GENERAL GEOLOGY AND WATER GEOCHEMISTRY OF GUA BEWAH, TASIK KENYIR, TERENGGANU

by

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A research proposal submitted in fulfillment of requirement for the Bachelor of Applied Science (Geoscience)

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GENERAL GEOLOGY AND HYDROGEOCHEMISTRY OF GUA BEWAH,

TASIK KENYIR, TERENGGANU.

ABSTRACT

The study focuses on the general geology, hydrology and geochemistry of Gua Bewah,Tasik Kenyir. The study area for this research lies between latitude 5° 09” 01.92” N 102°31” 36.33” E, 5° 09” 51.16” N 102° 56” 46.66” E and longitude 4° 48” 53.29” N 102°32” 06.16” E, 4° 48” 56.65” N 102° 56” 53.03” E. This research is intended to produce an updated geological map,to analyses the physical and chemical parameters of water at the study area and to identify geochemical process of water. The general study of Bewah cave which situated at lake Kenyir was conducted by field work investigation and laboratory analysis which is thin section or rocks sample. The study area consist of major limestone facies and minor sandstone also present in that area which aged Middle Permian. The method for data interpretation is by using piper trilinear diagram, and Schoeller diagram in order to classify the water type. Water samples were taken from 10 locations within the study area. The sampling site was chosen due to the availability of accessing the location. The analyzed chemical parameter include major cation like sodium (Na+), potassium (K+), calcium(Ca2+). magnesium (Mg2+) and anions such as bicarbonate (HCO3-), chloride (CL-), nitrate (NO3-). Generally, the water in study area is safe for drinking when compared with the WHO and MOH standard except for calcium, magnesium and bicarbonate which has slight high value compared to others.

Keywords: Gua Bewah Tasik Kenyir, geochemistry, Piper Trilinear Diagram, Schoeller Diagram, water type, WHO, MOH

GEOLOGI AM DAN HIDROGEOKIMIA DI GUA BEWAH, TASIK KENYIR,TERENGGANU.

ABSTRAK

Kajian ini terdiri daripada dua bahagian kajian. Kajian ini memberi tumpuan kepada pemetaan geologi am di Gua bwah yang terletak di tasik Kenyir dan analisis geokimia air di kawasan tersebut. Kawasan kajian terletak di bahagian hulu Terengganu pada kedudukan koordinat 5° 09” 01.92” N 102° 31” 36.33” E, 5° 09” 51.16” N 102° 56”46.66” E latitud dan 4° 48” 53.29” N 102° 32” 06.16” E, 4° 48” 56.65” N 102° 56”53.03” E longitud. Objektif kajian adalah untuk mengkaji geologi am kawasan kajian dan menghasilkan peta geologi yang terkini, untuk menganalisa parameter kimia dan fizikal di kawasan kajian dan untuk mengkaji proses geokimia air di kawasan tersebut. Empat sampel batu telah dibuat hirisan nipis iaitu granit,syal dan batu kapur. Litologi kawasan kajian terdiri daripada batu kapur major dan batu pasir minor yang berusia pertengahan Perm. Bagi interpretasi data, diagram Piper dan Schoeller digunakan bagi mengkelaskan jenis air. 10 sampel air telah diambil di kawasan berlainan dan kawasan ini dipilih dari segi kemudahan untuk mengakses tempat persampelan. Sampel air dikumpulkan dan dalam satu botol polyethene 1.5 liter yang dibilas dan dianalisis untuk parameter fizikal dan kimia. In-situ parameter diukur menggunakan YSI parameter mudah alih. Contohnya seperti suhu, kekonduksian elektrik,pH dan TDS. Parameter kimia dianalisis termasuk kation utama seperti sodium (Na+), kalium (K+), kalsium (Ca2+) dan anion seperti bikarbonat (HCO3-). Secara umumnya air sungai yang mengalir dari empangan utama di kawasan kajian selamat untuk diminum jika dibandingkan dengan piawaian WHO dan KKM kecuali bikarbonat (HCO3-) yang mencatatkan jumlah bacaan yang tinggi dan melebihi piawaian yang ditetapkan WHO dan KKM.

Kata kunci: Gua Bewah Tasik Kenyir, geokimia, Diagram Piper Trilinear, Diagram Schoeller, WHO, KKM.

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LIST OF ABBREVIATION

mg / l	milligram per liter
meq / l	milliequivalent per liter
µS / cm	microsiemens per centimeter
mS/cm	millisiemens per centimeter
AAS	Atomic Absorption Spectrometer
APHA	American Public Health Association
C	Celcius (Centigrade Temperature Scale)
EC	Electrical Conductivity
GIS	Geographic Information System
GPS	Global Positioning System
JKR	Jabatan Kerja Raya
JMG	Jabatan Mineral dan Geosciences
JPS	Jabatan Pengairan dan Saliran
MOH	Ministry of Health
NTU	Nephelometric Turbidity Unit
TDS	Total Dissolved Solid
TSS	Total Suspended Solid
pH	Hydrogen ion Concentration (Potential of Hydrogen)
ppm	Parts per Millions
ppt	Parts per Thousand
WHO	World Health Organization

LIST OF SYMBOL

℃	Degree celcius
%	Percentage
Ca^{2+}	Calcium ion
Cu^{2+}	Copper (II) cupric
Mg^{2+}	Magnesium ion
Mn	Manganese ion
Na^{+}	Sodium ion
K^{+}	Potassium ion
Fe^{2+}	Iron (II) ferrous
Zn^{2+}	Zinc ion
Cl^{-}	Chloride ion
Fl^{-}	Flouride ion
SO_4^{2-}	Sulphate ion
HCO_3	Bicarbonate ion

CHAPTER 1

INTRODUCTION

1.1 General Background

This research study entitled " General Geology and Water Geochemistry Gua Bewah, Tasik Kenyir, Kuala Berang, Hulu Terengganu. Hydrogeology and geological mapping are irrelated to each other and provides important data for accessing water resources.

Water is a natural resources unique to the planet Earth. It is approximately 50 to 70 times more plentiful than surface water (Fetter, 1994). As the Earth's surface has covered major by water around 70 percent but only 2.53 percent is fresh water (Kresic, 2009). The water resources can be divided into two components that are surface water and groundwater. Surface water can be found as rivers, lakes, and oceans as water bodies (Fetter, 2001). Groundwater hydrology is a subdivision of sciences of hydrology which deals with occurrences, movement and quality of water beneath the earth surfaces (Heath R.C, 2004). Groundwater is a vast and slow moving resources that greatly exceeds the volume of other available freshwater sources (Baskaran & Coram, 2009). The quality of groundwater depends both on the substances dissolved in water and certain properties and characteristics that these substances impart to water (Heath R.C, 2004). The term groundwater is usually reserved for the subsurface water that occurs beneath the water table in soils and geologic formations that are fully saturated (Freeze, R. Allan, 1979).

In Malaysia, there is about 97 percent utilized from the water supply system of surface water (Abdullah *et.al.*, 1997).

Table 1.1 **:** Water resources status in Malaysia (Samad , 1999)

Description	Quantity (billion m^2)
Annual rainfall	990
Surface runoff	566
Evapo-transpiration	360
Groundwater recharge	64
Surface artificial recharge (dams)	29.9
Groundwater storage (aquifers)	5000

Based on Table 1.1, the groundwater recharge is 64 billion m^2 and groundwater storage (aquifers) about 500 billion m^2 which can hold enough water supplied to our country. Therefore, it necessary to evaluate the aquifers chemistry of groundwater.

Groundwater is naturally replenished by surface water from precipitation, streams and rivers when this recharge reaches the water table (Sophocleous, 2005).Groundwater serves as a public water supply in much of the world, including Malaysia. In Malaysia, demand for water uses increases extremely and groundwater has been identified as one the alternative method to new water resources. Groundwater is the main sources for drinking, irrigation and industrial purposes and indiscriminate disposal of industrial waste on mother earth slowly makes groundwater susceptible to pollution (Tank & Chandel, 2010).

1.2 Problem Statement and Justifications

Based on preliminary research, most research done and focused on hydro-geochemistry, structural geology, petrology and rock formations.There are lack of record the updated general geology in the study area. In water geochemistry aspect, pollution might occur as the water itself might contact with foreign material due high

urbanization in Kuala Terengganu and increase in the human population densities.

Therefore, the analyzing surface water is important to determine the sustainability of water for drinking purpose and to ensure its sustainability due to increasing number of lake population.

From the finding of the study, the reliance on treated water supply from mainland through submarine pipeline could be reduced by fully utilize cheaper surface water resources from the reservoir.If contaminated surface water is recharging the aquifer, the aquifer will be polluted so its not suitable for drinking and others uses, it also can cause the health problem.

1.3 Research Objectives

The research objectives for this are :

i. To produce a geological mapped of study area with scale 1: 60 000.

ii. To analyses the physical and chemical parameters of water at the study area.

iii. To determine the types of water at the Terengganu river basin using Piper's Trilinear Diagram by determination of major ions.

1.4 Study Area

Tasik Kenyir is the largest man-made lake Southeast- Asia, was impounded in 1985 for the purpose of hydrolectric. The lake is situated at the coordinated latitude 5° 09" 01.92" N 102° 31" 36.33" E, 5° 09" 51.16" N 102° 56" 46.66" E and longitude 4° 48" 53.29" N 102° 32" 06.16" E, 4° 48" 56.65" N 102° 56" 53.03" E. The lake has an area 36,900 ha with a maximum depth of 145m and an average depth of 37m (Rouf, 2010). The lake had more than 340 Islands scattered within the Lake. The main source of the

lake is originated from two river : Sungai Terengganu and Terengan Sungai (Furtado *et al.,* 1997). Among the two, Sungai Terengganu is the largest, with draining area of 458,000 ha (35% of the State land area) which flow south and south-east to join the other river and finally turned east to joins the sea at Terengganu, the State capital (Yusoff *et al*., 1995). Some tributaries also drain into the lake : Sungai Lawit, Sungai Ketiar, Sungai Lasir, Sungai Petang, Sungai Lepar, Sungai Genong, Sungai Pertang, Sungai Cacing, and Sungai Terengganu (FFRC,1995). The nature and structure of the lake is irregular and dendrite in shape.

Gua Bewah is known as Gua Tahi Kelawar due to plenty of but make their habitat there. The name of Bewah Cave is believed from the name of Bewah Hill. Gua Bewah provides the spectacular sights of towering limestone hills. Nested, within the lake are reminder of many hilltops and highlands that remain unsubmerged at the height of 138 m above ground (Mohd Kamaruzaman, 2002).The secrets and mysteries of Gua Bewah still to be explored. The some archeologist from National Museum had discovered the skeleton of the Neolithic man (Nik Hassan Suhaimi *et.al.*, 1990). Among the artifacts found in 1970's were kitchen utensils, axes and tools. The towering formation in white limestone and its fabulous limestone curtains fit the ceiling. Bukit Taat is located at the southern end of Tasik Kenyir, 76 km from Kuala Terengganu (Mohd Kamaruzaman, 2002). Bukit Taat formed by limestone deposition during the Middle Permian (270.6 - 260.4 million years ago) (Fontaine, 1988).

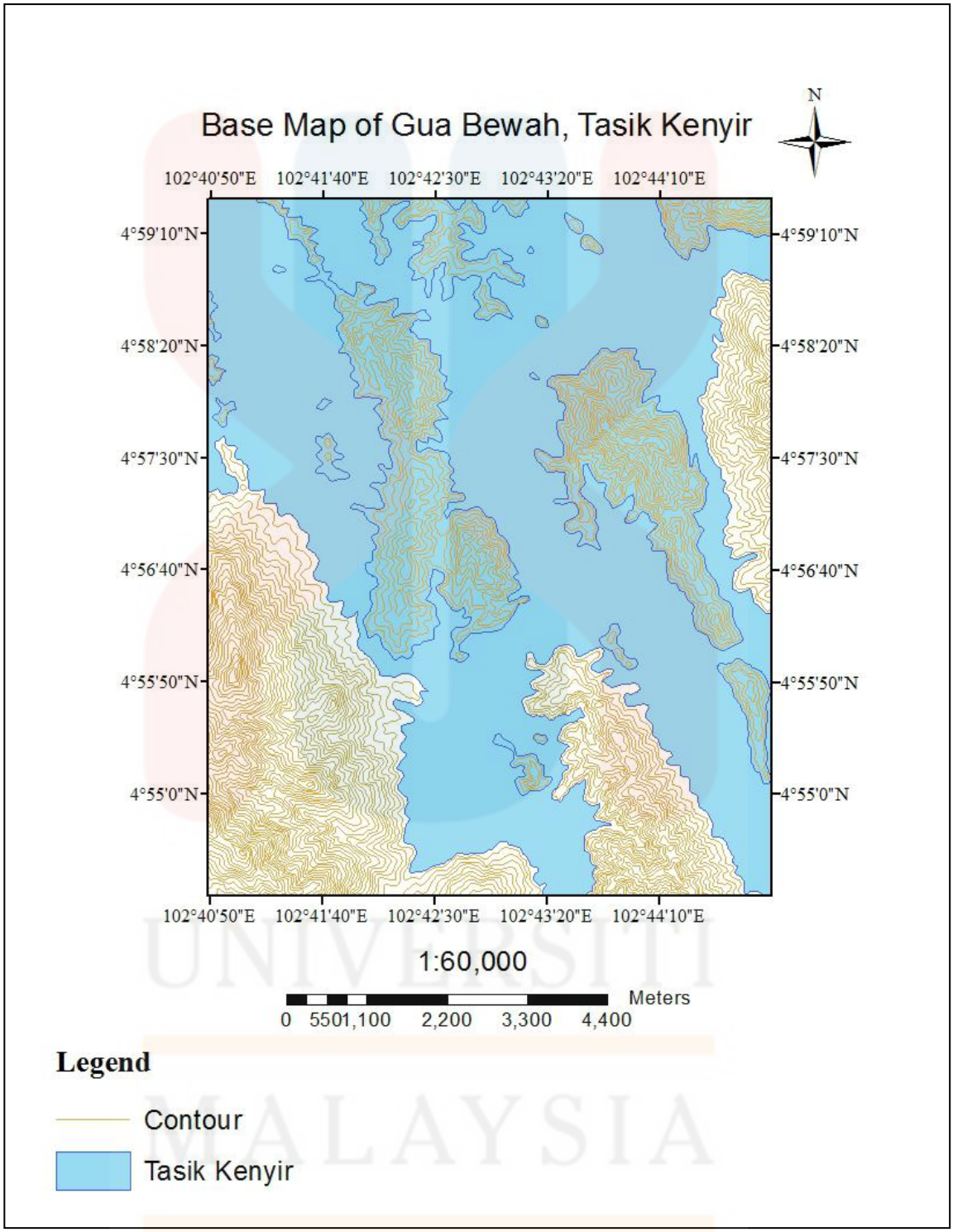


Figure 1.1 : The basemap of the study area

1.4.1 Geography

a. People Distribution

Table1.2:Table show distribution of races in Terengganu. (Data Asas Negeri Terengganu, 2011)

District	Citizen					NON CITIZEN	Total
	BUMIPUTERA		CINA	INDIA	OTHER		
	Malay	OTHER BUMIPUTERA					
BESUT	132,173	115	1727	180	324	2,044	136,563
DUNGUN	143,180	87	3446	300	305	2,533	149,851
HULU TERENGGANU	67,942	335	310	95	35	2,083	70,800
KEMAMAN	153,472	699	6800	729	259	4,791	166,750
KUALA TERENGGANU	319,813	643	11,617	867	287	4,326	337,553
MARANG	91,699	36	1,834	163	119	1,432	95,283
SETIU	53,287	29	123	10	21	1,093	54,563
TOTAL	961,566	1944	25,857	2,344	1,350	18,302	1,011,363

Table 1.2 refers to the distribution of people accordings to the differences races and districts in Terengganu (Data Asas Negeri Terengganu, 2011). According to the Table 1.2, the highest population in Terengganu was in Kuala Terengganu whereby Malay consist 319,813 peoples. Besides, the lowest population was detected in Setiu with population of 53,287 people.

Tasik Kenyir are in district Hulu Terengganu. Based on Table 1.2, the distribution of peolple is 67,942 people and other's Bumiputera consists of 335 people. Chinese consists of 310 peoples and Indians consists of 95 peoples. Other races consist of 35 peoples. Non-citizen consists of 2,083. Hence make it the total of peoples have 70,800.

Table 1.3 :Table show people distribution by each district from 2000 - 2010 (Data Asas Negeri Terengganu,.2011)

DISTRICT	2000	2006	2007	2008	2009	2010
BESUT	122,900	142,300	145,700	149,300	152,800	136,563
DUNGUN	132,800	155,500	159,700	164,000	168,300	149,851
HULU TERENGGANU	63,800	72,700	74,500	76,200	78,100	70,800
KEMAMAN	141,500	167,200	171,800	176,400	181,100	166,750
KUALA TERENGGANU	304,600	344,000	351,800	359,700	367,800	337,553
MARANG	85,300	98,800	101,400	103,900	106,500	95,283
SETIU	51,800	61,400	63,100	64,800	66,500	54,563
TOTAL	902,600	1,042,000	1,067,900	1,094,300	1,21,100	1,011,363

Based on the Table1.3, from the year 2000's until 2009, Hulu Terengganu shown an uprising of peoples. Year 2000's consists of 63,800 while year 2009 consists of 78,100. In 2010, people distribution reduced to 70,800.

b. Rain Distribution and Climate

Table 1.4 : The table of rain distribution of Terengganu, 2014 (Sources: Jabatan Metereologi Malaysia Kemenenterian Sains, Teknologi dan Inovasi)

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dis
Average (mm)	250	245	240	236	230	230	240	240	245	245	250	250

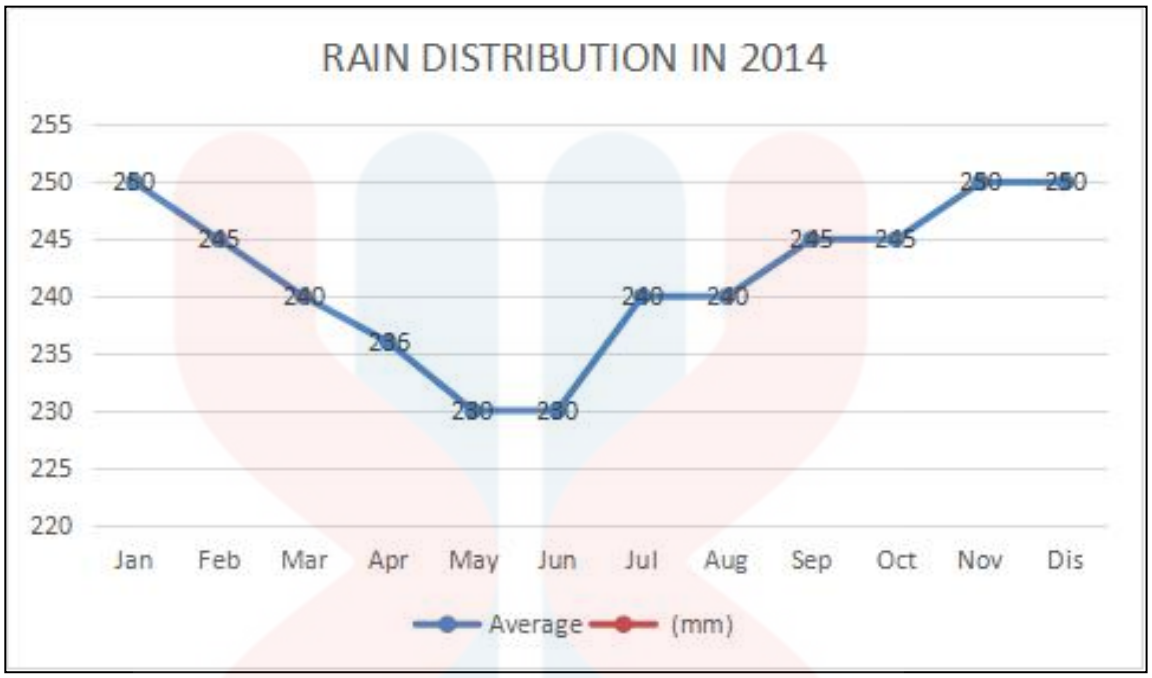


Figure 1.2 :The graph of rainfall distribution in 2014(Sources: Jabatan Metereologi Malaysia Kementerian Sains, Teknologi dan Inovasi)

Based on Table 1.4, show that rainfall in the State for the year 2014. Table 1.4 above shows the rainfall data was collected from January to December. The data obtained from the Meteorological Department, Ministry of Science, Technology and Innovation.

For January, the rainfall in the state was 250 mm, while for February showed a decrease of 5 mm to 245 mm. Next, for the month of March and April rainfall was recorded to be at the same level, which is 240 mm.In May showed that rainfall is decreasing, bringing the total distribution in May was 236 mm and in the following month of June also recorded rainfall is 230 mm. While for the month of July, the rainfall recorded shows on the same level with June.

Rainfall for Terengganu has improved slightly in August, bringing the total for the month was 240 mm. Rainfall was recorded in Table 1 indicate increased to 245 mm

for the month of September. In October, the uneven distribution of rainfall to rainfall in the previous month, totaling 240 mm.

While rainfall has been improving every month because it is so in November rainfall was recorded by the meteorological department of 250 mm. Next, the rainfall in December is the last month of 2014 did not change compared to the previous month, totaling 250 mm.

Table 1.5 : The table of climate of Terengganu 2014(Sources: Jabatan Metereologi Malaysia Kementerian Sains, Teknologi dan Inovasi)

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dis
Average (mm)	20	21	23	24	25	25	25	23	23	20	22	22

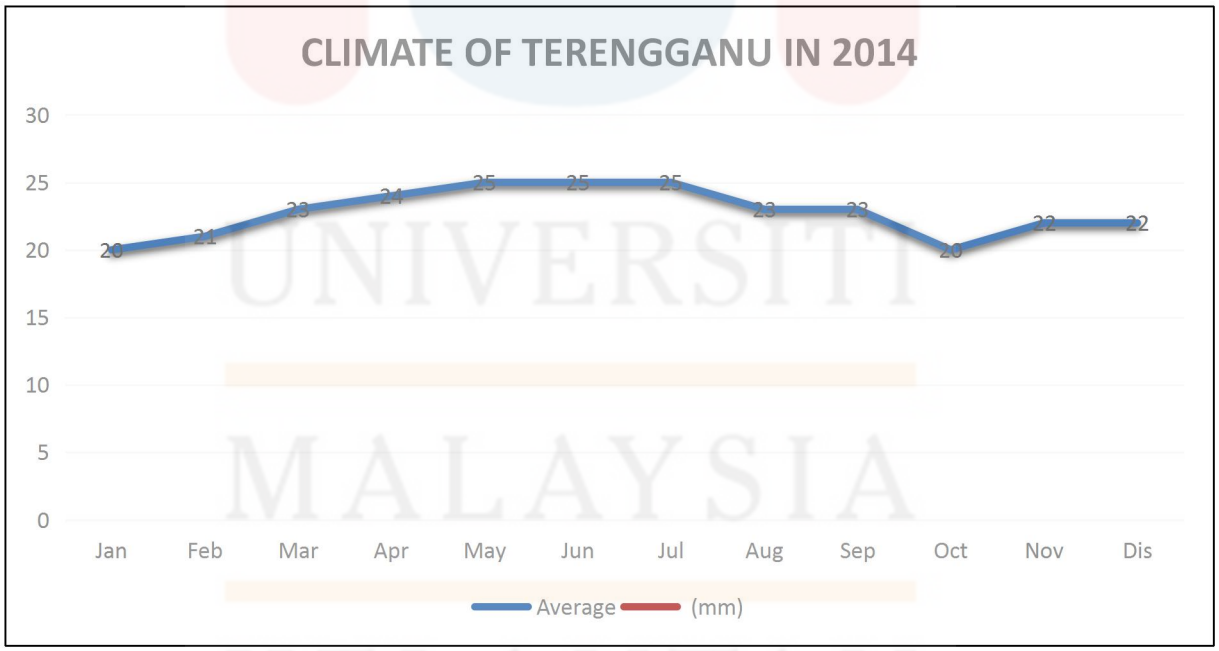


Figure 1.3 : The graph of climate of Terengganu in 2014(Sources: Jabatan Metereologi Malaysia Kementerian Sains, Teknologi dan Inovasi)

Based on Table 1.5, the temperature distribution in the state have taken readings from January to December of 2014. The distribution of temperature in the country has shown a pattern of change, data recorded has increased at first and then the temperature that has been recorded has declined. The temperature distribution of the data was taken at the Meteorological Department, Ministry of Science, Technology and Innovation.

