Therefore, this study is carry out to analyze the groundwater quality of the domestic wells to ensure that the water are free from pollution and safe for consumption. This present the study about the vulnerability of the groundwater towards any possible sources of contamination.

1.2 Problem Statement

The geological process and development activity can cause changes to the earth surface. The development activty such as road connection, railways, plantation and others can contribute to the changes. The topographic map are not updated with the latest development of the area. Due to these reason, the geological mapping are carry out to re-update the current topography and geomorphology of the study area.

Generally groundwater is prone to the contamination, in rural area the usage of groundwater is fully utilized by the communities but they do not give any attention on the issues of groundwater management and groundwater quality. The contaminated groundwater that is used for drinking can cause health problem humans. Therefore groundwater quality assessment analysis of the domestic well must be carry out to ensure the water is safe for drinking or not and follow the standard Ministry of Health Malaysia (MOH) and World Health organization (WHO). The communities of Tanah Merah area consume the groundwater sources for drinking purpose and for domestic used in daily life. If the water quality of the groundwater are not taken into serious measure by the community, it can cause a health problem to the consumers in the future.

Physico-chemical parameter of groundwater is important factor that reflect the composition of the groundwater. The Groundwater quality standard outline by WHO and MoH and also by Water Quality Index (WQI) calculation give help to determine the status of groundwater quality.

Groundwater quality of an area is influenced by its surrounding environment. Especially for any surface water presence at its surrounding. Surface water bodies commonly mixing with groundwater and it is more prone to contamination compare to groundwater. Groundwater especially in shallow aquifer usually have contact with surface water bodies. The contact between these two water bodies cause changes of the groundwater facies. By using Piper Trilinear diagram, the type of groundwater facies can be determine. The groundwater facies can indicate the mixing of the water bodies and determine the type of groundwater based on the major cation and anions.

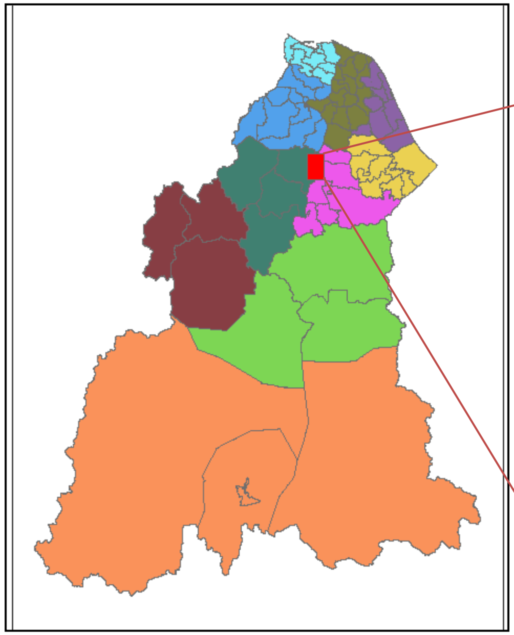
1.3 Research Objectives

The objectives of this research are as follow:

i. To produce an updated geological map of the study area at scale 1:25000.
ii. To analyze physico chemical parameter of domestic groundwater wells.
iii. To determined the suitability of domestic wells water for drinking purpose.

1.4 Study Area

The study area is located at Tanah Merah town. This study area is lies between longitude 102°8'20''E to 102°10'30''E, and latitude are 5°48'18''N to 5°53'10''N . Study area covered approximately 40km^2 The north of study area is suroounded by Pasir Mas district and the east covered by Machang district. Sungai Kelantan, is passing through toward north direction at the center of the study area. The south east direction of the study area is the Kuala Krai district and the south west direction is bordered by Jeli district. West part of the study area is the direction to Thailand. In the study area, the south part is covered by the center of Tanah Merah town. Most of the rural population is concentrated at the upper part of the study area. Right above the study area at the north direction is the location of Bukit Panau. The basemap of study area shown in the figure 1.1 be



Map of Kelantan

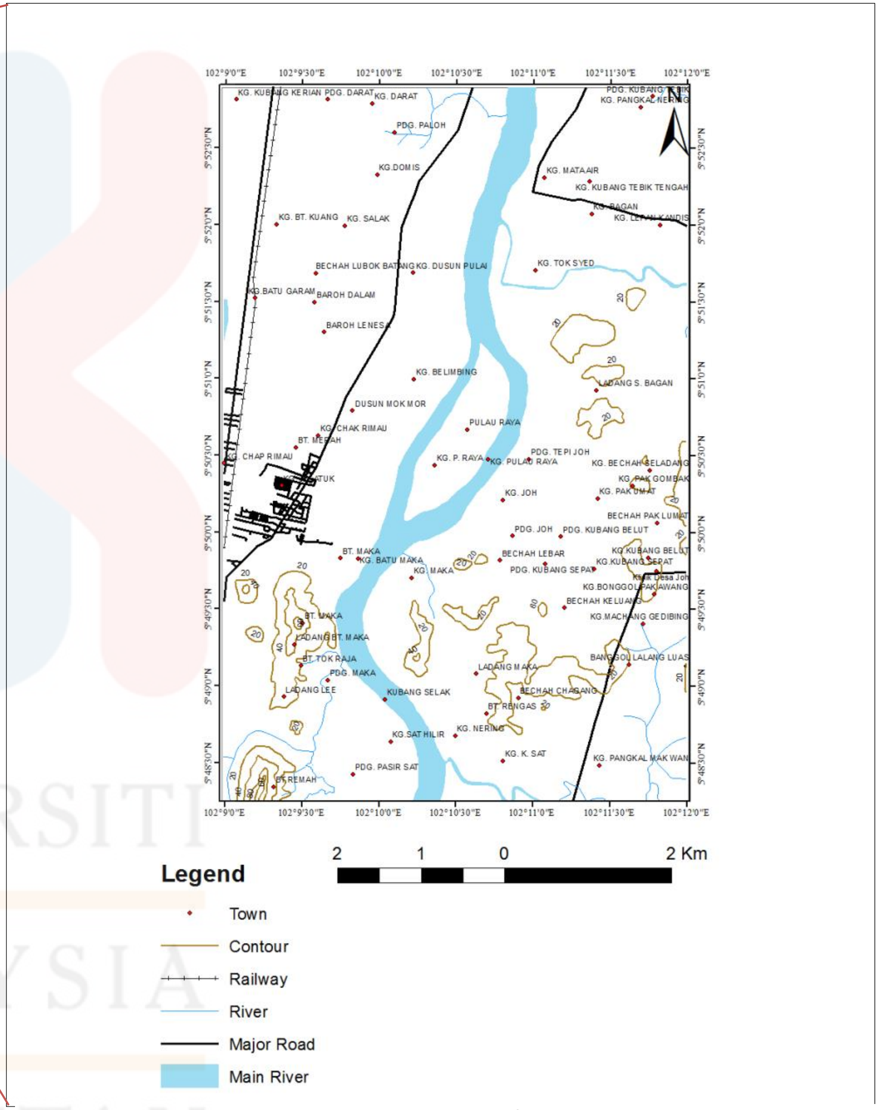


Figure 1.1: Base map of study area

1.4.1 Demography

a) People Distribution

According to the District Council of Tanah Merah, the most recent data showed the total population in the year 2010 is 115949 people. The population data was gained through the census survey of the community done by the Tanah Merah district. From the census survey more detail data that differentiate the community according to race is listed in the figure 1.2 below.

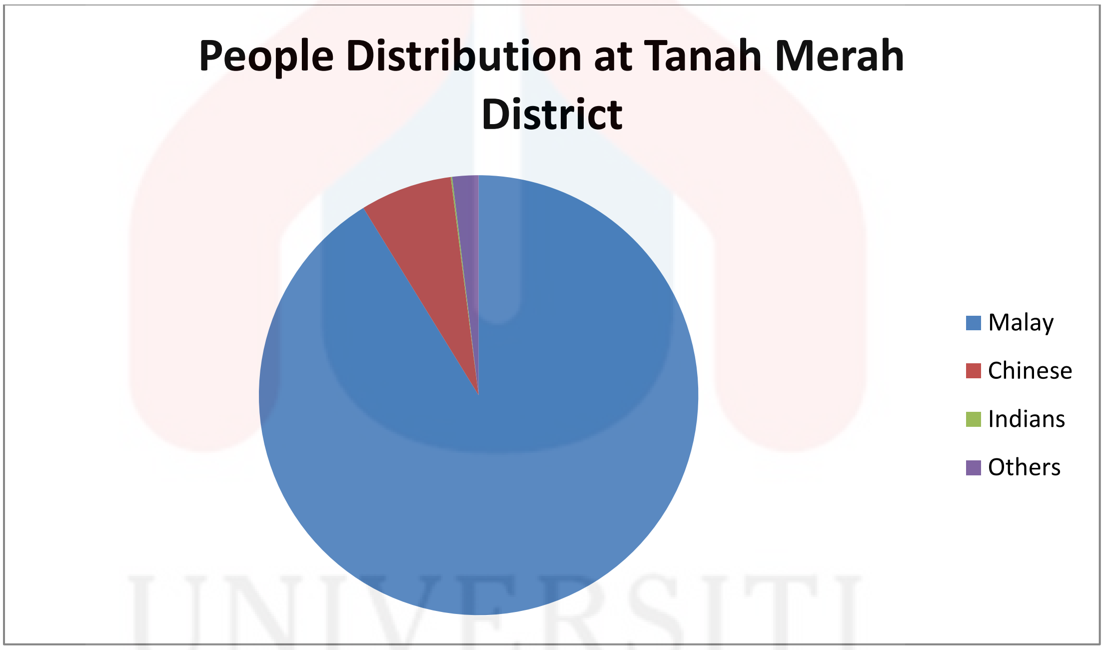


Figure 1.2: The Census Survey of Tanah Merah District, source from http://www.mdtanahmerah.gov.my/

From the pie chart in figure 1.2 shown that the Tanah Merah district is dominated by Malay community, and the community is highly populated at the area of Tanah Merah town.The community usually centered to the city due to the easy access to any facilities and work centered.

1.4.2 Rain Distribution

Total rain distribution at the study area is obtained from the January to November in the year 2015. Based on figure 1.3, the highest rainfall is recorded in month January in the year 2015.The highest rainfall at the early of the year is due to the moonson season. Monsoon season in Malaysia occurred from the October until March. The monsoon season highly affect the east part of peninsular Malaysia, which is Kelantan, Terengganu and Pahang. During the moonson season, the rainfall and river water level is frequenly monitored for the flood warning. The heavy rainfall usually occurred during the monsoon season and the rainfall can be continuos for somme extend of time.

As for the month April until September, the rainfall distribution is average. From April until September is the post-monsoon season, where the rainfall precipitation is lower than during the monsoon season. During this season, the rainfall precipitation is usually low until moderate.

The rainfall precipitation is one of the main factor that influenced the groundwater quality. The atmosphere air usually contain various type of gases such as gas from vehicle, factory, Carbon Dioxide, Nitrogen oxide, Sulphur Dioxide and many other type of gases. The rainfall precipitation dissolve the composition presence in the air. The high composition of Sulphur dioxide and Nitrogen dioxide release into the air making the rainfall become more acidic. The acidic rainfall will fall into the ground and infiltrate into the subsurface and reaching the water table. Thus contaminate the groundwater, the acidity of groundwater increase.

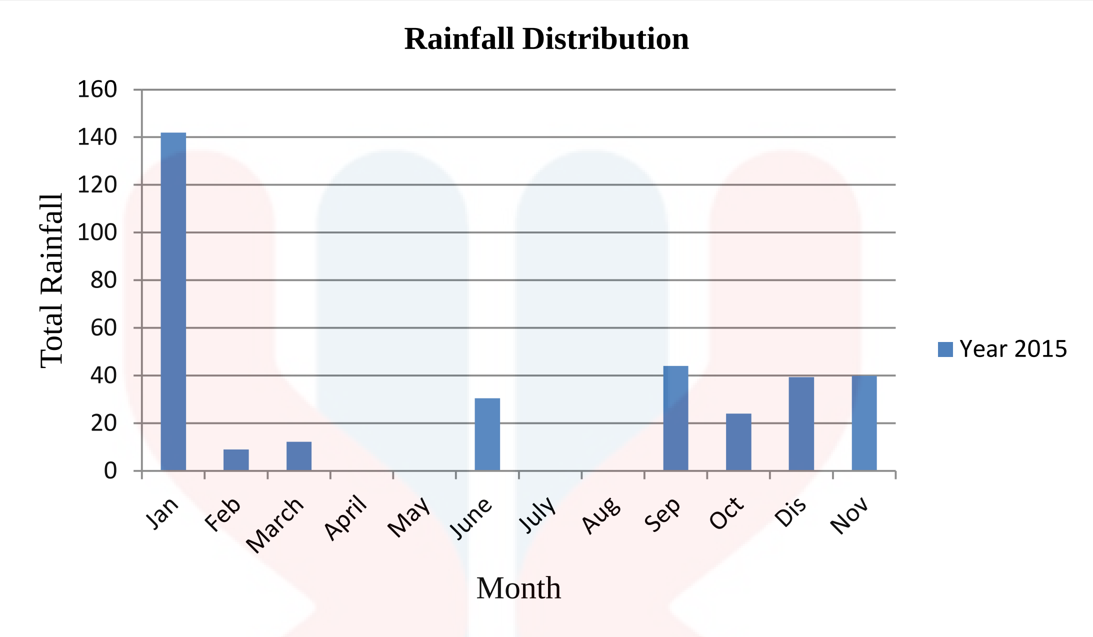


Figure 1.3: Rainfall distribution for the year 2015 (source: Department of Irrigation and Drainage Malaysia, 2016)

1.4.3 Landuse

The landuse in the district of TanahMerah is dominated by plantation activity and industrial activity. The major type of plantation in the area are rubber plantation and oil palm plantation. The rural communities also use their lands for vegetables and fruits plantation. Beside than plantation, another dominant landuse are the residential area, industrial area, town area and school area. A part at the west direction of the study is a quarry mine area. At the industrial area, there some factory presence such as timber factory, ice cube factory, wire factory, and steel factory. At the center of Tanah Merah town, there are some part of the area consist of government building, market, supermarket and others type of business.

1.4.4 Social Economic

The main social economic that generate the major income for the community in the district of Tanah Merah are from the plantation activity, business activity, industrial activity and others activity. Usually the plantation activity are done by the rural area population. The business activity and industrial activity are mostly concentrated at the center of Tanah Merah town. The factory is a part of major business operating at Tanah Merah town that are also contributed to the social economic of Tanah Merah. Since the Tanah Merah town is a high developed area compared to the surrounding area, therefore the community from the rural area such as Jeli, Ayer Lanas, Gual Ipoh, Kusial and others rural area always head to the Tanah Merah town for any purposes. This is also lead to the increase income of Tanah Merah community and indirectly generate the economy of the district.

1.4.5 Road Connection

The road connection in the study area is well connected. From Jeli district to Tanah Merah district followed the East-West Federal Highway. While from Tanah Merah district to Pasir Mas district is through Pasir Mas – Tanah Merah Street. Most of the road whether the main road or the arterial road are well paved. But at certain villages that are far distance from the town, the road are unpaved. This is because the villages located at the low developed area, and the villagers are in small amount due to the small size of the villages.The road connection map can be seen in figure 1.4.

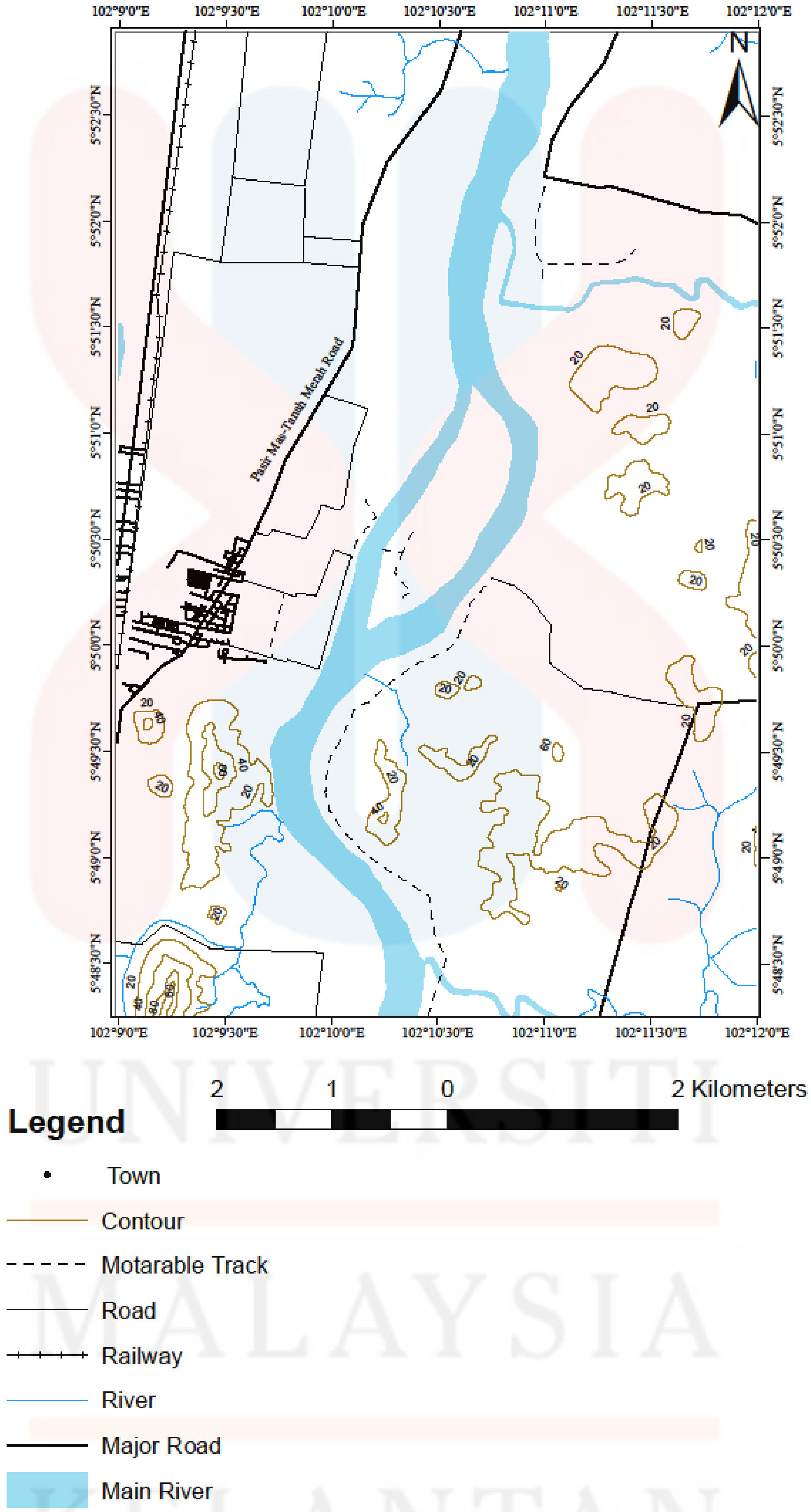


Figure 1.4: Road Connection in study area

1.5 Scope of Study

This study involved the town area of Tanah Merah district and some village surrounded Tanah Merah area. The east part of study area also include a part of Machang district. The groundwater sample for water quality studies is taken from the domestic wells that covered every part in the study area. The general geology of the area included the study of the geomorphology, lithology, stratigraphy and structural geology that presence in the study area. The geomorphology is one of the sub field under the general geology, the geomorphology include the drainage pattern, landform and weathering proess that taken place within the study area.

The groundwater quality analysis is the specification of the study. The groundwater analysis is done by measuring the physical and chemical parameter of the water sample. The chemical parameter include the analysis of major ctions and major anions. The result from the analysis is used in the data processing by using piper diagram and water quality index analysis. The result of groundwater sample analysis is compare with the standardize limit by WHO and MOH standard to determine the water quality.

1.6 Research Importance

This research study is carry out to reupdate geological map of Tanah Merah. Any changes of geomorphology due to natural processes and human activity at the study area can be reupdated in the geological map.

Another significant of the study is to know its quality studies of groundwater of domestic well and to determine whether the groundwater from the well is suitable for domestic purpose especially for drinking. The groundwater analysis can determine whether the groundwater is in good quality for consumption or vice versa. This study determine the status of the groundwater quality. Moreover, the research study will be very helpful in decision making before starting any project. This rsearch will fulfill the gap between the previos study. Therefore the research study can be helpful for future research.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In this chapter, the topic that will be discussed is about the general geology and also about the groundwater. The general geology will include the regional and tectonic setting, historical geology, lithostratigraphy, geomorphology, and structural geology. This chapter also focusing on the subtopic of groundwater such as, hydrological cycle, the type of aquifer, and groundwater quality parameter.

2.2 Regional Geology and Tectonic Setting

Peninsular Malaysia is subdivided into three types of belt, which is Western belt, Central belt and Eastern belt. These three type of belt is very distinctive it their stratigraphy. Kelantan state is located within the Central belt and Eastern belt. The Central belt stretches from Kelantan to Johor, the western part of the Central belt are upper Paleozoic rocks of the Gua Musang and Aring formation in south Kelantan and also Taku Schist in east Kelantan (Hutchison and Tan, 2009).

In Peninsular Malaysia, there are several major fault zones that occurred in some part of the state in Peninsular. As for Kelantan, there is Bentong-Raub Suture zone that can be seen along Gua Musang to Cameron, Lebir fault zone along Sg. Lebir near Manek Urai in Kelantan and another major fault zone are the Galas fault zone that striking from the NNW-SSE cutting the Stong complex, Kemahang Granite and the Tahan Range (Hutchinson and Tan, 2009). All of the feature regarding these three major fault zones can be seen expose on the surface at some part in Kelantan.

2.2.1 Stratigraphy

Lithostratigraphy studies are one of the very important parts in geology. The stratigraphy studies help to correlate the age of the formation that presence in Kelantan. Stratigraphy studies each layer of sediment, study the type of sediment and giving the information about the ancient environment that caused the buildup of the sediments. The geological formation of Kelantan involved three major chronologies that are Paleozoic, Mesozoic, and Cenozoic ranging from the Lower Paleozoic to Quaternary (Hutchinson and Tan, 2009).

In Paleozoic, involved formation is the Gua Musang Formation and Aring Formation. The Gua Musang Formation is a lateral equivalent of the pyroclastic Aring Formation and is synonymous with the Telong Formation in the south Kelantan (Foo, 1983). This stratigraphy age of Gua Musang is from the upper Paleozoic. The upper Paleozoic sediments include argillaceous, volcanic, calcareous and arenaceous rocks of the Raub group, Gua Musang Formation, Aring Formation and also Kepis beds (Hutchinson and Tan, 2009).

The Gua Musang Formation outcrop that expose on the surface showed the stratigraphy that age from the middle Permian to lower middle Triassic rocks (Hutchinson and Tan, 2009). The basal conglomerate is the oldest unit of the Gua Musang Formation that located on the west. While on the east of Gua Musang Formation is covered by the carbonates rock.

2.2.2 Structural Geology

Structural geology covering the tectonic structure such as faulting, folding , fracture and joint. In peninsular, the major fault presence are around 12 fault that covered almost all part of peninsular. In kelantan, the major fault that presence are Galas fault zone, and Lebir fault zone. The Lebir fault of NNW-SSE trending, showed a negative lineament at the Sungai Lebir near Manek Urai, Kelantan (Hutchinson and Tan, 2009). The fault passing along the boundary of granite batholite at the east of Sungai Lebir and it terminates at the intersectionwith the leper fault.

As for the Sungai Galas fault, this fault direction range from 300° to 340°. The lineament pass through the Saiong bed, then cut across Tomo fault near jeli and lastly passing through the Stong complex and Kemahang Granite. Galas fault is terminates when it merge with Lebir fault. The Galas fault zone consist of sheared granite forming the western margin of the upper cretaceous Kemahang granite (Hutchinson and Tan, 2009).

At the north Kelantan area, the alluvial plain is mostly underlain by Mesozoic granites and the bedrock also locally contains metamorphic rocks (Saghravani et al., 2014). The alluvium deposit results from the Simpang Formation that covered the sungai Kelantan area and its delta. This formation consists of terrestrial deposit containing clay and silt with peat (Saghravani et al., 2014). In the Kelantan Delta, the unconsolidated sediments increase in thickness eastward, with the deepest bedrock encountered at the depth of 150 m (Bosch, 1988).

2.2.3 Historical Geology

The oldest outcrop that presence in Kelantan state is the Gua Musang Formation from the middle Permian to upper Triassic (Mohd Shafeea Leman, 1993 and 2004). Another formation from the Paleozoic era is the Aring Formation. Both of this formation covered the area of south Kelantan.

After Paleozoic era, the Mesozoic era takes place. During the Mesozoic era, marine sedimentation centered in two areas, the northwestern Kodiang-Semanggol depocentre and the Gua Musang-Semantan depocentre in the central belt (Hutchison and Tan, 2009). The Gua Musang-Semantan depocentre was developed from the Paleozoic era and continuous until the Triassic period.

Simpang Formation is one of the formations that occurred during the Cenozoic era. Quaternary deposit from the Simpang Formation can be found within the broad valley of Sungai Kelantan and it's Delta (Hutchison and Tan, 2009). Another quaternary deposit that presence in north Kelantan is the Gula Formation. This formation formed during the Holocene. Both of these formations are presence in the north Kelantan. Thus the geology of the north Kelantan basin mainly consists of quaternary unconsolidated alluvium and marine sediments with variable thickness (MacDonald, 1967).