Temperature distribution that has been recorded in the state in January is 20 °C and for the next month temperature recorded was 21 °C. Temperature distribution obtained for March showed an increase of 2 °C makes the actual amount for the month is 23 °C.

Next, in April also recorded temperature is 24 °C and for the next three months, data showed that balanced, ie for May, June and July did not show any change and its distribution is also uneven with a total of 25 °C.

For August, the temperature distribution is recorded as a decrease of 2 ° C is the amount that has been taken by the department is as much as 23 ° C. Next month is the month of September also recorded a temperature distribution that is equal to the previous month, ie by 23 ° C it shows the temperature distribution does not experience any changes.

While the temperature distribution for the month of October also decreased the actual number for the month was 22 °C, which is decreased by 1 °C from the previous month. Next, the temperature distribution decreased by 2 °C for the months of November and December. The temperature distribution showed no change was recorded for the two months, ie by 20 °C

c. Land use

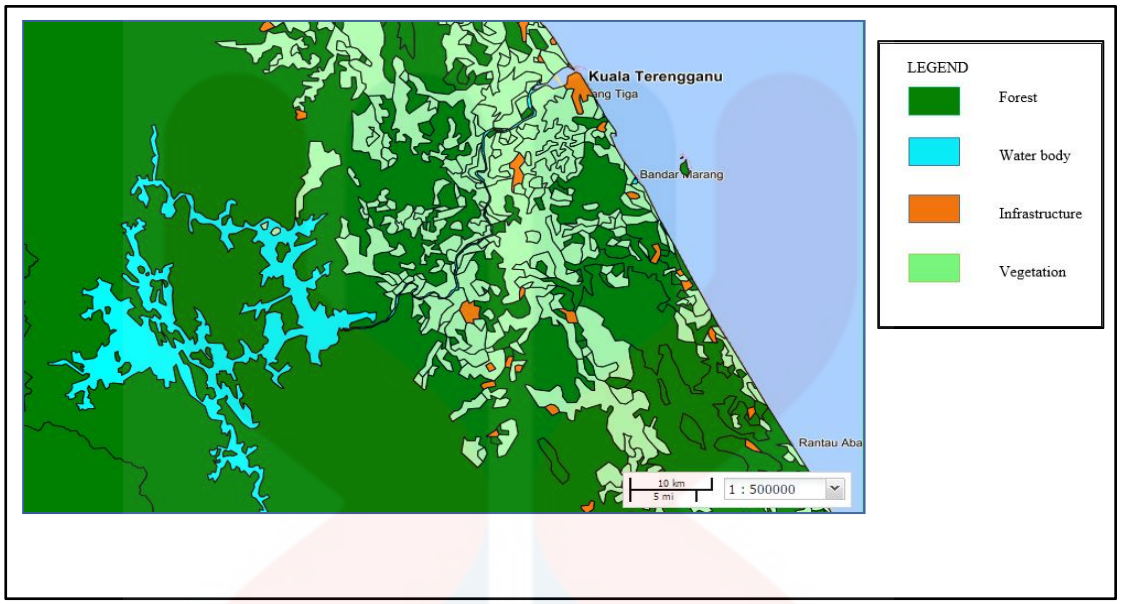


Figure 1.4 : Map of land use at Kuala Berang, Terengganu.,(Department of Planning Town and Village of Peninsular Malaysia, 2014)

Based on Department of Planning Town and Village of Peninsular Malaysia, 2014 shows the landuse in area Kuala Berang, Hulu Terengganu can be divided into four main type are forest, water body, infrastructure and vegetation. Based on the figure 1.3, the land use consists mostly forest, water body and vegetation. It is because there is no rapid urbanization occur in that particular area. Due to its richness with the nature, the villagers use the land to harvesting crops and farming the animals.

d. Social Economic

Table 1.6 : Table show social economic of Terengganu state (Data Asas Negeri Terengganu, 2011)

INDUSTRY	NUMBER OF PROJECTS	LOCATION	INVESTMENT VALUE (RM MILLION)				ESTIMATED EMPLOYMENT
			LOCAL	FOREIGN	J/VENTURE	TOTAL	
Fabrication & Steel	1	Teluk Kalong Kemaman	150.00	.	.	150.00	250
Fabrication & Warehouse	1	Teluk Kabong Kemaman (Tambahan)	2.42	.	.	2.42	187
Fabrication, Construction, Steel Repairing	1	Teluk Kabong Kemaman	2.50	.	.	2.50	53
Entrepreneurship	1	Gong Badak Kuala Terengganu	46.00	.	.	46.00	185
Oil and Gas	1	Teluk Kabong Kemaman	5.00	.	.	5.00	50
Entrepreneurship Based on Steel	1	Wakaf Tapai Marang	6.10	.	.	6.10	43
Offshore Service	1	Teluk Kalong Kemaman	4.85	.	.	4.85	81
Fabrication, Instrumentation, Mechanical Support	1	Batu 7 Tambahan Dungun	1.63	.	.	1.63	83

Based on the Table 1.6, with the investment value of RM 150,000,00, Fabrication and Steel industry are dominated in the Terengganu market. The second highest is Entrepreneurship industry with the value investment worth RM 46,000,00. The least investment value is Fabrication, The instrumentation and Mechanical Support industry with the investment value of RM 1,063,00. The economy level of Terengganu gives a better job vacancy, accommodation and lowers the poverty rate in the district.

e. Road Connection

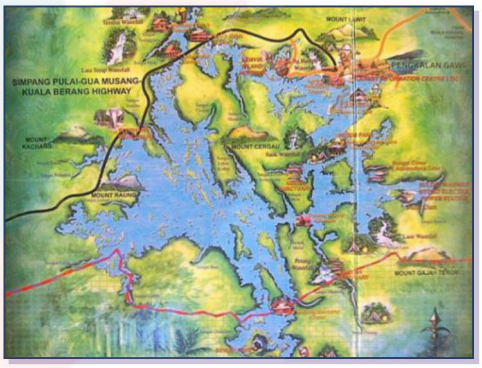


Figure 1.5 : Figure show mean of transportation in Terengganu. (Data Asas Negeri Terengganu,. 2011)

Kuala Terengganu is the urban area while Kuala Berang is rural area. Therefore, at Kuala Terengganu all roads are easy to access while some roads at Kuala Berang are difficult to access.There are three routes from KL to Kenyir: KL-Gua Musang-Kenyir, KL-Jabor-Kuala Berang-Kenyir and KL-Coastal Highway. Using the gps (so ever-helpful and useful), we took the never-taken KL-Gua Musang-Kenyir route. We drove past the Gua Musang town towards Kota Bharu until a half-hour later, we reached the exit to Felda Aring, on the right. More than half of this plantation road is in bad condition that I don't recommend you driving at night for fear of having your vehicles send to the workshops or you to the hospitals. Fortunately, the Terengganu road condition is very good which looks more like a highway and it was quiet. It took us 2 hours to reach Pengkalan Gawi, Kenyir from the Aring exit. This amount of time

included a few stops along the highway to view the Lake and a half-an-hour stop at the small Kuala Ketir Elephant Sanctuary.

1.5 Scope of Study

The scope of study involves of physical and chemical parameter of water, water geochemistry around the Tasik Kenyir and Terengganu river basin and the rock sampling. Water sample analysis will be taken at the lake, waterfall and rivers along the Terengganu. Water sample will be analyzed in situ parameter and in laboratory analysis of major cation and anion parameter. Not only that, the rock analysis using thin section method is conducted to determine the correlation between water and rock region.

1.6 Research Important

Through the research, updated geological map could be produced to conduct current and future reseach. Moreover, through geological mapping interrelation of geology and water geochemistry can be interelated. Besides, the knowledge on the mapping can be used to understand the process and concept of hydrogeology.

Tasik Kenyir, Kuala Berang, Hulu Terengganu had been selected as the case study because there is an ecotourism places for Malaysian and it is a the biggest man-made lake. Since there are many tourist come to visit the lake and it is the main sources of water at Terengganu , the source of clean water is needed. The groundwater chemistry can be affected by many factors such as mineralogy, precipitation ,infiltration, climate, and topography. These factors can combined to create diverse water types that change in composition spatially or temporarily (Chenini, 2009).

Thus, the study area selected to the evaluation of water chemistry. Tasik Kenyir was chosen in this study due to the limited information available concerning the hydro-geochemistry, either pertaining to protection or preservation, and the fact that this largest man-made dam has become a high water demand area due to the 15 development of tourism activities.

1.7 Chapter's Summary

In this study, geology is the fundamental parameters of the research. However, water qualities study also is vital as well. In order to complete this research, it have to full fill the objective of the research by updating geological map and analyzing water samples along Sungai Terengganu. There are some problems that have to be taken such as limited geological information regarding the mapping area and contamination might disturb the validity of water samples result.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The literature review comprises the regional geology and tectonic setting, historical geology, regional stratigraphy, structural geology, sedimentology, petrography, geochemistry and hydrogeology concept.

Peninsular Malaysia, with a total land area of 130, 268 km, forms part of Sundalands, which includes Borneo, Java and Sumatera, as well as the intervening shallow seas from which emerge a number of smaller islands (Van Bemmelen ,1949).It is also divided into three parts known as Western Belt, Central Belt and Eastern Belt (Searle et.al., 2004).

Sundaland is the partly submerged southeastern extension of the Asia continent to which the Peninsula is connected by the Isthmus of Kra, which at its narrowest is only 64 km wide. The Peninsula is elongated in a general NNW-SSE direction with a maximum length of 750 km and breath of 330 km.

To the south, it is separated from Singapore Island by the narrow Johor Strait whilst, to the west, it is separated from Sumatra Island by the Straits of Malacca. To the southeast and east the South China Sea separates the Peninsula from Borneo Island.

2.2 Geological Review

Geological specification in research study are mainly divided into regional geology and tectonic setting, historical geology, regional stratigraphy, structural geology, sedimentology, petrography, geochemistry and hydrogeology. Based on the reserach

study of General Geology and Water Geochemistry of Gua Bewah, Tasik Kenyir, Kuala Berang, Hulu Terengganu it comprises all the subunits og geological specification.

2.2.1 Regional Geology and Tectonic Setting

Peninsular Malaysia is a part of east Eurasian Plate and tectonically located north of currently active subduction arc zones of the Sunda arc (Kamar Shah Ariffin, 2012). Four types of major rocks namely, unconsolidated sediments, extrusive rocks, sedimentary or metasedimentary rocks and granitic rocks are distributed in Kelantan and Terengganu (Dony *et.al.*,2014). Peninsular Malaysia can be divided into 3 longitudinal belts, Western, Central and Eastern, each of which has its own unique characteristics and geological development. The Western Belt can be subdivided into a northwest sector and a Kinta-Malacca sector. The northwest sector consists of clastics, limestones and minor volcanics (Ghani,2004). The time of the Langkawi folding phase of Koopmans (1965) is revised from Devonian to mid-Permian and this phase is not only confined to southeast Langkawi but covers the whole of Langkawi and Terutao area and extends southeast into mainland Kedah forming a northwest trending belt called the Patani Metamorphics.

There is some evidence for a Devonian phase of folding and uplift as well but evidence for it is not strong. The post mid-Permian saw deposition of carbonates and clastics in this sector and the whole region was uplifted by the culminating late Triassic orogenic event which affected the whole of the peninsula.

In the Kinta-Malacca sector, there was deposition of argillaceous and calcareous sediments in the early Palaeozoic followed by more limestone deposition in the Kinta

region but by clastics in the Kuala Lumpur area. There is evidence for a post-Silurian event of folding and metamorphism in the Kuala Lumpur area, possibly Devonian. In the Kinta region there is scant evidence to date this tectonic event. There is no known Mesozoic sediment in this sector (Khoo,1983).

2.2.2 Regional Stratigraphy

In Eastern belt formation, Paleozoic sediments of predominantly Carboniferous to Permian age are distributed from east Kelantan through Terengganu and east Pahang into east Johor in the south. Large areas of Carboniferous sediments of the Charu and Sagor Formations and Panching Limestone, belonging to the Kuantan Group, are found in east Pahang.

Southwards extensions of the Group are the Seri Jaya and Kambing Beds while the Sungai Perlis Beds in Terengganu are its northward extension. Most of these sediments are shallow marine argillo – arenaceous deposits with some isolated reefal limestone lenses and volcanics.

Isolated occurrences of Carboniferous plant fossil – bearing beds and Permian conglomeratic deposits along the east coast point to restricted terrestrial to paralic sedimentation alternating with shallow marine deposition in a marginal marine setting.

Sedimentation was continuous from the Carboniferous to Early Permian in the northern part of the basin, and Middle to Upper Permian sediments of the Dohol and Linggui Formations were deposited in east Johor.A marked reduction of volcanic facies in the northern part of the Eastern Belt, compared to the Central Belt, might indicate increased distance from the volcanic source (Foo, 1983).

The absence of marine sediments younger than Permian suggest that the Eastern Belt was uplifted towards the end of Permian, coinciding with the explosive deposition of the largely Lower Triassic Johor ignimbrite. This set the stage for Mesozoic continental sedimentation within the mobile Central Belt and subsequent tripartite evolution of the Peninsula (Foo, 1983).

2.2.3 Structural Geology

The structures of the Peninsula reflect a long and complex tectonic evolution, starting possibly from as early as Cambrian right up to the Cenozoic. It is thought that the western Gondwana part of the Malay Peninsula (Sibumasu) collided with the IndoChina continental block (East Malaya) during the Upper Triassic Indosinian Orogeny.

The Bentong- Raub Line is taken as the collision suture zone, extending from Thailand to Peninsular Malaysia, has been widely accepted in almost all palaeo- tectonic reconstruction of Southeast Asia, it is also believed that the Bentong-Raub Line could represent a major normal fault (Tan, 1976) that formed the western boundary of a Mesozoic graben and that the geology reveals a major orogeny in the Permian and a less severe deformation in the Cretaceous (Harbury *et al*., 1990)

These contrasting views on the palaeo- tectonics have wide implication for the tectonic development of Southeast Asia as well as the evolution of Gondwanaland and the Tethys.

2.3 Petrography

The Peninsular Malaysia granite are distributed in three parallel belts which have been grouped into two granite provinces; the Main Range provinces with an age range off 200 Ma to 230 Ma and the Eastern provinces with a range 200 Ma to 264 Ma (Cobbing *et.al.*, 1986).

2.3.1 Plutonism

The plutonic rocks are part of the Southeast Asian tin belt (Schwartz et al., 1995). More than 90% are granitic. The granitoids of Malaysia, Thailand and Myammar have petrologicl and geochronological characters that permit them to be put into belts (Cobbing et. al., 1992). They have been divided into three: Western province,Eastern province and Main Range province (Hutchison & Taylor, 1978; Beckinsale, 1979; Cobbing et al. 1986). In Terengganu, there are four recognized plutons which are Maras Jong Granite, Jerong Batholith, Kapal Batholith and Perhentian Granite.

The Maras Jong granite is the most easterly granitic pluton in the Eastern Belt of mainland Terengganu. The rock is coarse grained and consists of plagioclase, Kfeldspar, quartz, biotite, apatite, tourmaline, opaque phases, muscovite, sericite, chlorite and epidote. Small dykes of microgranite and quartz porphyry are fairly common . The granite is characterised by tourmaline clots bordered by felsic material. The size of the clots usually is less than 15 cm across.

The Jerong batholith is located immediately to the south of the Maras Jong granite. The batholith is a rather small but complex body having a compositional range from gabbro to granite. It consists of several plutons such as the Tanggol, Wakaf, Kenanga granites and the Mempelas gabbro (Cobbing et. al., 1992).

Kapal batholith, one of the largest granitic bodies in the Eastern Belt, extends from the Setiu River in the north to Gunong Irong in the south . The batholith also consists of several smaller granitic plutons such as Saok Granodiorite, Chengal Granite and Kesing Granite. The batholith is a composite body ranging from diorite to monzogranite in composition and dominated by granodiorite.

The Perhentian granite is located off Terengganu in the Perhentian Island. The granite is similar to the Maras Jong granite, both in grain size and mineralogy. It forms the whole of Pulau Perhentian Besar and Pulau Rawa and part of Pulau Perhentian Kecil.

2.4 Geochemistry

Geochemistry of groundwater refers to the investigation of major ion chemistry to understand the effects of geochemical process on the groundwater in the study area along a continuum of increased rock-water interaction represented by increase in dissolved solids concentration (Kresse et. al., 2012). The chemical and biochemical interactions between groundwater and the geological materials of soils and rocks provide a wide variety of dissolved inorganic and organic constituents.

Physical properties of water such as pH, electrical conductivity, hardness, total dissolved solids, resistivity, dissolved oxygen, oxygen-reduction potential can be conducted in field to determine according the standard methods of APHA (1992).

2.5 Hydrogeology

The study of water chemistry, is useful in hydrogeology in a number of ways. The interpretation of the distribution of hydro-chemical parameters in groundwater can help in the understanding of hydrogeological conditions and can also aid decisions relating to

the quality of water intended for drinking water. The occurrence of groundwater within the earth's crust and the emergence of springs at the ground surface are determined by the lithology of geological materials, regional geological structure, geo-morphology of land forms and the availability recharge sources.

The values of basic hydrogeological parameters are given, and evaluations are made of the geological, geomorphological, hydrological, clmatic, and others factors affecting the recharge and formation of underground water (Fao-Swalim, 2012).

In recent years there has been considerable attention paid to the concept of the world water balance (Lvovitch, 1970; Sutcliffe, 1970: Nace, 1971), and the most recent estimates of these data emphasize the ubiquitous nature of groundwater in hydrosphere. Based on Table 2.1, consideration the 94 percent of the earth's water that rests in the oceans ad seas at high levels of salinity, then groundwater accounts for about two-thirds of the freshwater resource of the world.

Table 2.1 : Estimate of Water Balance of the World (Nace, 1971).

Parameter	Surface area (km^2)x 10^6	Volume (km^3)x 10^6	Volume (%)	Equivalent depth (m)*
Oceans and seas	361	1370	94	2500
Lakes and reservoirs	1.55	0.13	<0.01	0.25
Swamps	<0.1	<0.01	<0.01	0.007
Rivers channels	<0.1	<0.01	<0.01	0.003
Soils moisture	130	0.07	<0.01	0.13
Ground water	130	60	4	120
Icecaps and glaciers	17.8	30	2	60
Atmospheric water	504	0.01	<0.01	0.025
Biospheric water	<0.1	<0.01	<0.01	0.001

* Computed as though storage were uniformly distributed over the entire surface of the earth

2.6 PHYSIOGRAPHY

2.6.1 Topography

In general, the topography Tasik Kenyir standing about 138 meters above the sea level. The hill regions of Tasik Kenyir are a world of untouched virgin tropical jungle estimated to be millions of years old. There is no exact estimated of the no of species of plants and wildlifes existing within this vast ecosystem. The highest peak in Tasik Kenyir itself is Mount Chergau. Meanwhile Mount Gegeau, with an elevation of 4.514 feet above the sea level, is the second highest peak in the national park. And also there are many mount in Tasik Kenyir such as Bongsu, Tembat and Raung.

There are two caves accessible at Kenyir, Gua Bewah and Gua Taat. They are located at the southen end of the lake, and lie within Taman Negara. Before creation of the lake, there were probably several caves accessible is Batu Tok Bidan caves. Insides these caves an extraordinary sight of stalactites and staglamites awaits the explorer. In addition in Taat and Bewah caves there are many secret of the past.

There are many spectacular waterfalls in Tasik Kenyir. In Tasik Kenyir there are 14 waterfalls; however the most interesting waterfalls are ‘ Langsir Waterfall’, ‘ Tembat Waterfall’ and ‘Saok Waterfalls’.

2.6.2 Climate

The climate here is between 23 degree Celsius to 31 degree Celsius yearly. More or less the temperature is depended on weather condition similar with other part of Terengganu and Malaysia. The existence of the tropical forest landscape and the numbers of river sources within the lake area make the temperature fall down. That

makes us cool especially when the smooth breeze touches our skin. Between November to February each year, the temperature will be cooler around the area due to the rainy but you still can enjoy the luxurious scene and having activities around the Kenyir Lake.

2.6.3 Drainage

In the study area, based on figure 2.1 it consist 2 main rivers that is Sungai Terengganu and Sungai Kuala Berang. It also shows the flow of water movement that move towards to south of the study area. Rivers can flow down mountains, through valley (depression) or along plains. A current, in a river or stream, is the flow of water influenced by gravity as the water moves downhill to reduce its potential energy. The current varies spatially as well as temporarily within the stream, dependent upon the flow volume of the water, stream gradient, and channel geometrics. Usually river water will flow to weak water current flow that called weak zone. The water in the river is usually confined to a channel, made up of a stream bed between banks. In the study area, form the observation it maybe a dendritic drainage pattern where many contributing stream which are then joined together into the tributaries of the main river .

Other pattern can be observe at the study area is parallel drainage system. It can saw by the pattern of rivers caused by steep slope with some relief. The streams are swift and straight with very few tributaries and all the same directions because of the steep slopes. Rectangular drainage system also can be found at the study area. It was develop on rocks that are approximately uniform resistances to erosion. But it must have two directions of joint at approximately right angles.

The dominant pattern of drainage this study area is dendritic pattern. The water flow of river in the study area is laminar and turbulent flow both. Laminar flow is occurs

when a fluid in parallel layers, with no disruption between the layers. It has a low velocity of fluids tend without mixing the particle in the river. Turbulent flows is occurs when a fluid flow in random direction. It has a rapid velocity of fluids tend with mixing all particles in the river.

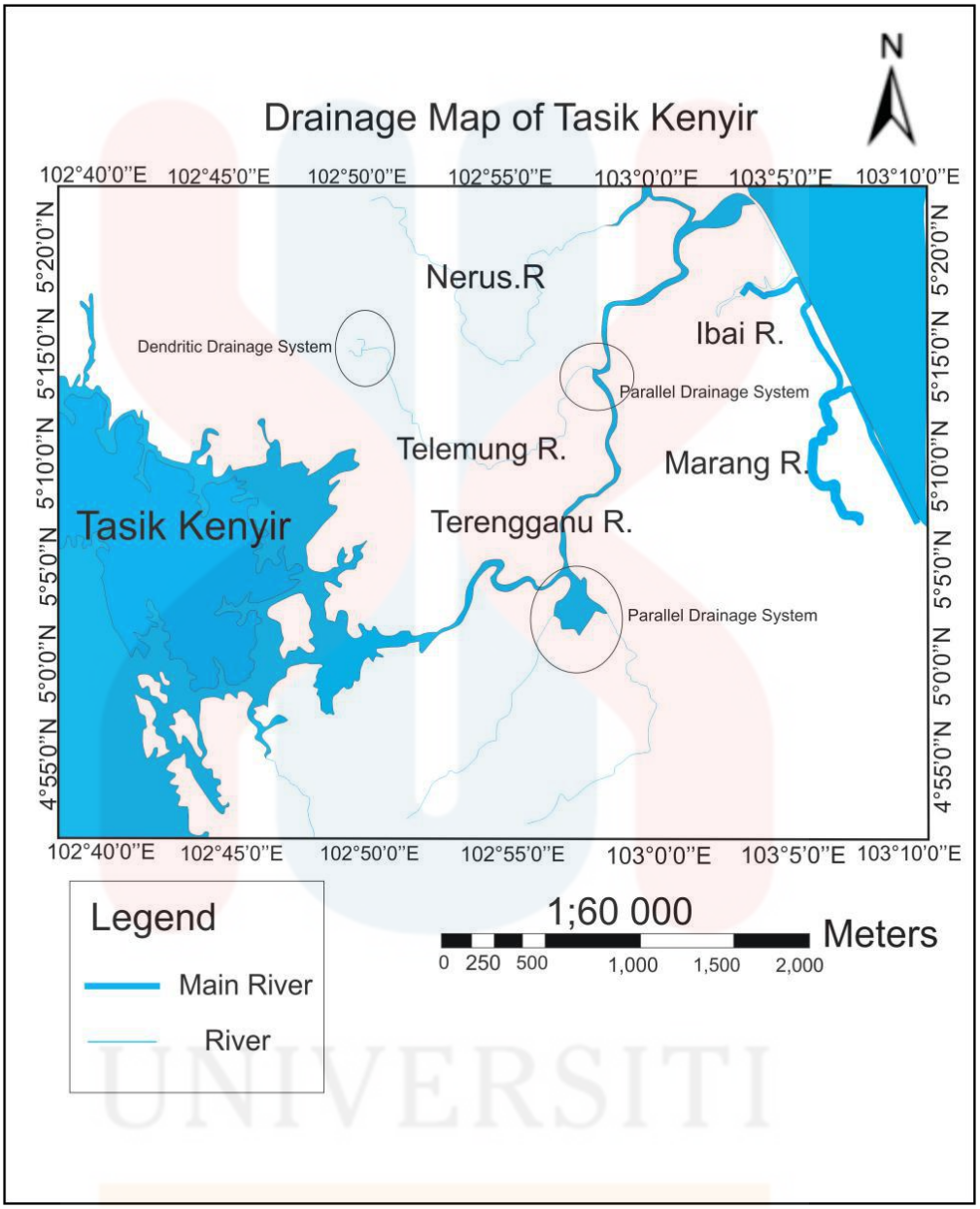


Figure 2.1 : The figure shows the drainage systems in the study area.