2.2.5 Petrography

The petrography analysis is done to classify the rock type, description of the rock, and also to interprete the origin of the rock. The analysis is done on the thin section of the rock sample presence at the study area. In the study area at the Tanah Merah town, the type of rock presence is the igneous rock. From the thin section, the rock mineral content, color of the mineral, the degree of crystallinity and the rock texture. The observation from the petrography analysis will be use to classify the rock type by referring to the International Union of Geological Sciences (IUGS). The IUGS have develop a specific standardize for the igneous rock nomenclature.

2.3 Hydrogeology

Hydrogeology is the study of subsurface water distribution, movement and chemistry. In general at Tanah Merah town, the water supplies by the government is fully dependence on surface water such as river. At Tanah Merah, there is four water treatment center that supplies water covering all the area in Tanah Merah. The sources of the water is from the river, Jedok rriver, Jegor river and Kelantan river. The groundwater resources also presence at Tanah Merah but in small quantities that are not enough for the whole town. Usually at rural area, the villagers area are using the groundwater as their water resources. But the open well presence at the village is not under the surveilleince from the government. The water quality of the groundwater is not being monitor regularly. The open well presence is fully under their own responsibility.

Aquifer system is a part of hydrogeology scope of study. Aquifer is a geologic unit that enable to stored and transport water at reasonable amount to a well (Fetter C.W., 2001). There are two main type of aquifer, a confined aquifer and unconfined aquifer. A confined aquifer are overlay and underlain by confining layer.

Confining layer is a geologic unit that have low intrinsic permeability. The confining layer can be divided into aquitard, aquifuge, and aquiclude. Aquitard is a geologic unit that able to store groundwater but transport the water at slow rate. Aquifuge is a unit that able to stored water but absolutely impermeable layer, unable to transmit water. As for the aquiclude is one unit that unable to store water and also unable to transmit water.

As for the unconfined aquifer is a geologic unit that underlain by impermeable layer but the upper part of water table is the zone of aeration. The water table of unconfined aquifer usually close to the earth surface and follow the topography of the earth. The recharge of the unconfined aquifer is by the direct infiltration from the earth surface and also from the surface water bodies. But for the confined aquifer the recharge occurred from the leaky confining layer and also can by direct infiltration. The water level of the unconfined aquifer is represent by the potentiometric surface. The potentiometric surface is surface representative for the water level at which water will rise in the well due to high water pressure at the confined aquifer (Fetter C.W., 2001).

An important characteristic of aquifer is the porosity of the aquifer. The porosity of the rock is the portion of rock and soil that are not filled by solid material and can be occupied by water, the space are knowns as voids, interstices, pores and pore space (Todd D.K. and May L.W., 2005) .There are three type of porosity, which is primary porosity, secondary porosity, and tertiary porosity. The primary porosity is the void space presence during the formation of the rock. While the secondary porosity is the fracture and joints that occurred after formation of the rock. As for the tertiary porosity is the porosity presence due to dissolution process, usually this type of porosity presence at the karst aquifer. The porosity of the rock influenced the water storability of the rock.

2.4 Groundwater Quality

Groundwater has been utilized for domestic usage and it is well qualified for drinking because in general the groundwater is less polluted compared to surface water, basicly groundwater are filled in the pore space between the rock and the water moves in between the space. The rocks become the natural filter for the groundwater (Soltan, 1997). The quality and quantity of groundwater is also important. If the water quantity is very small thus it is not worth to drill because of the high drilling cost . Same goes if the quantity is large but the water is contaminate, low quality water that are not suitable for drinking purpose. The quality of groundwater has become a great concern due to strong possibility of being anthropogenically contaminated by various types of pollutants (Zaini Hamzah et al, .2014). Naturally groundwater is enriched in mineral such as Potassium, Calcium, Sodium, Magnesium and few others mineral. The content of the major ions is one of the important spec in determine and measuring th equality of the groundwater.

The groundwater quality is determined by the physiochemical analysis. The physiochemical analysis include the major ions analysis, minor ions and trace elements analysis.The content of the chemical is very crucial for determination the suitable purpose of the groundwater. Commonly groundwater that have high chemical content can affect human health, therefore it is more suitable for the industrial purpose, municipalities and daily usage. Groundwater that is suitable for drinking must fulfill the criteria that have been set up by WHO and MOH.

Table 1.1 : Groundwater Quality Standard based on MoH and WHO

Physiochemical Parameter	Ministry Of Health (MoH) standard	World Health Organization (WHO) standard, 2011
Temperature	-	-
pH	6.5-9.0	6.5-8.5
Total Dissolved Solid (TDS)	< 1000 mg/L	< 1000 mg/L
Turbidity	5 NTU	< 5 NTU
Electrical Conductivity	-	1400
Hardness	500 mg/L	500 mg/L
Calcium	-	-
Chloride	250 mg/L	200-300 mg/L
Nitrate	10 mg/L	-
Potassium	20 mg/L	20 mg /L
Ferum	1.0 mg/L	-
Magnesium	150 mg/L	-
Sodium	200 mg/L	200 mg/L
Fluoride	0.4-0.6 mg/L	-
Silica	-	-
Bicarbonate	-	-
Zinc	3 mg/L	4 mg/L
Sulphate	250 mg/L	< 250 mg/L

2.4.1 Physiochemical Parameters

i. Temperature

Temperature does not particularly exert a direct effect on the human health. However it play an important role in controlling the chemical reaction occurred in the water. At high temperature, the microorganism able to survive and multiply. The increasing microorganism will enhance the reaction to occur and eventually will caused effect on the taste, odour, color and corrosion in the water. Chemical contaminant prone to occur at high temperature. In opposite, low temperature water does not generate any significant effect and cold water have more pleasant taste.

ii. pH

pH play an important role in water quality parameters. A neutral pH in between 6.0 until 8.0 is the most preferable in water quality. A lower pH can produce a corrosive effect on the pipe system. The corrosion should be minimized by stabilizing the water pH, a vigorous corrosion will release metal element such as Zinc, ferum, Copper and Lead into the water. At high pH which higher in alkalinity can affect the water taste and speed up the scale formation in water heating machine. Therefore pH stabilizing is very crucial before the utilization of the water.

iii. Turbidity

Turbidity is the water cloudiness that caused by the suspended particle, clay, silt, organic matter and microorganism that obstruct the transmission of light in the water. The turbidity reading is expressed by using the nephelometric turbidity units (NTU) unit. Turbidity does not cause an adverse effect to health, however turbidity can be an indicator to a contamination. The turbidity issues can be overcome by filtration process, coagulation and sedimentation. This process is important in producing a safe drinking water.

iv. Total Dissolved Solid (TDS)

Total dissolved solid in the water are the result from dissolve mineral and also from organic substances. The common composition of dissolved solids are such as carbonates,bicarbonates, chloride, potassium and many others element. High in TDS in water does not cause majored effect on human health, however it can affect water taste. Water with high TDS value also not suitable for irrigation purpose since it can increase the salinity of the soil and caused death of the plant.

v. Hardness

Hardness are the result from calcium and magnesium elements that present in the water. The anion that responsible for the water hardness are from the bicarbonates, carbonate, sulphate, chloride, nitrate and silica that present in the water. Groundwater with high hardness are not suitable for drinking purpose because it can produced adverse effect such as cardiovascular disease, kidney stone, and diabetes (Sengupta P., 2013). In positive view, the hard water enhance scaling in pipe system that can be helpful in preventing corrosion, the thin scale layer form halt the metal from the pipe mixing with the water.

vi. Electrical Conductivity (EC)

The conductivity present in the water help to transmit electric current. Electrical conductivity is the vice versa of the resistivity. Higher EC indicate low resistivity, while low EC indicates high resistivity. EC also correlate with TDS value. A higher TDS value indicated higher cations and anions element present in the water. An increase in ions enhance the efficiency water in conducting electric current. Therefore by only measuring EC value, the TDS value can be estimate. Conductivity measurement is crucial in determining the suitability of water for irriogation purpose. However conductivity does not caused an adverse effect on health.

vii. Calcium (Ca^{2+})

Calcium is one of the natural abundances substances that present in the surface water and groundwater. The present of calcium does not cause negative impact on human health and other living organism. This is because calcium is one of the crucial nutrients that are needed for the development of an organism.

The calcium containing rock are such as limestone, dolomite and chalk. The chemical weathering on the rock result on the release of calcium element. The calcium that react with water will form calcium hydroxide. Another source of calcium are from disposal of waste and sewage. A high composition of calcium in the water will contribute to the increasing of water hardness and making it unsuitable for drinking and irrigation purpose. At high pH calcium concentration can be reduce due to the precipitation of calcium into calcium carbonates, $CaCO_3$.

viii. Magnesium (Mg^{2+})

Magnesium is one of the common major ions present in the surface water and groundwater. The magnesium ions commonly occurred along with calcium ions, this is due to the natural contributor of magnesium are dolomite, $CaMg(CO_3)_2$. Dolomite has calcium to magnesium ratio of 1:1, which gives composition intermediate between $CaCO_3$ and $MgCO_3$ (Mukherjee, 2011). Another source of magnesium are from the industrial waste and sewage. Magnesium present in the water does not a health risk, however at high concentration it may cause an adverse effects. A high concentration of magnesium will contribute to the hardness of the water and hard water are unsuitable for drinking purpose.

ix. Sodium (Na^+)

Sodium is the naturally occuring cations. The cation is on of the major element presence in igneous rock and sedimentary rock. The elements is especially high in limestone and dolomite, this is due to the influx of seawater during the formation and the presence of skeletal material (Billings and Ragland 1968). Another contributor to Sodium contain is from the industrial waste and domestic waste that are rich in sodium. The concentration of sodium in freshwater is lower compare to calcium and magnesium, this is due to the highly soluble characteristic of sodium in water. The presence of sodium in groundwater does not caused negative impact to human health, however at very high concentration it may caused some disease and change the water taste become more salty.

x. Potassium (K^+)

Potassium is another natural occuring elements. The source of potassium may result due to the weathering process and also from waste that contain high concentration of Potassium. The presence of potassium in the water does not give any risk to health but at high concentration it may be laxative to the consumers.

xi. Ferum (Fe)

Iron is a chemical element that occured abundancely. Iron are high in solubility at acidic pH, the lower pH will help in the oxidation process of iron. Acidic water that run through soil will release the iron, thus causing increase of iron content in the water. There two types of iron, which is insoluble iron as ferric hydroxide and soluble iron as ferrous bicarbonate (Metzger M.,2005). Groundwater iron content commonly in the ferrous state due to the lack of oxygen. However at the groundwater pH that are more alkaline, the iron will be in the state of ferrous bicarbonate. The sources of iron in the water are from the corrosion of the pipe system and also result from the weathering process. Excessive iron contain in the water will give rusty appearance in the water and effect the taste of the water.

xii. Nitrate (NO_3^-)

Nitrate is a product from the oxidation process of nitrogen. Nitrate accumulation in the groundwater are coming from two type of source, which is natural source and anthropogenic sources.The natural source of nitrate are such as soil mineralization and atmospheric of nitrogen, while the anthropogenic sources are such as industrial waste, intensive agriculture and septic tanks (Noraziah Jamaluddin, 2013). The contamination of nitrate in well water is a prime concern because it's poses health risk to humans. The example of possible disease are such as gastrointestinal illness, multiple digestive tract impairment, indigestion, and inflammation of the stomach (Surinda Suthar, November, 2009).

xiii. Sulphate (SO_4^{2-})

Sulphate is a mineral element of Sulphur that react with oxygen. Sulphate is a part of naturally occurring mineral in surface water and also groundwater. Rain water can become one of the sulphate sources, particularly at area with high atmospheric pollution result in high concentration of sulphate in rainfall. Other sources of sulphate are from discharge of industrial waste and also domestic sewage. Sulphate presence in the water are highly soluble but can also become sulphur and hydrogen sulfide due to redox reaction. Groundwater contaminate with sulphate can result in negative effect such as scale buildup in pipes wall, water become bitter and cause laxative effect on humans (Oram, 2014).

xiv. Chloride (Cl^-)

Chloride naturally occured in freshwater and groundwater. The chloride concentration are usually lower than sulphates and bicarbonates. However the concentration increase if the water are contaminated with the discharge of domestic waste. High concentration of chloride can change the water taste become salty and also caused corrosive effect.

xv. Bicarbonate (HCO_3^-)

Alkalinity of the water is determine by the concentration of bicarbonate ions presence. Bicarbonate ions is formed when the dissolution process of CO_2 in water. Dissolved CO_2 started to hydrated and formed carbonic acid (H_2CO_3), then further reaction will produce bicarbonate ions. Surface water and groundwater that contain CO_2 element enable percolating water dissolve calcite and carbonate minerals from rocks and soils. This contribute to the increase of bicarbonate concentration in the water. The presence of bicarbonate ions in the water does not caused health risk but can cause changes in the taste, at high concentration of carbonates water becomes salty.

xvi. Fluoride (F^-)

Fluoride is an anion that form when fluorine acquire negative charge. Fluoride ions represent 0.06-0.09 per cents of the earth's crust. All naturalwater contain fluoride at certain concentration, for seawater common concentration is around 1 mg/L, for river and lake typical concentration is 0.5 mg/L (J. Fawell, 2006). However fluoride concentration in groundwater can be relatively high and low depending on the rock type that contain fluoride bearing minerals. Fluoride minerals existence commonly associated with igneous rock and sedimentray rock.

Fluoride anions is one of the very minor chemicals that has been shown to posses health risk to humans through drinking water. At low concentration, fluoride contain in water can be very beneficial for teeth. However, at high concentration of fluoride in drinking water can result in adverse effect to humans.

xvii. Silica (Si^{-})

Silica is the major earth element that covered 27.7 % of the earth's crust (Mukherjee, 2011). Silica bearing minerals are such as pyroxene, olivine, feldspar, phyllosilicate, quartz and mica. These minerals are the sources of silica concentration in the groundwater. The presence of Silica can cause groundwater contamination by the dissolution process and weathering of the soil or mineral bearing silica. The concentration of Silica in drinking water does not standardize by WHO and MoH, this is due to the reason that silica does not caused any health risk to human (WHO,2011)

CHAPTER 3

MATERIALS AND METHODOLOGIES

3.1 Introduction

This chapter will be discussing about the material and methods use to carry out the analysis of the groundwater quality. The water and soil sample will be taken from the study area and all the sample will be test using the enlisted method to studies about the composition of the water and the type of soil. The flow of the research study can be seen in the flow chart in the figure 3.1.

3.2 Materials

There are a several materials that will be uses during completing this research. The materials and methods are enlisted in table 3.1. The image for the materials used can be seen in appendix A.

Table 3.1: List of materials that used for the research

No.	Materials
1.	Garmin Global Positioning System (GPS)
2.	Brunton or Suunto compass
3.	Geological Hammer
4.	Hand Lenses

5.	Dilute Concentration Hydraulic Acid 0.1 mol (HCL)
6.	Atomic Absorption Spectrophotometer (AAS)
7.	Spectrophotometer HACH DR5000
8.	Colorimeter
9.	Multiparameter
10.	Measuring Tape
11.	Sample Bag
12.	Polyethelene Sample Bottle
13.	Siever
14.	Nitric Acid

3.3 Methodology

3.3.1 Preliminary Research

The preliminary research is done by studying the previos research that are related to the groundwater quality. The method used to determine the groundwater quality from the previous case study are used as the references in this research.

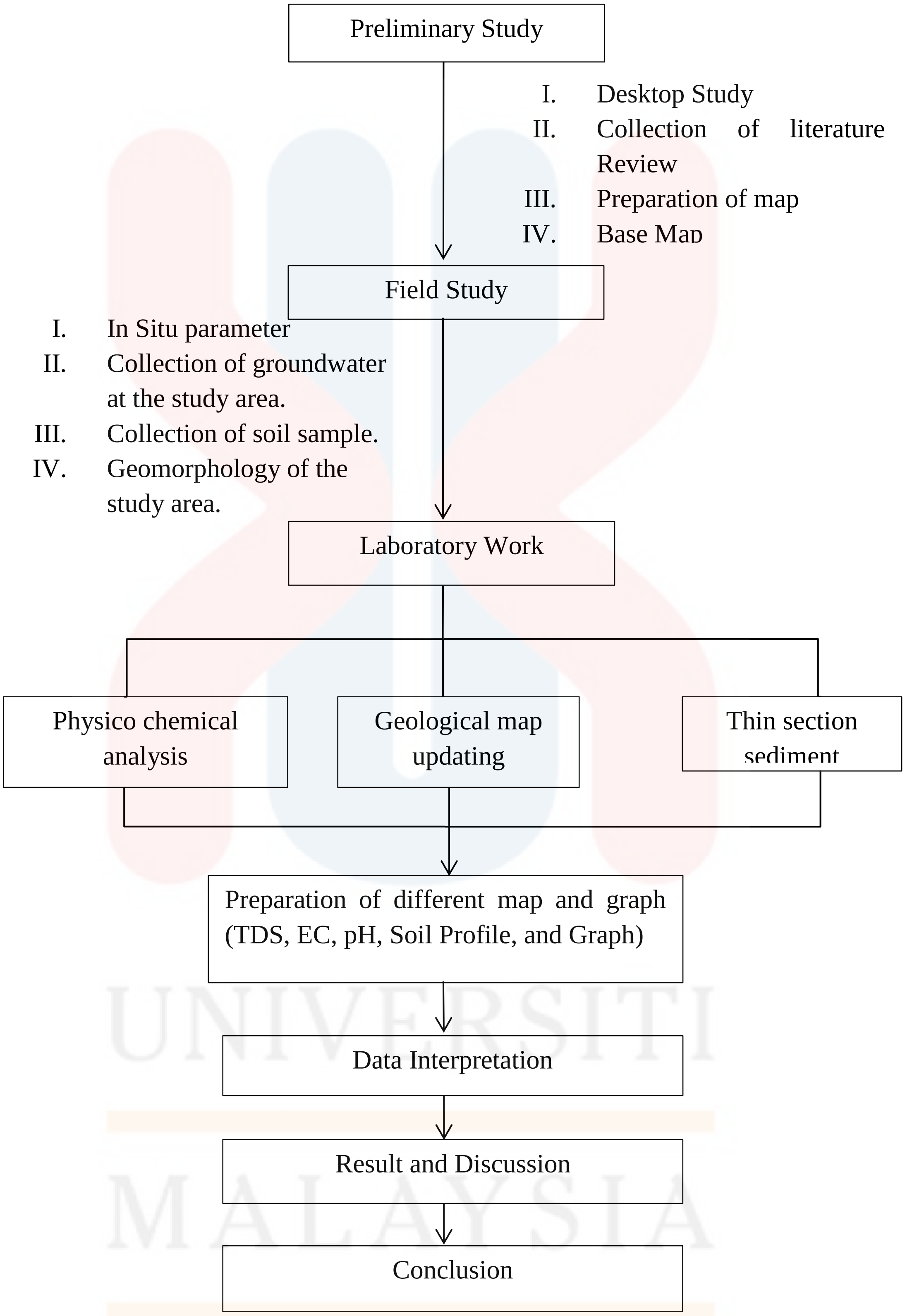


Figure 3.1: Research methods flowchart

3.3.2 Field Studies

a) Fieldwork

The geological mapping will be conducted around the Tanah Merah town area to produce an updated geological map by using the software Geographic Information System (GIS). The geological mapping of the study area will be update in the geological map and the outcrop sample will be taken to produce a thin section for the petrography analysis.

Fieldwork activity will be carry out consistently during the completion of the FYP research. A base map of the study area is compulsory to be carry out during the fieldwork. Other compulsory materials have already enlisted in table 3.1. All these materials will be use during the fieldwork. Water and Soil sample will also be taken at the study area. There are two methods of filedwork that have been listed in the table 3.2, the methods are as follow :

Table 3.2: list of methods used in the fieldwork.

Methods	Description
Traversing	The traversing method will be carry out by walking along the road and river. The observation will done during the traversing and all the info about the study area will be recorded in the field notes. The ground photo all aover the study area also will be taken during travers.
Geological contact	This method is applied when there is a contact with the outcrop presence at the study area. The geomorphology of the contact area will be observed, the coordinate of the outcrop, the structural structure, strike and dip and others reading are taken.

b) In Situ Analysis

This analysis involving the physical properties of the groundwater such as, temperature, pH measurement, Electrical Conductivity (EC),Total Dissolved Solid (TDS), turbidity, and Total Suspension Solid (TSS). These physical criteria need to be taken on the spot because it easily changes in respond to the environment changes. The water from the wells and the soil sample also should be taken for further experimental analysis. The equipment that are used for taking the groundwater parameter are the Multiparameter, TSS portable meter, and Turbidimeter.

3.3.3 Laboratory Investigations

The experimental analysis that has been carried out in this research are the groundwater analysis, titration method, gravimetric method and the thin section of sediments. The groundwater analysis is done by measuring the physico- chemical aspect of the water, such measure the major cation, major anions, trace elements and others aspect. The measurement of the physico-chemical parameter is done by using the Atomic Absorption Spectroscopy (AAS), titration method and gravimetric method. The outcrop sample taken from the study area is processed into thin section for the petrography analysis. From the analysis, the anions parameter is determined.

Table 3.3 : Method Classification for Physico-chemical analysis.

Method	Measured Parameters
Atomic Absorption Spectroscopy (AAS)	Calcium Magnesium Ferum Potassium Sodium
Gravimetric	Sulphate
Titration	Bicarbonate Chloride
Calorimeter	Nitrate Fluoride Silica

I. Titration Method

a) Total Alkalinity, Bicarbonates and Carbonate

The titration method is a low cost method with more accuracy in measuring the total alkalinity of the water sample. Total alkalinity titration is to measured the potentiality of water to neutralize the strong acid.

Reagent used for titration:

- Methyl orange indicator, 0.05%. This reagent is prepared by dissolving 0.5g of methyl orange in 100ml of distilled water.
- Phenolphtalein indicator. The reagent is prepared by dissolving 0.5g of phenolphthalein in 50ml of 95% ethanol and 50ml distilled water. 0.05N CO_2 solution is added dropwise until the solution changes colour to faintly pink.
- Hydrochloric Acid, 0.1N

The titration is carried out by prepared 100ml of sample in Erlenmeyer flask and the sample is titrated by strong acid. At first, two drops of phenolphthalein indicator is added to the sample. The colour changes is observed. There is two possibilities of colour changes, whether the sample colour remain colourless or the colour change to pink. From the analysis that has been done, all the sample does not showed any colour changes, which indicate there is no presence of hydroxyl ions and carbonate ions. Then the same sample is added with two drops of methyl orange and this solution is titrated by 0.1HCl until the colour changes to faintly pink. The end point of the HCl used is recorded and the sample is titrate three times for each sample to ensure the accuracy of the titration. The value of HCl used will included in the calculation 3.1 to measure the total alkalinity presence in the well water.

Calculation 3.1:

$$\text{PA as } CaCO_3\text{, mg/l} = \frac{(A\times \text{Normality}) \text{ of } HCl\times 1000\times 50}{\text{ml of sample}}$$

$$\text{TA as } CaCO_3\text{, mg/l} = \frac{(A\times \text{Normality}) \text{ of } HCl\times 1000\times 50}{\text{ml of sample}}$$

Where,

A = volume of HCl used with only phenolphthalein.

B =Volume of HCl used with phenolphthalein and methyl orange

PA = Phenolphthalein alkalinity

TA = Total alkalinity

The concentration of carbonates, hydroxyl ions and bicarbonates can be determine from the table 3.4.

Table 3.4: Valus of Hydroxyl ions, carbonates and bicarbonates from the values of phenolphthalein and total alkalinities.

Result of Titration	OH alkalinity as $CaCO_3$	CO_3 alkalinity as $CaCO_3$	HCO_3 alkalinity as $CaCO_3$
P = 0	0	0	T
P < ½ T	0	2P	T-2P
P = ½ T	0	2P	0
P > ½ T	2P-T	2 (T-P)	0
P = T	T	0	0

b) Chloride

The titration of chloride used silver nitrate solution to react with chloride and white precipitation of AgCl will slightly formed. After all the chloride precipitated, the free silver ions wil react with chromate to form silver chromate of reddish brown colour.

Reagents used in titration:

- Silver Nitrate, 0.02N. The reagent is prepared by dissolved 3.4g of dried $AgNO_3$ in distilled water to produce 1L of solution.
- Potassium Chromate, 5%. This solution is prepared by dissolving 5g of K_2CrO_4 in 100ml of distilled water.

The titration is carried out by prepared 50ml of water sample in the Erlenmeyer flask and 2ml of K_2CrO_4 is added to the solution. Then the solution is titrated against 0.02 N of $AgNO_3$ used is recorded. The titration is repeated three times for each sample to ensure the accuracy. The average reading is taken into the calculation 3.2.

Calculation 3.2:

$$\text{Chloride, mg} = \frac{(\text{ml}\times\text{N}) \text{ of } AgNO_3 \times 1000 \times 35.5}{\text{ml of sample}}$$

II. Gravimetric Method

The gravimetric method is carry out to determine the concentrations of sulphate presence in the water. In the hydrochloric acid medium, the sulphate element will precipitated as the barium sulphate with the addition of barium chloride solution. The sulphate can precipitate at high temperature that near to the boiling temperature condition. The sulphate precipitation is filtered and washed. The washing of the sulphate precipitate is important in order to remove the chloride presence. Then, the sulphate precipitated is left to dry and weighed as barium sulphate, $BaSO_4$. The weight of the barium sulphate will be used in the calculation 3.3 to obtain the result. The calculation equation are as follow:

Calculation 3.3:

$$SO_4 \text{ mg/L} = \frac{BaSO4\ mg\ x\ 411.5}{ml\ of\ sample}$$

If the result number from the calculation is high value, this means that there is positive error due to the suspended matter, silica, nitrate and suphate element presence. In vice versa, if the result is at low value, it showed the presence of metal elements such as iron and chromium.

The reagents used in the gravimetric methods are as follow:

i. Methyl red indicator

ii. Hydrochloric acid

iii. Barium chloride solution

iv. Silver nitrate- nitric acid reagent

3.3.4 Data Processing

i. Classify the Groundwater Type by using the Piper Trilinear Diagram

Piper Trilinear Diagram is a graphical method that visualize the type of water facies. This method help to interprete the water chemistry with the basic of cations and anions. Piper diagram is a combination of cations and anions triangle, also include the diamond shape between both triangle. The example of Piper-Trilinear diagram can be seen in the figure 3.3 below.

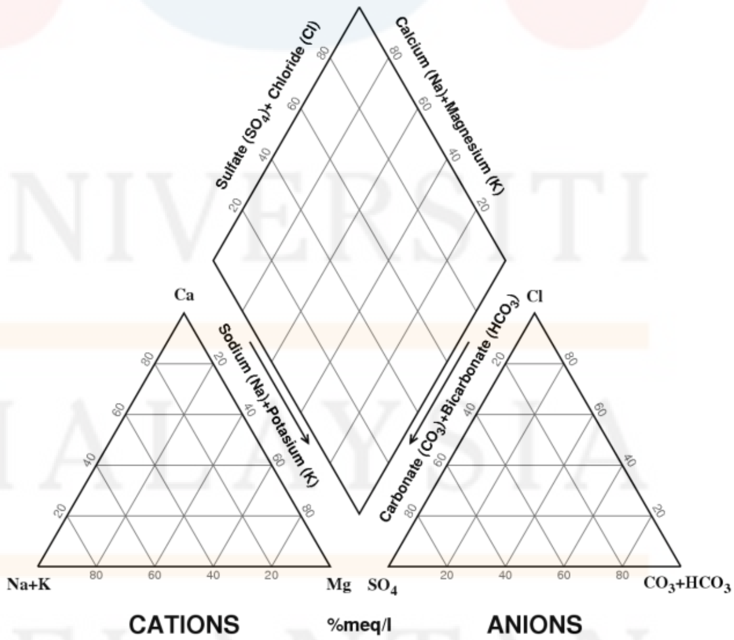


Figure 3.2: Piper-Trilinear Diagram source fromhttp://warmada.staff.ugm.ac.id/ (last accessed on 3rd May 2016)

The cations triangle is used to plot the cations elements, Na^{+}, K^{+}, Ca^{2+} and Mg^{2+}. Same goes for the anions triangle that were used to plot the anions elements, which is HCO_3^{-}, CO_3^{2-}, Cl^{-}, and SO_4^{2-}. While the diamond shape in the middle used to replot the analyses and categorized the type of water facies. The result of cations and anions element that presence in the groundwater sample will plotted in the Piper- Trilinear diagram. From the analysis we can classify the groundwater facies of the sample.

ii. Water Quality Index

Water Quality Index (WQI) is the interpretation method that determined the overall quality of the groundwater by using the physico-chemical parameter of the water. The value of physico- chemical parameter were used in the calculation of WQI. The calculation of WQI involved a fews step starting from the parameter weightage calculation (W_i), then followed by the calculation of water quality rating (q_i) for each of the water quality parameters and last step is the summation of these sub-indices in the overall index (Sirajudeen & R, 2014). The calculation formula for the WQI is by using the following calculation3.4:

Calculation 3.4:

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

Where, n = the total number of water quality parameter

W_i = Weightage factor of the parameter, the value is calculate by using the equation $W_i = K/S_i$. where K = constant of proportionality with the value of 1 and S_i = standard value of the i^{th} water quality parameter

qi = the water quality rating for the i^{th} water quality parameter and calculated by using the calculation 3.5:

Calculation 3.5:

$$qi = 100V/ S_i$$

where,

V_i = the value of i^{th} parameter in mg/L, and

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

The calculation result of WQI will determine the quality status of the groundwater. The value starting from 0 until above 75, the number range represent the quality of the groundwater from very good, good, poor and very poor. The water status from WQI number range can be seen in the table 3.3 below. When the WQI value reach the very poor status, that indicates that the groundwater is not suitable fro drinking.

Table 3.5: Groundwater status from WQI analysis

WQI	Groundwater Quality
0 – 25	Very good
26 – 50	Good
51 – 75	Poor
Above 75	Very poor

CHAPTER 4

GENERAL GEOLOGY

4.1 Introduction

General geology is describing the whole geology of an area in general and in wide range of geological view. The example of geological view for genereal geology consist of the geomorphology of the study area, lithology, and structural geology present at the study area.

First and foremost, the study of structural geology of the study area is crucial in determine the process that undergo by the rock at the study area and also indicate the type of rock presence. The rock structure is vary for each igneous type, sedimentary type and also metamorphic type of rock. For example igneous rock exhibit structure such as columnar jointing, pillow basalt and some flow surface feature. As for the sedimentary rock showed structure such as bedding, channel structure and ripple mark. While metamorphic rock can recognized by the presence of foliation structure.

Another aspect of general geology is the geomorphology of an area. The geomorphology of an area is influenced by the type of lithology presence at the area, the weathering and erosion process, and also geological hazard that able to cause changes in the geomorphology of an area. Geomorphology of an area is constantly changing over time due to all the occuring process. Therefore by traversing the study area, the geomorphology of an area can be observed.

From the general geology study of the study area, all the data recorded is generated into a map of geomorphology, lithology, and structural. These map are generated by using the ArcMAP software. Based on the figure 4.1, most part of the study area are traversed to observed the geomorphology, lithology and also for domestic well water sampling.

4.2 Geomorphology

Geomorphology is the study of landform that related to its origin and evolution. The geomorphological process can be divided into three types, which is endogenic process, exogenic process and extraterrestrial process. At the study area, only two type of process occurred, which is endogenic and exogenic process. endogenic process is caused by the uplifting of rock from the subsurface and exogenic due to the weathering and erosional process.

At the study area, the geomorphology study include the drainage pattern of the river, the landform of the study area and the weathering process that take places in the study area. Drainage pattern in at an area can be diifer due to the characteristic of river flow that followed the earth topography and also influence by the lithology of the area. Landform of an area is naturally form over time. However, the landform is not constant, its gradually change overtime due to the occurrence fault, fold and also due to the weathering and erosion process.

The weathering and erosion process occurred due to the presence of geomorphological agents, which is water, wind and glacier. However in the study area, the main geomorphological agent is water.

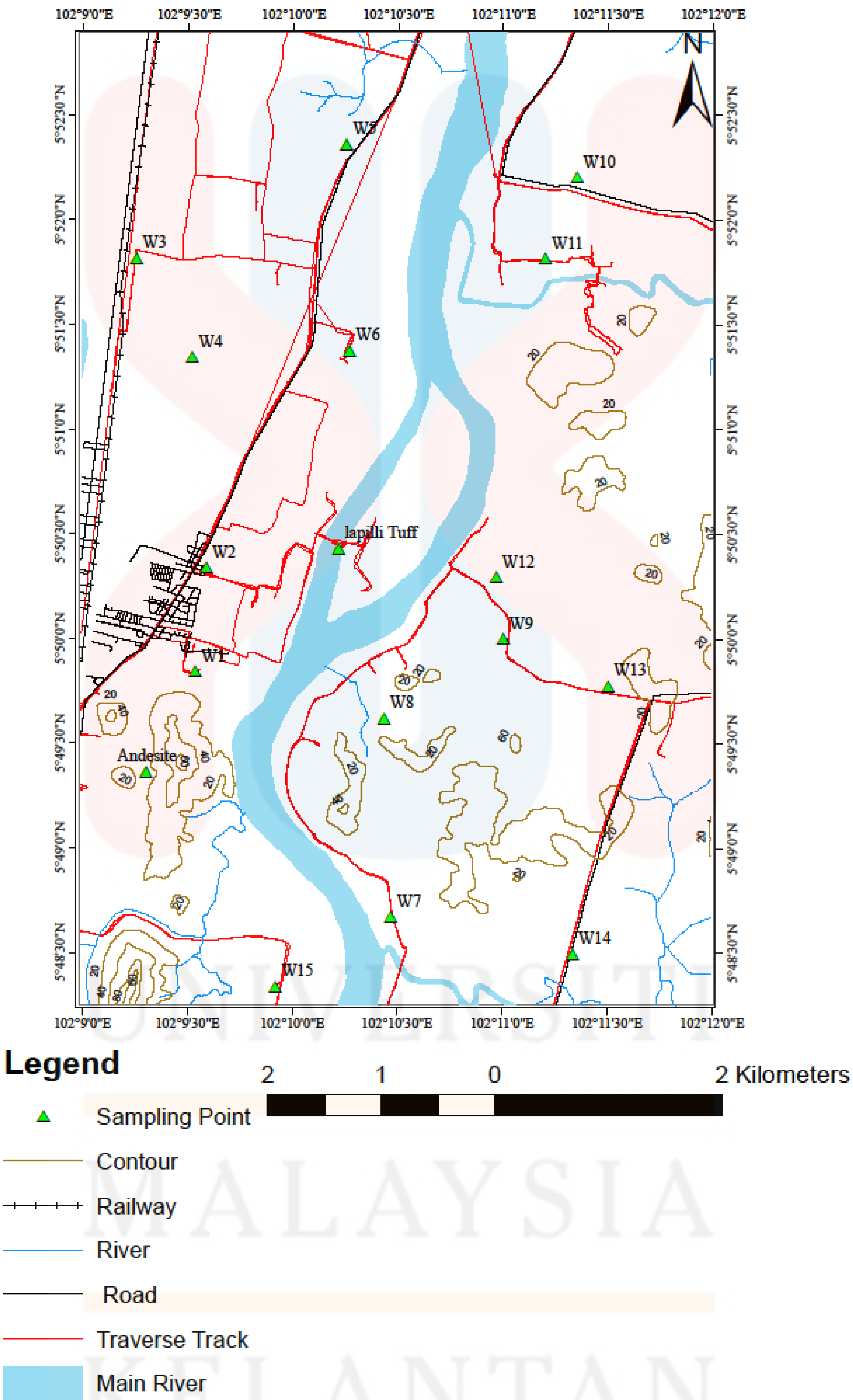


Figure 4.1:Traverse Map of Study Area.

4.2.1 Drainage Pattern

Drainage classification commonly involve the classification of channel pattern such as straight type, meandering and braided. The channel pattern is usually affected by the others factor such as grain size, sediment load, riparian vegetation, channel roughness, width and depth (Dr.Montgomery, 2013). There is six type of channel pattern, which is dendritic, braided, parallel, annular, contorted, rectangular, trellis and multi-basinal. Based on the figure 4.3, the type of channel presence in the study area is classified as dendritic. Dendritic pattern is a irregular branching of the streams. This type of channel pattern usually occurred at the areas that have uniform resistence of erosion. Commonly occurred at the area that covered by crystalline rock that existed as bedrock of the area.

Based on figure 4.3, the main river of Kelantan showed a meandering river pattern. Meandering of the river is occurred due to the effect of streamline curvature of river flow. The streamline curvature result in secondary flow, this flow moves the high velocity water towards outer bank and the slow velocity water toward inner bank (Goudie, 2004). The water flow caused the erosion of the outer bank and sediment deposition on the inner bank, that caused the formation of point bar.

The channel pattern of the river effect the load transport in the river. Based on the figure 4.2, the channel pattern in study area are classified as pattern number 4 and number 3 type. Both channel pattern are classified as meandering channel. Channel pattern number 4 is the main Kelantan river and the channel pattern number 3 is Bagan river. Referring to the figure 4.2, the abundance suspended load are presence at Bagan river, as for Kelantan river, the rock or any other particles are transported from the bed of the river.

From the morphology of the river, the Kelantan river can be classified as mature river. This is due to morphology of the river that showed slight meandering, the formation of floodplain on both side of the channel and also due to the presence of tributaries stream that flow into Kelantan main river (Massachusetts Glacial Geology, 2013).

From the figure 4.3, bar presence at the center of the main river. Bar is an elevated region of sediment that are formed and deposited by the water flow. There is three type of bar, which is point bar, mid-channel bar and mouth bar. The one existed at the study area is the mid-channel bar type. The mid-channel bar at Kelantan river showed finite elongation and width. The formation of mid channel bar is influenced by the sediment and flow of water. The mid-channel bar started to form at the condition when water flow changes from turbulent to laminar and the sediment transport is dominated by bed load and some of the suspended load are deposited at the bed of the channel (Mat Salleh M.Z., 2015).

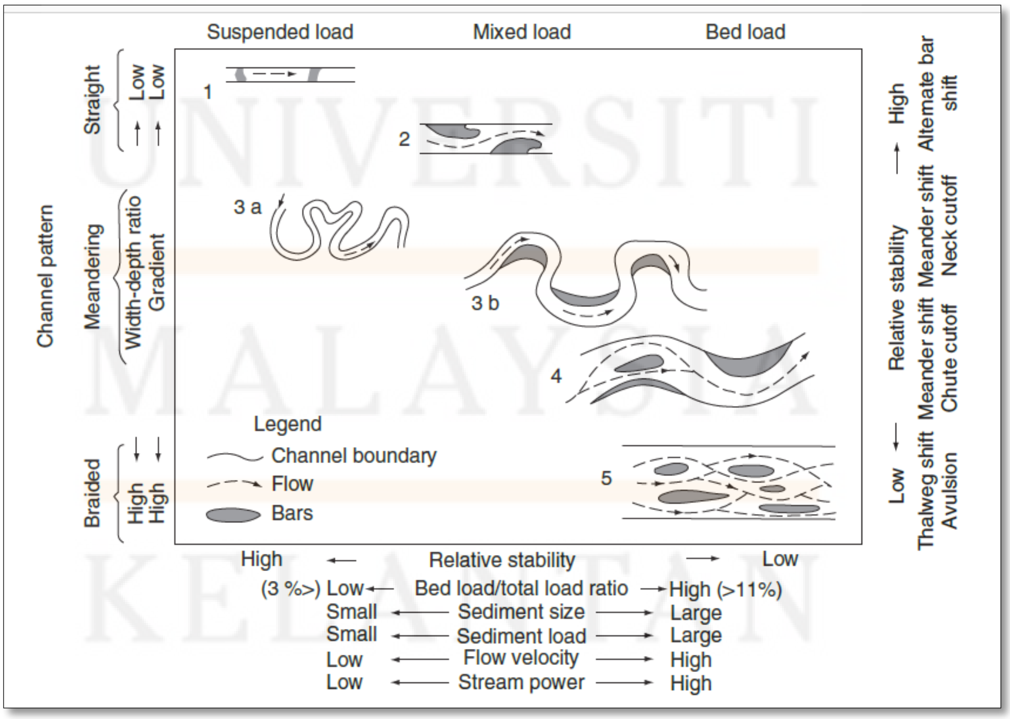


Figure 4.2 : Classification of alluvial river. source from (Dr.Montgomery, 2013)

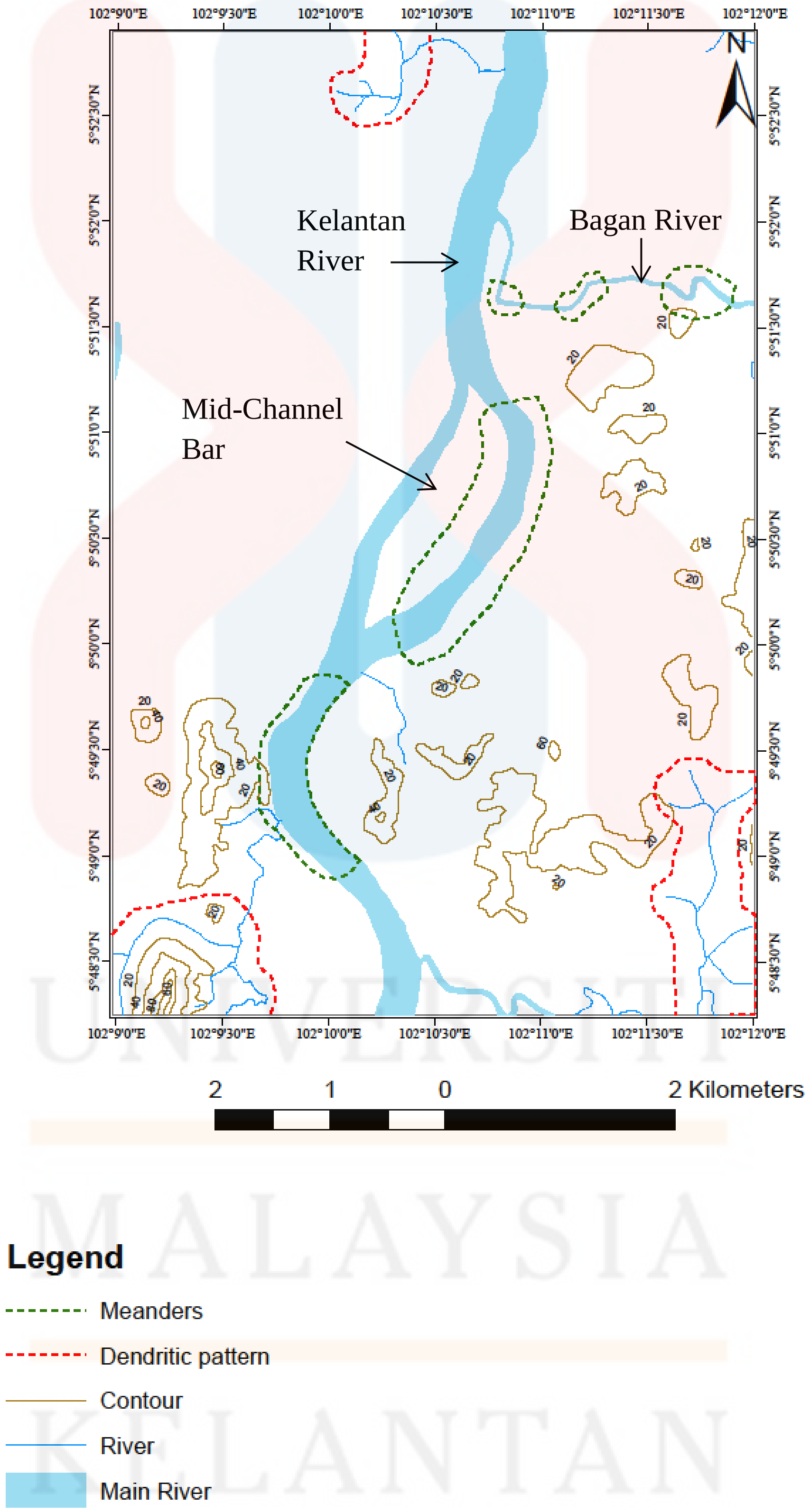


Figure 4.3: Drainage map of study area.

4.2.2 Weathering

Weathering is the process of disintegration and deformation of a rock. The process can be divided into three, which is chemical weathering, mechanical weathering and biological weathering. All types of weathering are related to each others. Mechanical weathering is the breakdown of the rock formation into smaller frangment but does not affect the rock composition (Nelson, 2015). As for the chemical weathering is the dissolution and the reaction of chemical that occurred on the mineral composition in the rock formation that leads to the deformation of the rock. Biological weathering is the deformation process due to the chemical or physical agents of the organism (Nelson, 2015).

All type of weathering can be occurred at the study area. Based on figure 4.4 showed the mechanical weathering occurred at the study area due to the abundance of joint structure on the tuff rock formation and crystal growth. The joint structure presence on the rock can be due to the compressional or extensional force acting on the rock. Crystal growth process occurred when water enter the rock formation through fracture and pore spaces. The water that enter the can caused the formation of crystal due to the precipitation from the ions contain in the water. Eventually the crystal growth in the pore spaces will exert outward force that caused the rock deformation.

Based on figure 4.4, the chemical weathering that occurred on the rock is due to the river water reaction, this is because the tuff outcrop is located near the river. Water is one of the main agent of chemical weathering. The river water that seep into the rock by fracture will alter the mineral composition of the rock and also caused dissolution of the mineral. Eventually caused disintegration of the rock.

Another type of weathering acting on the rock formation is the biological weathering that can be seen in figure 4.5. This type of weathering can be observe on the andesite rock formation, whereas, the outcrop is covered by vegetation. The roots from the vegetation can go into the fracture presence on the outcrop, thus lead to further deformation of the rock..


Figure 4.4: Tuff rock formation that undergo mechanical and chemical weathering


Figure 4.5 :Andesite outcrop undergo biological weathering

4.2.3 Landform

The formation of the earth surface is fully dependence against the exogenic and endogenic process. The process from both process caused the changes in the landform at an area. Landform is also influence by the lithology at an area. The exogenic process are resulting from the weathering and erosional process that take place on the surface of the earth. While the endogenic process are resulting from the lifting, uplift, folding and cracking that occurred at the subsurface of the earth. Both of the process caused the changes on the landform of the earth surface.

At the study area, there is two types of landform presence, which are fluvial landform and hill landform. Fluvial landform consist of the main river at the study area. Fluvial landform include the flood plain, levees formation, bar, meanders, terrace, alluvium fan, and delta. All of these feature make up the fluvial landform and the feature are constanly changing due to the erosional process and depositional process by the water. The high velocity of water caused the erosion of river bank and water able to transport abundance of sediments, until it reach a point when the water flow become laminar flow, the deposition process started to occur. The levees, flood plain and terrace feature constantly changes when river water exceed river bank level.

Hill landform existed at the study area is resulted from the andesitic rock. The geomorphology surface of hill area is dependence on the physical properties of the rock, chemical properties and also structural properties. All these properties determine the rate of weathering and erosion of the rock (Tanot Unjah, 2013).

4.3 Stratigraphy

Stratigraphy is the study of rock layers that include their relative, absolute age and the relationship between each layer. By studying stratigraphy of an area, it can help to interpret past environment of the earth. This can determined by studying the physical characteristic of the rocks and the changes in environment that develop over time. Basically the stratigraphy of study area are composed of volcanic igneous rock and sedimentary rock. There is two types of igneous rock presence at the study area, which is andesite and tuff. Both of the rock are volcanic rock type. The stratigraphy of study area is presented in figure 4.6 and the description of the stratigraphy is presented in stratigraphy columm in table 4.1.

Table 4.1 : Stratigraphy columm of lithology at the study area.

Lithology Unit	Age/Period	Rock Description
Alluvium	Recent	Composed of gravel beds, lateritic layer and residual sediments
Sedimentary Rock	Createaceous (Malaysia & Thai Working Groups, 2006)	Consist of argillite bed and fine grain sandstone.
Volcanic Igneous Rock	Carboniferous-Triassic, Aw (1990).	Consist of two types, which is lapilli tuff and andesite. The lapilli tuff is made up of andesitic composition.