CHAPTER 3

MATERIALS AND METHODS

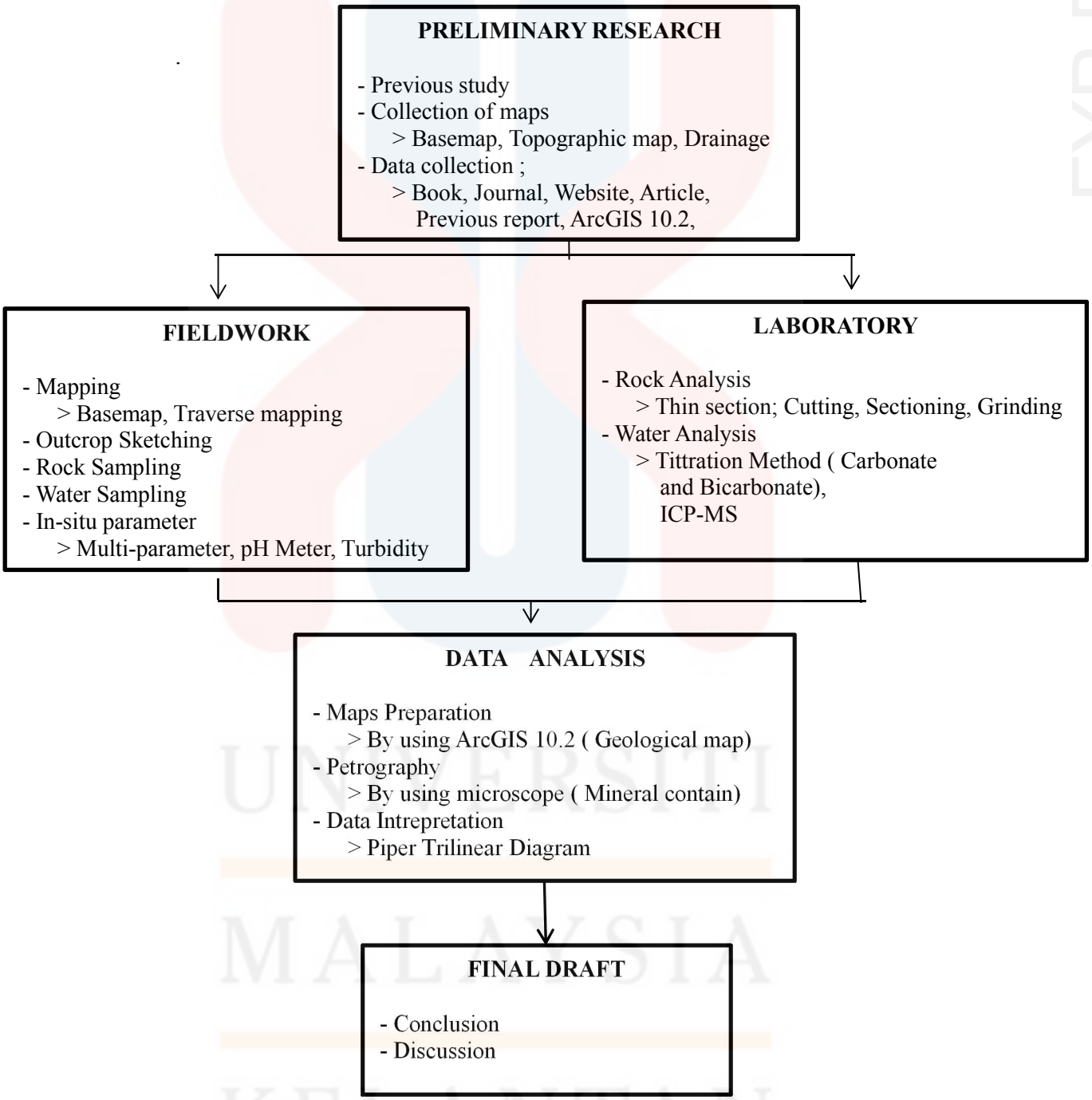


Figure 3.1 : Flow chart of the research proposal

3.1 Introduction

This chapter will briefly discuss the flowchart on progress towards work flow of the research that are covered the preliminary research, materials, field study, sampling, laboratory investigations, and data analysis. Spesific methodology and material was used to conduct research on water geochemistry.

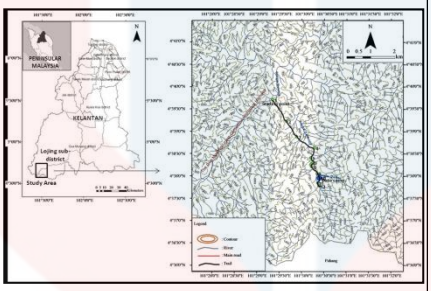
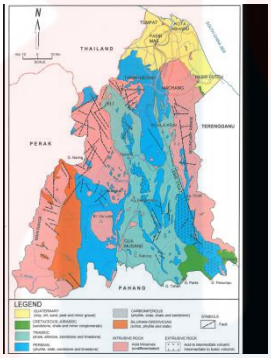
3.2 Preliminary Researches

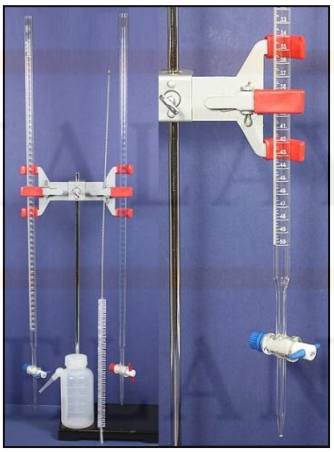
Preliminary research is the initial research has to be done before doing the research and going to site. This is includes studied of related topic, objectives, knowledge regarding the scope of study and study area. The sources of research study such as journal, article, websites, and search engines are done. It can be collected from Library University Malaysia Kelantan and Geology of Mineral and Geo-sciences Department. A series of collection data was taken into consideration as an aid for the research.

3.3 Materials and Methods

Spesific material and equipment are needed in order to conduct a research on mapping and water geochemistry Gua Bewah, Tasik Kenyir, Terengganu. Material and equipment which is needed for the analysis purpose are stated in Table 3.1.

Table 3.1 **:** The material and apparatus and the description of the apparatus and material.

Apparatus / Material	Pictures	Details / Uses
Base Map of the study area		- To have basic view of the study area. It has geospatial information on map such as country name, generalized river, and more.
Geological Map of study area		- Able to visit and outline every significant rock outcrop in an area and have better guidance for geological mapping.
Brunton Compass		-This compass is much accurate than Suunto compass. Brunton compass is used on the field by geologist, students and lecturers. Brunton compass provide hand level capability and can be used by waist and eyes level. Examples of the usage of Brunton compass are taking reading azimuth, pinpoint location on map,and used in geological mapping.

Hand Lens		-It used to identify the mineral on the volcanic rock by naked eyes on the field. Basically, it used to identify the physical properties such as colour, texture and identifiable mineralogy.
Hydrochloric Acid		-It is used to observe the reaction of the rock in order to differentiate between calcite and chlorite. It also used to distinguish most common carbonate rock, dolomite and limestone.
Measuring Tape		-It is used to take measurement of lithology and structure. As an example, in layering, it is necessary to measure the thickness of each layer precisely.
Burette		- a burette is a deviced used in analytical chemistry for the dispensing of variable, measure amount of chemical solutions. A volumetric burette delivers measured volumes of liquids. Pistons burrete are similar to syringes, but with precision bore and plunger. This is used to determine the carbonate and bicarbonate anions.

Plastic sample		- Sample bags are required to collect rocks samples and be useful to prevent the samples from any disturbances that might affect the origin of the sample.
Sampling Bottles		- Any water sample must be taken after data collection in-situ that will be analyzed to laboratory analysis for further the research. This sample bottels are required to prevent any influence that may affect the chemical within the water sample.
Field notebook		- During in the field, it is required to take every data collection that has been observed and identified which can be recorded after the survey. It is must be covered by hard cover and put in safe resistance to water.
YSI-556 MPS Multiparameter		- YSI 6920 used to take reading of temperature, Dissolved Oxygen, pH, turbidity, temperature and salinity

Portable pH meter Hanna HI 8314		- is a rugged portable pH meter designed to be easy usable carry, reliable and practical. HI 8314 shows the reading together with the current mode that are pH , electric conductivity and temperature.
HACH 2100P Turbidimeter		- is a portable that is a turbidity analyzer with a digital readout or manual ranges modes. The ranges is 0 - 1000 NTU in automatic ranges mode, while 0 - 9.99. 10 - 99.99 and 100- 1000 NTU in manual range selection. The accuracy of this instrument is + - 1 and + - 3% of reading 500 - 1000 NTU. The resolution is 0.01 NTU on lowest ranges.
Atomic Absorption Spectrometer		-is a spectroanalytical procedure for the quantitative determination of chemical element using the absorption of optical radiation(light) in free atom in gaseous state. In analytical chemistry the technique is used for determining concentration of a particular elements in sample to be analyzed. The instruments calibrate the concentration of major cations.

ICP - MS		- is a type of mass spectrometry which is capable of detecting metals and several non-metals at concentration as low as one in part 10^{15} (part per quadrillian, ppq) on non-inferred low background isotopes. This is achieved ionizing the sample with inductived couple plasma and then using mass spectrometer to seperate and quantify those ions. This allows determination of elements with atomic ranges 7 to 250 (Li to U).

3.4 Fields Studies

During the field study, literature review should be analyzed to get a logical and valid data about study area before taking any sampling. First, geological mapping are intended to identify the geo-morphology and lithology of the study area. A spesific study area was selected from the 8 x 8 km Tasik Kenyir area to conduct desk study about region. After the information or knowledge identification, field work was carried out to obtain secondary information from community around and the establish connection with the research work. The base map or geological map is updated by observation in the field by following spesific.

In terms of water quality aspect, fields studies are conducted by taking water sample near the bank of river, the main river and its tributaries. In-situ method also conducted on the field.

There are few instrument that being used in taking reading at the field for water quality aspect. First and foremost, multimeter model YSI 6920. By dipping the rode, the device can read the temperature, salinity, dissolved oxygen, turbidity and pH reading.

In order to take water samples, one must rinse the polyethylene bottle with the water of the site before dipping it. One must rinse it 3 times before really taking the water sample to avoid contamination with foreign materials inside the bottle.

After rinse process, the polyethylene bottle must be submerged a few centimetres deep below the surface area. After taking the water sample, the polyethylene bottle is being labelled with marker writing at the polyethylene bottle. It is marked with the location of the site that being taken.

There are 10 checkpoints that being established along Sungai Terengganu river for water sampling. In each checkpoint, 4 samples will be taken for sampling. After taking the samples at the site, it will be put in Coleman's box where the inside box has ice in it. The function is to preserve the water samples at the sites.

3.4.1 Rock Sampling

A rock sample belongs to a greater geologic formation, which likely has published information discussing its origin and evolution.Rock samples are used to define lithology. Field and lab analyses can be used to measure the chemical and isotopic constituents of rock samples.Provides information about the time and environment which formed a particular geologic unit. Microscopic rock textures can be used to estimate the history of stress and strain, and/or faulting.

3.4.2 Water sampling,

Water samples (groundwater, surface water and lake) will be collected to analysis.

In-situ parameter will be measured by using multi-parameter and pH meter to measure the hydrogen ion concentration which indicates the samples ' acidity or alkalinity'.

3.5 Laboratory analysis

3.5.1 Petrology

Besides that, the rock sample that take during mapping are used to do a thin section. The purpose of doing thin section is to analyze the mineral under the microscope. The process doing during thin section are cutting, sectioning, gridding, and etc.

3.5 2 Water analyses

In laboratory analysis, spectrophotometer model DR2800 will be used to measure Total Suspended Solid (TSS), Ammonical Nitrogen, Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) by referring to Standard Method for Examination of Water and Wastewater (APHA 2005).

TSS is a measure of the mass of fine inorganic particles suspended in the water. Ammonical Nitrogen is a measure for the amount of ammonia, a toxic pollutant often found in waste products, such as liquid manure, sewage and other liquid organic waste products.

3.5.3 Geochemical analysis

Titration method was conducted to analyze carbonate and bicarbonate. The tittration methods for bicarbonate are as follow :

- Take 100 ml os sample in volumetric flask and add two drops of phenolphthalein indicator.
- If solution remain colourless, PA=0
- If colour changes to pink after addition of phenolphthalein, titrate with 0.1N hydrochloric acid until the colour disappear at end point. This phenolphthalein alkalinity (PA) as shown in equation 3.1.
- Add two to three drop of methyl oranges to the same sample and continue titration further until yellow colour changes to pink at end point. This is Total Alkalinity (TA) as shown in equation 3.2.

Therefore PA or TA of bicarbonate concentration (mg/l) can be obtain as follow :

$$PA\ (mg/l) = \frac{(A \times \text{normality}) \text{ of HCL} \times 1000 \times 50}{\text{ml of sample}} \qquad (3.1)$$

$$TA\ (mg/l) = \frac{(B \times \text{normality}) \text{ of HCL} \times 1000 \times 50}{\text{ml of sample}} \qquad (3.2)$$

A = ml of hydrochloric acid used with only phenolphthalein

B = ml of total hydrochloric acid used with phenolphthalein and methyl orange

PA = phenolphthalein alkalinity

TA = total alkalinity

Inductive Coupled Plasma - Mass Spectrometry (ICP-MS) is an analytical technique used for elemental determinations. This is used for calibrate the anions

elements such as fluoride, chloride, sulphate, bicarbonate.

Atomic Absorption Spectrometry is a spectro-analytical procedure for quantitative determination of chemical elements using the absorption of optical radiation (light) by free atoms in the gaseous state. This is used for calibrate the cations element calcium, magnesium, sodium, potassium, iron, mangenese, copper, zinc.

3.6 Data Analysis and Interpretations

The data analysis and interpretation can be done by obtained the data from ArcGis. In geological mapping, every position has been marked and sampling taken are collected and recorded to be converted as primary data.

In petrography analysis, data interpret based on minerals content according to QAP diagram to draw and identify the rocks name.

Piper diagram will be used to identify the value of major ions that can be used in of water type determination.

3.7 Chapter's summary

For hydrogeochemical studies of water at Gua Bewah, Tasik Kenyir, Terengganu research, the methodology that will carry out is the field work and laboratory work. It was divided in to two because it must be done In-situ analysis and mapping at the field. The laboratory work will do the rock sample and water sample are collected from study area. For laboratory, the methodology that will carry out is thin section analyses, titration methods, Atomic Absorption Spectrophotometer, and ICP-MS. For field work, it focus on mapping, rocks sampling, water sampling, and In-situ analysis for water sample.

CHAPTER 4

GENERAL GEOLOGY AND STRATIGRAPHY

4.1 Introduction

This chapter will be briefly describes the geography in Gua Bewah, Tasik Kenyir area approximately about 30 $km^{2.}$ The study area focused on the geomorphology research through by topography, drainage system and weathering process that has been occured in the area. Besides that, the observation and survey also involved of petrography and stratigraphy which give overall description of geology condition in the study area. Geological mapping are done at study area and each point of entering are recorded and traversed as shown in figure 4.1 below.

In this chapter also, will be briefly describes field observation and mapping that has been resulted through a survey of the area. Geology is a group of sciences concerned with the study of the earth, including its structures, long-term history, composition and origins (Harry, 1990).

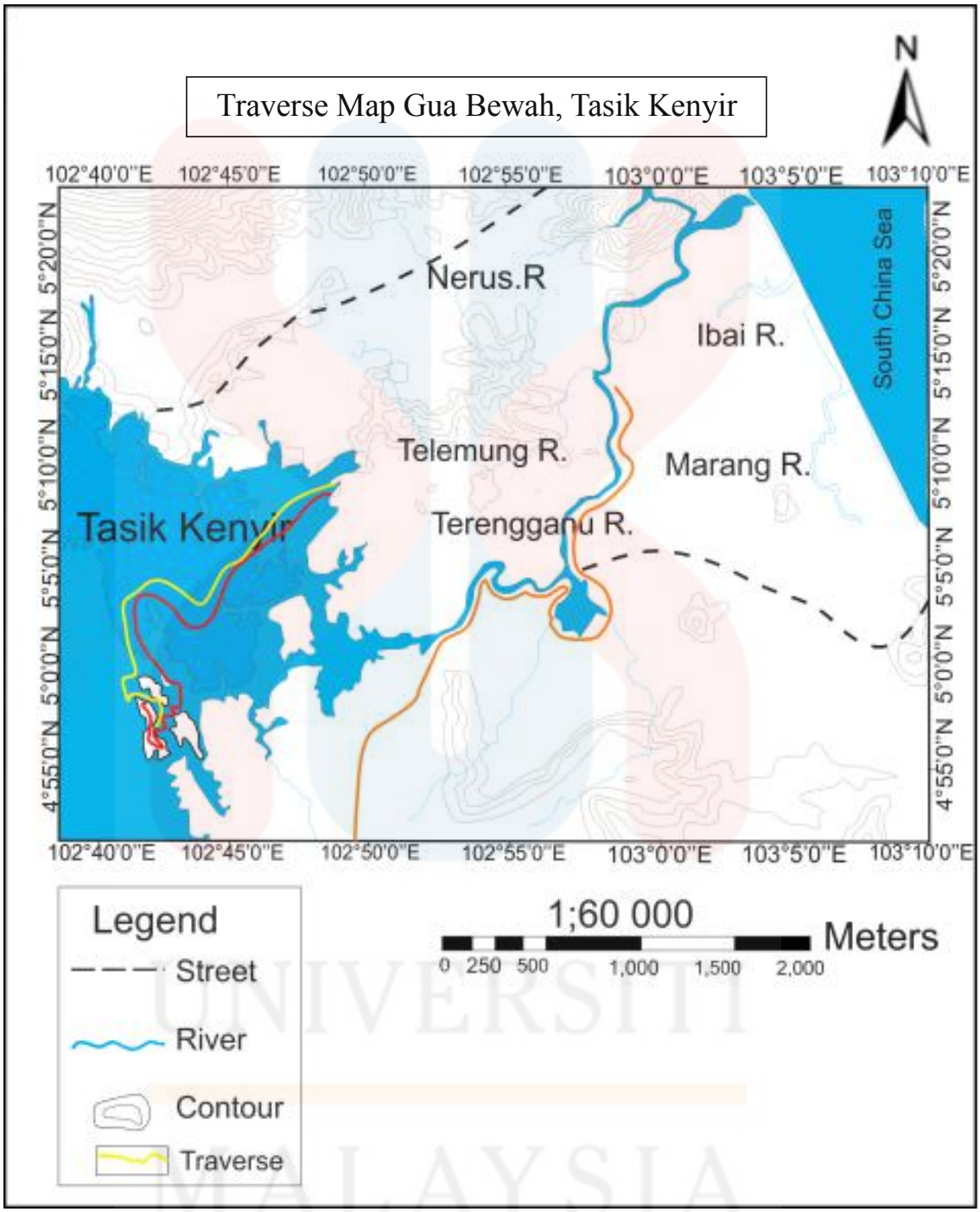


Figure 4.1 : Traverse map

4.2 Geomorphology

Geomorphology is therefore a discourse on Earth forms. It is the study of the physical lands surface features, its landforms - rivers, hills, plains, beaches, sand dunes, and myriad others, processes and landscapes evolution of the earth. Some workers include submarines landformes within the scopes of geomorphology.

Geomorphology is the process that occurs on the earth comprising of topography, drainage, weathering and erosions.Geomorphology is the study of the landforms about the origin and nature, which is the changed of the landforms with continually processes of weathering and erosion to form new formation that occured in atmosphere and hydrosphere (Roe, Whipple, & Fletcher, 2008).

Geomorphological process involving the changes of earth surface that of the shaped earth surface that result from physical, chemical, and biological process. This processed are influenced by certain agents such as water, wind, animal, plant, and other things that able to transport and changing structures that are on this earth surface. Table 4.1 shows the process and agents geomorphology by Tija (1987).

Table 4.1 **:** The process and agent of geomorphology (Tija, 1987)

Process	Types	Example	Agents
Exogenitic Process (earth's surface)	a) Degradation	- Weathering - Mass wasting or Gravitative Transfer - Erosion	- Running water - Groundwater - Waves, current, tides and tsunami - Winds - Glaciers
	b) Aggradation	- Deposition	
	c) Work or organism, including man		- Animal - Plant - Human
Endogenitic Process	a) Vulcanism		- Magma - Phyroclast - Gas and water vapour
	b) Diastrophism	- Uplift - Lifting - Folding - Faulting - Cracking	
	c) Earthquake		
Extraterrestrial Process	a) Cosmic Dust Rain b) Meteorite Fall		- Cosmos dust - Meteorite

4.2.1 Topography

Topography is the of the shape and features of the surface of the of the earth and other observable astronomical objects including planets, moons, and asteroids. Topography in a narrow senses involve the recording of relief or terrains, the three-dimensionals quality of the surface, and the identification of spesific landforms. Hugget (2011) stated formation process play important factors in knowing the sources and the development of earth surface.

Ibrahim Komoo (1989) defines that mountainous area can be seen trough the spesific slope categories which are steep slope and vice versa. Slope are usually presented by contour that are close to one anaother and non-steep slope and presented by contour that furthering apart when seeing down.

Five topographic units can be distinguished based on the differences in mean elevations as stated in Table 4.2. Low lying areas whereby less than 15m mean elevation occurs at along coast and narrow tracts extending inland from the coastal plain.This low lying area show depositional terrain and overlie unconsilidated alluvial, coastal and marine sediment of variable thickness. Next, rolling to undulating and hilly to mountainous mainly represent denudation terrain as result of weathering and erosion.

Terrain is the vertical and horizontal dimension of land surface. Terrain is used as a general term in physical geography, referring to the lay of the land. This is usually expressed in terms of the elevation, slope and orientation of terrains features. Terrain can affects surface water flows and distribution. Over a large area, it can affect weather and climate patterns. In terms of environmental quality, agriculture, and hydrology, understanding the terrain of an area enables the understanding of watershed boundaries, drainage characteristics, water movement, and impacts on water quality.

Table 4.2 **:** Topographic unit based on mean elevations (Raj, 1982)

Topographic units	Mean Elevation (metres above sea level)
Low lying	Less than 15
Rolling	16 - 30
Undulating	31 - 75
Hilly	76 - 300
Mountainous	More than 300

As shown below in figure 4.2 and 4.3, hilly area can be clearly seen and distinguish from low area and these hilly area mostly karst morphology which was formed many years ago.

4.2.2 Lake

A lake is a large body water (larger and deeper than a pond) within a body of land. As a lake is seperated from the ocean, it is not a sea. Some lakes are very big. River act as the main feature on earth where water flows through drainage openly and continously. The figure of river segment are closely related with respected area where it flows. Tija (1987) stated that drainage pattern is an important factor in geomorphology and geology interpretation. Drainage system is the prototype formed by the river and stream by a particular drainage basin. A drainage pattern is a pattern formed by the aggregate of drainage systems in the area despite of either it is dominanted by permanent streams or seasonal ones. Whereas, a stream pattern is a design deelop by a single drainage route (Arthur, 1967). The density of drainage may contribute information on permeability and composition materials.

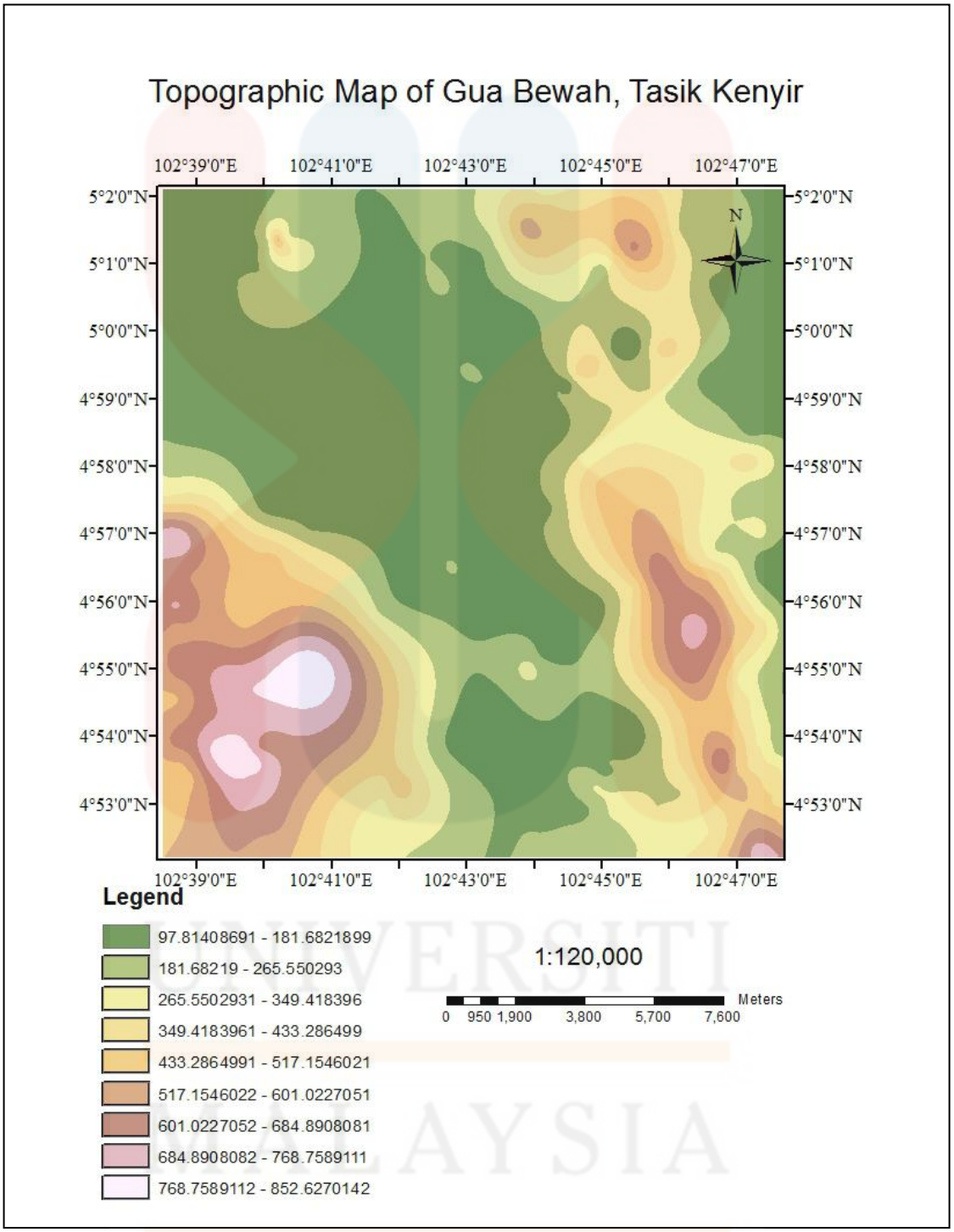


Figure 4.2: Topographic map

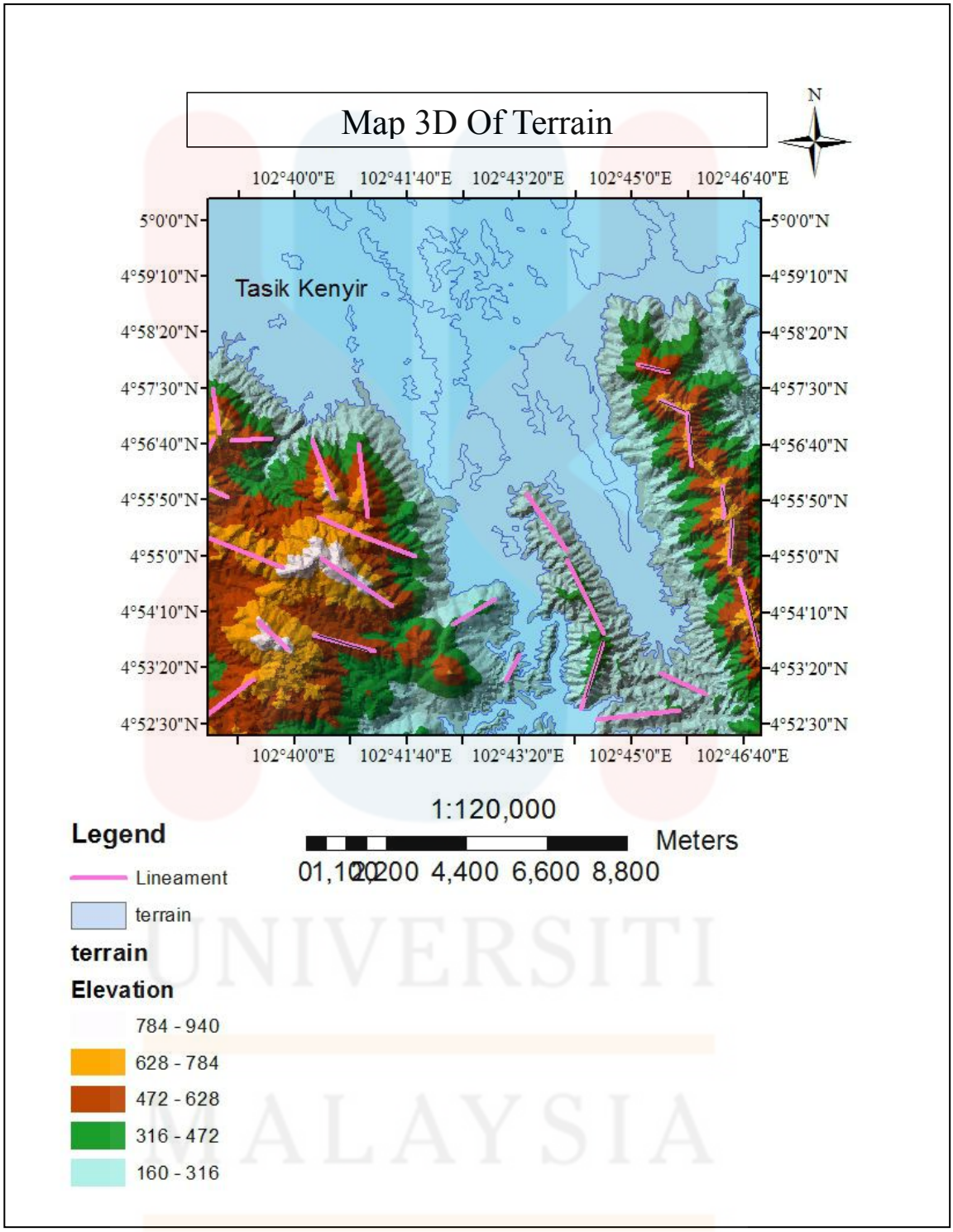


Figure 4.3 : The map 3D of terrain

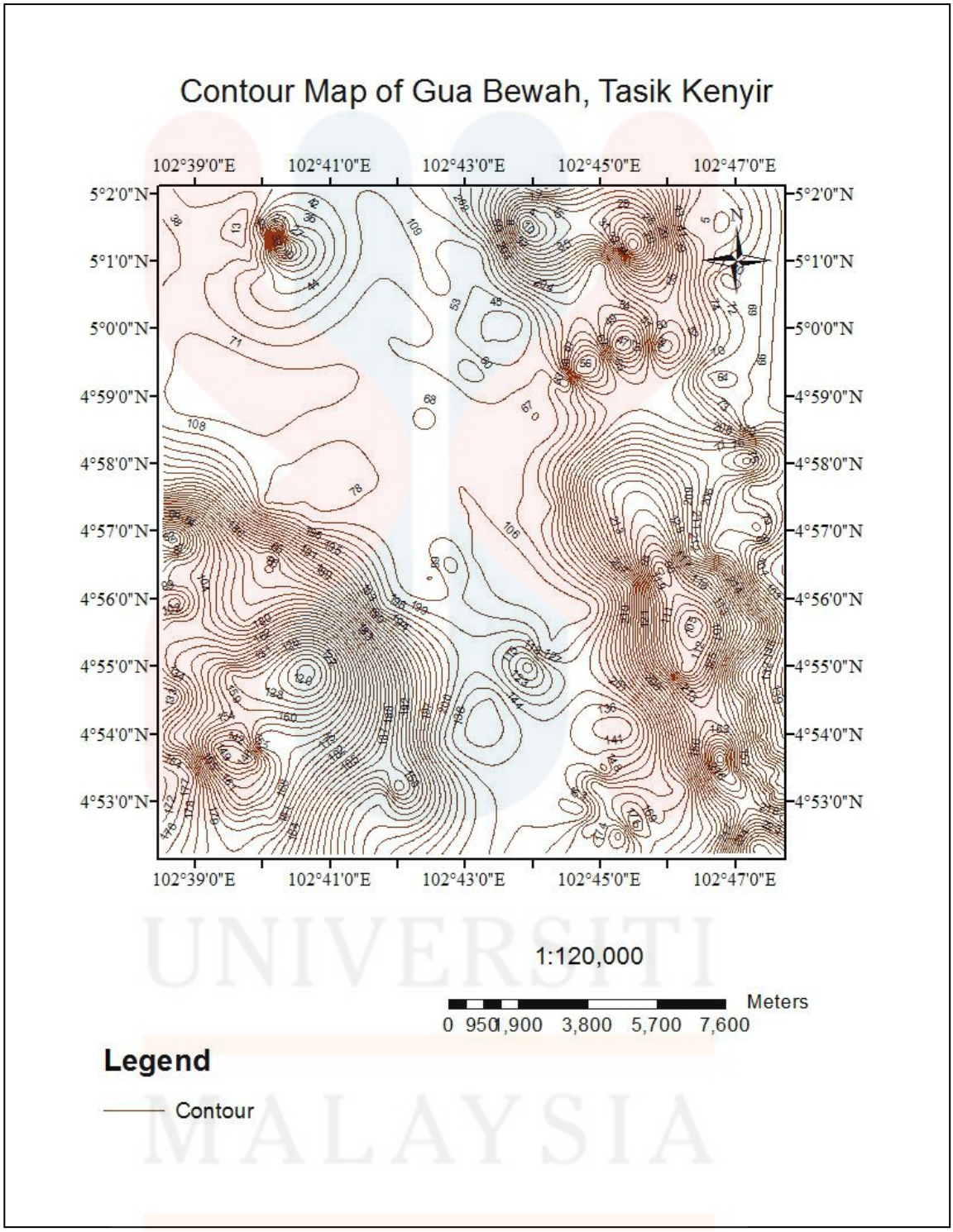


Figure 4.4 : The contour map of the study area

Figure 4.5 **:** This figure shows the hilly area which is karst morphology in the study area. The azimuth 210° from north. (Location: 04° 50’ 37.2” N, 102° 43’ 17.9” E)

Figure 4.6 **:** This figure shows the low lying area in the study area. The azimuth 231° from north. (Location : 04° 50’ 42.0” N, 102° 43’ 22.1” E)

4.2.3 Weathering and Erosion

Weathering is the adjustment and breakdown of rocks minerals and rocks masses when they are laid open to the climate. Weathering process that will be discussed is related to landforms that involved the study of the geomorphology as weathering process is the fundamental process on earth's surface. Weathering progressions rocks from a hard state, to wind up much softer and weaker, making them all the more efficiently disintegrated. Two primary assemblage of weathering procedure are recognized, with a third supporting group which is the physical weathering, substances and biological weathering (Will Bland, 1998).

Physical weathering is the process, for example, ice wedging and volume progressions of minerals, which bring about the mechanical disturbance of rocks. For instance, granular disintegration, exfoliation, joint block separation, shattering, by changes in temperature or pressure.

Chemical weathering is the decay of rock framing minerals formed by water, temperature, oxygen, hydrogen, and mild acids. Example would be disintegration, hydration, oxidation, carbonation.

Biological weathering is the processes that are created by, or aided by, the vicinity of vegetation, or to lesser degree creatures, including root wedging and the generation of organic acids.

According to Fookes et al. (1971), weathering process has been classified into 6 grades. This classification has been used and modification has been done by Dearman (1974) and Beavis (1992). The classification can be referred to the Table 4.3.

Table 4.3 : Weathering classification (Fookes, et al., 1971)

Grades of Soil	Explanation
First (I)	Fresh rock
Second (II)	Rock which might undergo a bit weathering process
Third (III)	Rock which undergo medium weathering process
Fourth (IV)	Highly weathered rock
Five (V)	Rock which experienced complete weathering process
Six (VI)	Alteration of rocks into soil state

Figure 4.7 : The process of spheroidal weathering.

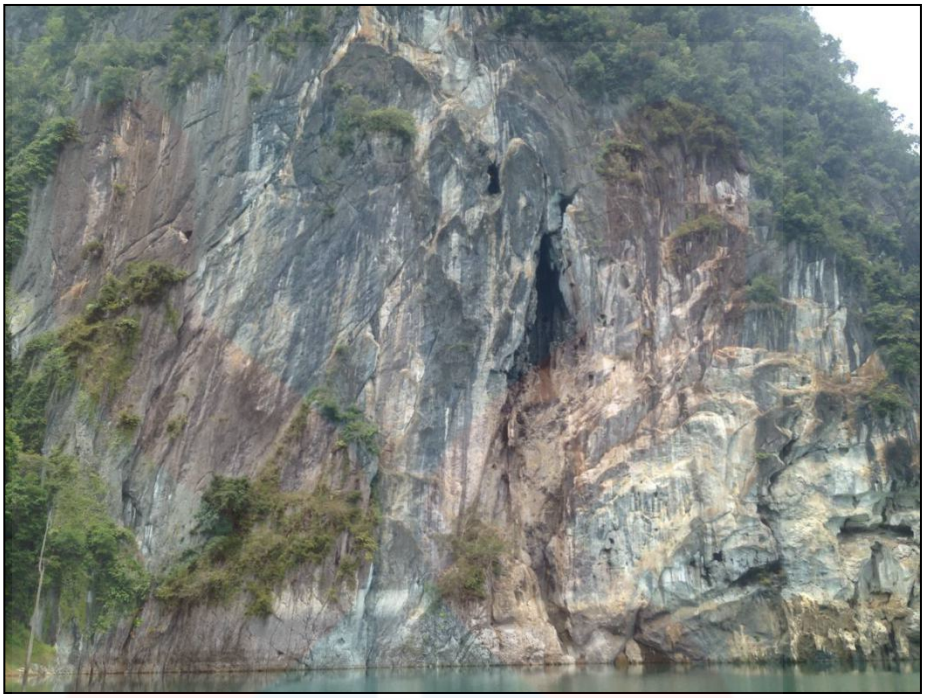


Figure 4.8 : The process chemical weathering.

4.3 Petrography

Petrography is the part of petrology that concentrates on complete classifications of rocks. The mineral constituents and the textural connections within the rocks are reported in detail. Rusty (2005) define petrography as a schematically characterization and classification of rock by identifying mineralogy and structure of specified rock. Through specific analysis, one can determine rock petrography, rock texture, and rock maturity which are introduced by Pettijohn (1975).

Petrographic analysis provides a detailed description of the texture which includes grain size, sorting, and grain contacts, sedimentary structures which are laminations, bioturbation, framework grain composition, authigenic minerals, and types and distribution of macroporosity seen in a thin section.

Four rock samples were collected during geological maping at tasik kenyir for

petrographic analysis.

Petrographic classifications begin with the field observation at the outcrop also including megascopic information of hand specimens. As for this petrography analysis, the picture of thin section of rock are taken using two method which are cross polarized light (XPL) and plane polarized light (PPL) as shown in photomicrograph 1-3.

4.3.1 Petrographic analysis of igneous

Reference No. : AF 005
Location : Gua Bewah — Name of Rock: *Granite*

Rock Type **:** Igneous

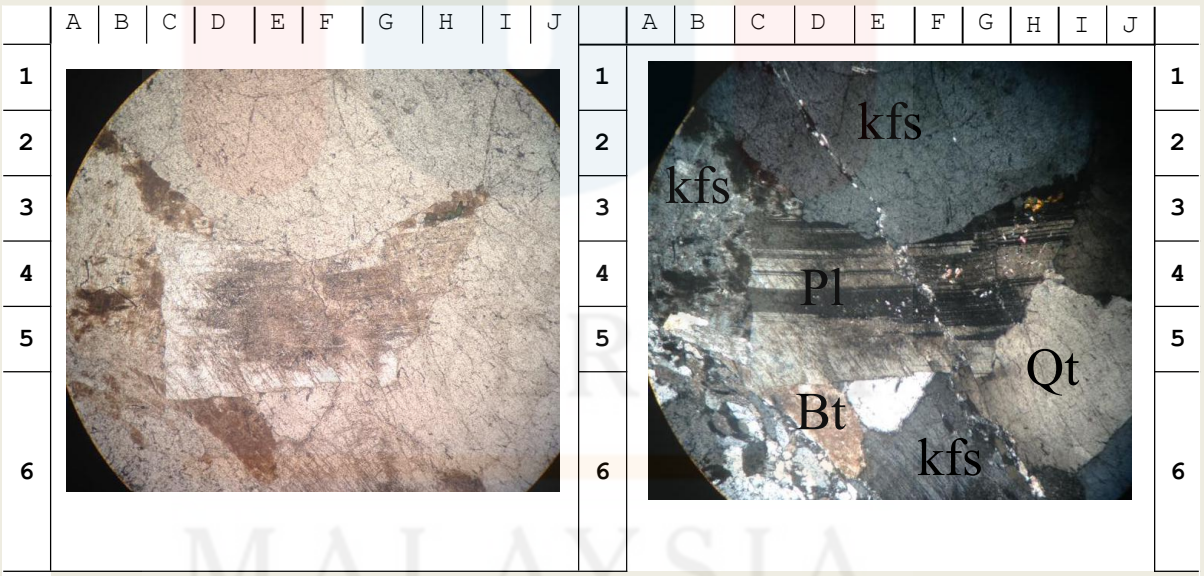
Classification **:** QAP triangle

Microscopic **:10 x 10 magnificant**

Description of Mineralogy

Composition of Mineral	*Amount* (%)	*Description of Optical Mineralogy*
• **Quartz**	20	Gray to white, featureless grains in crossed polars
• **Plagioclase Feldspar**	20	*Twining visible*
• **Alkali Feldspar**	50	*Light grey in a finer matrix of quartz*
• **Biotite**	10	Indicating brown grains in plain light

Foto



Fotomicro 1.1 : Shows granite rock sample under microscopic with 10x10 magnification.. kfs=alkali feldspar;Qt=Quart;Pl=Plagioclase;Bt;Biotite

Figure 4.9 : The shows of petrology of igneous rock.

These are photographs of a thin section of Granite with magnification of 10x10, By comparing the plane polarized light at the left side and crossed polarizer images at the right side, we can see that there are three minerals in this granite which are Biotite indicating brown grains in plain light and pinkish brown with crossed polars. The brown color is due to a property called Pleochroism, typical of minerals that are rich in iron. Quartz which showing gray to white, featureless grains in crossed polars and Plagioclase which showing gray to white grains under crossed polars, with banded or plaid-like striping or twininng, and sometimes flecked with fine sparkly grains of Sericite or an alteration mineral due to weathering. The rock is a coarse grain granite with large phenocrysts of alkali feldspar in a finer matrix of quartz, with little presence of biotite and with minor plagioclase feldspar.

a. QAP Diagram

Based on the calculation for mineral percentage, it is found that this rock sample consist of 20% of quartz, 20% of plagioclase, 10% of biotite and 50% of alkali feldspar. Thus, the QAP ternary diagram is plotted to classify igneous rocks with visible mineral grains which known as phaneritic structure from the alkali feldspar and quartz content. Based on the plotting of the rock sample, the type of rock concluded is granite which then further classified as monzo-granite . Figure 4.6 shows the plotting for the rock sample and its position which exhibits the proper classification of plutonic rocks.

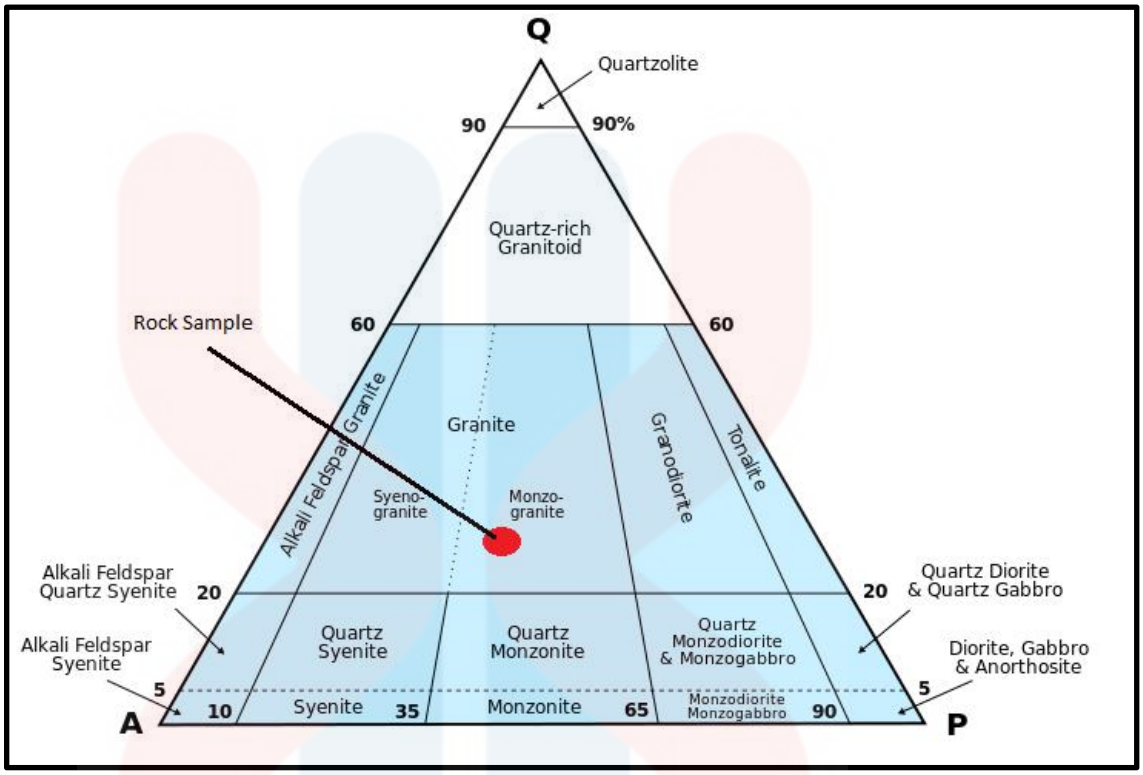


Figure 4.10 : QAP plotting showing the type of rock sample.