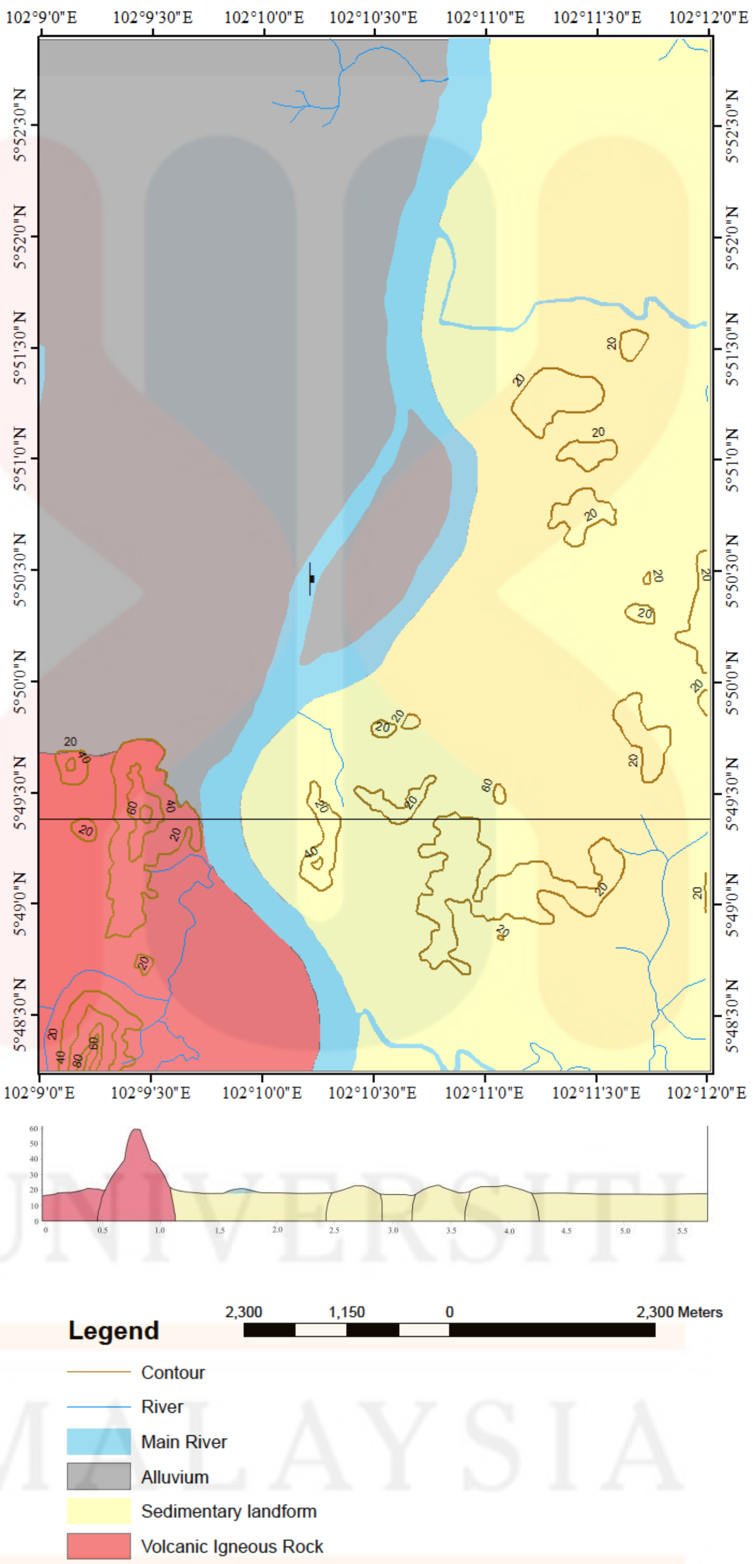


Figure 4.6: Cross section map of study area

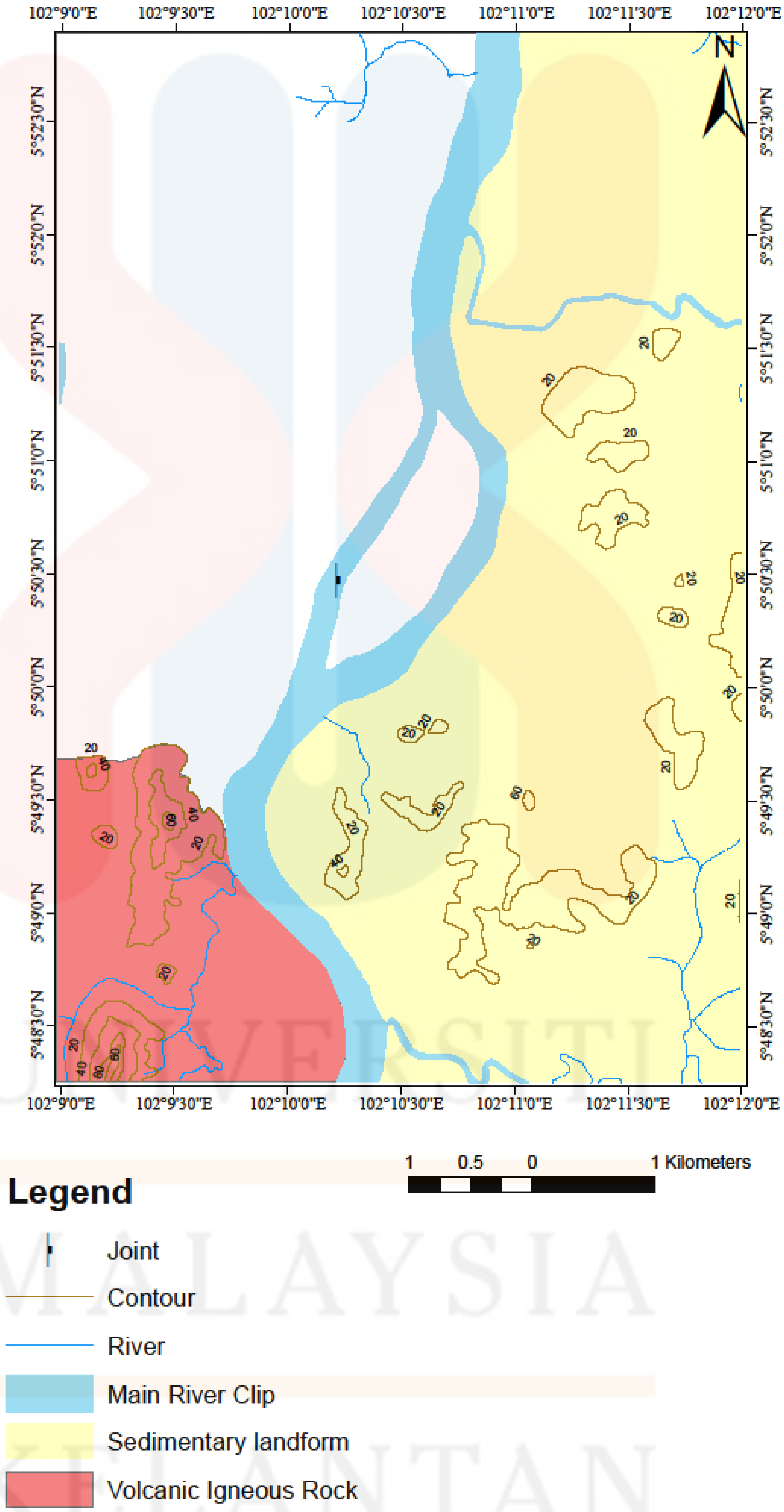


Figure 4.7 : lithology of study area

4.3.1 Andesite

Andesite is a type of extrusive volcanic rock that are formed from the explosive volcanoes. Andesitic texture are fine grained and porphyritic mineral (Bonewitz, 2008). The common mineral composition of andesite are such as plagioclase feldspar mineral, oligoclase, pyroxene and also biotite (Bonewitz, 2008). andesite found are grey in color with fine grained texture and less structure such as joint and fracture present. Major formation of andesitea at the study area become one of the active andesite quarrying activities. So at this location we can observe a fresh sample result from the quarrying activities that can be seen in figure 4.8. The andesite rock formation also have the presence of xenolith that can be seen in hand sample of figure 4.9. Xenolith is county rock of the region that included during andesite flow and solidification (K.Lutgens, 2011).

Figure 4.8 : Andesite outcrop at Quarry

Figure 4.9: Andesite Hand sample

Based on the thin section analysis of andesite outcrop in figure 4.11, the major mineral presence are the plagioclase feldspar mineral, pyroxene and also biotite. Almost 70% of the andesite rock composed of feldspar mineral and pyroxene mineral. based on figure 4.10, andesite outcrop also showed circular feature that showed lighter in color compared to surrounding rock color but the rock composition is still the same.. This feature formed due to the different rate of solidification.

Figure 4.10: Andesite Outcrop at the quarry mine (the red line showed the circular feature)

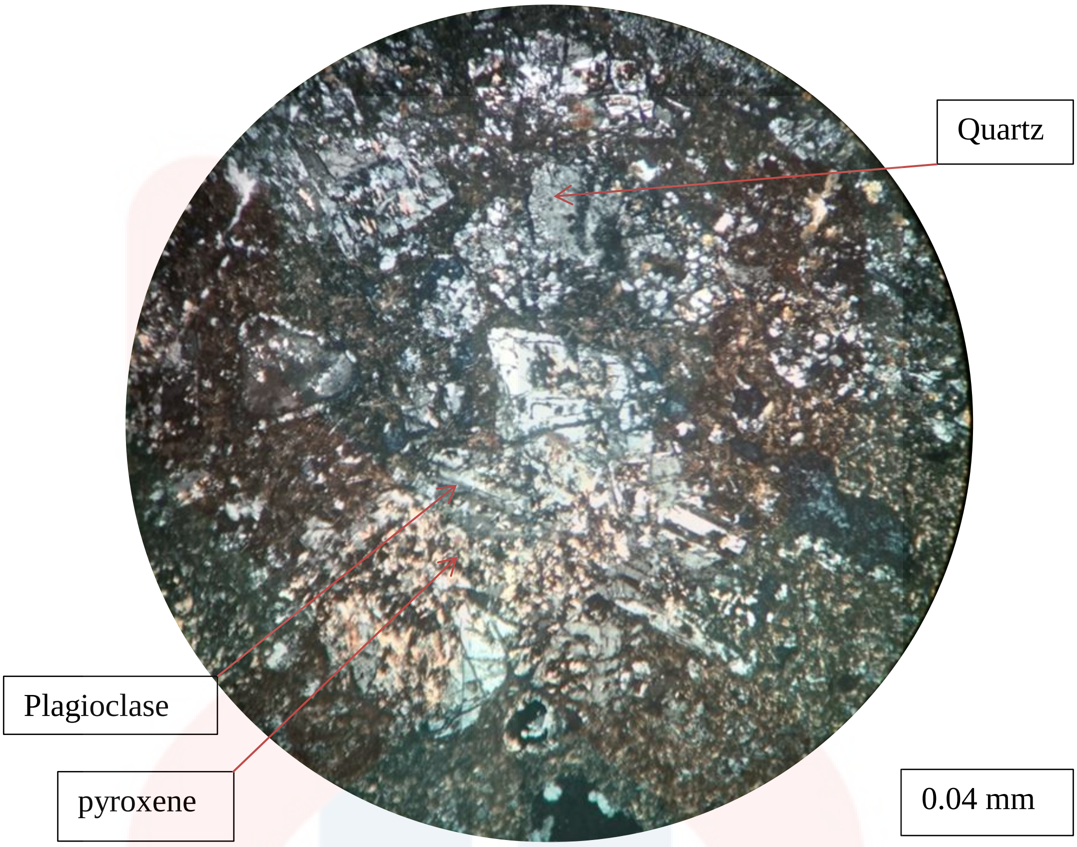


Figure 4.11: Thin section of Andesite rock.

Table 4.2 : Mineral Characteristic of Andesite

Mineral Characteristic	Pyroxene	Plagioclase
Mineral Group	Tectosilicate	Inosilicate
Colour	Brown	White
Mineral Shape	Irregular	Tabular and bladed shape
Description	Minerals size is in small fragments but abundance	Mineral twinning presence

4.3.2 Tuff

Tuff is a type of igneous rock that formed from the pyroclastic mineral ejected during the volcanic eruption. The loose material from the eruption will deposited and lithified forming tuff. Tuff can be greatly vary in texture, chemical and mineralogical composition. This is due to the variation in the ejected materials from the eruption and also varies in their condition of formation (Bonewitz, 2008). Tuff formation commonly include a range of fragment size, which range from the fine grained dust that are classified as ash tuff, medium sized fragment classified as lapilli tuff and large volcanic block that are classified as bomb tuff (Bonewitz, 2008).

There is two types of tuff, which is vitric tuff and lithic tuff, both differ in the fragment composition aspect. For the vitric tuff fragment are mainly composed from ash size such as rhyolitic, trachytic, or andesitic composition. As for the tuff that are found in the study area that has been shown in figure 4.12, is a type of lapilli tuff that are made up from andesitic composition.

Figure 4.12 : Tuff outcrop at study area

Lapilli tuff at the study area is andesitic lapilli tuff. Since the tuff is made up of andesitic composition, therefore the mineral content is similar with the andesite rock, this can be seen in figure 4.14. However tuff is differ from andesite rock in the aspect of fragment size presence in the tuff rock. Lapilli tuff is dominated by ash-sized particle and the larger size clast is less than 25% of the tuff composition. The formation of tuff from the volcano ejection resulted in higher porousity of the rock compared to andesite rock and higher porousity caused the reduce in strength of the andesitic lapilli tuff. Mineral orientation that can be observed on the outcrop is one of the important criteria that indicate tuff rock type.

Figure 4.13: Hand sample of tuff outcrop

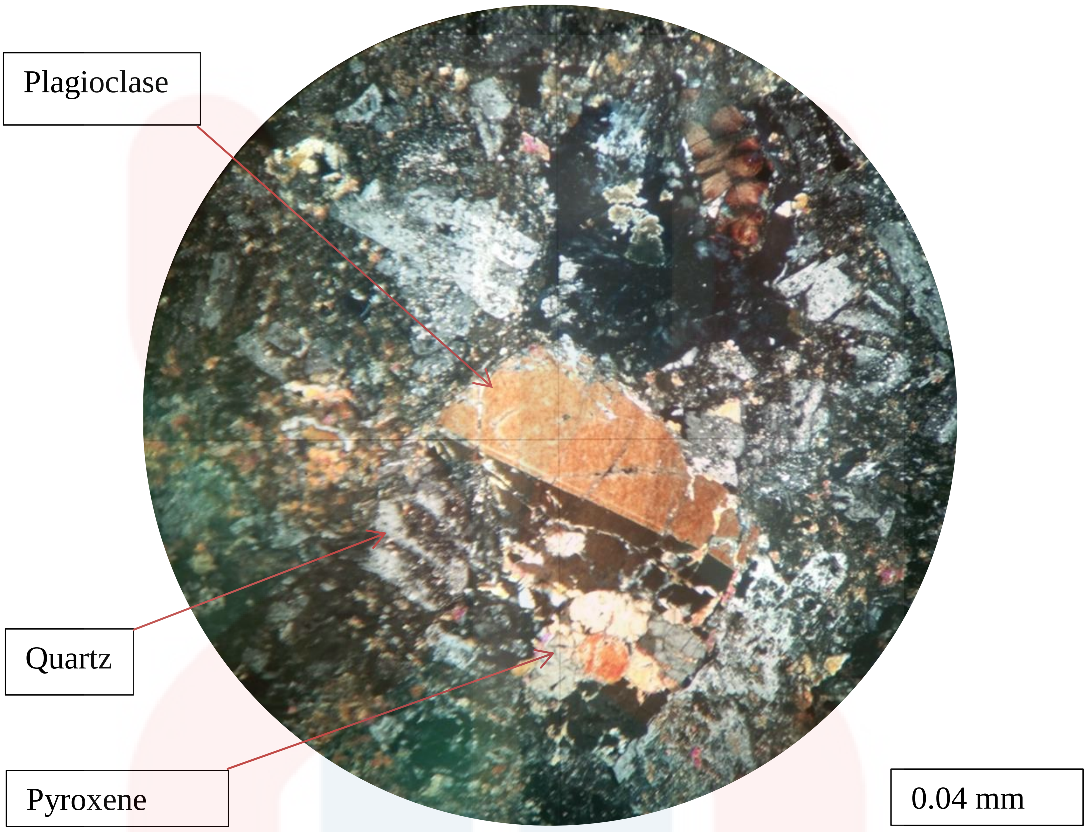


Figure 4.14 : Thin section of Tuff

Table 4.3: Mineral Characteristic of Tuff

Mineral Characteristic	Quartz	Plagioclase	Pyroxene
Mineral Group	Tectosilicate	Tectosilicate	Inosilicate
Colour	White	Brown	Brown
Shape	Irregular	Irregular	Triclinic
Description	Minor minerals presence	Major mineral presence Showed twinning	Major mineral presence but in small size

4.4 Structural Geology

The structural geology is the deformation of rock formation that are caused by fault, joint and fracture. Stress and strain that acted upon the rock caused the rock to deformed. For the determination the of the structure presence, lineament analysis is carried out to act as an indicator for the existence of structure. Lineament analysis is the analysis process by using the factual image or map model that followed the earth surface. The lineament analysis include the feature such as linear stream channels, line of vegetation, soil and relief break are correlated with geological structure existence. Based on figure 4.14, a lineament map of study area is generated with straight lines that indicate the area that have the possibility of structural existence. From the lineament analysis in figure 4.14, a Rose diagram of lineament analysis is generated in figure 4.15

Another analysis that can be used is joint analysis to find the direction of force acting upon the that lead to rock deformation. This analysis is a part of structural geology interpretations. The analysis include strike reading from the joint and fracture presence on the outcrop. The joint and fracture that occurred on the rock is due to the force that acting on the region. Two possible force that occurred on the rock formation, is the compressional forse and extensional force. Both of the forse result in the rock deformation. The direction of force acting on the rock can be distinguish by using rose diagram reading in figure 4.16.

Figure 4.14: Lineament map od study area

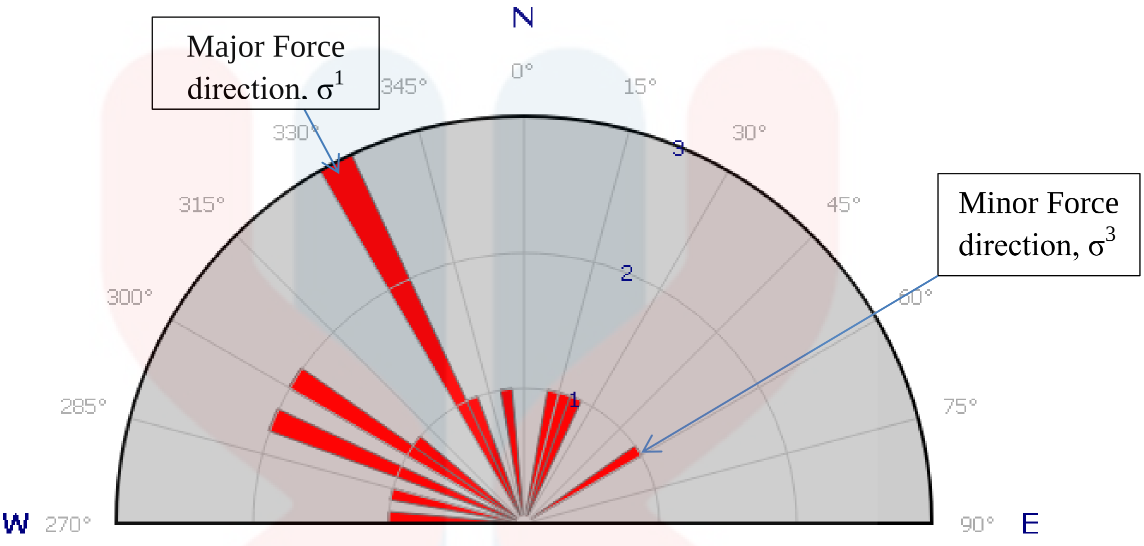


Figure 4.15: Rose Diagram of Lineament analysis

Based on the figure 4.15, the major force from the lineament analysis comes from the North-West direction at 330°. As for the minor force is coming from North-East direction at 60°.

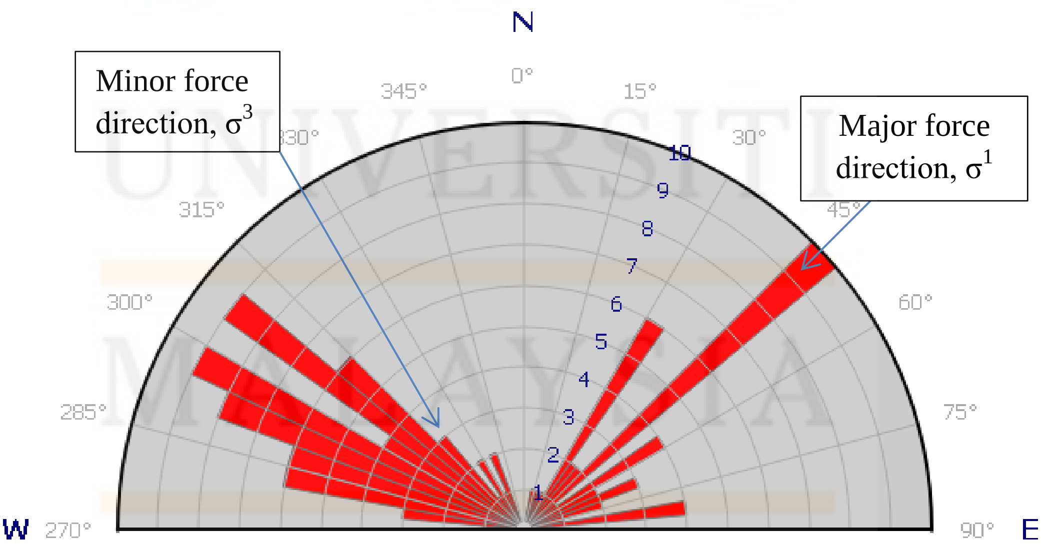


Figure 4.16 : Rose diagram of joint analysis

Based on the figure 4.16, the rose diagram of the joint analysis showed the major force acting against the rock is in the North-east direction at 45°. At North-West direction also showed a relatively high force acting on the rock formation and this direction of forces is correlate with the major force direction in figure 4.15. The minor force direction is coming from 320° at north west direction. From the comparison of both figure, the major force acting upon the rock is coming from the North-West direction.

4.5 Historical Geology

Tanah merah volcanic formation are consist of andesite flow, andesitic tuff and angglomerate.According to MacDonald (1967) state that the rock unit of Tanah Merah age ranged from carboniferous to Triassic. Aw (1990) also state that the main volcanic activities occurred during Permo-Triassic period.At the study are, there are two main type of rock presence, which is andesite and tuff. Both of the rock formed due to the volcanic eruption. The andesitic flow from the volcanic eruption will directly solidified due to the changes in temperature.

Another type of rock found is tuff. The rate of tuff formation can be vary due to its dependence on it pyroclastic material. After the eruption, the loose materials is deposited, and continues with the lithification process. Tuff will slowly lithify due to the process of campacting and cementation with calcite or silica-like sedimentary rock (Bonewitz, 2008). However, if the tuff is released along with the pyroclastic material thatare high in temperature, therefore the tuff can also directly solidified. The final nature and the rate of tuff formation is determined by composition of the pyroclasticmaterial. After the volcanic igneous rock formation, sedimentary rock formation occurred during cretaceous period, which consist of argillite bed and fie grained sandstone. Followed by Alluvium that recently formed.

CHAPTER 5

RESULTS AND DISCUSSION

5.1 Result and Discussion

Result from the in- situ parameter, major cations and major anions analysis are discussed in this chapter to determine the quality of the domestic well water.The result is compared with safe limit value for each parameter that have been standardize by WHO and MoH. The result for the In-situ Parameter is listed on the table 5.1 and the result for major cation and anion is listed in the table 5.2 and 5.3. The sampling water location is shown in figure 5.1.

Table 5.1 : Result of In-Situ parameters

Well No.	Latitude	Longitude	Elevation (m)	Water Level (bsl)	Water Contour (amsl)	Temperature (°C)	pH	Salinity	TSS (mg/l)	EC (µS/cm)	Turbidity(NTU)	TDS (mg/L)	Hardness(mg/L)
W1	05° 49' 50.56" N	102° 09' 32.25" E	23	3	20	29	6.0	0.02	12	52	15	580	72
W2	05° 50' 20.27" N	102° 09' 34.88" E	22	2	21	29	6.0	0.03	17	104	6	453	590
W3	05° 51' 48.89" N	102° 09' 14.79" E	21	2	19	28	5.2	0.02	19	67	19	485	64
W4	05° 51' 20.56" N	102° 09' 31.35" E	22	1	21	29	6.0	0.02	12	117	9	440	84
W5	05° 52' 21.45" N	102° 10' 15.50" E	22	2	20	28	6.3	0.02	14	175	13	471	746
W6	05° 51' 22.46" N	102° 10' 15.98" E	21	4	17	29	6.1	0.03	47	79	42	456	60
W7	05° 48' 40.30" N	102° 10' 27.90" E	25	2	23	28	6.2	0.03	23	54	26	435	39
W8	05° 49' 37.10" N	102° 10' 26.10" E	27	1	26	28	5.2	0.02	23	34	7	299	15
W9	05° 49' 59.70" N	102° 11' 00.10" E	17	3	14	27	5.4	0.03	22	81	20	240	65
W10	05° 52' 12.20" N	102° 11' 20.80" E	22	2	20	27	6.3	0.02	1	41	1	350	43
W11	05° 51' 48.90" N	102° 11' 12.00" E	22	4	18	28	6.1	0.02	1	71	5	421	143
W12	05° 50' 17.50" N	102° 10' 58.10" E	24	2	22	28	6.0	0.03	7	294	3	200	294
W13	05° 49' 46.40" N	102° 11' 30.00" E	32	5	27	29	5.3	0.02	2	32	1	222	161
W14	05° 48'	102° 11'	22	2	20	30	6.5	0.02	3	67	3	367	109

	29.70" N	20.20" E											
W15	05° 48' 20.20" N	102° 09' 55.40" E	25	1	24	27	6.0	0.02	12	78	12	237	68

Table 5.2 : Result for Major Cations and Major anions

Well No.	Ca	Fe	K	Na	Mg	Nitrate	silica	Fluoride	SO4	HCO3	Chloride
W1	9.601	0.397	2.983	8.209	1.477	2.8	14	0.86	124	408.33	32.7
W2	17.86	0.272	3.764	13.41	1.484	3.4	8	0	37	363.33	23.2
W3	9.541	0.376	3.601	13.34	0.836	3.1	6	0	45	383.33	28.9
W4	9.86	0.12	4.964	12.44	0.732	2.6	8	0	53	306.67	51.1
W5	6.895	0.091	5.869	7.85	1.125	1.2	15	0	80	326.67	43.1
W6	4.276	0.287	4.691	8.315	1.547	3.5	12	0	62	350.33	21.8
W7	17.64	0.202	2.637	10.72	0.811	1.9	10	0	21	346.67	35.5
W8	8.648	0.312	1.608	6.081	0.454	1	6	0.05	33	230.00	19.9
W9	11.59	0.526	2.746	11.32	0.357	1.6	10	0	4	180.00	27.5
W10	12.14	0.119	2.942	4.887	0.827	1.2	11	0	12	296.67	23.2
W11	14.99	0.487	8.42	14.08	2.048	4.6	11	0.1	16	328.33	32.7
W12	1.947	0.733	9.58	13.5	1.77	9.7	9	0.28	33	120.00	11.4
W13	6.801	0.843	1.155	4.783	0.309	1.5	3	0	37	123.33	46.9
W14	6.109	1.438	4.807	2.986	0.702	2.6	5	0	8	326.67	15.1
W15	11.26	1.398	2.338	7.75	1.85	4.1	11	0.37	16	181.67	12.8

Value exceed standardize limit by WHO and MoH

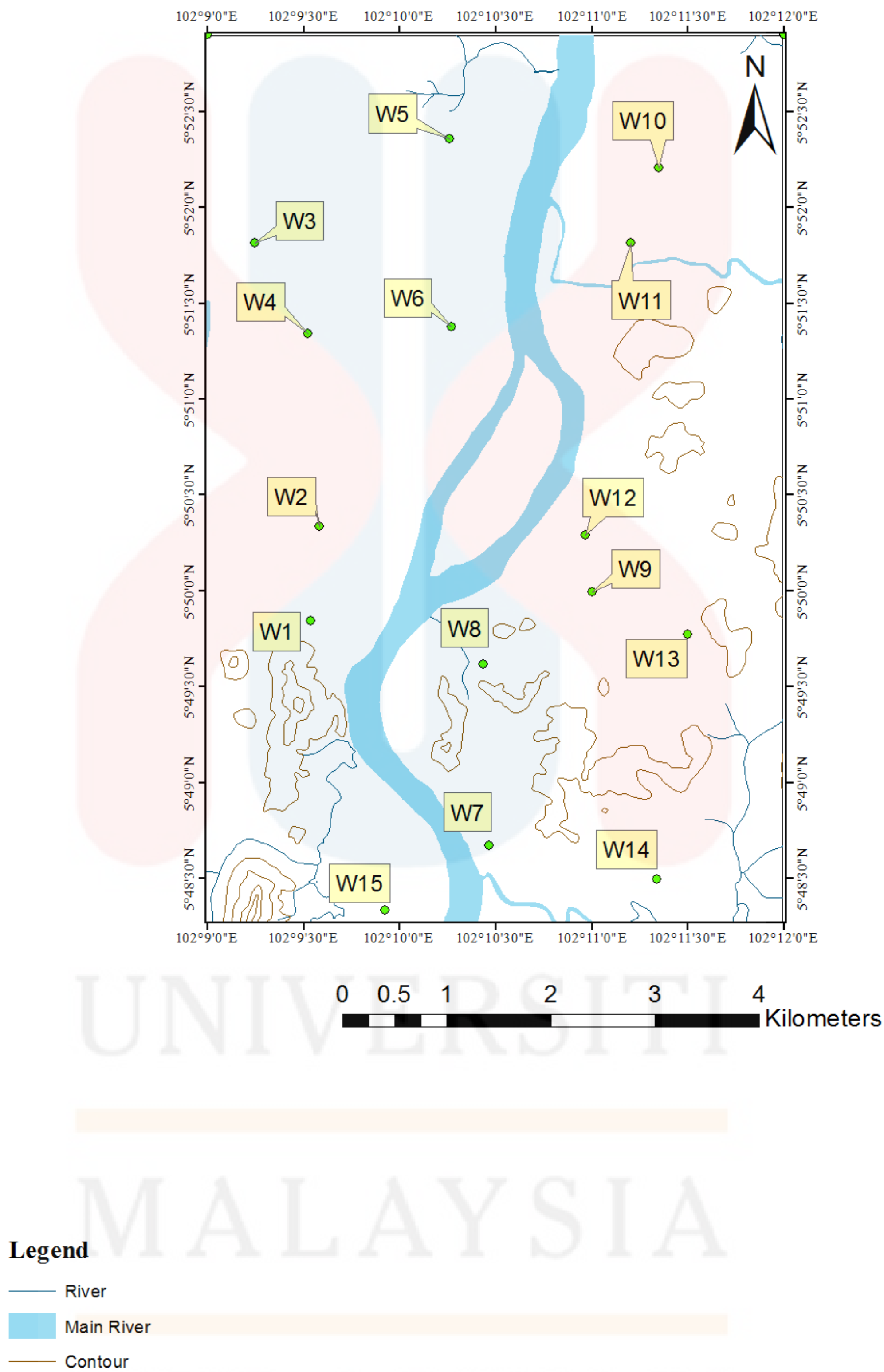


Figure 5.1: Sampling well map at study area

5.2 Groundwater Movement

Groundwater movement showed the flow direction of the water in the aquifer. The behavior of water movement is influenced by the topography and lithology of the study area. commonly water from high elevation will flow toward the low lying area due to the influence of gravity. The subsurface lithology at the study area is also one of the importance feature that determine the groundwater movement. There is two types of possible lithology, which is impermeable layer and permeable layer. Permeable layer commonly a layer that are made up of sandstone, which have high permeability and high potential to become aquifer. Shale layer also enable water movement, but the permeability is lowered compared to sandstone, this layer can act as aquitard. As for the impermeable layer is such as clay layer that inhibit water movement through the layer, this layer suitable as aquifuge. The direction of Groundwater movement can be observed from the water level contour map in figure 5.3.

5.2.1 Water level

Water level in the study area are measured in 15 well around the study area. From the figure 5.2, the water level in the study area ranges from the 1.29 m to 4.71 m. The lowest water level is at well 15 and the highest water level is at well 13. The water level is not fixed and constantly changed in respond with water infiltration. The measurement of water level is important in determining the discharge rate and recharge rate of water table.

Another factor that caused the changes in water level is the rate of rainfall distribution. This factor is highly influenced the water level. At monsoon season, where the rainfall distribution is high, the water level increase due to continuous recharge from rain precipitation. However, during past-monsoon season, the rate of rainfall distribution started to reduce thus lowered the water level of the aquifer. during this season, the rate of water discharge need to be control to ensure there is no excessive discharge occur that can affect aquifer. The rate of discharge and recharge need to be in equilibrium state.

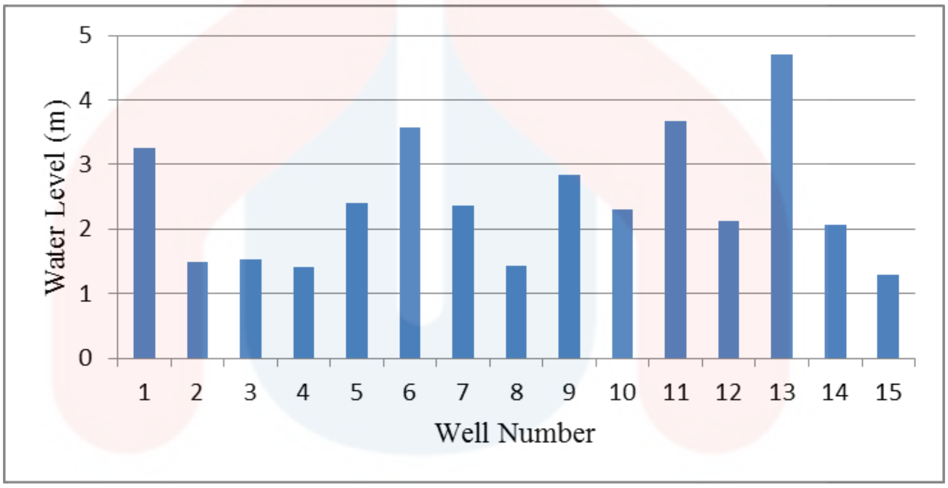


Figure 5.2: Water level graph at study area.

5.2.2 Water level Contour map

Water level contour map is generated by substracting the ground surface elevation with the water level in well. The water contour in the study area ranges from 14.2 m to 27.3 m. The highest contour distribution is at well 13, located at Kg. Machang Gedibing, while the lowest contour is located at well 9 located at the area of Kg. Joh. Water Contour are also used in determining the groundwater flow direction in figure 5.3.

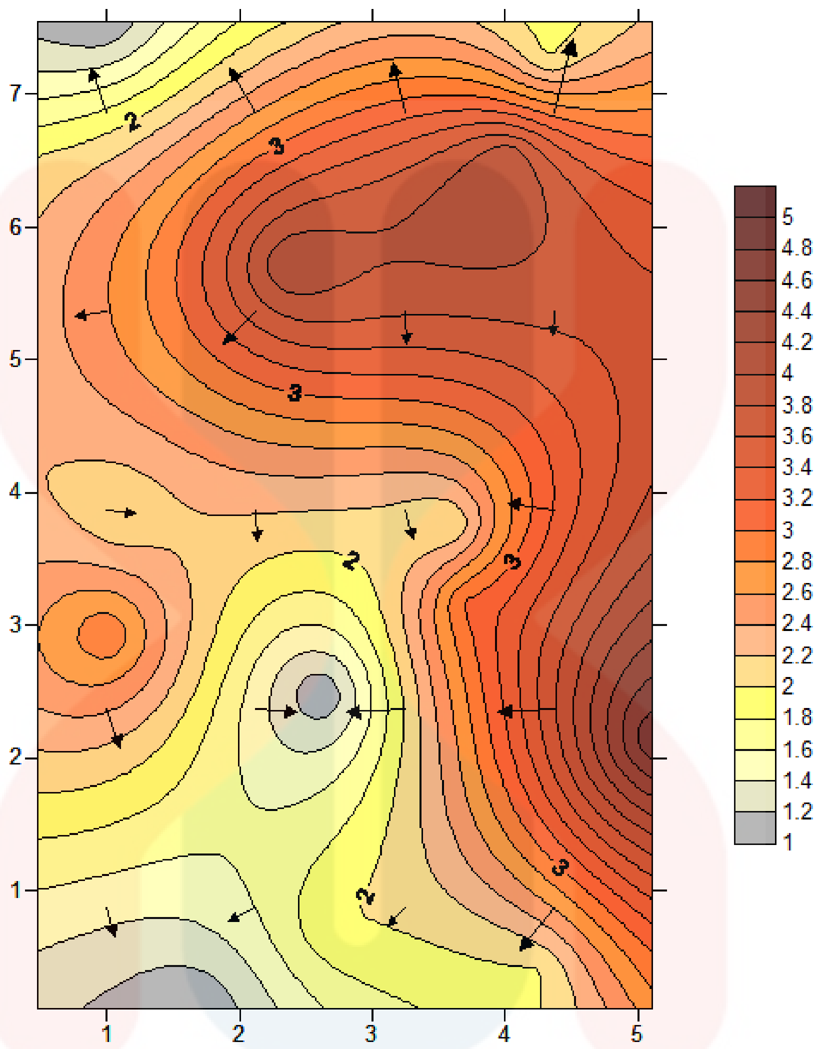


Figure 5.3: Groundwater flow direction at study area

5.3 In-situ Parameter

I. Hardness

Groundwater hardness are mainly made up from calcium and magnesium concentration. Based on the figure 5.4 , the groundwater hardness at study area ranged from 15 mg/L to 746 mg/L. Most of the well water hardnes are below 300 mg/L, exceptional for well 2 and well 5 hardness that exceed the WHO and MoH safe standard limit. In well 2, hardness of water is high due to the high concentration of magnesium ions presence in the water. As for the well 5, the hardness of well water is caused by high concentration of calcium. Both calcium and magnesium played as important source of elements that determine the hardness of the well water. Another contributor to water hardness are from the anions and cations presence in the water. From the observation, the result for well water number 2 and 5 showed relatively high concentration of nitrate, silica, bicarbonate, sulphate and chloride. These anions presence in the water caused the increase of water hardness.

Overall result of water hardness analysis showed that the well water is safe to consume for drinking purpose and others purpose, exceptional for well 2 and 5. The well water in well number 2 and 5 are not suitable for drinking purpose and irrigation purpose, because it can result in adverse effect to humans and affect the soil.

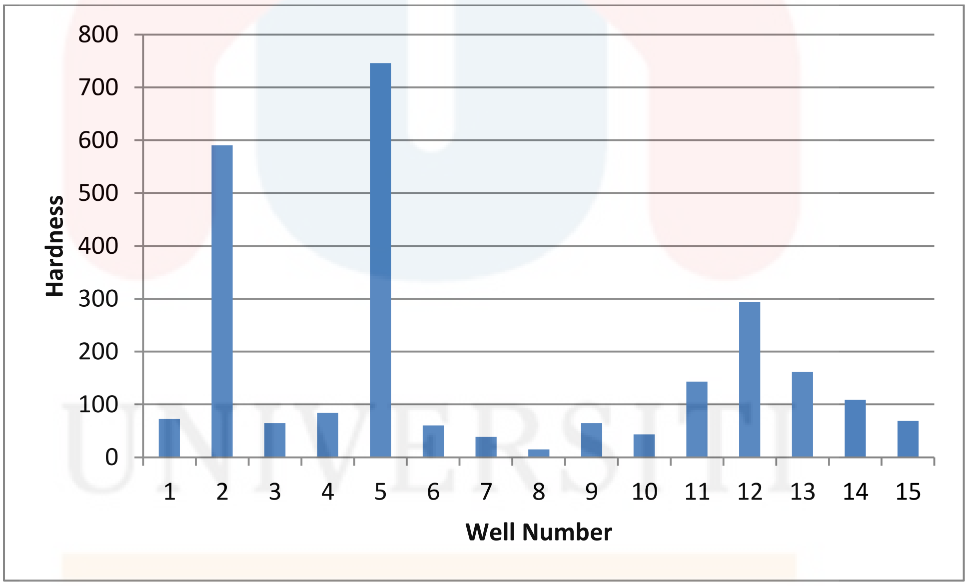


Figure 5.4: Hardness value at study area

II. pH

From the figure 5.5, the ranges of groundwater pH in the study area are from 5.2 to 6.5. According to WHO and MoH standard the safe limit pH for drinking water are in between 6.0 – 9.0. Therefore, majority of the domestic well water are within the safe limit, an exceptional for well 8, well 9 and well 13 that showed the water are acidic. The acidic water indicate the presence of strong mineral acids, weak acids, salts of strong acid and weak base. Commonly the dissolution process of carbon dioxide is the main contributor to the groundwater acidity. Well water pH is crucial in determine the total alkalinity of well water. Carbonates and Bicarbonate ions presence is influence by pH. At lower pH, carbonic acid tend to formed, but at higher pH, the carbonic acid converted to bicarbonate ions.

Figure 5.5 : pH barchart of study area

III. Total Dissolved Solid (TDS)

Total dissolved solid in water influenced by the dissolved cations, anions and also organic materials. The TDS presence in the study area ranges from 200 mg/l to 580 mg/l. From the figure 5.8, the distribution map display the highest concentration is toward west direction, while the lowest concentration is toward east direction

The highest value are observed at Well 1 which is located around Bt. Maka at west direction and the lowest in well 12 that located near Kg. jelatuk heading east direction. From the figure 5.6, the scale of overall TDS values presence in the study area are still within safe limit of WHO and MoH standard.

High value of TDS at well 1 is correlate with the value of cations, nitrate, chloride, high concentration bicarbonate and sulphate contain in the groundwater. Other organic matter also contribute to the TDS value. As for the lowest TDS at well 12 is due to low concentration in bicarbonate and chloride.

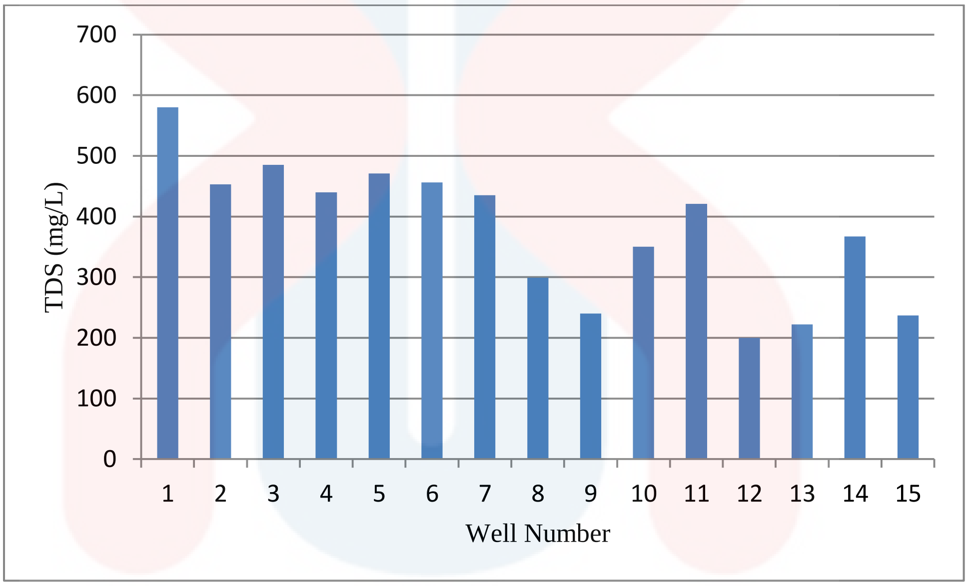


Figure 5.6 : Total Dissolved Solid values at study area

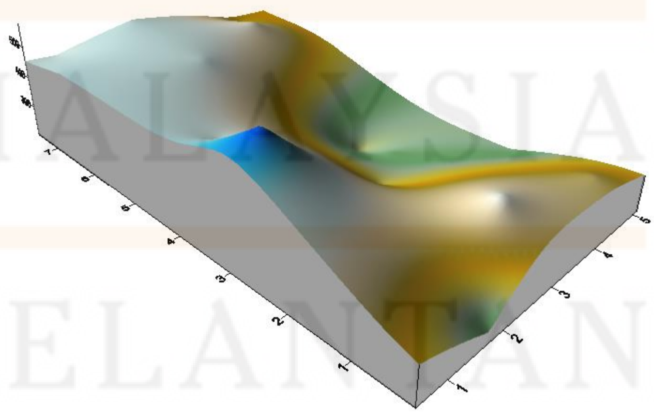


Figure 5.7: 3Dimensional map of TDS

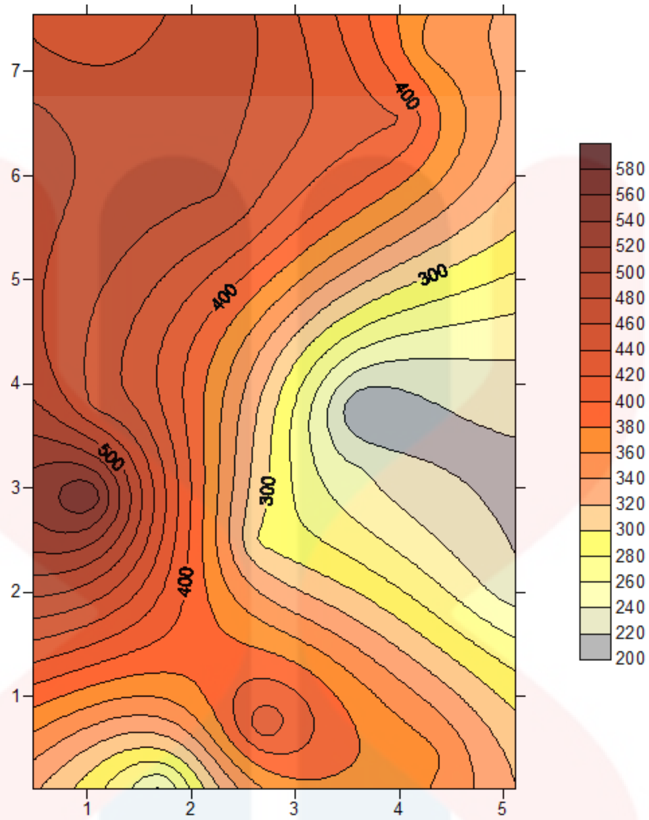


Figure 5.8 : Distribution map of TDS at study area.

IV. Electrical Conductivity (EC)

Electrical conductivity determine the efficiency of water in conducting current. In the study area, the value of EC ranges from 294 µS/cm to 32 µS/cm. Based on figure 5.9, the highest value are recorded at the well 12 that located at Kg Joh. The value of EC is highly influenced by value total dissolved solid of cations and anions. The ions presence in the water helps in transmitting current, higher ions presence will increase water EC. This explained the high value of EC at well 12 that correspond with high contain of Mg, Na, K and Fe. All the cations presence contribute to large number of charge ions in the water. Along with the high values of cations, thus the TDS value at well 12 is also high with the reading of 294 mg/l.

As for the lowest EC at well 13, the EC value is low in correspond with low value of TDS in the groundwater. From the figure 5.8, the reading of TDS at well 13 is the lowest with the value of 19 mg/l.

Figure 5.9 : Electrical Conductivity data at study area.

5.4 Major Cations Analysis

Major cations concentration include elements of Calcium, Magnesium, Ferum, Potassium and Sodium.

I. Calcium (Ca^{2+})

From the figure 5.10, the highest reading of Calcium is 17.86 mg/L and the lowest reading is 1.95 mg/L. The highest Ca value observed at well 2 and the lowest is at well 12. Well 2 is located near the near the area of Kg. Jelatuk. The main contributor of calcium concentration is from the dissolution process of calcium presence in the soil and the weathering process of calcium bearing mineral at the surrounding outcrop area. Rainfall precipitation will dissolve the calcium during the seepage runoff and during the infiltration of water into the aquifer. The lowest calcium in well 12, that is located near the area of Kg.Joh. In some others well also showed a relatively high concentration of calcium, especially well 7 and well 11.

WHO and MoH does not stated any specific standardize of calcium presence in the water. However, the presence of calcium in the water can be beneficial for human because calcium is one of the nutrient that included in the compulsory daily intake nutrient.

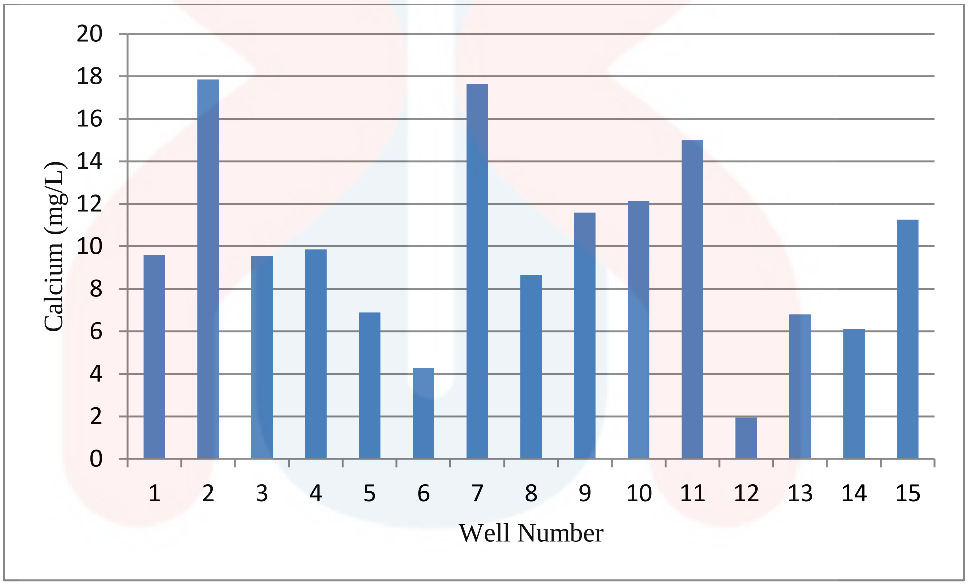


Figure 5.10: Calcium concentration at study area

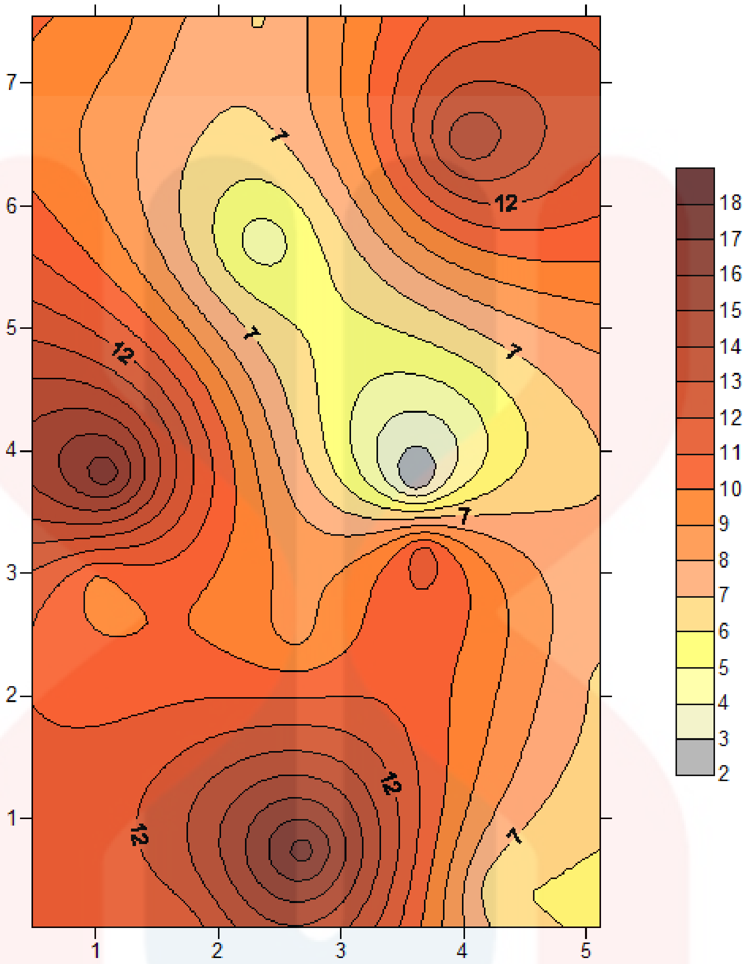


Figure 5.11: The distribution map of Calcium concentration

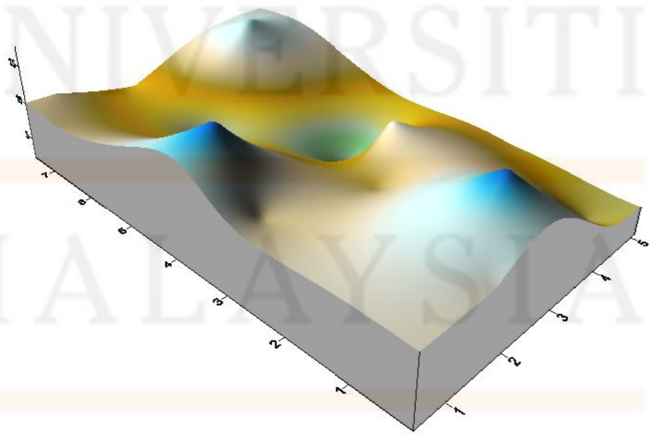


Figure 5.12: 3Dimensional map of Calcium concentration.