4.3.2 Petrographic analysis of Limestone

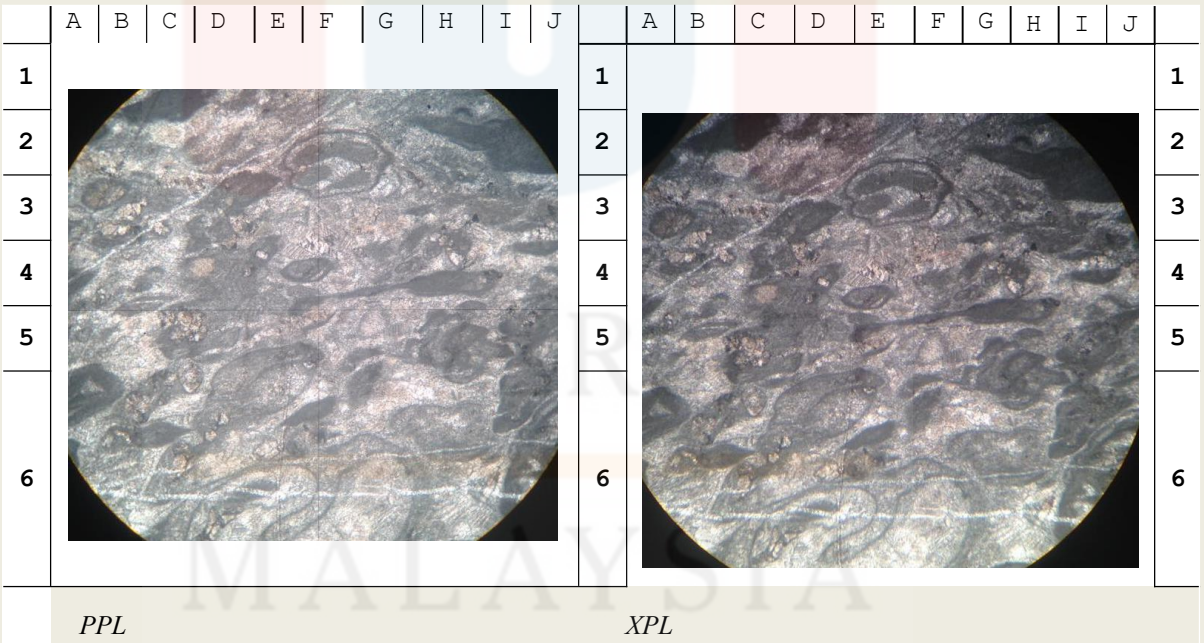
Reference No. : AF 003 Location : Gua Taat		Name of Rock: Packstone
Rock Type	**: Sedimentary rocks**	
Classification	**: Dunham (1962)**	
Microscopic	**: 10 x 10 magnificant**	

Description of Mineralogy

Abundance of fossil can bee seen un 10x10 magnificant

Composition of Mineral	*Amount (%)*	*Description of Optical Mineralogy*
• **Grain (Skeletal Grain)**	**13**	Only minor presence of grain can be seen.
• **Sparite (Calcite)**	**87**	Calcite skeletal, which contain less than 4 mole % magnesium in the calcite, include some foraminifera, brachiopods, bryozoans, trilobites,

Foto



PPL *XPL*

Fotomicro 1.2 : Shows limestone rock sample under microscopic with 10x10 magnification..

Figure 4.11 : The petrographic of sedimentary rocks of packstone.

Reference No. : AF 001
Location : Gua Bewah
Grainstone

Name of Rock :

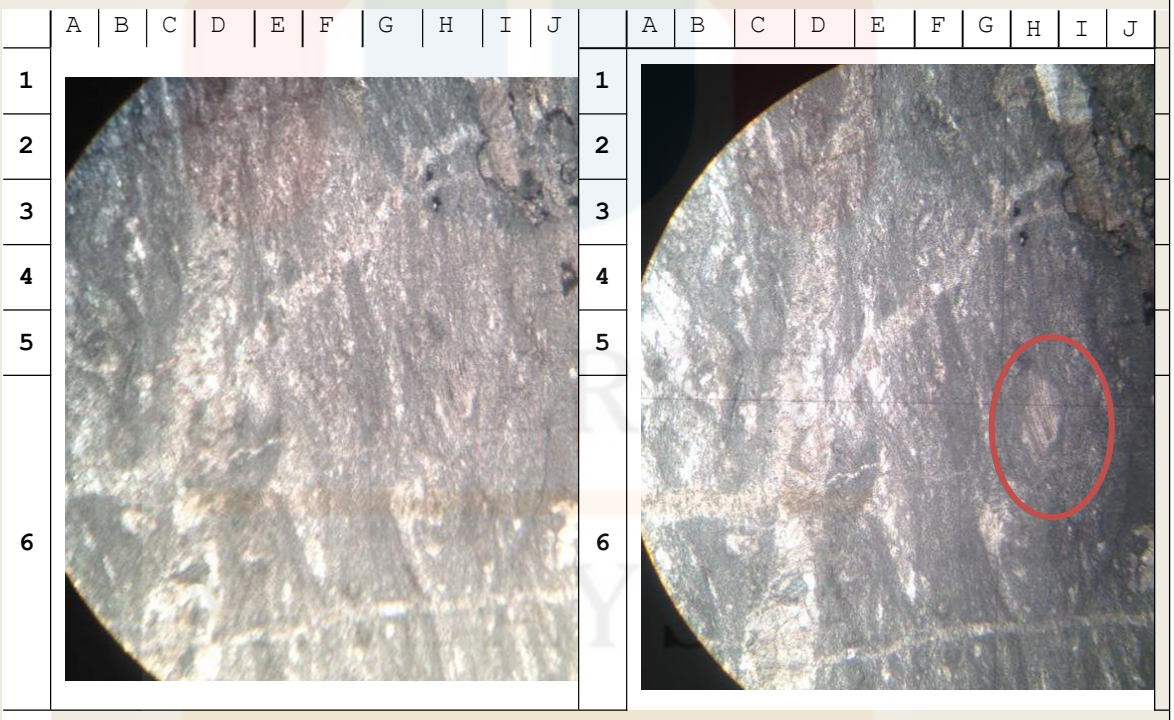
Rock Type	**:** Sedimentary rock
Classification	**: Dunham (1962)**
Microscopic	**: 10 x 10 magnificant**

Description of Mineralogy

Abundance of fossil can bee seen un 10x10 magnificant such macrofossil which is bivalve are clear seen under the microscopic.

Composition of Mineral	*Amount (%)*	*Description of Optical Mineralogy*
• **Grain (Skeletal Grain**	**13**	Most grains in limestone are skeletal fragments of marine organisms such as coral or foraminifera.
• **Sparite (Calcite)**	**87**	Surrounded by calcite.

Foto



PPL *XPL*

Fotomicro 1.3 : Shows limestone rock sample under microscopic with 10x10 magnification..

Figure 4.12 : The petrographic of sedimentary rock of grainstone

a.Dunham Classification

The Dunham classification scheme is primarily textural description, with grain packing grain-to-matrix ratio. Describing grain packing includes observing the degree of grain support. A grain supported limestone was probably porous at the time of formation, with sparry cement. A matrix supported limestone with floating grains probably originally formed as micrite which later recrystallized as secondary sparry cement. By using Dunham Classification table as shown in figure 4.10 below, limestone in figure 4.8 and figure 4.9 are classified. Dunham classification stated that mudstone and wackstone are both mud supported where mudstone consisted less than 10% grains and wackestone consisted more than 10% grains. By comparing these percentage of grains with limestone in figure 4.8 and figure 4.9 it is clearly seen that both limestone in study area are grain supported due to abundance of fossils lacks of mud. Hence, by referring to Dunham table classification, it is concluded that photomicro images 1.2 and 1.3 are packstone and grainstone respectively.

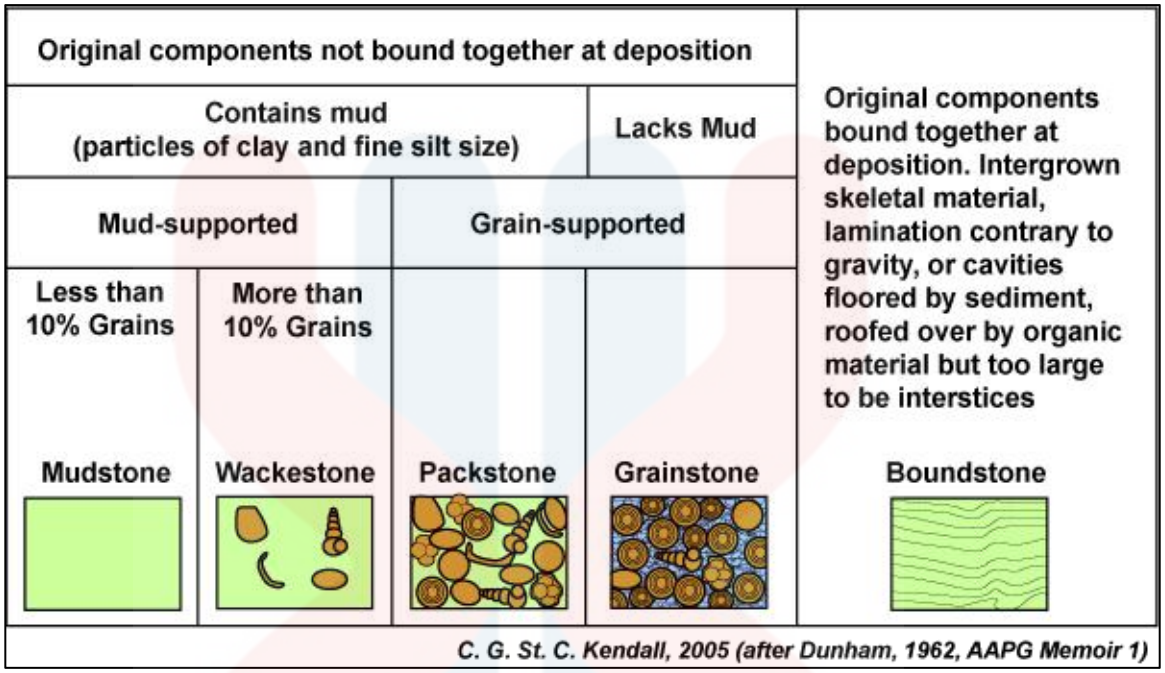


Figure 4.13 shows table of Dunham classification for carbonate sedimentary rocks by C.G.St.C.Kendall, 2005

4.4 Stratigraphy

Sanudin & Baba (2007) stated that stratigraphy discussed about properties and physical contain of the earth that related with the arrangement of earth's crust and rock layer in it. Limestones of Bukit Bewah and Bukit Taat, Kenyir Lake, Terengganu represent a limestone unit that was deposited during the Middle Permian. The limestone is made up of mudstone, wackestone and packstone with subordinate grainstone. The dominant tests and grains comprise shells of shallow marine organisms that dwelled on the sea bottom during the Permian age. The rock has undergone several diagenetic processes including surface or near surface cementation when the sediment was at the sea bottom and late burial cementation. The existence of these two limestone hills has form it own geology and geomorphology unit which differ from surrounding rocks.

Surrounding rocks are comprised of clastic sediment which has undergone low grade metamorphism ranging from slate and phylite. The close position between these two hills are the result of facies changes that happened during deposition. The existence of limestone unit in rock clastic sequence are norm in East belt. As for today, there are about 80% of whole Terengganu are made up of rock aged Carbon while only Bukit Bewah and Bukit Taat are proven aged Middle Permian (Fontaine, 1988). Chung (1962) stated that limestone of Bukit Bewah aged Permian are above shale and quarzite which aged from Carboniferous until Early Permian. The whole geological history of Lake Kenyir are further explain in figure 4.11 below.

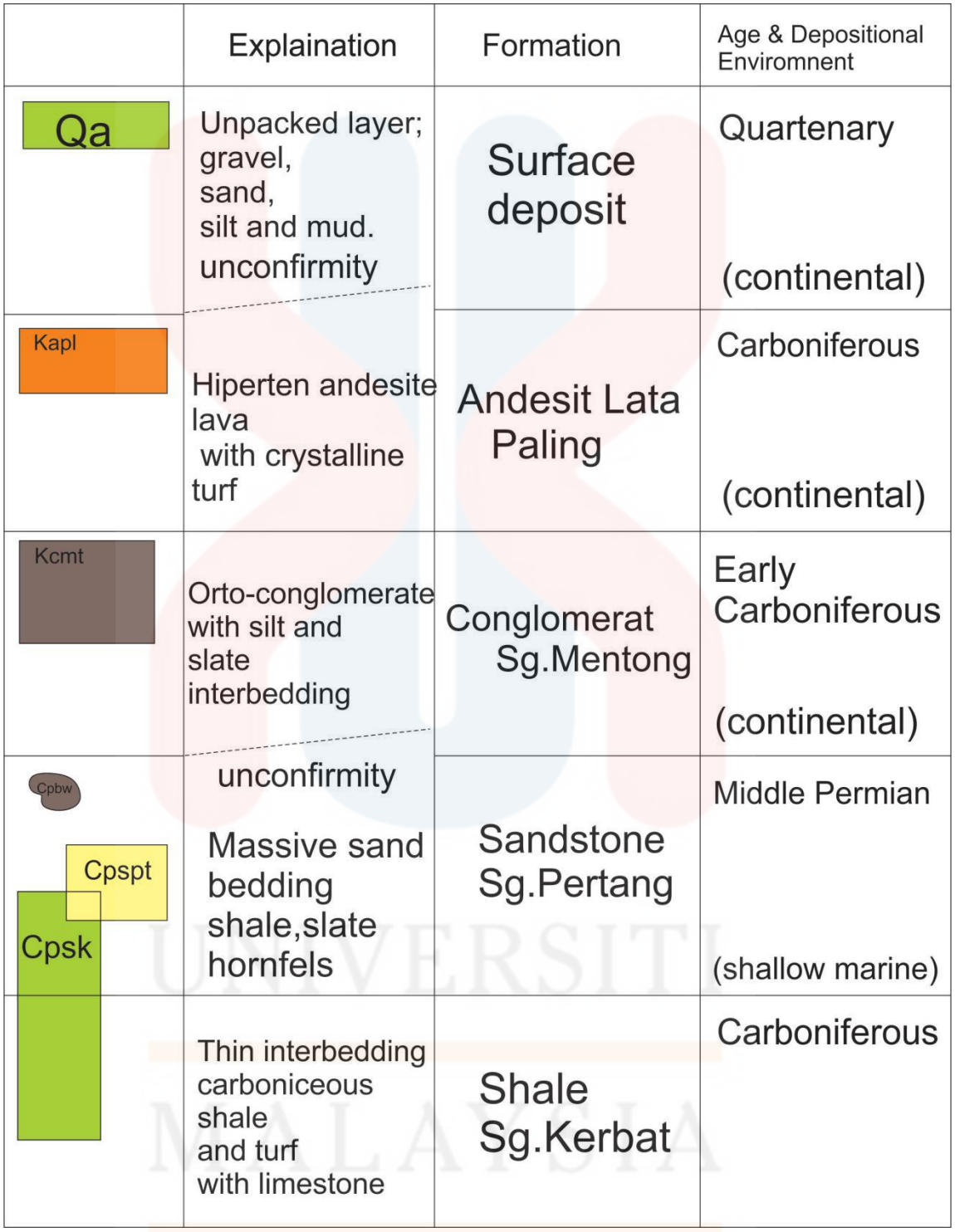


Figure 4.14 shows stratigraphic column of Tasik kenyir.

4.5 Litostratigraphy

Geology of Tasik kenyir can be divided into two types of sediment rocks and two type of main igneous rocks consisted from granite and also associated rocks. Sediments rock units are made up of Sungai Kerbat shale, Bewah limestone, Sungai Petang Limestone, Sungai Mentong congomerat and Gagau group while volcanic rock unit known as Andesit Lata Paling (Chow,2001) also exsited in lake Kenyir. Granitoid rock known as Granit Kapal has intrude all sediments rocks aged Palaeozoic in Lake Kenyir. Geological information showing that the oldest rock in lake kenyir was form in sea depositional about 310 million years ago during late Carboniferous. Pebbels sediment deposition,muddy sand happened in deep sea deposition.

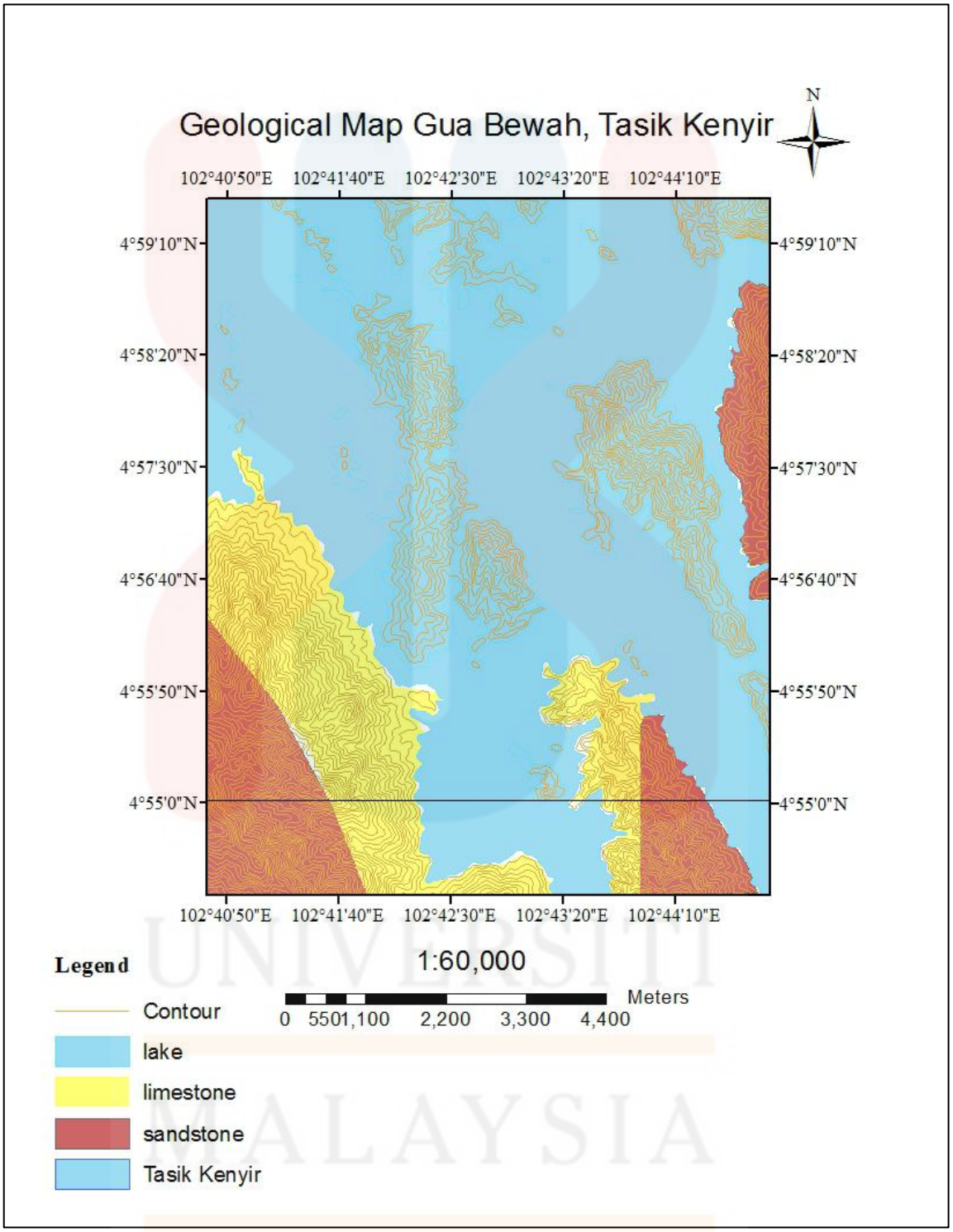


Figure 4.15 : Geological map of study area

4.6 Structural Geology

Structural geology is the study of the three-dimensional distribution of rocks units considering their deformation histories. The essential idea of reveal data about the historical back drop of deformation (strain) in the rocks. A standard plan is to comprehend the structural advancement of particular region regarding locally boundless examples of rocks distortion (Caran,1981). Structural geology based on the landforms that has been undergone geological tectonic activities which affect the structural of the rocks body. The geological structures can be done by identified the structures such as veins, joints, faults, folds, fractures and crackes with can be analyzed the forces that has been transmitted froms. The observation can be analyzed the data during field works.

Bukit Bewah and Bukit Taat are two hills situated close to each other and form by massive limestone and showing no clear bedding plane. Field observation done in east of Bukit Bewah and there outcrops in west of Bukit Taat showing these limestone hills were formed by medium thick bedding until thick bedding with north-south strike direction and with slope laye of 30 degree down until -40 degree. These two hills shows strike and dip confirmity which then can be assume that these two hills were made up of same unit nad only separated by discontinuity between them. Geomorphology of Lake Kenyir are controlled by main structures such as fold and fault. Major anticline structure formed ridges which divided Lake Kenyir into two parts crossing from north-north west to south-south east. This anticline ridges are cut by major fault which running from east to west forming valley that conected two parts of the lake at Tanjong Mentong.

4.6.1 Lineament analysis

A lineament is a linear characteristics in surroundings which is a distribution of an underlying geographical structures , for example, a fault.Lineament analysis referred to linear features that revealed the weakness zone and structural displacements in the crust of earth. A lineament is mappable linear or curvilinear fe surface whose parts align in a straight or slightly curving relationship (Hung L.Q, Batelan O., *et.al.*, 2005).

Lineament consist of two types which are positive lineament and negative lineament. A positive lineament is represented by ridges, mountain peak or seen bodies while negative lineament are represent by river, valley and drainage. Lineament are mostly form due to tectonic deformation can be use to represent strike layer, or fault zone.

a. Positive Lineament analysis.

Positive lineament analysis are made by using 3D ridges as shown in figure 4.15 below. Height differences can be seen clearly using this image. Angle counted from this ridges line are key in georose software in order to know the direction of deformation. As shown in figure 4.16, the deformation direction are north-west and south-east.

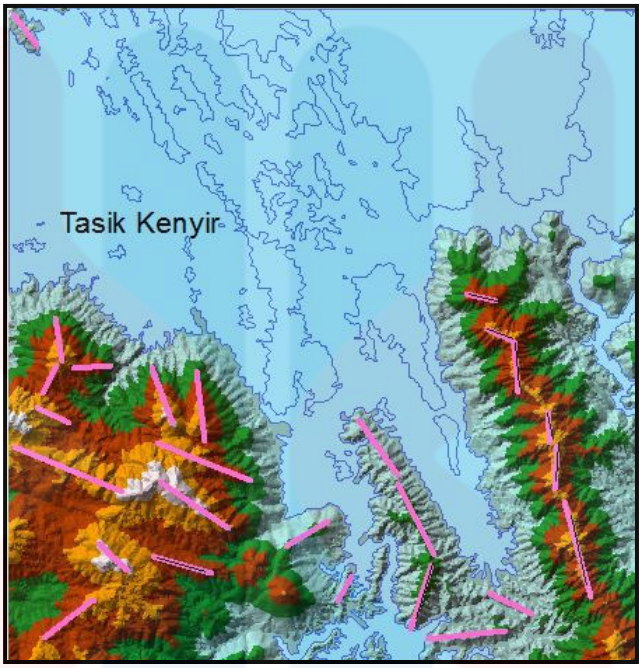


Figure 4.16 : Positive lineament

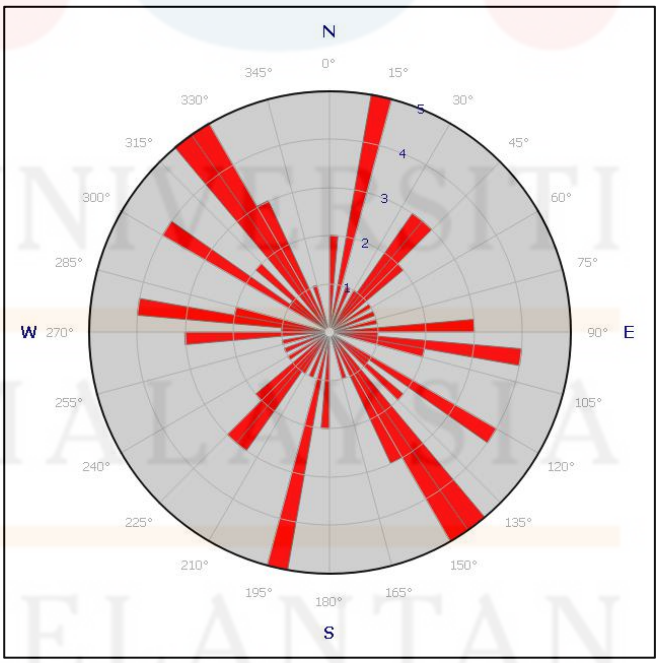


Figure 4.17 : Positive lineament using georose software.

4.6.2 Folding

Structural geology such as folding was found in study area as shown in Figure 4.17 below. Folding are form due to high pressure or high temperature around it. The basic cause is likely to be some aspect of plate tectonics. When two forces act towards each other from opposite sides, rock layers are bent into folds. The process by which folds are formed due to compression is known as folding. Folding is one of the endogenetic processes and it takes place within the Earth's crust.