II. Ferum (Fe)

Ferum presence in the study area ranges from 0.091 mg/L to 1.438 mg/L. From the figure 5.14, the distribution map showed the increase in ferum concentration from north to south direction. The highest ferum concentration is observed at well 14 located near Kg. Machang Gedibing area at south-east direction . While the lowest value is at well 5 near the area of Kg. Domis at north direction. The ferum concentration in 3 dimensional can be seen in figure 5.15.

The concentration of ferum is closely related with the pH value, this is due to oxidation process enhance with increasing water acidity. The water acidity at well 14 is more acidic compared to well 5, thus explained the higher ferum concentration at well 14. However, eventhough the water pH is acidic, but if the surrounding soil and rocks does not have or lacking in iron contain, thus it will reduce ferum concentration..From the figure 5.13, the overall value of ferum contain in groundwater is within the standard of WHO and MoH, which is below 0.3 mg/L. Exceptional for the well 9, 12, 13, 14 and well 15 that have ferum contain higher than 0.3 mg/L.

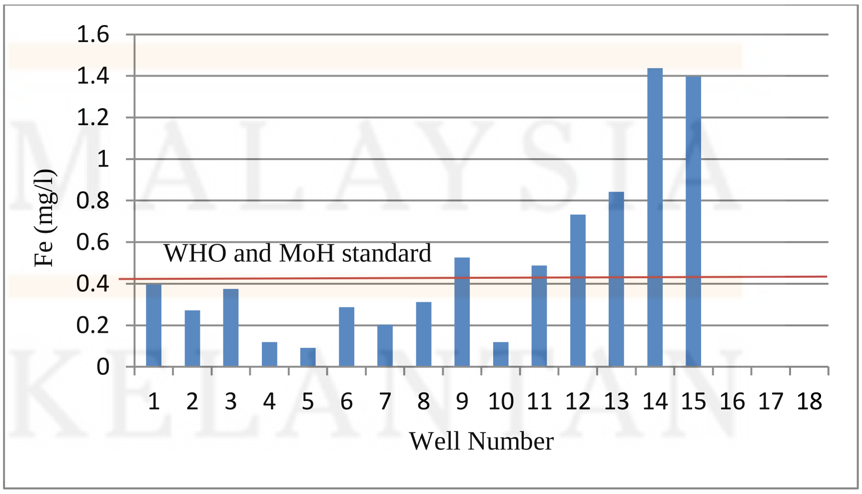


Figure 5.13: Barchart of Ferum Concentration

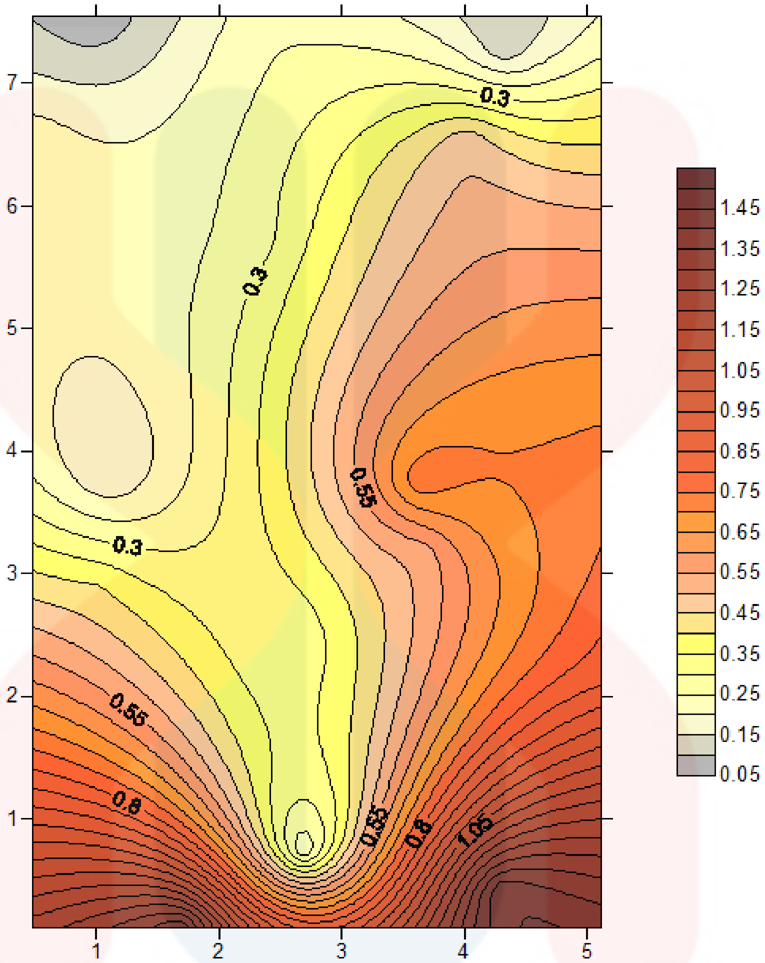


Figure 5.14: Distribution Map of Ferum concentration

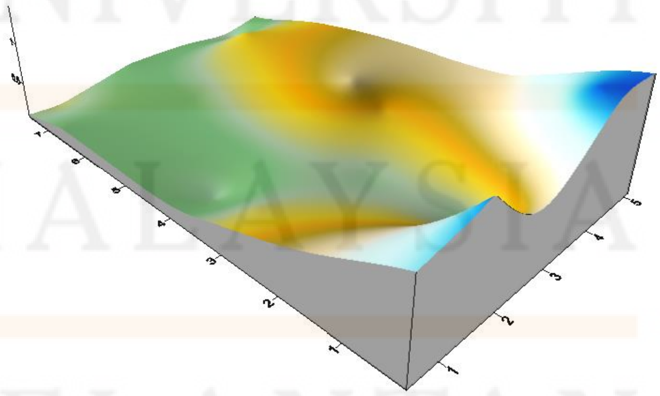


Figure 5.15: 3Dimensional map of Ferum concentration.

III. Magnesium (Mg^{2+})

From the figure 5.17, the distribution map of magnesium concentration present that the highest concentration is at north direction and the lowest concentration is at south direction. The Mg concentration is display in 3 dimensional view in figure 5.18.

Based on the figure 5.16, the Magnesium presence in the study area ranges from 0.309 mg/L to 2.048 mg/L. The highest concentration of Mg is located at well 11 near the area of Kg. Tok Syed at north direction and the lowest mg concentration in well 13 located at near Kg. Machang Gedibing at south direction.

According to MoH standard, the maximum magnesium contain in drinking water is 150 mg/L. The overall reading of Mg in all the well are within the standard of MoH, thus the well water is free from magnesium contamination. The presence of magnesium is crucial in the drinking water due to the role of magnesium as one of the important nutrient that should be taken daily. The lack of mg in daily intake can cause health risk to humans.

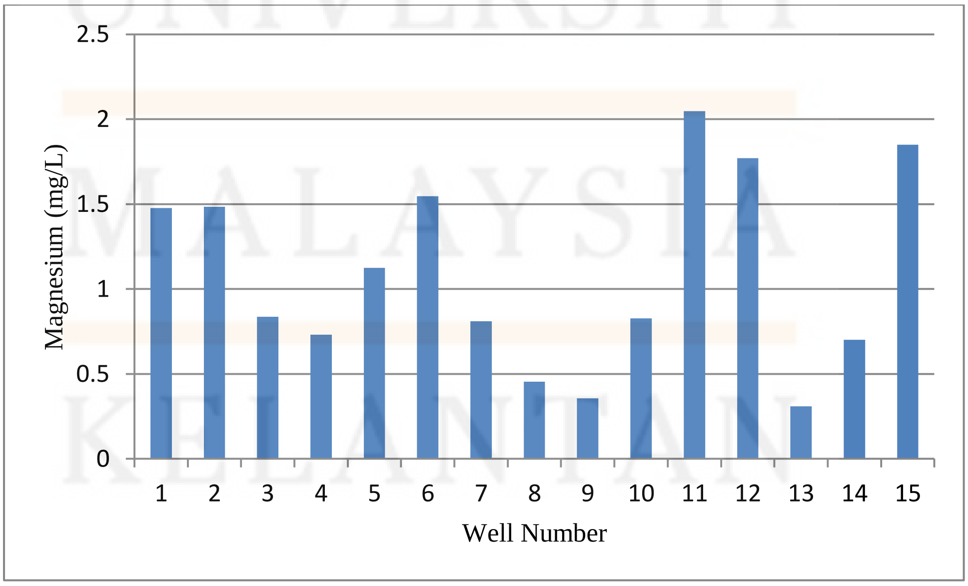


Figure 5.16: Magnesium concentration at study area

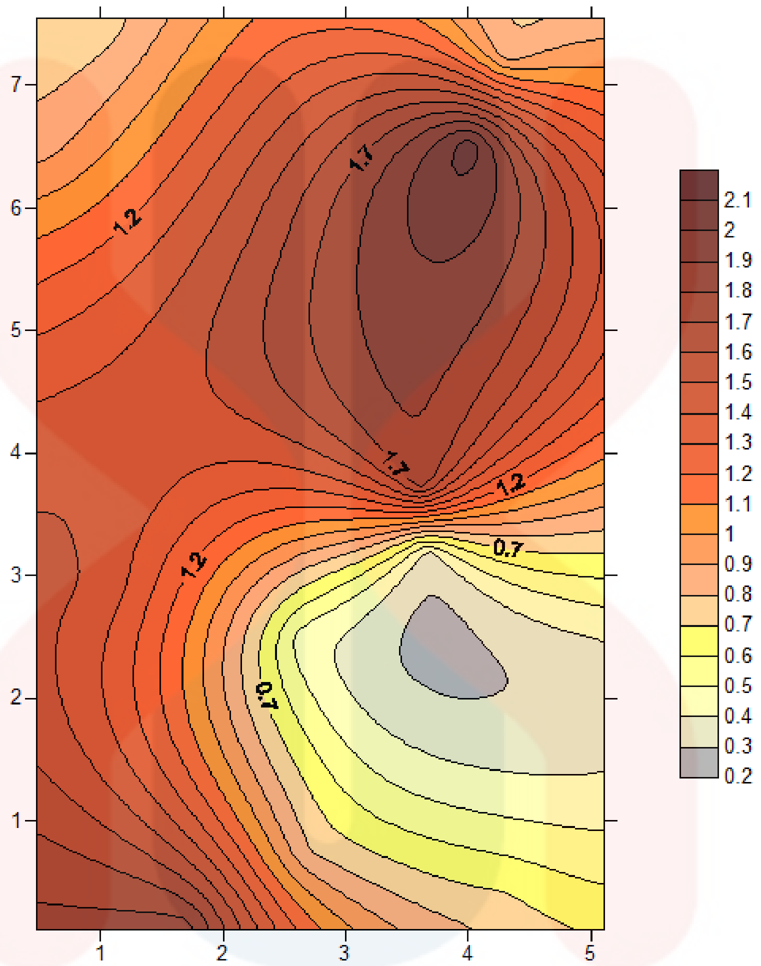


Figure 5.17: Distribution map of Magnesium concentration.

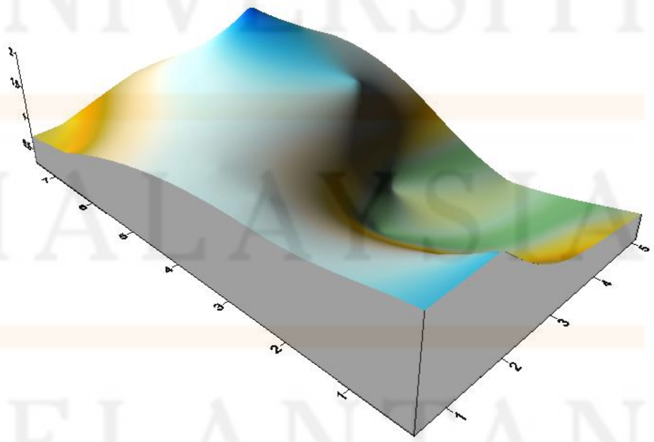


Figure 5.18: 3Dimensional map of Magnesium concentration

IV. Potassium (K^+)

The distribution map in figure 5.20, showed that the highest concentration is toward north direction. While the lowest concentration is towards south direction. Based on figure 5.19, the value of Potassium in the study area ranges from 1.155 mg/L to 9.58 mg/L. The highest concentration of potassium is in well 12 located near Kg. Joh at north direction, while the lowest concentration is in well 13 located at low lying area near Kg. Machang gedibing at south direction. Potassium is a naturally occuring element that presence in the water due to the dissolution process of the rocks and soil that contain potassium element. From the figure 5.19, all the well water potassium contain is within the standard of WHO and MoH, which is below 20 mg/L. The potassium concentration at study area is display in 3dimensional in figure 5.19.

The presence of potassium in all the well water can be very beneficial in supplying the potassium nutrient to humans. The daily intake of potassium can increase result from the nutrient presence in drnking water.

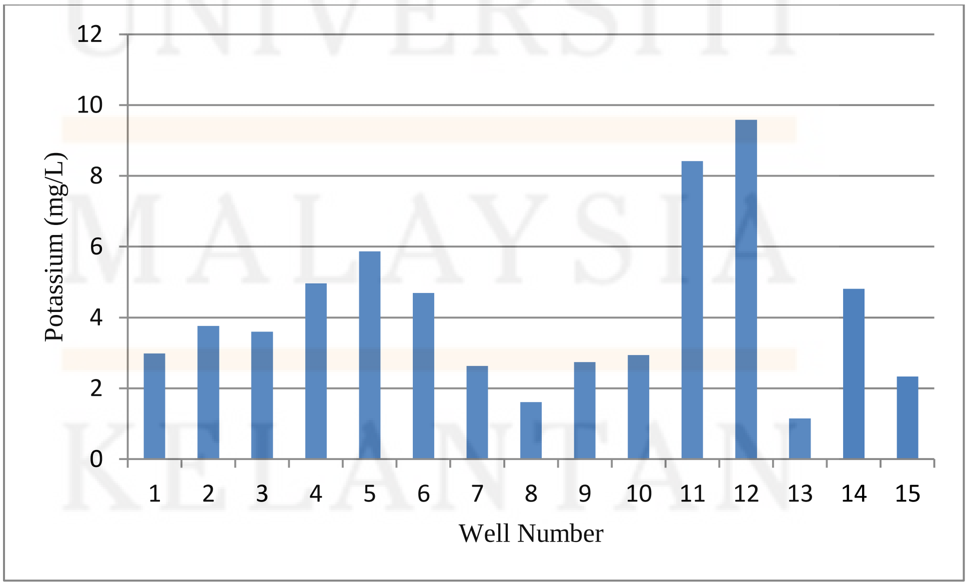


Figure 5.19: Potassium concentration at study area

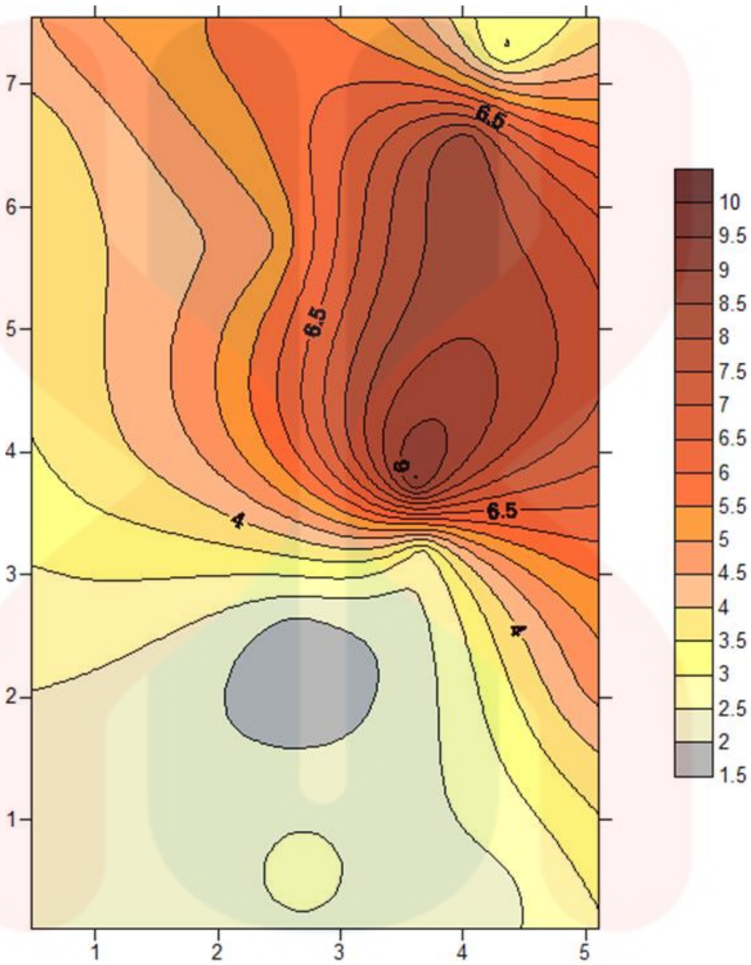


Figure 5.20: Distribution map of Magnesium concentration

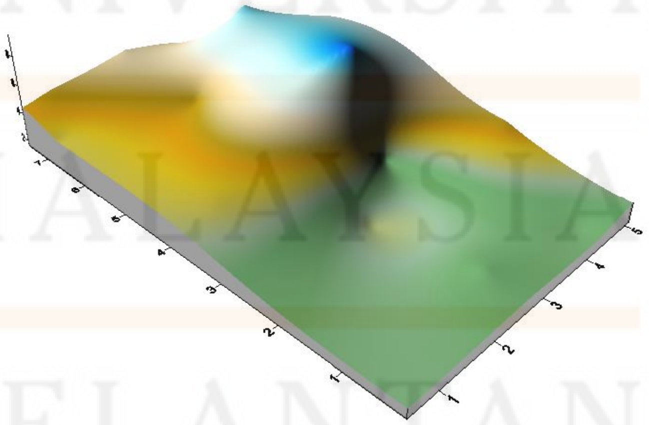


Figure 5.21: 3Dimensional Map of Potassium concentration

V. Sodium (Na^+)

Sodium is another naturally occuring element that commonly presence in the igneous rock and sedimentary rock. Figure 5.23, showed the distribution of sodium concentration, lowest at south-east direction and increase toward north direction. From the figure 5.22, the total ranges of sodium presence in well water is between 2.986 mg/L and 14.08 mg/L. The highest concentration is observed in well 11 located at Kg. Tok Syed, while the lowest concentration is in well 14 located at the south-east direction near Kg. Pangkal Mak Wan. The area toward north direction is a low lying area and the well sampling point is near to the Bagan river. The presence of sodium in the well can be due to the influent flow of surface water from the river into the aquifer. This explained the high concentration of sodium at well 11. The sodium concentratin at the study area is display in 3 dimensional in figure 5.24.

Based on the figure 5.22, the overall values for sodium concentration in all wells are still within the drinking water standard by WHO and MoH, which is at 200 mg/L. Therefore, the well water at all sampling point is safe from contamination.

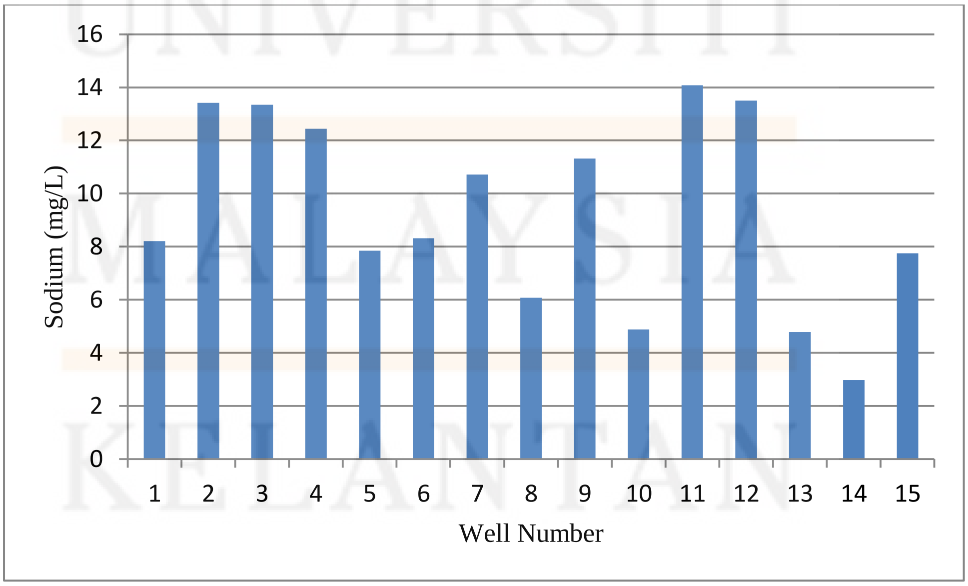


Figure 5.22: Sodium concentration at study area

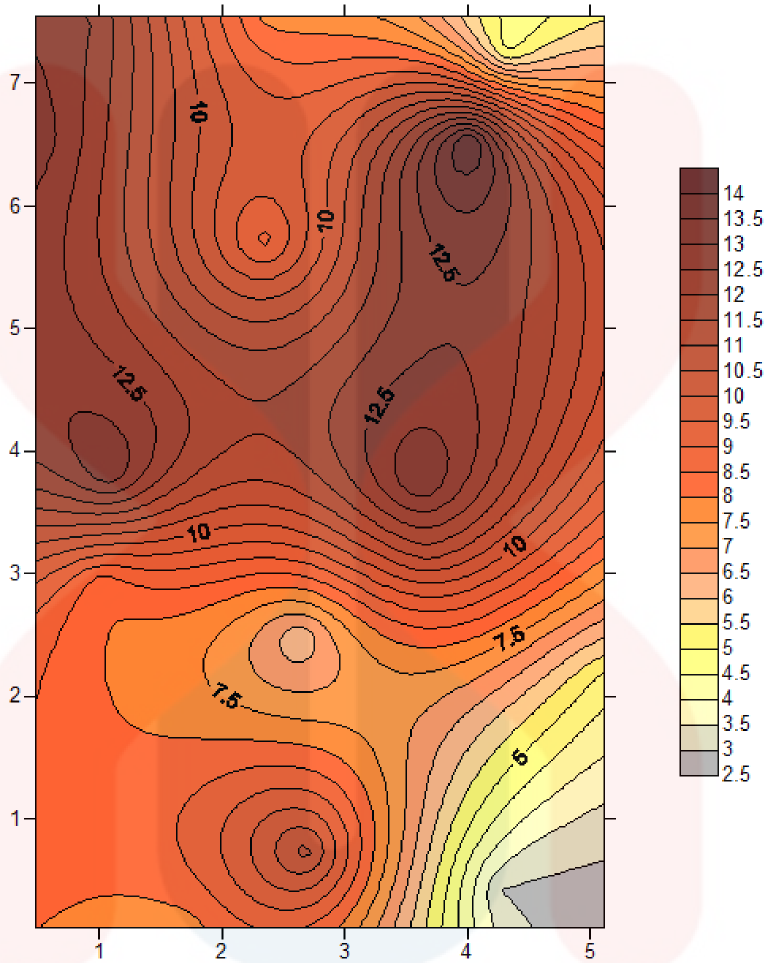


Figure 5.23: Distribution map of sodium concentration

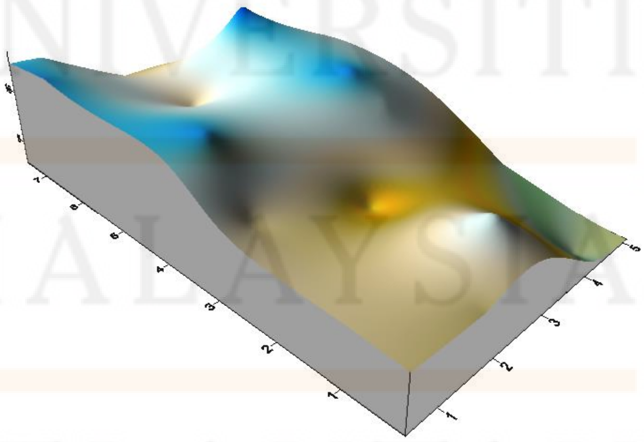


Figure 5.24: 3Dimensional map of sodium concentration

5.5 Major anions Concentration

I. Nitrate (NO_3^-)

Based on the figure 5.25, the nitrate concentration at the study area are ranged from 1.0 mg/L to 9.7 mg /L. The highest nitrate concentration are in well 12 that located near Kg. Joh and the lowest concentration is in well 8 that located at Kg. Maka. The landuse at Kg.Joh area are mostly for the agriculture purpose of palm oil and rubber plant, the plantation activity covered most of the area at Kg.Joh. The landuse influnced the high concentration of nitrate in well 12, this is because agriculture field is one of nitrate souces. The nitrate concentration in well water increase due to the surface runoff at the agriculture field are rich in nitrate.