Figure 4.18 : The folding that has been in Gua bewah

4.6.3 Joint Analysis

A joint is a break or fracture of natural origin in the continuity of either a layer or body of rock that lacks any visible or measurable movement parallel to the surface of the fracture. Joints result from brittle fracture of a rock body or layer as the result of tensile stresses.

Joint analysis gives information about sequence, time and direction of brittle deformation of rock. Joint reading especially along the river can help to understand the connection between joint itself and it influence towards drainage system and topography form that existed in study area. Figure 4.18 shows joint analysis using georose software and it showing deformation direction of west-north-west and east-south-east.

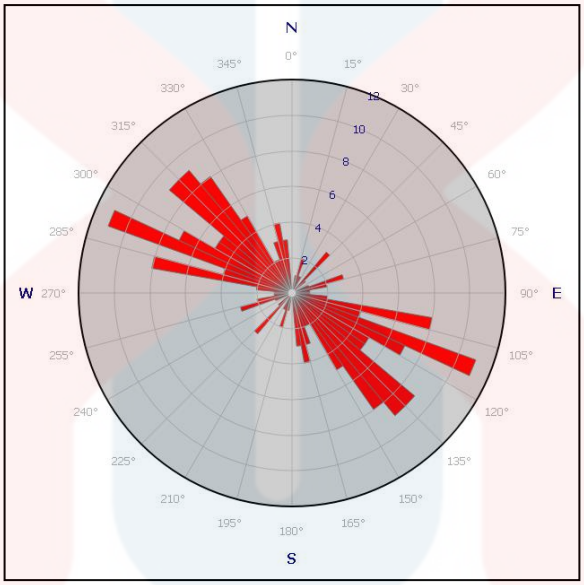


Figure 4.19 : The georose of joint in Gua bewah

4.7 Historical Geology

4.7.1 Formation of caves

A caves is a natural opening in the ground extending beyond the zone of light and large enough to permit the entry of man. Occuring in a wide variety of rocks types and widely differing geological processes, caves ranges in sizes from single small rooms interconnecting passages many miles long.

The types of Gua Bewah, Tasik Kenyir are solution caves. Solution caves are formed in carbonate and sulphate rocks by the action of the slowly moving the groundwater that dissolves the rocks to forms tunnels, irregular passages, and even

larges caverns along joint and bedding planes.

Limestone experiencing significant diagenesis process and form Gua Bewah and Gua Taat. The effects of diagenesis are available including cementing beginning by calcite in shallow marine environment, nitrartion, late cementing, dolomitization, neomorfisme and replacement of calcite by silica materials (Che Aziz et al., 2006)

Figure 4.20 : The interface of the caves.

4.7.2 Caves Features (Stalagtites and Stalagmites)

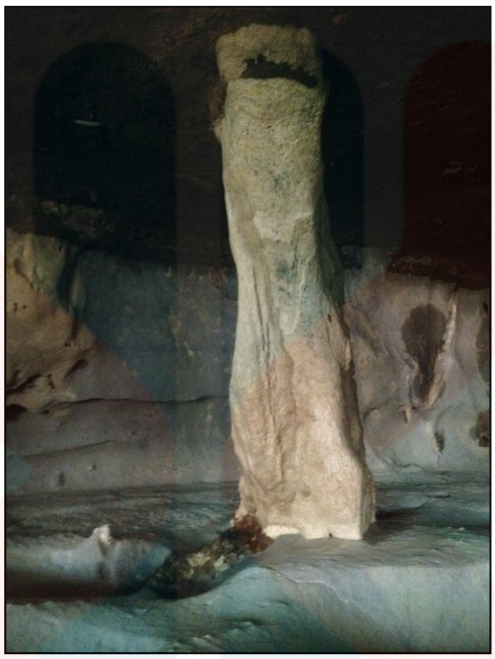


Figure 4.21 : The stalagtite and stalagmite

A stalactite is an icicle-shaped formation that hangs from the ceiling of a cave, and is produced by precipitation of minerals from water dripping through the cave ceiling. Most stalactites have pointed tips.

A stalagmite is an upward-growing mound of mineral deposits that have precipitated from water dripping onto the floor of a cave. Most stalagmites have rounded or flattened tips.

4.7.3 Caves feature (sea notch)

Figure 4.22 : The caves feature of sea notch at Gua Bewah

A wave-cut platform, coastal benches, or wave-cut benches is the narrow flat area often found at the base of a sea cliff or along the shoreline of a lake, bay, or sea that was created by (Wilson, 1998) the erosion of waves. Wave-cut platforms are often most obvious at low tide when they become visible as huge areas of flat rock. Sometimes the landward side of the platform is covered by sand, forming the beach, and then the platform can only be identified at low tides or when storms move the sand

CHAPTER 5

RESULT AND DISCUSSION

PHYSICAL PROPERTIES AND WATER GEOCHEMISTRY ANALYSIS

5.1 Introduction

Geochemistry of water analysis referred to the investigation of major ions chemistry to understand the effects of geochemical that take along the direction of flow on the groundwater in the study area (M. Senthilkumar, 2013). The major ion included calcium(Ca2+), magnesium(Mg2+), sodium(Na+), potassium(K+), iron(Fe2+), mangenese(Mn), copper (Cu2+), zinc(Zn2+), flouride(Fl-), chloride(Cl-), sulphate(SO4-), bicarbonate(HCO3). The determination value of major anions such as nitrate(HNO3), chloride (CL-), and sulphate(SO4) can be associated by influenced of anthropogenic activities on the groundwater composition (Mohd Muqtada Khan, Rashid Umar,.*et.al.*, 2009).

Surface water regulation was recognized as a sources as a source of such negative environmental impacts as transformation of the river flow, modification of the river-bed, intense sedimentation in the reservoirs, and harmful effects on aquatic and riparian ecosystems (Jansson et al. 2000; Koch 2002; Osmundson et al. 2002; Renöfält et al. 2010). Although the effect of hydropower regulation on the river flow regimes is well documented (Renöfält et al. 2010), studies on changes of dissolved and particulate major and trace element transport are fewer (Brydsten et al. 1990; Rondeau et al. 2005; Huang et al. 2009), and various effects of hydropower regulation on the river element transport are thus still poorly understood (Humborg et al. 2008). This is partly related to the limited knowledge about the connection between surface water and groundwater and

their interaction in systems exposed to frequent river discharge variations.

Groundwater chemistry is regulated primarily by the combination of various process that are weathering process of minerals such as silicates, carbonate and lime, the intrusion or input of chloride and sulphate salts and generation of nitrates through the nitrification process and aerobic decomposition of organic matter (M. Senthilkumar, 2013). Increasing concentrations of major anions and cations towards the top of the aquifer suggest that they come mostly from surfaces sources (Kangjoo. Kim, 2005). Futhermore, geological formation of the area can be a contribution of mineral weathering of silicates are triggerd by protons geberated from nitrate generation due to weathering of silicates are triggered by protons generated from nitrate generation and water chemistry could be affected by lime applied to cultivate land carbonates in cement materials (Timothy M.Kresse, 2012).

Water in the other word is a solvent and breaks down minerals from the rocks that react with it. The widely recognized disintegrated mineral substances are sodium, calcium, magnesium, potassium, chloride, bicarbonate and sulphate. In water chemistry, these substances are called regular constituents and it is well known fact that no straightforward reasons can be imputed for deterioration of water quality, as it is dependent on several water quality parameters. Existed there is strong correlations among different parameters and a combined effect of their inter-relatedness indicates the water quality (Mohammad Muqtada Ali Khan, 2012).

Other than that, geo-physical properties of groundwater such as pH, electrical conductivity (EC), turbidity, total dissolved solid (TDS), hardness, temperature (℃), are required for evaluation of geo-physical evaluation.

Quality of water play an important role as it quantity and it gives a lot of benefit for existance of flora and fauna. They are many purposes that can be knows by determine the chemical properties and physical properties. Reliability of the water for the various can be decided by chemical and physical quality of water.

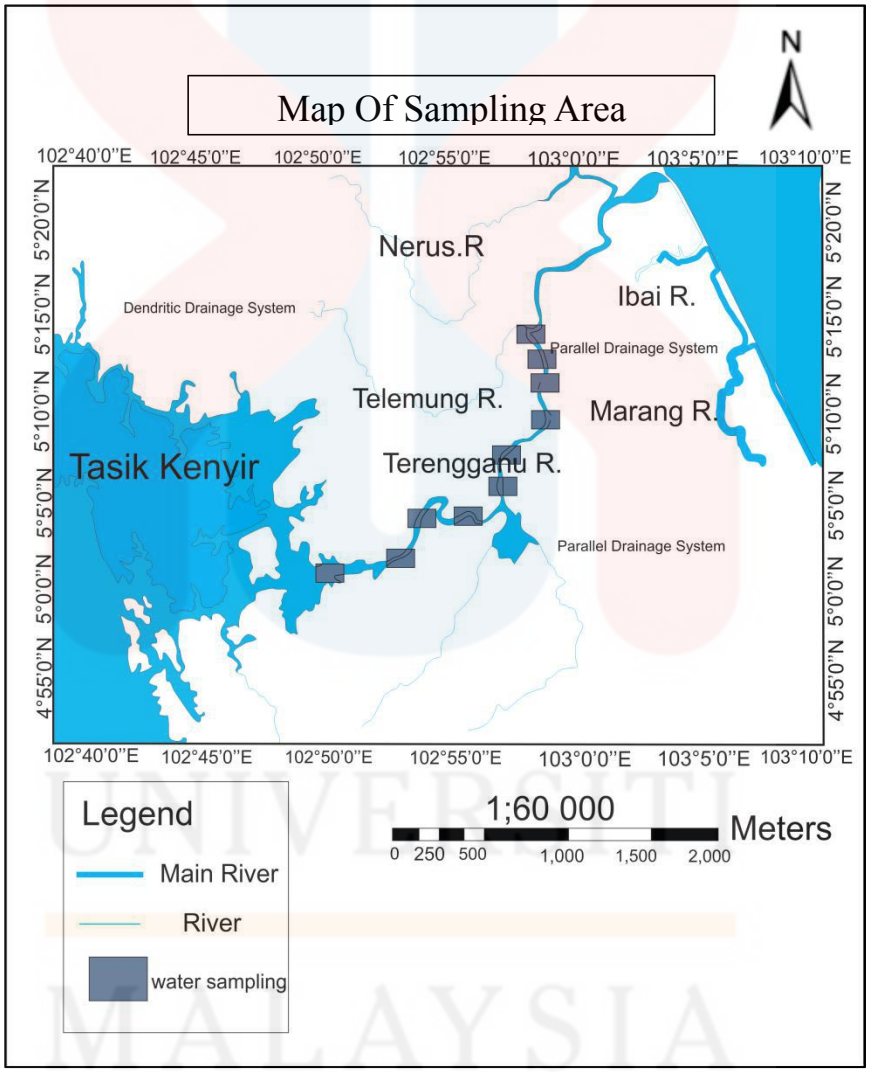


Figure 5.1 : Location water sampling

5.2 Physical Properties of Water

Physical properties of water including pH, electrical conductivity (EC), turbidity, total dissolved solid (TDS), hardness, temperature (℃), salinity, total suspended solid (TSS), was measure during field works by different parameter. The variety parameters were used to conduct to get high possibility of accuracy of reading.

5.2.1 Temperature

Temperature is a numerical measure of hot and cold conditions. In Malaysia, the climate is wet and dry by month. Temperature measurement by detection of heat radiation or particle velocity or kinetic energy or by the bulk behaviour of a thermometric material in Celcius scales (Claire, 2009).

Based on the Figure 5.2, the temperature of the water collected in the study area ranges between 27.7 - 32.8℃. The highest temperature of the water sample is 32.8℃ and the lowest is 27.7℃. Higher temperature of water is direct influence due the input heat trough the sun because the sampling was during sunny day. The temperature readings are collected in the field for in-situ parameter. The water sample are collected in the same month in this year, 2016. Figure 5.2 shows the temperature of water in study area.

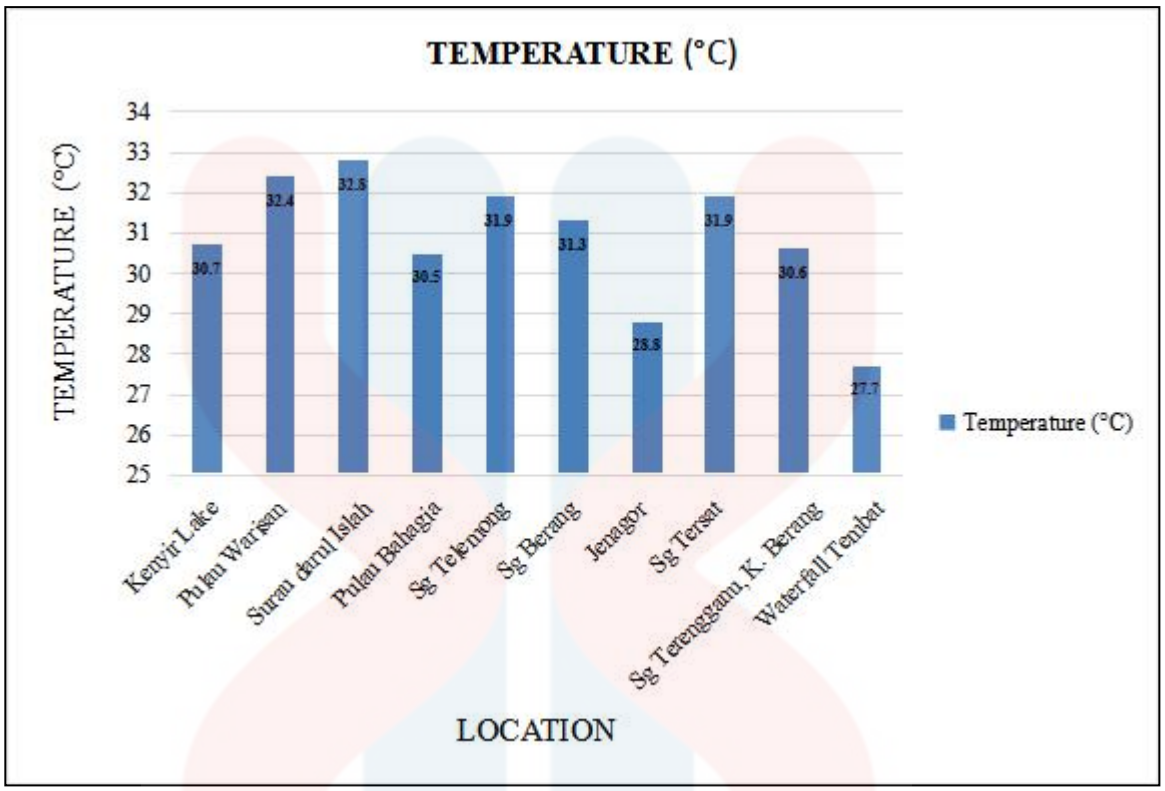


Figure 5.2 : Bar diagram show temperature of water in study area.

Based on the Figure 5.3, the range of distribution of the temperature in the study area are between the 27.7℃ to 32.8℃. The darker the color the higher the temperature in the study area. The lighter the color the lower the temperature in the study area. The distribution of temperature are shown below.

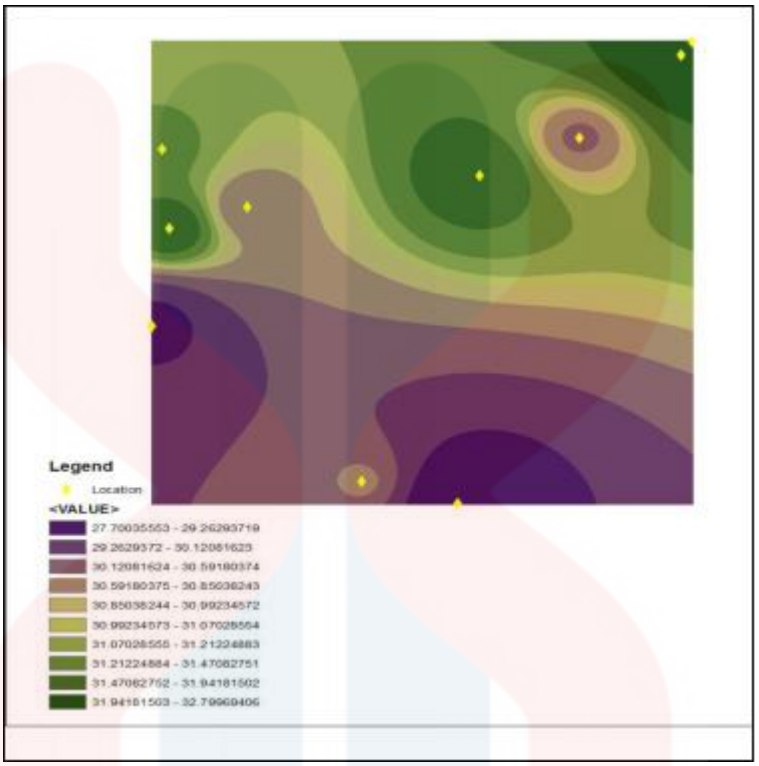


Figure 5.3 : The of distribution water temperature in the study area.

5.2.2 Hydrogen Ion Concentration (pH)

Hydrogen Ion Concentration (pH) is a measure of the acidity or alkalinity of water. The pH concentration can be divided into three parts that is acid, neutral and base. Water with pH of 7 has equivalent quantities of hydrogen (H^+) and hydronium (OH^-) particles and is termed neutral. pH of precipitation is marginally acidic at 5.7 and has tendency to develop to more neutral conditions in the environment (Claire, 2009). pH is crucial in light of the fact that it manages larges portions of the chemical responses including water and like wise firmly impacts the vicinity or non-appearance of arsenic, iron, manganese, and nitrogen. Acidic water is destructive in nature, while alkaline water has tendency to be encrusting.

Based on the figure 5.4, the hydrogen ion concentration (pH) ranges from 6.7 to 6.92 with average 6.84. It may influences by the freqeuncy of rainfall at study area. The maximum pH value is 6.93 of Sg. Berang and the minimum value is 6.7 of Kenyir lake. All the water pH reading shows below neutral value (6.5 - 7.0 pH). Most probably water sample is shallow aquifers that easily to react with soil cause the decreasing value of pH.

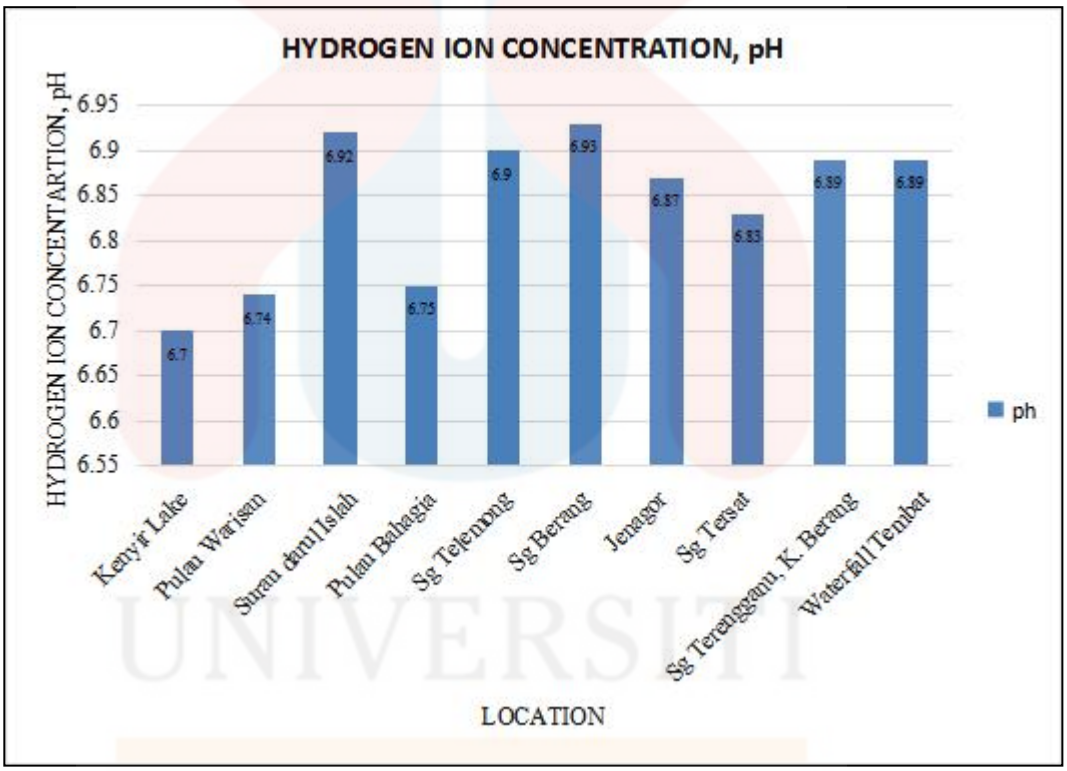


Figure 5.4 : Bar diagram show hydrogen concentration ion, pH in the study area.

Based on the figure 5.5, the range of distribution of the hydrogen concentration ion, pH in the study area are between the 6.7 to 6.92. The darker the color the higher the pH in the study area. The lighter the color the lower the pH in the study area. The distribution of temperature are shown below.

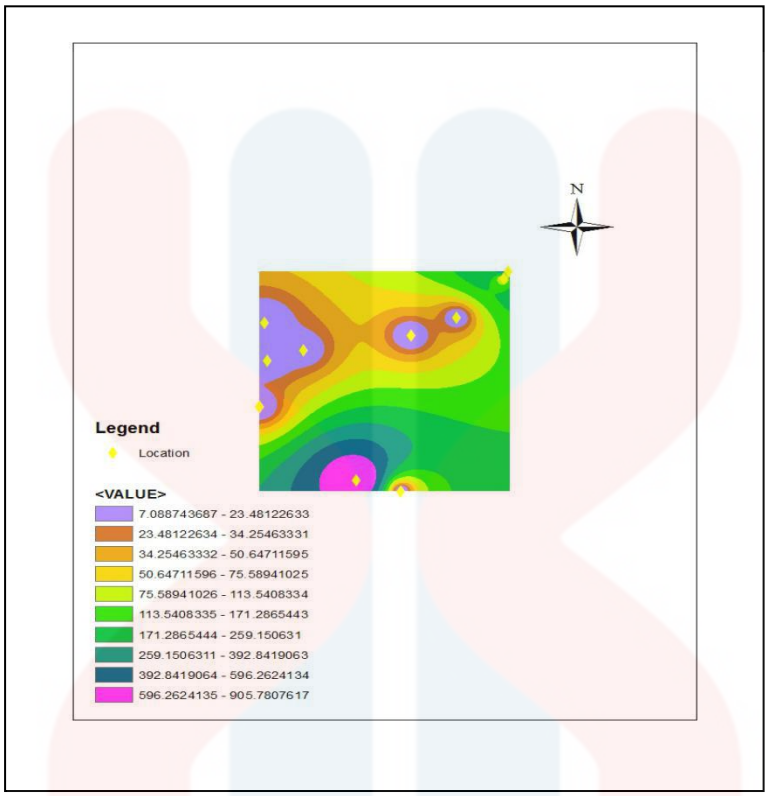


Figure 5.5 : The distribution of pH in the study area.

5.2.3 Hardness

Hardness can locally in water from chemical and mining industry effluent or excessive application of lime to the soil in agricultural areas. Hard water requires more soap and synthetic detergents that produced by home laundry, washing and contributes to scaling in boilers. Water hardness can be classified by the amount concentration of calcium and magnesium, and to lesser extent, iron in the water. Water hardness is measured by adding up the concentration of calcium, magnesium and converting the value to an equivalent concentration of calcium carbonates ($CaCO^3$) in milligrams per litre (mg/L) (Stewardship, 2007). Hardness is measure by using the value of calcium and magnesium into the formula :

Total hardness = (2.497 (Ca)) + (4.115 (Mg))

Based on formula water hardness is the amount of calcium and magnesium. The water hardness is measured by adding up the concentration of calcium, magnesium, and converted the value to an equivalent to an equivalent concentration of calcium carbonate in mg/L of water. Hardness can be divided into several categories according to the Guideline for Canadian Drinking Water Quality Hardness as following categories :

Table 5.1 : Hardness category (Suzannah,2007)

Hardness category	Equivalent concentration of $CaCO_3$	Benchmarks
Soft	< 60mg/L	98% sample (sample 3-10)
Medium hard	60 mg/L < 120 mg/L	
Hard	120 < 180 mg/L	
Very hard	180 mg/L or greater	2% (sample 1 and 2)

Water is considered soft if it contain <60 mg/L of hardness, moderately hard from 60 to 120 mg/L, hard between 120 to 180 mg/L and very hard if more than 180 mg/L.Based on the results shown, the highest value of hardness is sample 1 that is the value 905.865mg/L that influenced from concentrations of magnesium is 178.6 mg/L and calcium is 58 mg/L. While the lowest value of hardness calculated is 7.0104 mg/L which is 10 that affected from the concentration of magnesium 0.49 mg/L and calcium 2 mg/L.

From the result, it is revealed that the highest value of hardness is 905.865 mg which is slightly unsafe ranges of hardness in drinking water as the optimum range for

drinking water is 80 - 100 mg/L. The water hardness of surface water can be influenced of the surface is por-phyritic phaneritic granite as rich in silicate minerals. Beside that, the application of fertilizer may affect the hardness value.

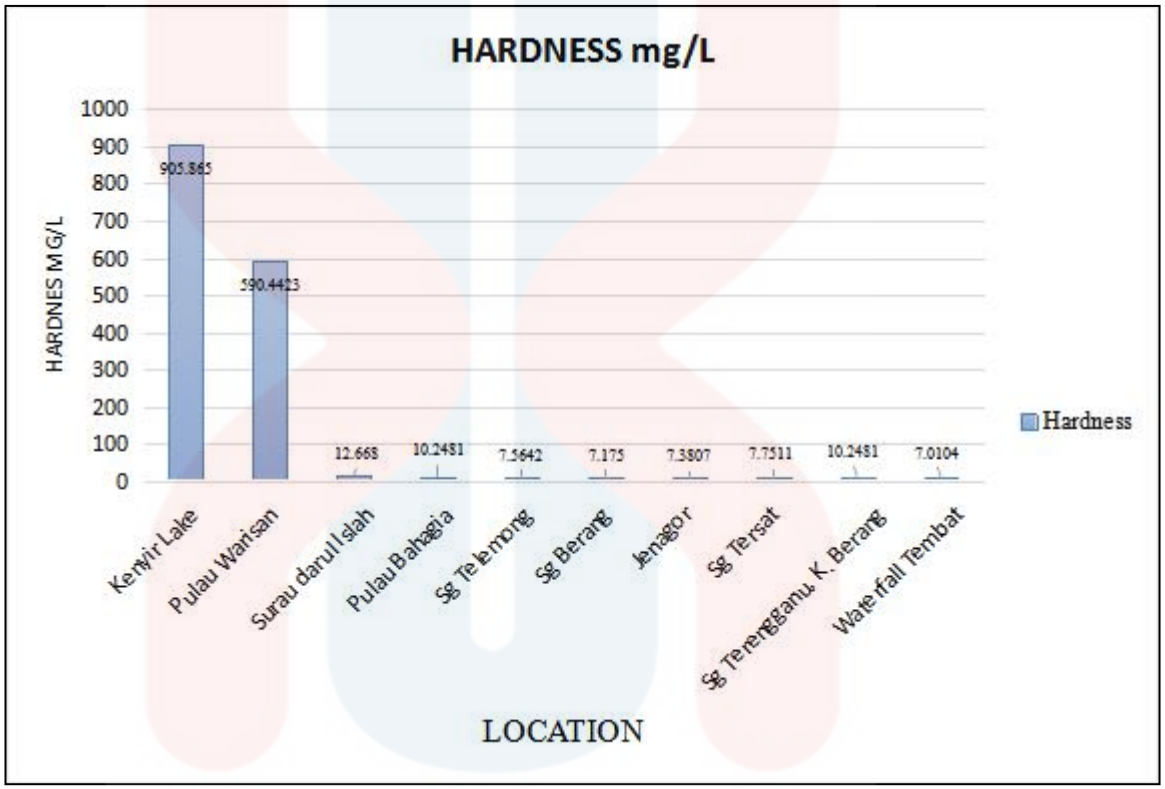


Figure5.6 : Bar diagram shows hardness of water sample in the study area.

Based on the figure 5.7, the range of distribution of the hardness in the study area are between the 7.0104 to 905.856. The darker the color the higher the hardness of the water in the study area. The lighter the color the lower the hardness of the water in the study area. The distribution of hardness are shown below. The higher value of hardness of water its not suitable for drinking purpose.

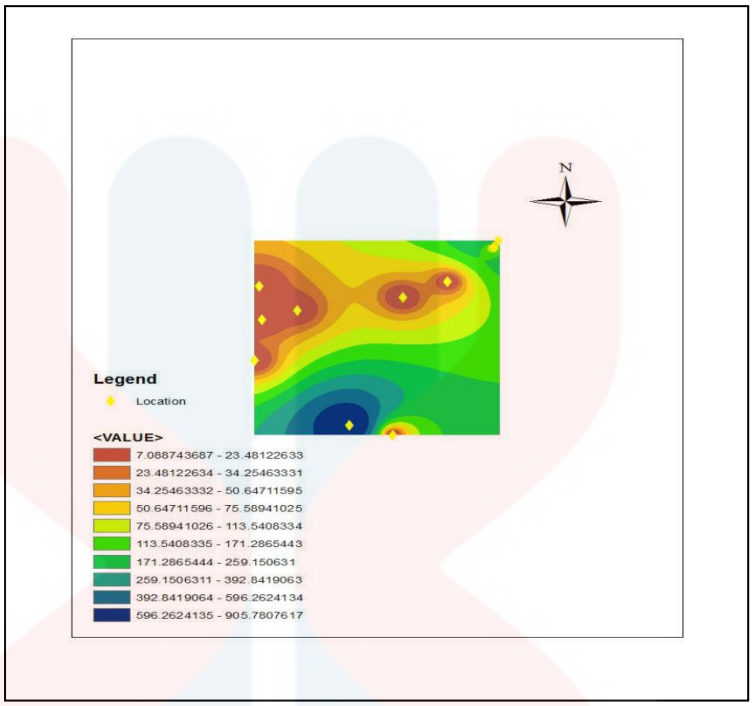


Figure 5.7 : The distribution of hardness in the study area.

5.2.4 Total Dissolved Solids (TDS)

Total Dissolved Solid (TDS) is to measure inorganic salts and small amount of organic matter present in solution in water. TDS level also depend on the geology of the region, climate, weathering, and geological features that affect sources of dissolved material and its transport to a water system (World Health Organization, 2003). The Dissolved Solids (TDS) are total amount of dissolved compounds mineral or immobile ions such as minerals, salts or metals dissolved in water. Dissolved solids are presence of other material that has dissolved in pure water (Kresic, Chapter 5: Groundwater Quality, 2009).Dissolved solids comes from many sources such as organic sources that are leaves,silt, plankton, industrial waste and septic tank (Hantush, 1961). Dissolved solids also comes from inorganic material such as rocks and air that contain calcium

bicarbonate, nitrogen, iron, phosphorus, sulphur, and others minerals (Philip J. Carpenter, 2012). All of the dissolved solids in water are either positively or negatively charged ions. The total negative charge of the anions always equals to the positive charge of cations. A higher TDS value means that there are more cations and anions in the water. The higher the presence of ions in the water, electrical conductivity (EC) of the water increases. At a high TDS concentration, water become more saline. Water with TDS concentration that is more than 500 mg/L is not recommended for drinking purposes (EPA secondary drinking water guideline). Water with TDS concentration above 1500 to 2600 mg/L (EC greater than 2.25 to 4 μmhos/cm) is generally considered problematic for irrigation use on crops with low or medium salt tolerance.

Table 5.2: Classification of water samples based on TDS (Suzannah, 2007).

Category	TDS (mg/L)	Water Samples
Fresh water	0-1,000	98% (8 sample)
Brackish water	1,000-10,000	2% (2 sample)
Saline water	10,000-100,000	None
Brine water	>100,000	None

In the study area , the readings for total dissolved solids (TDS) were taken by summing up all the major cations and anions. The values ranges from 16.29 to 8024 mg/L. The 8 samples have TDS value ranging within 1-1000 mg/L while the another two sample have TDS value ranging 1,000 - 10,000. Hence, the TDS values in eight area show that to be very good as it all lies within the range of fresh water. Another sample

are in brackish water, it because the tidal currents, which act independently and mixing the salt and fresh water.

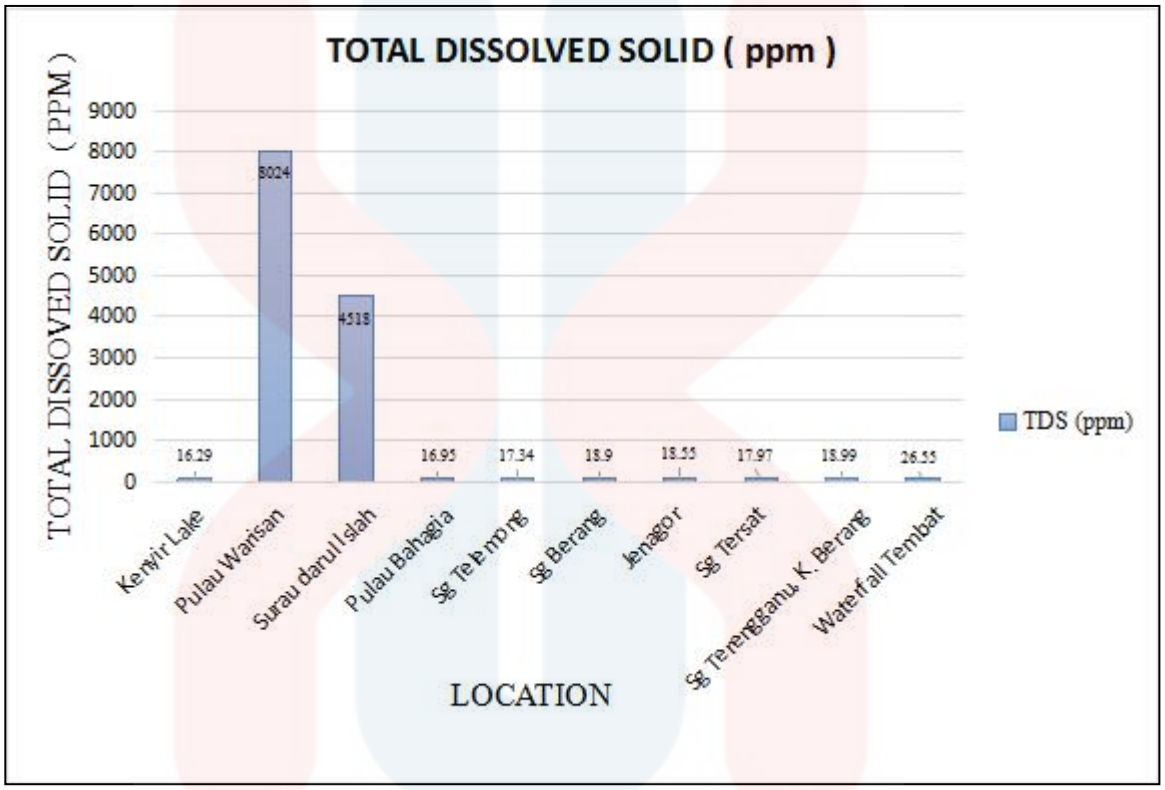


Figure 5.8 : Bar diagram show the total dissolved solid in study area.

Based on the figure 5.9, the range of distribution of the total dissolved solid,tds in the study area are between the 16.29 to 8024. The darker the color the higher the total dissolved solid,tds of the water in the study area. The lighter the color the lower the total dissolved solid,tds of the water in the study area. The distribution of the tds are shown below. The higher value of tds of water its not suitable for drinking purpose.

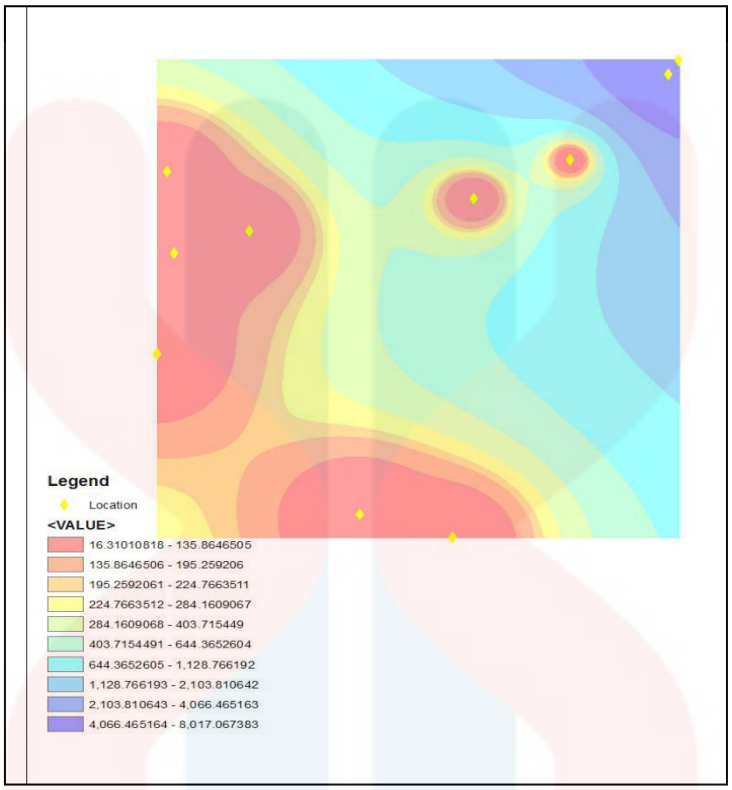


Figure 5.8 : The distribution of the total dissolved solid in study area.

5.2.5 Electrical Conductivity

Electrical conductivity is a measure of the ability of aqueous solution to carry an electrical current due to the migration of ions (electrolytes) in solution. The ability of water to conduct electricity depend on several factors, such as the concentrations and types of dissolved materials present. Water containing dissolved inorganic salt and the resulting ions are relatively good conductors when dissolved organic compounds that do not separate contribute very little to conductivity (John et al., 1990). The electrical conductivity (EC) is important as it measures of salinity which greatly affects the taste and thus has a significant impact on the user acceptance of the water. The higher the ionize able solids, the greater the electrical conductivity. The unit of EC is Seimen's per

unit area (e.g. mS/cm or miliSeimens per centimeter). The electrical conductivity of the water depends on the water temperature. The higher the temperature of water, the higher the electrical conductivity. The electrical conductivity of water also increases by 2-3% for an increment of 1 degree Celcius of water temperature.

Table 5.3 : Classification of water samples based on EC (Sarma & Swamy, 1981)

Class	EC (µS/cm at 25˚C)	Water Samples
Low Conductivity	<500	98% (8 sample)
Medium Conductivity, Class I	500-1000	None
Medium Conductivity, Class II	1000-3000	None
High Conductivity, Class III	>3000	2% (2 sample)

The figure 5.10 shows the electrical conductivity in groundwater at study area. The ranges of EC between 5948 to 27.9 µS/cm. The highest EC for this study area is 5948µS/cm where the lowest EC is 27.9µS/cm and the average reading of EC of water is 907.39. The classification of EC for the sample 16002 and sample 16003 is high conductivity where others sample are in low conductivity.

Based on the figure 5.11, the range of distribution of the electrical conductivity in the study area are between 27,9 to 5948 µS/cm . The darker the color the higher the electrical conductivity of the water in the study area. The lighter the color the lower the EC of the water in the study area. The distribution of the EC are shown below. The

higher value of EC the more electrolyte can conduct through the water.

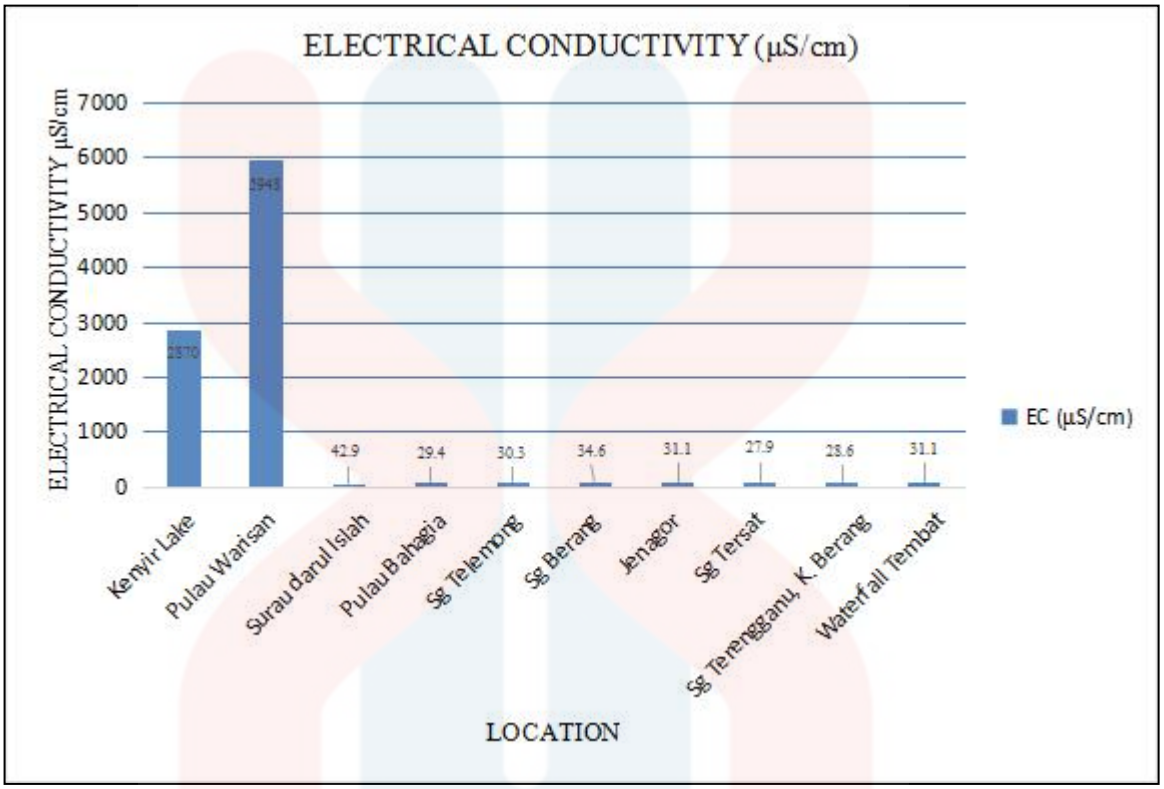


Figure 5.10 : Bar diagram show the electrical conductivity in study area.

5.2.6 Turbidity

Turbidity is an indication of the clarity of water and is defined as the optical property that causes light to be scattered as it passes through water. It may be caused by the presence of clay, silt, suspended matter, colloidal particles, plankton and other microorganisms. Turbidity can be measured by turbidity and nephelometry. Turbidity of water affects other water quality parameters such as color, when it is imparted by colloidal particles.Water that is crystal clear has low turbidity and usually contains very few suspended solids that are closely related by it the amount and type of suspended solids. Water that has high turbidity will appear as a cloudy. Microorganisms are

typically attached to particulates, and removal of turbidity by filtration will significantly reduce microbial pollution. It also affects the chemical quality of drinking water through the formation of complexes between the turbidity causing humic matter and heavy metals.

Turbidity is precededby nephelometric turbidity units (NTU) and can be initially noticed by naked eye above approximately 4.0 NTU. However, to ensure effectiveness of disinfection, turbidity should be no more than 5 NTU and preferably much lower (WHO, 2011).

In the study area, turbidity value ranges from 2.05 to 11.09 NTU . Surface water sample from 6 water sample out of the 10 water sampled records value of turbidity more than 5 NTU. Nevertheless, sample 16001, 16002, 16006, 16007 gives a turbidity value of 2.37 NTU, 3.93 NTU, 2.92 NTU, and 2.05 NTU. The color of the water sample also manifests cloudiness and yellowish color. The higher value might be caused by the sample take after raining

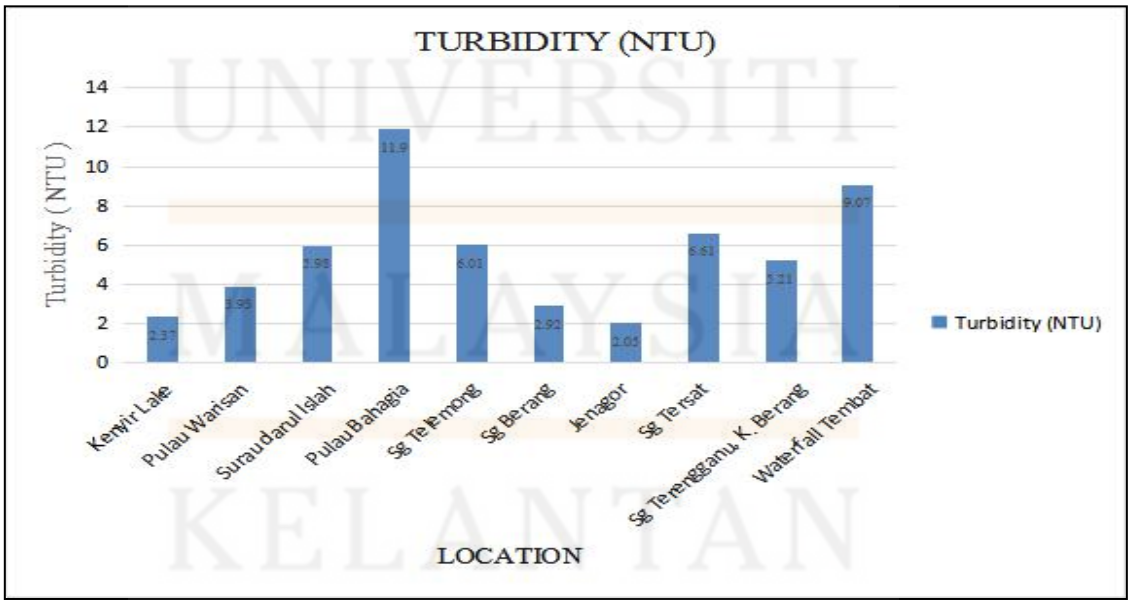


Figure 5.11 : Bar diagram show the turbidity (NTU) in the study area.

Based on the figure 5.11, the range of distribution of the turbidity in the study area are between 2.05 to 11.9 NTU . The darker the color the higher the turbidity of the water in the study area. The lighter the color the lower the turbidity of the water in the study area. The distribution of the turbidity are shown below. The higher value of turbidity the more cloudy the water.

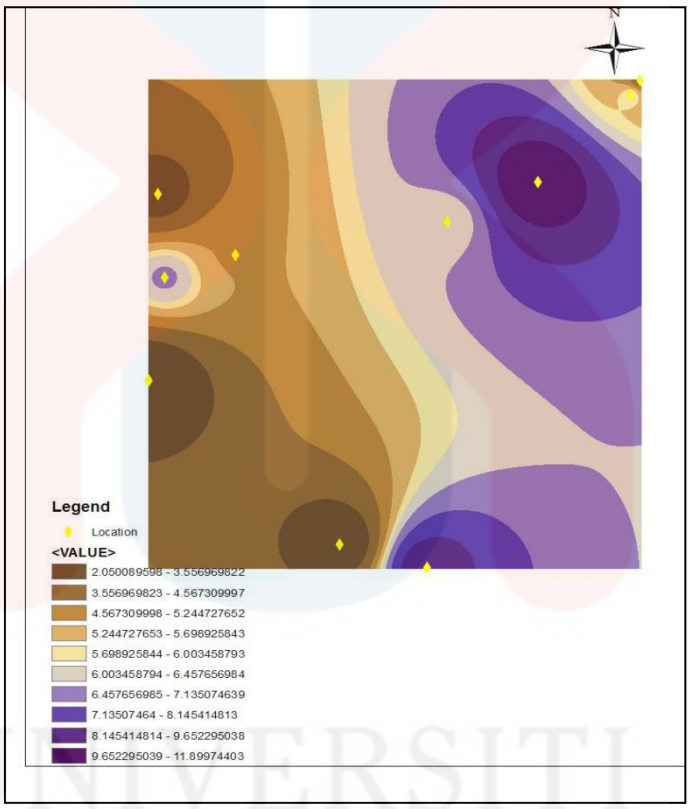


Figure 5.12 : The distribution of turbidity in the study area.