As for the well 8 is located at hilly area, the concentration is lower due to contributor of nitrate in well water are coming from natural sources of soil mineralization, atmospheric nitrogen and lack of agriculture plantation.. The overall values of nitrate concentration in all the sampling well are within the standard of MoH at 10 mg/L. Therefore, all the well water is safe from nitrate contamination

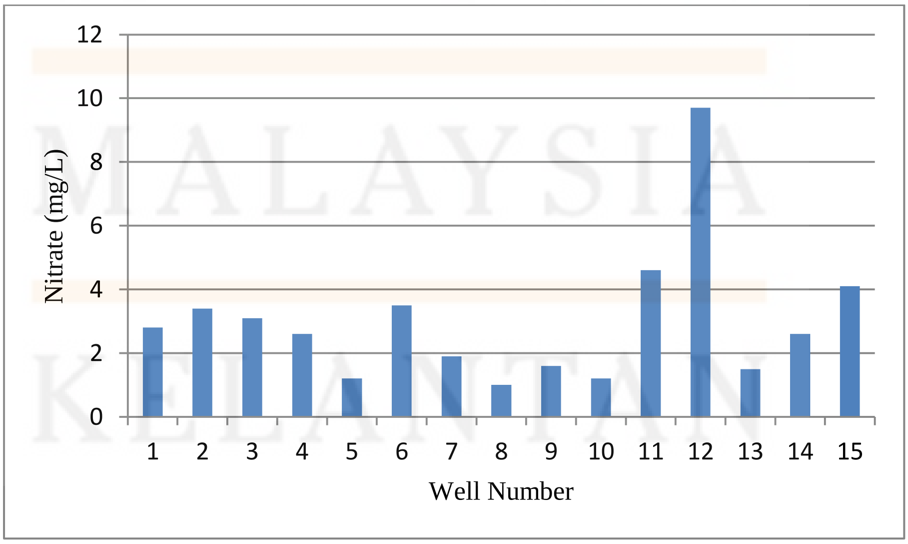


Figure 5.25: Nitrate concentration at study area

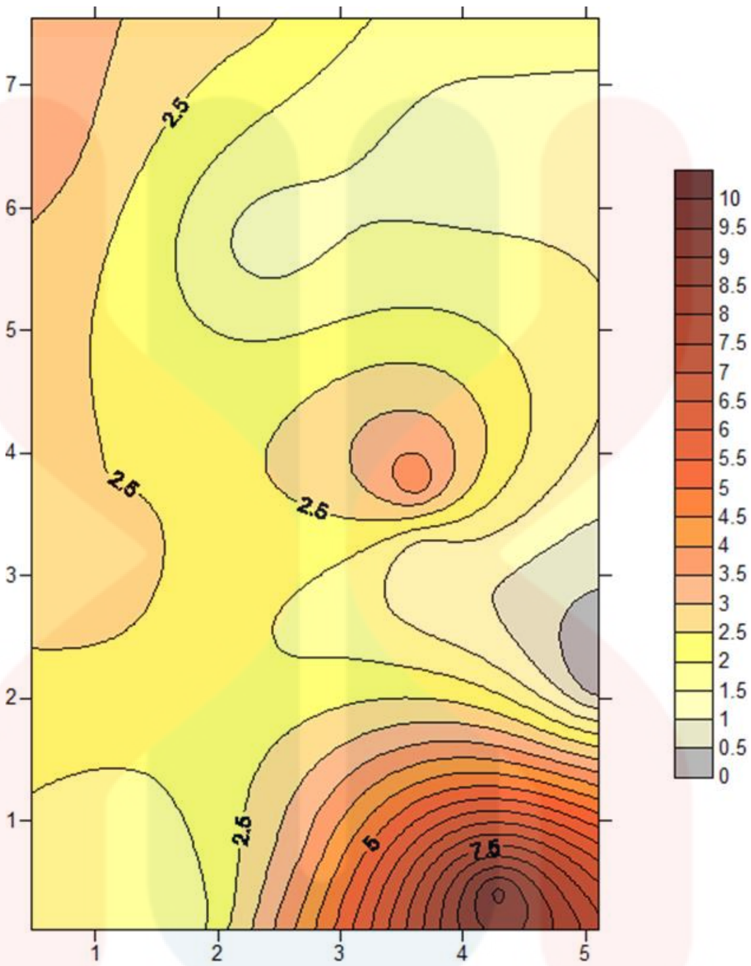


Figure 5.26 : Distribution map of Nitrate concentration

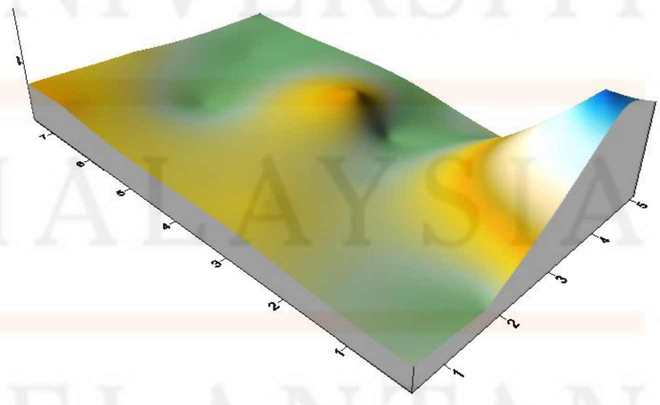


Figure 5.27: 3Dimensional map of Nitrate concentration

II. Sulphate (SO_4^{2-})

Sulphate is a naturally occuring anions that commonly presence in surface water and groundwater. Based on figure 5.28, the sulphate concentration in study area are ranged from 4 mg/L to 124 mg/L. From the result, most of the sulphate values are below 60 mg/L, only well 1 and well 5 showed high concentration of sulphate. The highest concentration in well 1 and the lowest are in well 9.

The sulphate concentration in well water can be influenced by the condition of surrounding area. From the figure 5.30., well 1 showed the highest peak of sulphate concentration. Sulphate concentration can increase due to the rainfall rich with sulphate especially at an area with atmospheric pollution. Well 1 is located at the town area that is highly populated area and common with industrial activity. The surrounding condition can contribute to atmospheric pollution at the region, therefore the rainfall precipitation near well 1 area can be rich in sulphate due to reaction with atmospheric pollution. Another source of sulphate at well 1 can be due to the accumulation of soluble salt in the soil. This is explained by high concentration of Sodium at well 1.The lowest sulphate concentration in well 9 that is located outside town area, therefore the atmospheric pollution at the area is at lower rate compared to the town area. This factor indirectly contribute to lowest sulphate concentration in well 9.

From the figure 5.28, all the sulphate values recorded are still within safe standard limit. WHO and MoH have standardize the sulphate content in drinking water must be below 250 mg/L, since all the well water contain sulphate concentration lower than the standard, thus the well water in the study area are safe to consume and does not cause health risk.

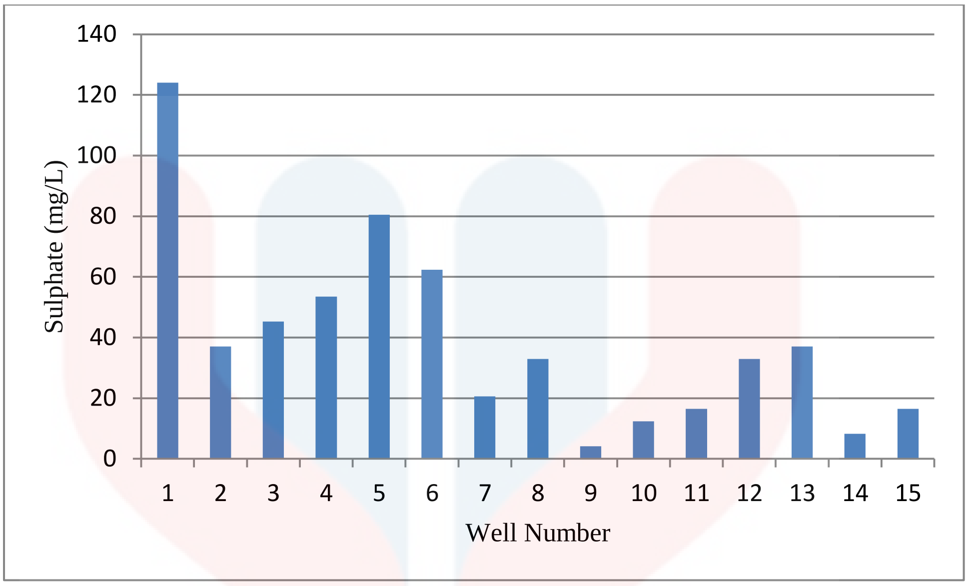


Figure 5.28: Sulphate concentration at the study area

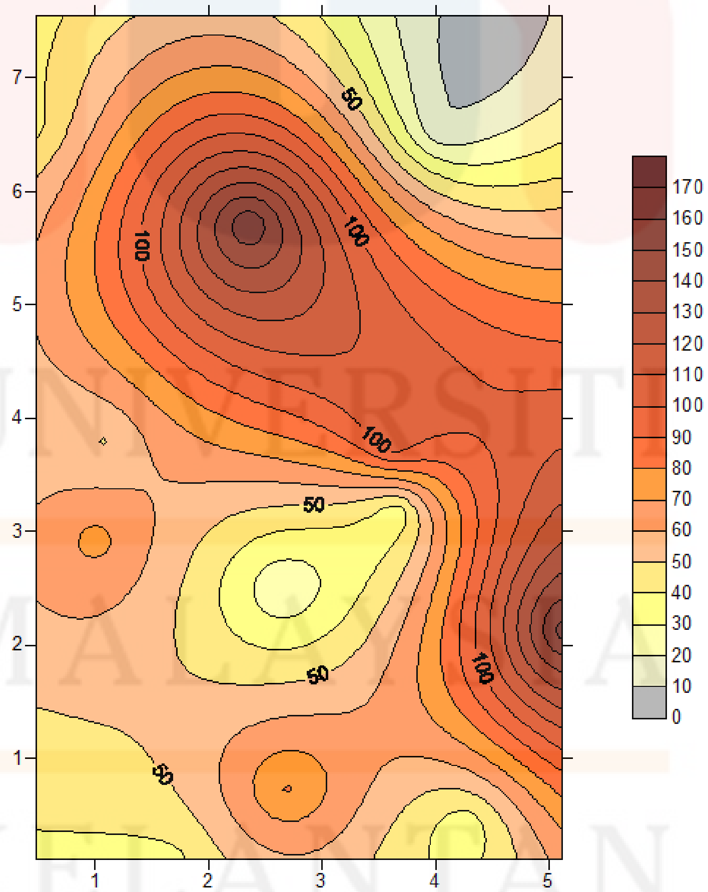


Figure 5.29: Distribution map of Sulphate concentration

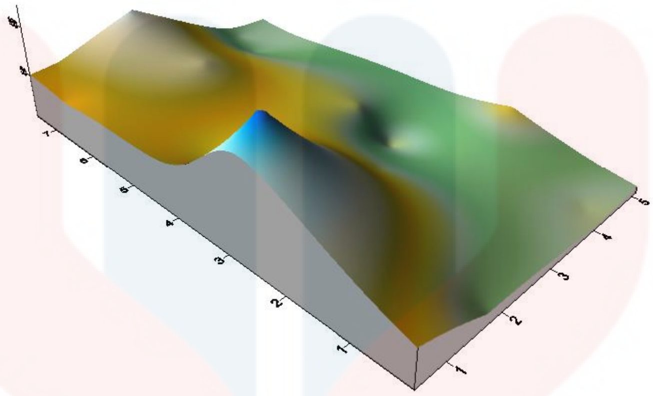


Figure 5.30 : 3Dimensional map of Sulphate concentration

III. Bicarbonate (HCO_3^-)

The distribution map of bicarbonate concentration in figure 5.32, showed that the increase in concentration from east direction toward west direction. The distribution is displaye in 3 dimensional in figure 5.33. The 3 dimensional map display the highest peak at west direction.

From the figure 5.31, the bicarbonate concentration in the study area ranged from 120 mg/L to 408.33 mg/L. The highest bicarbonate content is at well 1 and the lowest is at well 12. The bicarbonate ions can be generated from the reaction of carbonic acid in the well water and also due to silicate weathering. The chemical weathering of silicates minerals cause reaction of soil carbon dioxide, CO_2 becomes dissolved bicarbonate that contaminate into the groundwater (E.K. Berner, 2005). Another source of bicarbonate can be due to influent of river water into the aquifer. river water can be dominanted by HCO_3^- in the form of dissolved inorganic carbon that sources from carbonic acid weathering of noncarbonated minerals such as feldspar, mica and olivine, another sources is from dissolution of carbonate minerals presence in the river (M.Meybeck, 2005). Due to the silicate weathering and influent river flow contribute to high concentration of bicarbonate in well 1

The presence of bicarbonate does not posses any health risk, however it can change the taste of water become salty. WHO and MoH does not provided specific standard for the bicarbonate content in the water. Therefore, the domestic well water in study area can be consume as long as the taste is palatable.

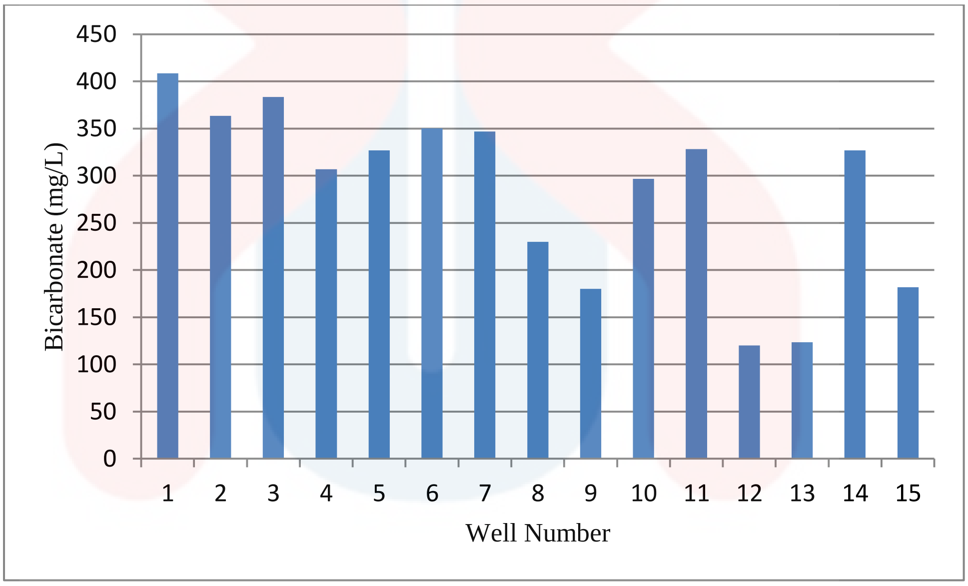


Figure 5.31: Bicarbonate concentration at study area

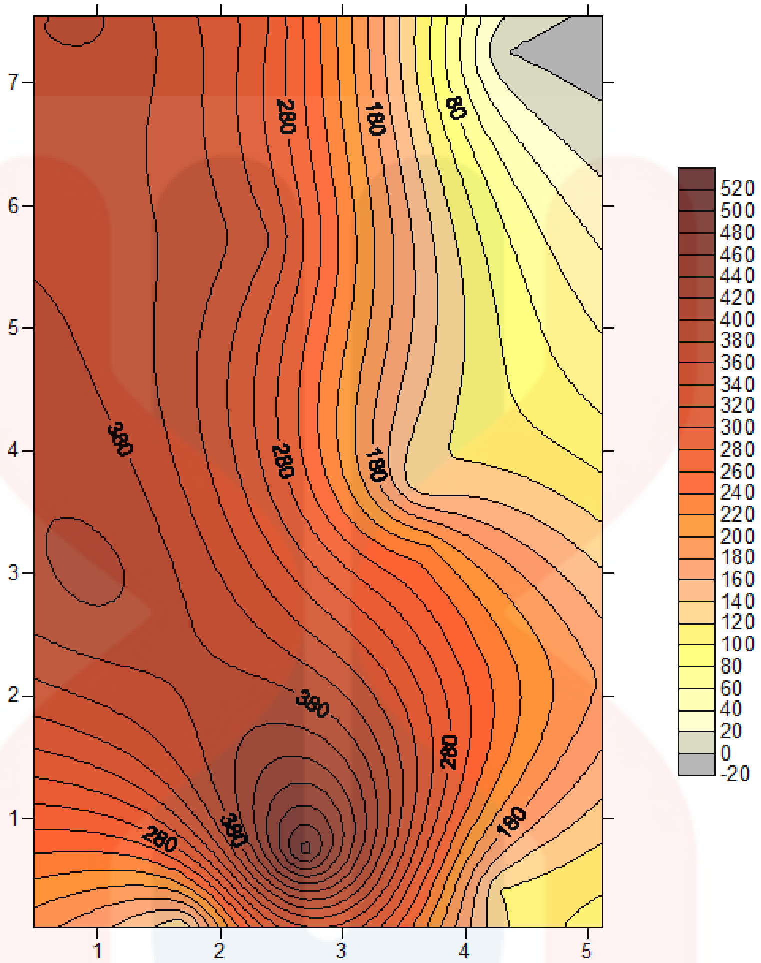


Figure 5.32: Distribution map of Bicarbonate

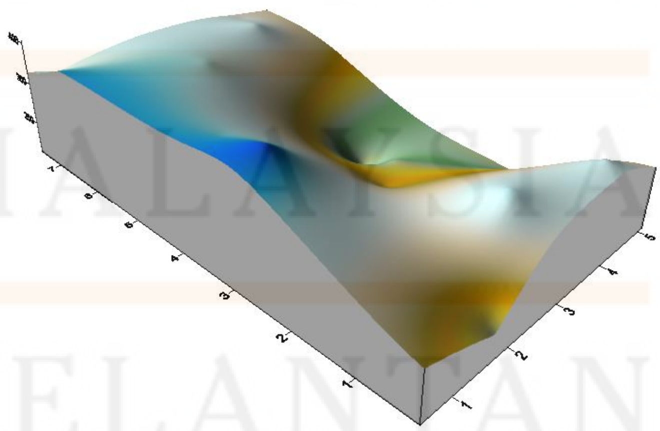


Figure 5.33 : 3Dimensional map of Bicarbonate concentration

IV. Fluoride (Fe^{-})

Based on the figure 5.34, the fluoride contain in well water ranged from 0-0.86 mg/L. The highest concentration is in well 1 that located Bt. Maka at west direction. Fluoride contain in the well can be influenced by the surrounding condition of the area that located near the andesite quarry. Fluoride minerals that low in solubility commonly occurred in igneous rock and sedimentary rock. This explained the high concentration of fluoride in the well water due to the andesitic rock presence nearby the well. Fluoride bearing mineral are abundance and has become contributor to fluoride concentration in the well water. Majority of the well in study area showed absence of fluoride anions. This is due to the lack of fluoride bearing minerals presence at the area.

According to WHO and MoH, the safe limit fluoride standard for drinking water ranged from 0.4-0.6 mg/L. The overall fluoride concentration in well water is still within the safe standard limit, exceptional for the well 1 that exceed the standard concentration. Therefore, all well water are safe to consume except for well 1 water that need to undergo removal of excessive fluoride process before consumption.

The distribution of fluoride concentration is display in figure 5.35, the distribution showed the highest point toward west direction and the lowest fluoride concentration toward north direction. The distribution is also displayed in 3 dimensional map in figure 5.36, the 3 dimensional map showed two relatively high peak of fluoride concentration, one is located at the west, which is the location of well 1, while the another high peak is at south-east direction, this is the location of well 15 that have the second high fluoride concentration with the value of 0.37 mg/L.

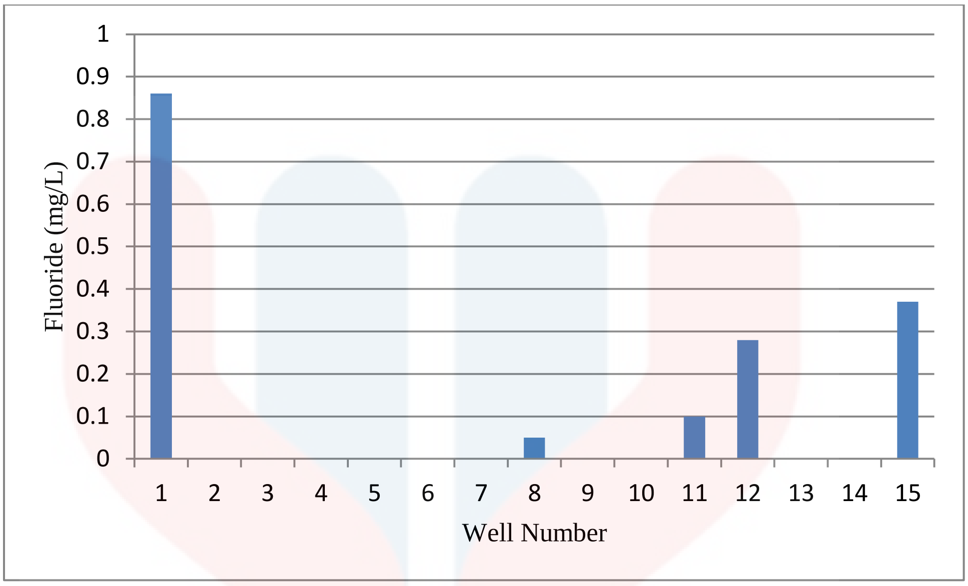


Figure 5.34: Fluoride concentration at study area

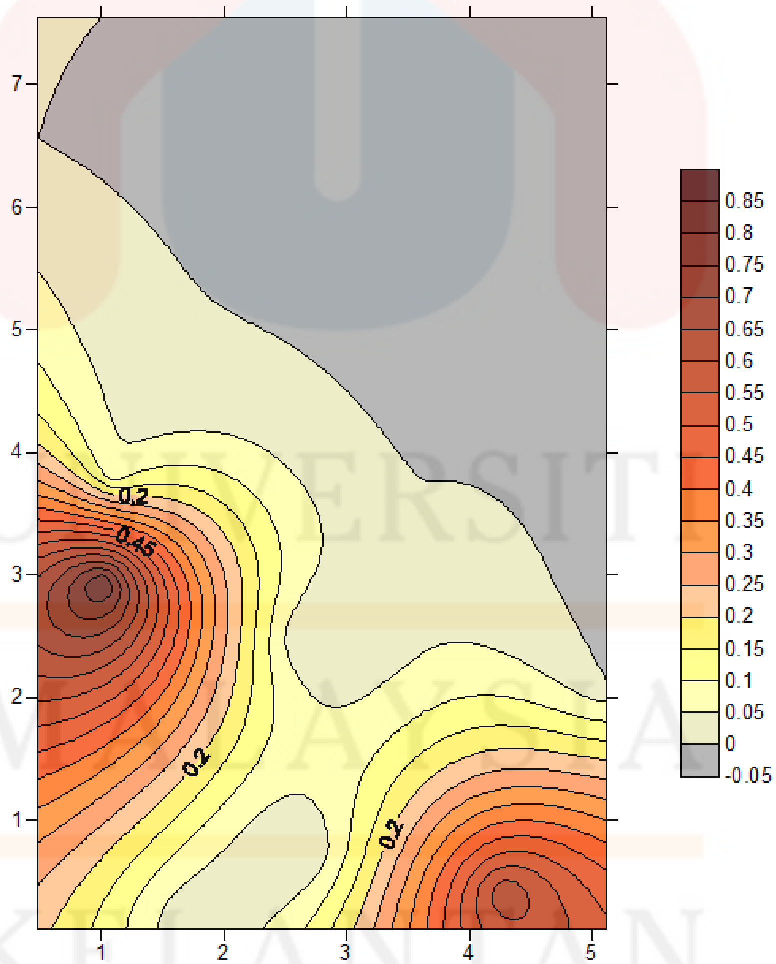


Figure 5.35: Distribution map of Fluoride concentration in study area

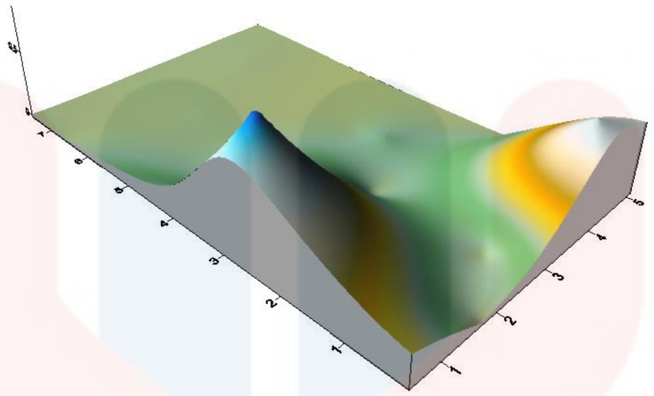


Figure 5.36: 3Dimensional map of Fluoride concentration

V. Silica (Si^-)

Based on figure 5.37, the silica concentration at the study area ranged from 3.0 mg/L to 15 mg/L. The highest range of silica is observed in well 5 that located near Kg. Domis area toward north direction and the lowest silica contain is in well 13 located at Kg. Machang Gedibing toward south-east direction. WHO and MoH does not provide a standardize limit for silica contain in drinking water due to the reason that silica does not posses any health risk. However using a high silica water in a boiler may caused formation of glassy scale.

The distribution map in figure 5.38, showed tht the highet silica concentration distributed at north direction and also toward south-west direction. As for the lowest silica concentration is located toward north-east direction, which is the location of well 13. The silica concentration distribution is also displayed in 3 dimeensional in figure 5.39, the 3dimensional map showed a obvious high peak that pointed toward north direction, this is the location for well 5. Well 5 are surrounded by well 6 and well 10, that also showed a relatively high silica concentration. Due to this reason, the 3dimensional map showed a high distribution of silica toward north direction.

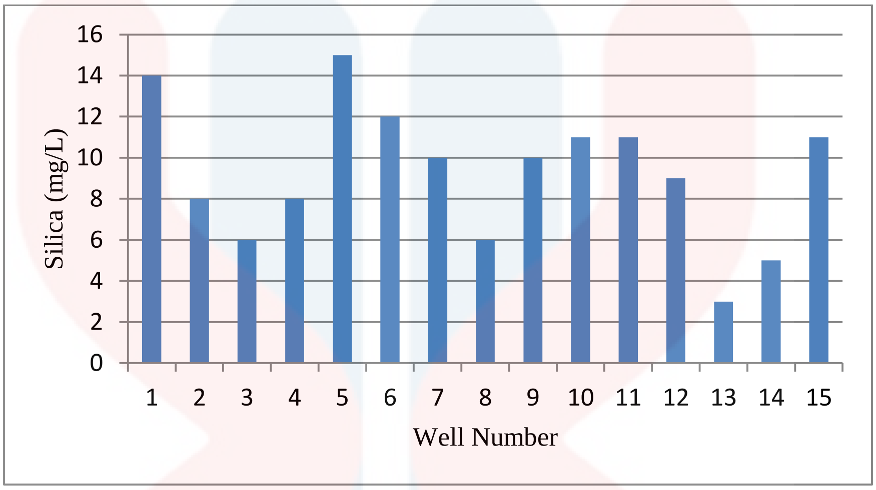


Figure 5.37: Silica cocentration at study area

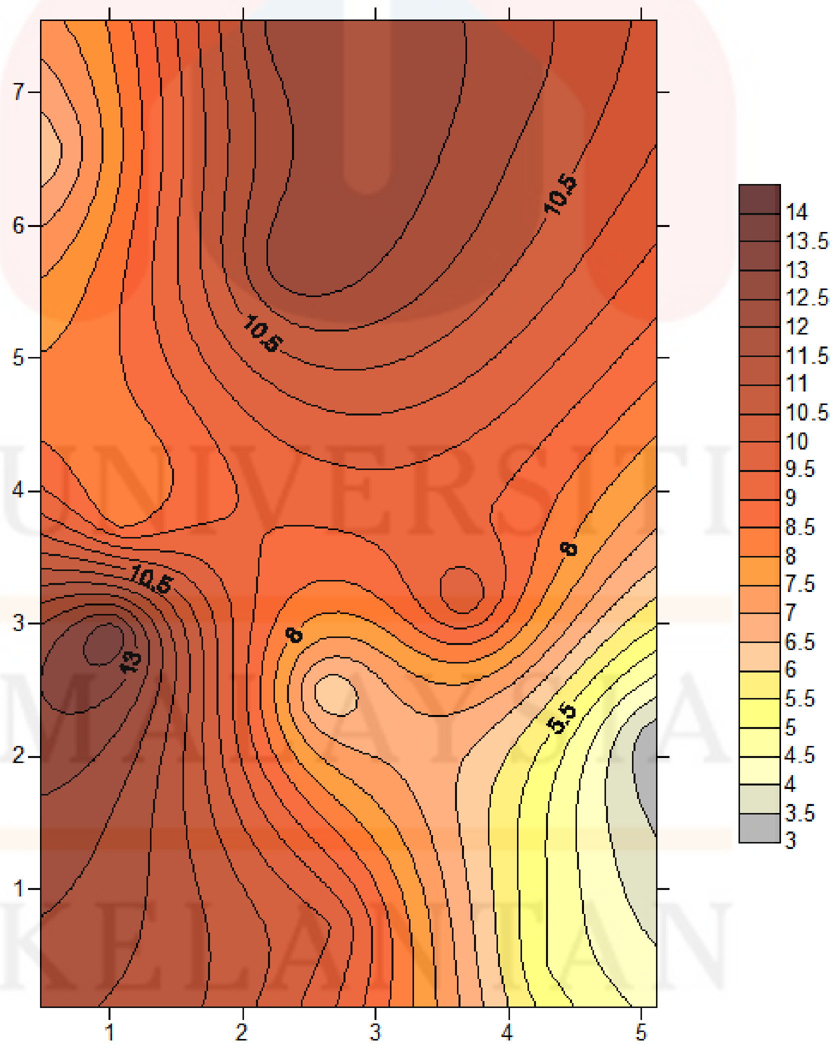


Figure 5.38 : Distribution map of Silica concentration

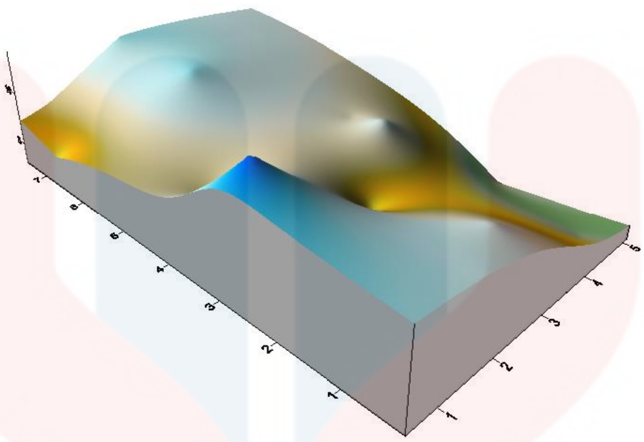


Figure 5.39: 3Dimensional map of Silica concentration

VI. Chloride (Cl^-)

Based on the figure 5.40, the chloride contain at the study area ranges from 11.4 mg/l to 51.1 mg/l. The highest concentration of chloride is in well 4 and the lowest concentration is in well 12. From the overall result of chloride presence in the well water is still within the safe limit standardize by WHO and MoH. Therefore, all the domestic well at the study area is free from chloride contamination.

Chloride concentration is diplay in distribution map in figure 5.41. The distribution map showed that the highest distribution at north-west direction and south-east direction. The lowest concentration distributed at the center and toward east direction. The distribution map is correlated with the 3dimensional distribution map of chloride concentration in figure 5.42. In 3 dimensional view, there is a few peak of high chloride concentration, the highest is toward north-west direction, which is the location of well 4. The others peak showed the relative high concentration of well 5, well 13, well 7 and well 11.

Figure 5.40: Chloride concentration at study area.

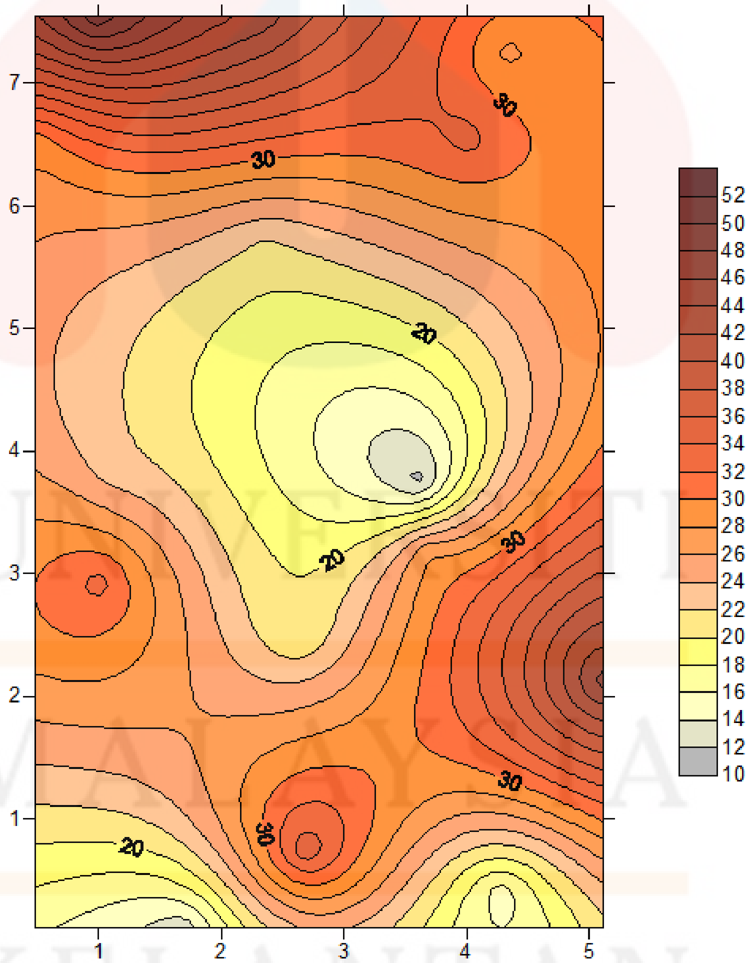


Figure 5.41 : Distribution map of Chloride concentration

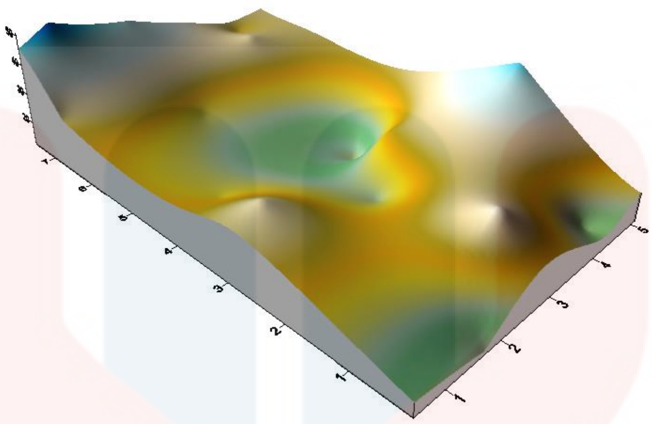


Figure 5.42 : 3Dimensional map of Chloride concentration

5.5 Piper Diagram Analyis

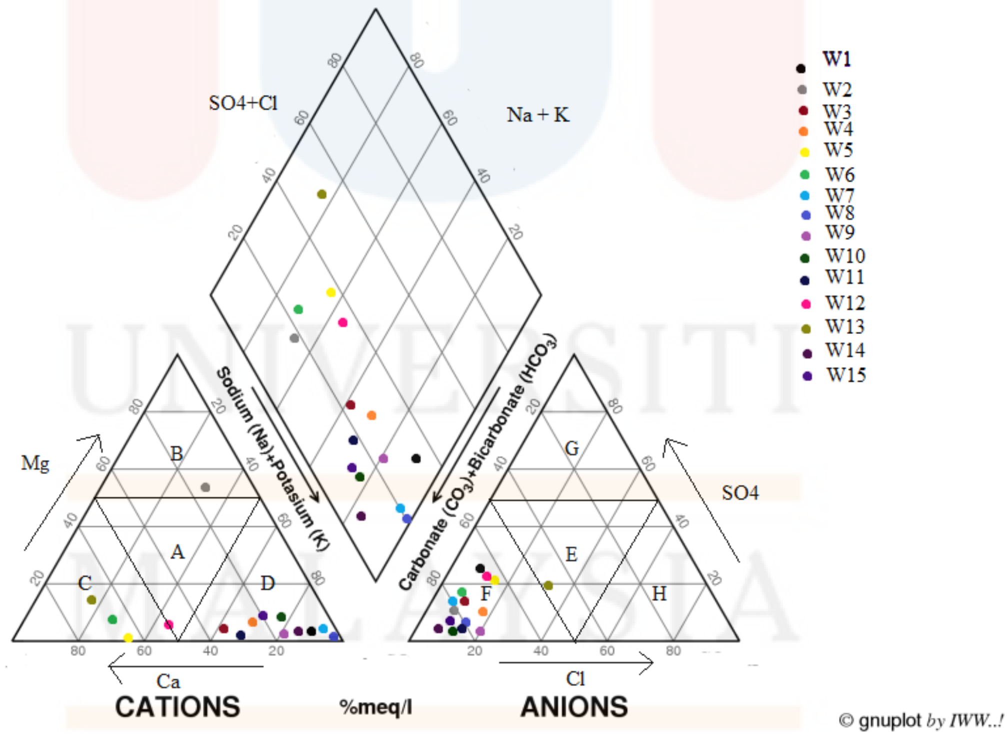


Figure 5.43: Piper diagram of the groundwater analysis

A &E : No dominant type
B : Magnesium Type
C : Calcium Type
D : Na+K Type
F : Bicarbonate Type
G : Sulphate Type
H : Chloride Type

Table 5.3: Ions dominant in water according to piper.

Ions Dominant	Well Number
Calcium	W5, W6, W12, W13
Magnesium	W2
Bicarbonate	All well sample except W13
Sodium + Potassium	W1, W3, W4, W7, W8, W9, W10, W11, W14, W15,
Sulphate	None of the well sample
Chloride	None of the well sample
No dominant	W13

Based on figure 5.43 the cations and anions value was superimposed on the diamond shape. From the superimposed of the ions dominant on the diamond shape, the hydrochemical facies is divided into three group. The majority of the domestic well water are grouped as bicarbonate-sodium-potassium. The second minority facies with only 4 welll is grouped as bicarbonate-calcium-magneium. The third group consist only one single point that is grouped as calcium-magnesium-chloride-sulphate facies. Overall analysis from the piper diagram analysis the domestic well water at the study area is dominant with bicarbonate-sodium-potassium facies.

5.7 Water Quality Index Analysis

Water Quality analysis is carried by included all the physico-chemical parameter that have standardize limit of elements by WHO. The element that are included can be seen in table 5.5.

Calculation of WQI value by using the calculation 3.4:

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

$$WQI = 518.16/3.85$$

$$WQI = 134.59$$

The value of WQI is compared with the table in figure 3.5, water qulity status is determined according to the range. From the comparison with figure 3.5, the value of WQI at the study area is qualified in very poor quality status.

Table 3.5: Groundwater status from WQI analysis

WQI	Groundwater Quality
0 – 25	Very good
26 – 50	Good
51 – 75	Poor
Above 75	Very poor

Table 5.4 Calculation of WQI values for Groundwater Samples Collection.

Physico-chemical Parameter	Mean value in ppm (V_i)	Highest Permitted Value (WHO) (S_i)	Unit Weightage (W_i)	$W_i \times Q_i$
pH	6.0	6.5	0.154	14.22
Electrical Conductivity (EC)	89.7	1400	0.00071	0.037
Total Dissolved Solid (TDS)	377.1	1000	0.001	9.75
Turbidity (NTU)	12.0	5	0.2	240
Nitrate	2.9	10	0.1	29
Chloride	28.4	200	0.005	14.2
Ferum	0.51	0.3	3.33	170
Potassium	4.14	20	0.05	20.7
Sodium	9.31	200	0.005	4.65
Sulphate	39	250	0.004	15.6

CHAPTER 6

CONCLUSION AND RECOMMENDATION

6.1 Conclusion

From the general geology at the study area in Tanah Merah, the geological map of the study area is produced by using ArcGis software. From the research, there is two types of lithology presence at the study area, which is sedimentary rock and volcanic rock. The volcanic rock divided into two types, which is andesite and tuff. As for the sedimentary rock consist of argillite layer and fine grained sandstone layer.The volcanic igneous rock outcrop are deformed due to the structure of joint and fracture presence on the rock. The presence of joint and fracture enhance the weathering activity over time.

The domestic well water quality is influenced by the physico-chemical parameter. The result from the analysis is compared with the standardize limit by WHO and MoH. From the analysis some of the domestic well water is contaminated and become unsuitable for drinking purpose. pH is one of the in-situ parameter reading that showed someof the well water pH is below the standardize limit, the well water is high in acidity and making it become unsuitable for drinking purpose and also for irrigation purpose.

As for some physico-chemical parameter such as hardness also showed a high concentration value at well 2 and well 5 that caused the contamination of the well water. The increased in water hardness can result in adverse health affect if the well water is used for drinking purpose by the community. Another parameter that reduce the water quality is the presence of high concentration of iron in well water, particularly in well 14 and well 15.

Therefore, for the well 2, well 3, well 5, well 8, well 9, well 13, well 14 and well 15 need to undergo water treatment and removal of excessive ions process before consumption for drinking purpose. The well water that are contaminated might not be suitbale for drinking purpoe, but it can be used for industrial or domestic purpose. As for the others well, the physico- chemical parameter is still within the permissible limit, so the water are safe to consume for drinking purpose.

From the WQI analysis also showed the overall result that display the water status in poor quality. The main contributor that cause to this result is due to the high concentration of TDS value and also EC.

6.2 Recommendation

All the domestic wells at Tanah Merah are mostly developed at the backcountry area. The well are mostly used by the villagers for daily usage. Since the wells are not a part of government, therefore the water quality ot the domestic well at the study area is not under the responsibility of government. The owners of the well itself need to ensure that their well undergo regular water quality monitoring by any non-government consultancy. The regular monitoring of the groundwater quality is important in ensure that the water are free from contamination and does not cause any adverse effects to health. The control of discharge rate is also one of the important factor to ensure that the excessive water discharge does not occur.

Another method to prevent well water contamination are by setting up a systematic drainage pattern of sewage system. By having a systematic drainage system, the sewage waste can be prevented from mixing with groundwater. This method help to reduce the possibility of well water contamination.

Drilling into the deep aquifer is another method that can be very helpful as prevention step from groundwater contamination. Shallow aquifer are prone to contamination. However, a deep aquifer are free from contamination and the aquifer are not easily contaminated. This is due to the characteristic of the aquifer that is overlayered by impermeable layer thus inhibit the movement of contamination sources infiltrate into the aquifer.

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Appendix A

Figure 6.0 : In- Situ parameter intruments. (A) Portable Total Dissolved Solid, (B) Calorimeter, (C) Turbidimeter, (D) Portable Total Suspended Solid.

Figure 6.1: Some of the intruments that were used during geological mapping. (A) Brunton compass, (B) GPS, (C) Chisel hammer.

Appendix B

Table 6.0 : Joint reading for GeoRose analysis

301	227	280	309	297
310	305	307	262	310
249	223	309	280	276
229	238	295	193	285
217	260	157	303	229
201	291	298	312	284
318	320	303	214	206
253	281	315	278	335
325	260	289	295	291
302	296	309	288	299
291	282	257	314	329
310	332	307	312	225
260	251	228	225	243
295	238	213	246	233
228	236	226	243	298
245	285	292	294	306
293	220	293	290	211
195	237	214	211	218
210	274	297	226	229
319	285	288	306	305

Table 6.1: Lineament reading for GeoRose analysis

155	172	150	146	115
146	100	114	120	130
90	130	15	20	55
5				

Appendix C

Table 6.2: Total Alkalinity, carbonates and bicarbonates calculation

Well Number	End Point 1 (ml)	End Point 2 (ml)	End Point 3 (ml)	Average Reading (ml)	TA as $CaCO_3$
W 1	8	8	8.5	8.17	408.33
W 2	6.6	7.2	8	7.27	363.33
W 3	7	8.5	7.5	7.67	383.33
W 4	5.9	6	6.5	6.13	306.67
W 5	6.2	6.4	7	6.53	326.67
W 6	7.2	7	6.8	7.00	350.33
W 7	6.6	7.2	7	6.93	346.67
W 8	4.8	5	4	4.60	230.00
W 9	4	3.5	3.3	3.60	180.00
W 10	5.4	6.4	6	5.93	296.67
W 11	6.8	6.9	6	6.57	328.33
W 12	1.9	2.5	2.8	2.40	120.00
W 13	2.6	2.4	2.4	2.47	123.33
W 14	6.6	6.7	6.3	6.53	326.67
W 15	3.4	3.9	3.6	3.63	181.67

Table 6.3: Gravimetric method calculation

Well Number	Initial pH	Final pH	Weight before burn (g)	Weight after burn (g)	Volume of SO4 (g)	volume SO4 (mg)	Total Sulphate (mg/L)
W 1	6	4.8	34.502	34.532	0.03	30.13	124
W 2	6	4.7	36.043	36.052	0.009	9	37
W 3	5.2	4.5	33.388	33.498	0.11	110	453
W 4	6	4.8	33.193	33.206	0.013	13	53
W 5	6.3	5	36.508	36.547	0.039	39	80
W 6	6.1	4.8	38.804	38.824	0.02	20	62
W 7	6.2	4.5	37.544	37.549	0.005	5	21
W 8	5.2	4.5	35.964	35.972	0.008	8	33
W 9	5.4	4.5	31.127	31.128	0.001	1	4
W 10	6.3	4.8	36.056	36.059	0.003	3	12
W 11	6.1	4.6	34.353	34.357	0.004	4	16
W 12	6	4.5	34.723	34.731	0.008	8	33
W 13	5.3	4.5	36.126	36.135	0.009	9	37
W 14	6.5	5	37.408	37.41	0.002	2	8
W 15	6	4.6	37.515	37.519	0.004	4	16

Table 6.3: Chloride titrimetric calculation

Well Number	End Point 1 (ml)	End Point 2 (ml)	End Point 3 (ml)	Average Reading (ml)	Total Chloride (mg/L)
W 1	2.8	2.3	1.8	2.3	32.7
W 2	1.8	1.5	1.5	1.6	23.2
W 3	2.2	2	1.8	2	28.9
W 4	3.8	3.5	3.4	3.6	51.1
W 5	3.4	3	2.7	3	43.1
W 6	1.8	1.5	1.3	1.5	21.8
W 7	2.8	2.5	2.2	2.5	35.5
W 8	1.6	1.4	1.4	1.4	19.9
W 9	2.2	2	1.6	1.94	27.5
W 10	1.8	1.6	1.5	1.63	23.2
W 11	2.5	2.2	2.2	2.3	32.7
W 12	1	0.8	0.6	0.8	11.4
W 13	3.4	3.3	3.2	3.3	46.9
W 14	1.2	1	1	1.06	15.1
W 15	1	0.8	0.9	0.9	12.8

Table 6.4: Piper Diagram unit conversion

Well No.	Ca (meq/L)	Mg (meq/L)	SO4 (meq/L)	Chloride (meq/L)	HCO3 (meq/L)	Na +K (meq/L)	Total Cation	Total Anion
W1	0.4791	0.1215	2.5831	0.9225	6.6926	0.4334	1.0340	10.1982
W2	0.8912	0.1221	0.7711	0.6543	5.9550	0.6796	1.6929	7.3804
W3	0.4761	0.0688	0.9424	0.8145	6.2828	0.6724	1.2172	8.0398
W4	0.4920	0.0602	1.1138	1.4421	5.0263	0.6681	1.2203	7.5821
W5	0.3441	0.0925	1.6757	1.2151	5.3541	0.4915	0.9281	8.2449
W6	0.2134	0.1273	1.2971	0.6142	5.7420	0.4817	0.8223	7.6533
W7	0.8802	0.0667	0.4284	1.0015	5.6819	0.5337	1.4807	7.1117
W8	0.4315	0.0373	0.6854	0.5608	3.7697	0.3056	0.7745	5.0159
W9	0.5783	0.0294	0.0857	0.7745	2.9502	0.5626	1.1703	3.8103
W10	0.6058	0.0680	0.2570	0.6543	4.8624	0.2878	0.9616	5.7737
W11	0.7480	0.1685	0.3427	0.9213	5.3814	0.8278	1.7442	6.6454
W12	0.0972	0.1456	0.6854	0.3205	1.9668	0.8322	1.0750	2.9727
W13	0.3394	0.0254	0.7711	1.3219	2.0214	0.2376	0.6024	4.1144
W14	0.3048	0.0577	0.1713	0.4273	5.3541	0.2528	0.6154	5.9527
W15	0.5619	0.1522	0.3427	0.3605	2.9775	0.3969	1.1110	3.6807

Table 6.5: Value for Piper diagram in percentage

Well No.	Ca (%)	Mg (%)	Na +K (%)	SO4 (%)	Cl (%)	HCO3 (%)
W1	46	12	42	25	9	66
W2	53	7	40	10	9	81
W3	39	6	55	12	10	78
W4	40	5	55	15	19	66
W5	37	10	53	20	15	65
W6	26	15	59	17	8	75
W7	59	5	36	6	14	80
W8	56	5	39	14	11	75
W9	49	3	48	2	20	77
W10	63	7	30	4	11	84
W11	43	10	47	5	14	81
W12	9	14	77	23	11	66
W13	56	4	39	19	32	49
W14	50	9	41	3	7	90
W15	51	14	36	9	10	81