5.2.7 Salinity

Salinity is the measure of all salts dissolve in water. Salinity is usually measured in parts per thousand (ppt or). The average ocean salinity is 35 ppt and the average river water salinity is 0.5 or less. This means every kilograms (1000grams) of seawater, 35 grams are salt. Because the water in estuaries is a mix of fresh water and ocean water, the

salinity is most estuaries is less than open ocean. The type and concentration of salts depend on the environment, movement, and source of the groundwater or surface water. The higher concentrations of dissolved constituents are found in groundwater than in surface water because of the greater exposure to soluble materials in geologic strata. Salinity varies with specific surface area of aquifer materials, solubility of minerals and contact time, values tend to be highest where movement of groundwater is least. Hence, salinity increases with depth. In the study area, water salinity ranges from 0.00 to 1.40. The Pulau Warisan and Surau Darul Islah that higher salinity because this river is near the ocean and its become salt water intrusion.

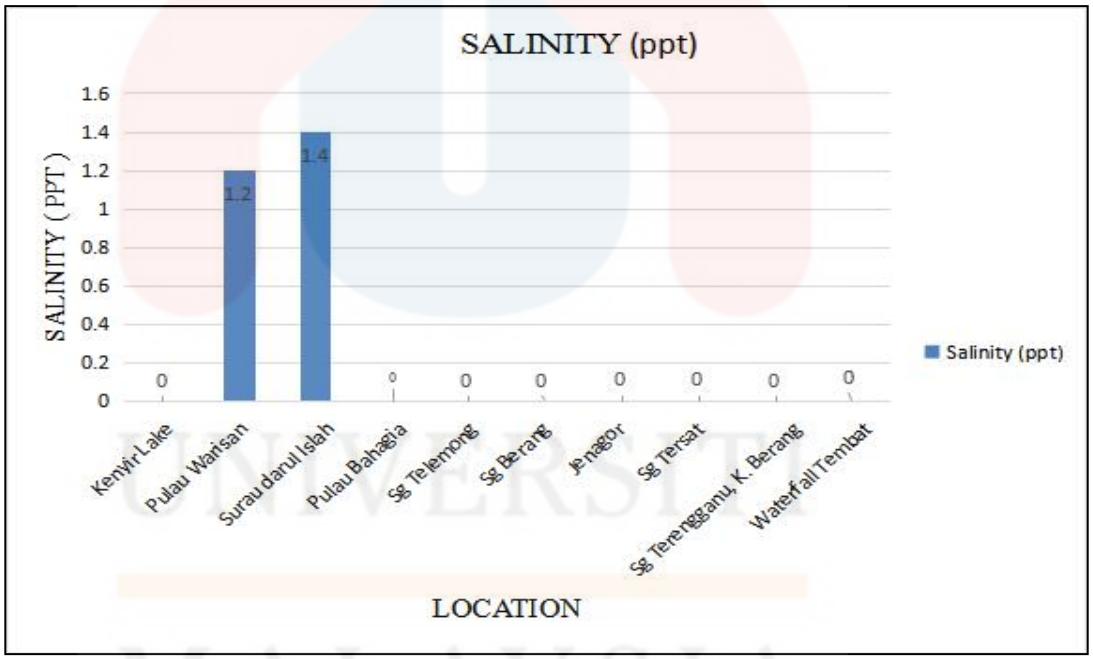


Figure 5.13 : Bar diagram show the salinity of the sampling area.

Based on the figure 5.14, the range of distribution of the salinity in the study area are between 0 to 1.4 ppt . The darker the color the higher the salinity of the water in the study area. The lighter the color the lower the salinity of the water in the study area. The distribution of the salinity are shown below. The higher value of salinity the higher the salt water intrusion.

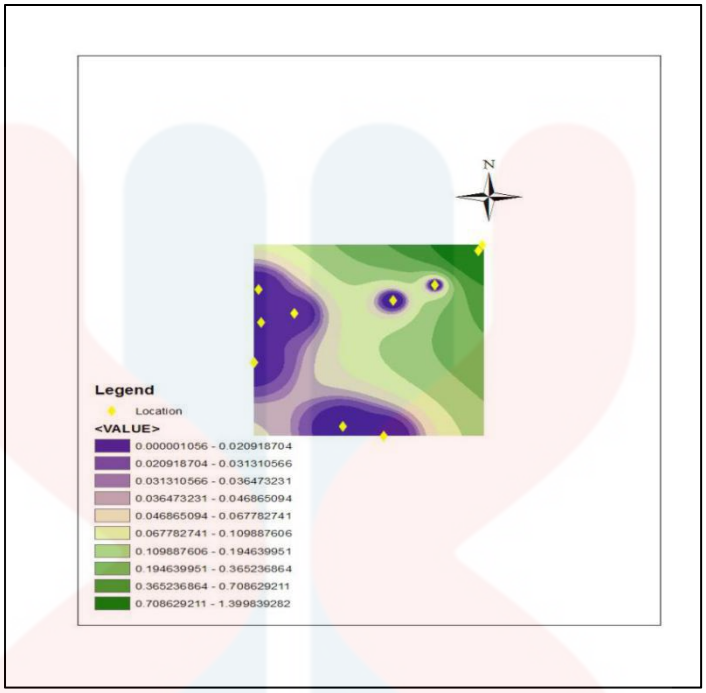


Figure 5.14 : The distribution of salinity in the study area.

5.2.8 Conductivity

Conductivity of water is referred to the ability of water to pass an electrical current. Water conductivity affected by several factors that are inorganic matter that dissolved solids such as chloride, nitrate, sulfate, and phosphate ion and sodium, magnesium, calcium, iron, aluminium cations (C.R.Glover, 1996). Compound that dissolves into ions known as electrolytes. The more that ions are present, the higher the higher the conductivity of water. Meanwhile organic compound also affected the water conductivity such as soil, phenol, alcohol, and sugar (Timothy M.Kresse, 2012). The sea water are the higher conductivity.

Conductivity is usually measured in micro- or millisimens per centimeter (µS/cm or mS/cm). Based on figure 5.15, the highest conductivity are at Surau Darul Islah 5984, while the lowest conductivity is 27.9.

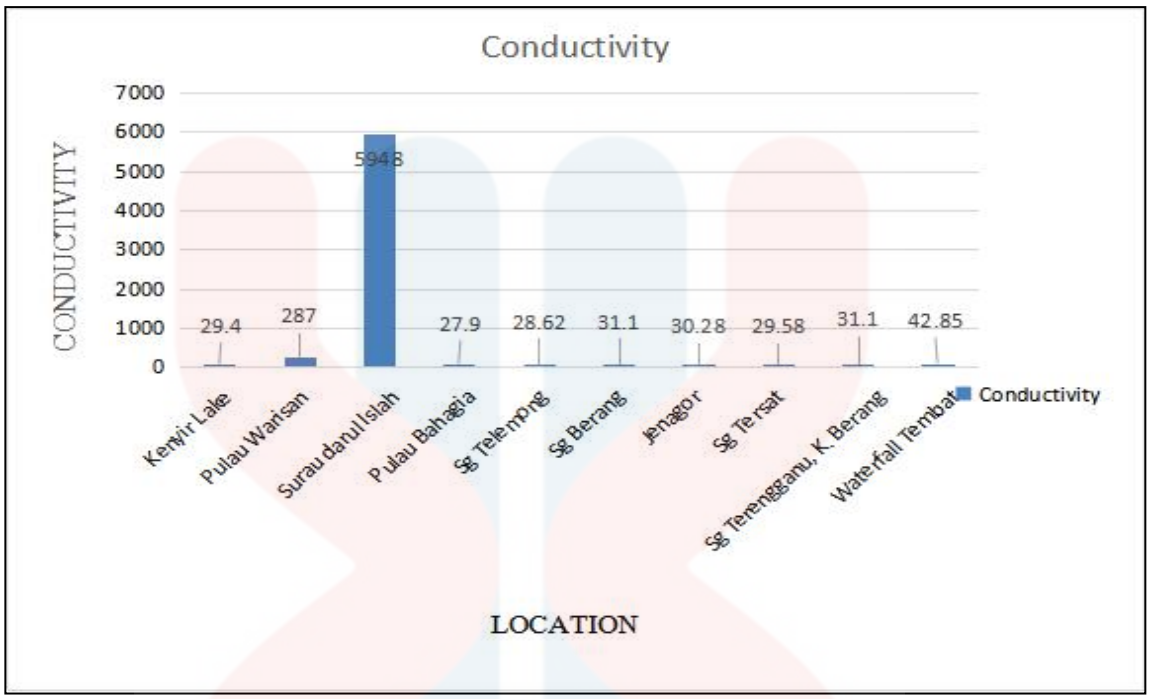


Figure 5.15 : Bar diagram shows the conductivity of the study area.

Based on the figure 5.16, the range of distribution of the conductivity in the study area are between 29.4 to 5948 . The darker the color the higher the conductivity of the water in the study area. The lighter the color the lower the conductivity of the water in the study area. The distribution of the conductivity are shown below. The higher value of conductivity the higher water can conduct electricity.

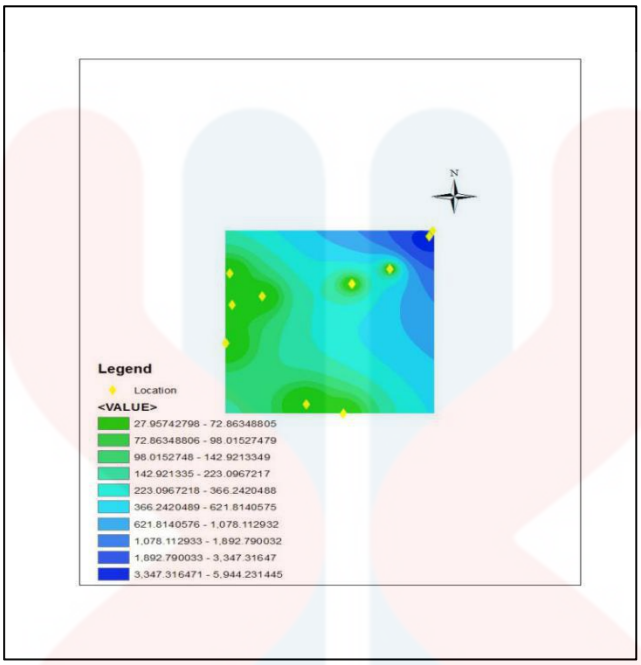


Figure 5.16 : The distribution of conductivity in the study area.

5.2.9 Total Suspended Solid (TSS)

Total Suspended Solid (TSS) are solids in water that can be trapped by a filter. TSS can include a wide variety of material, such a silt, decaying plant and animal matter, industrial wastes, and sewage. High concentrations of suspended solids can cause many problems for stream health and aquatic life. Suspended solid refers to a small solids particles which remain in suspension in water as a colloid or due to the motion of the water.

Based on the figure 5.17, the highest of total suspended solid are at Pulau Bahagia which 160 g/L while the lowets total suspended solid are 0. The higher of the total suspended solid are because of the precipitation in the water.

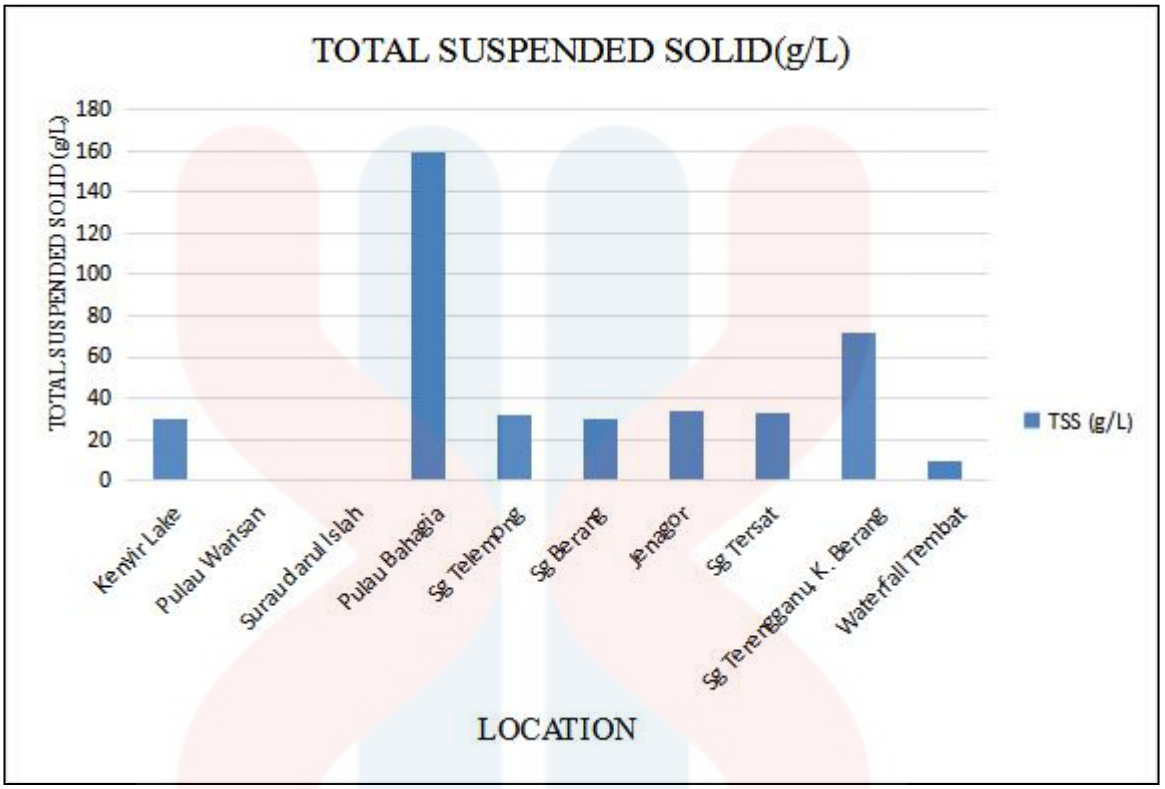


Figure 5.17 : Bar diagram show the total suspended solid at the study area.

Based on the figure 5.18, the range of distribution of the total suspended solid in the study area are between 29.4 to 5948 . The darker the color the higher the total suspended solid of the water in the study area. The lighter the color the lower the total suspended solid of the water in the study area. The distribution of the total suspended solid are shown below. The higher value of total suspended solid the less suitable water drinking purpose.

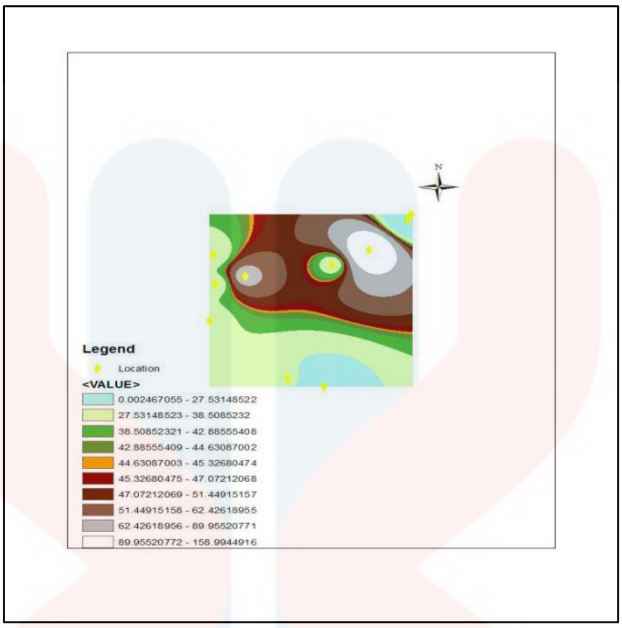


Figure 5.18 : The distribution of total suspended solid in the study area.

5.3 Chemical Properties of Water

5.3.1 Major Cations

a. Sodium (Na)

Sodium ions are found in essentially in drinking-water. However, centralization of sodium in consumable water are typically lower than 20 mg/L, they can incredibly exceed this in any region. Sodium is a highly soluble chemical element and is often naturally found in groundwater. Sodium commonly found in soils and rocks which is in slowly upon dissolution of rocks (Minnesota Pollution Control Agency, 1999). The range values of Na are from 2.00 to 58.00 mg/L. The Kenyir Lake have a highest concentration of sodium ion. All the values are within the permissible limit of WHO (2011) and MOH (2010). Therefore, the water is safe for drinking purpose. soils containing appreciable amounts of clay that sodium and potassium are released.

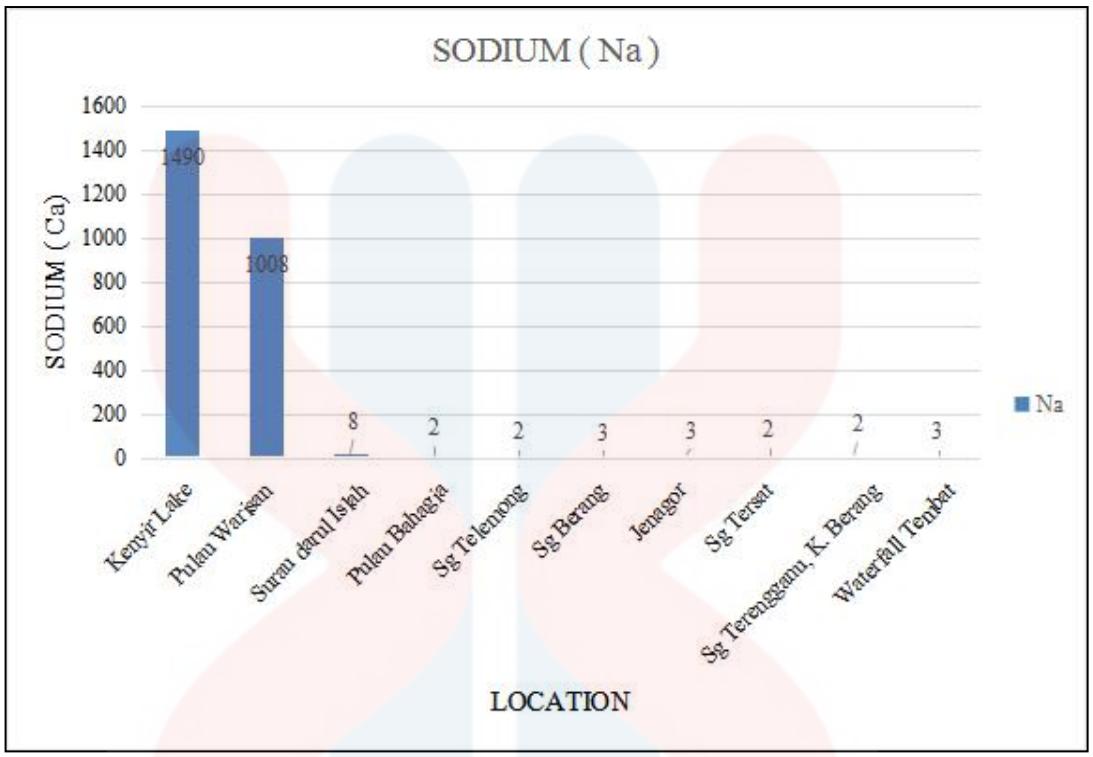


Figure 5.19 : Bar diagram show the sodium distribution of study area.

b. Calcium (Ca)

Calcium ion is one of the common, abundant natural element. Calcium occurs in water naturally. Seawater contains approximately 400 ppm calcium. It flows into the freshwater system during the weathering of rocks, mainly limestone, and from the soil through seepage, leaching and runoff. The leaching of calcium from the soil has been discovered to rise significantly with the acidity of rainwater. The concentration of calcium in the water depends on the residences period of the water in calcium-rich geological deposit. Calcium is an important determinant of water harness, and it also functions as a pH stabilizers, because of its buffering qualities. Calcium also gives water better taste. The important of calcium for our health are calcium phosphate is required for bone structure and teeth structure of terrestrial organism. Calcium carbonate also good for building stones of skeletons of most marine organism and eye lenses.

Based on the figure 5.20, the range of calcium concentration are between 58 mg/L to 2.0 mg/L in study area. All the concentration of calcium in the study area is less than 75 mg/L. This value of magnesium in the study area within the permissible limit of WHO (2011) and MOH (2010).

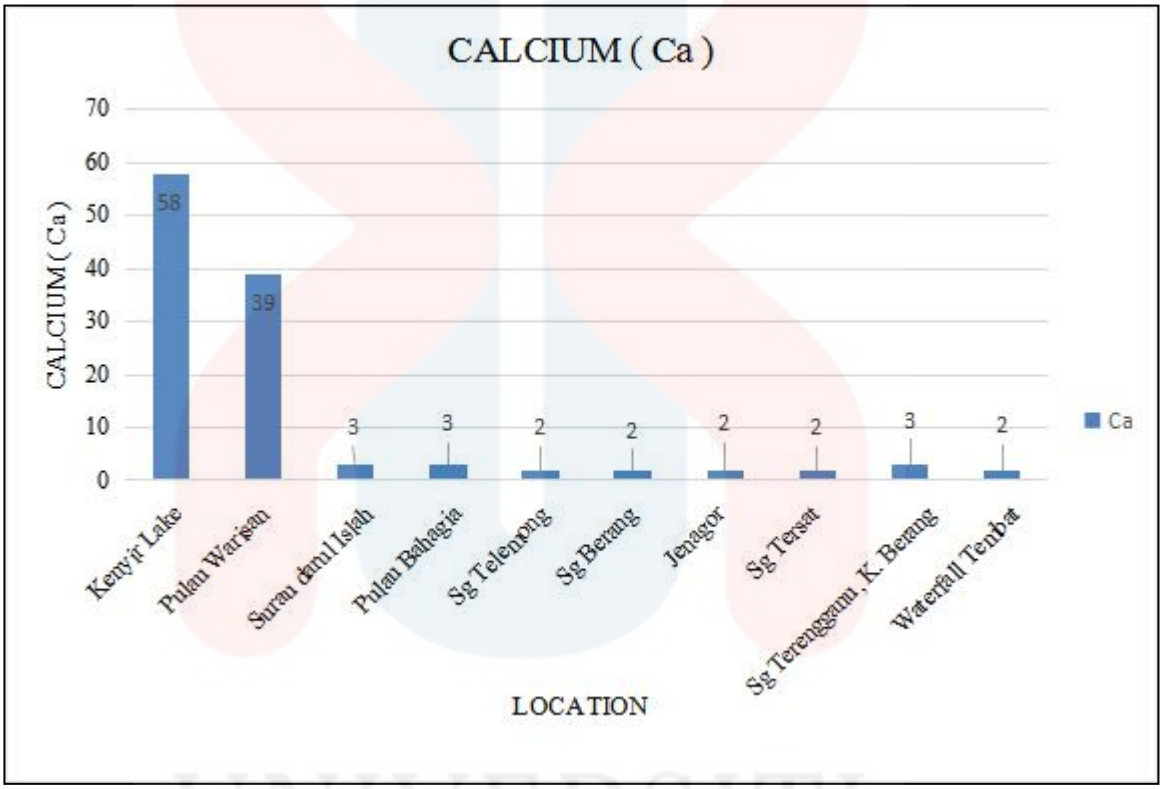


Figure 5.20 : Bar diagram show the concentration of calcium in the study area.

c. Magnesium (Mg)

Magnesium ion is available in all water and groundwater and is an actual donor to water hardness. Magnesium is present in seawater in amount about 1300 ppm. After sodium is commonly found cation in ocean. Ferromagnesium mineral found in igneous rocks and magnesium carbonates in sedimentary rocks are believed to be primary source of magnesium in natural waters.Magnesium is one of the real benefactors to water hardness, which is talked about in a different survey. Magnesium might contribute

undesirable taste to drinking water if exceeds 500 mg/L. The allow limit has been accounted to be 50 mg/L based on WHO (2006) and around 150 mg/L based on MOH (2010) for an average human consumption. Adverse effects may come about in an indirect way from the laxative impact of magnesium in relationship with sulphate ion.

Based on the figure 5.21, the range values from magnesium at the study area are from 0.49 mg/L to 178.6 mg/L. The highest concentration of magnesium are at samlpe ID 16002 with 178.6 mg/L while the lowest concentration of magnesium are at sample ID 1610 with 0.49 mg/L. All the water is within the permissible limit of consumption based on the WHO (2006). However, based on MOH (2010) the water is still suitable to be as drinking water but only two water from sample ID 16002 and 16003 are exceeds the MOH scale and doesn't suitable for drinking purpose. The possible reason of this occurrence could be from the seawater nearby as magnesium is found in large amount in seawater. The bar diagram 5.21 below will show a clear distribution of magnesium ion in the study area.

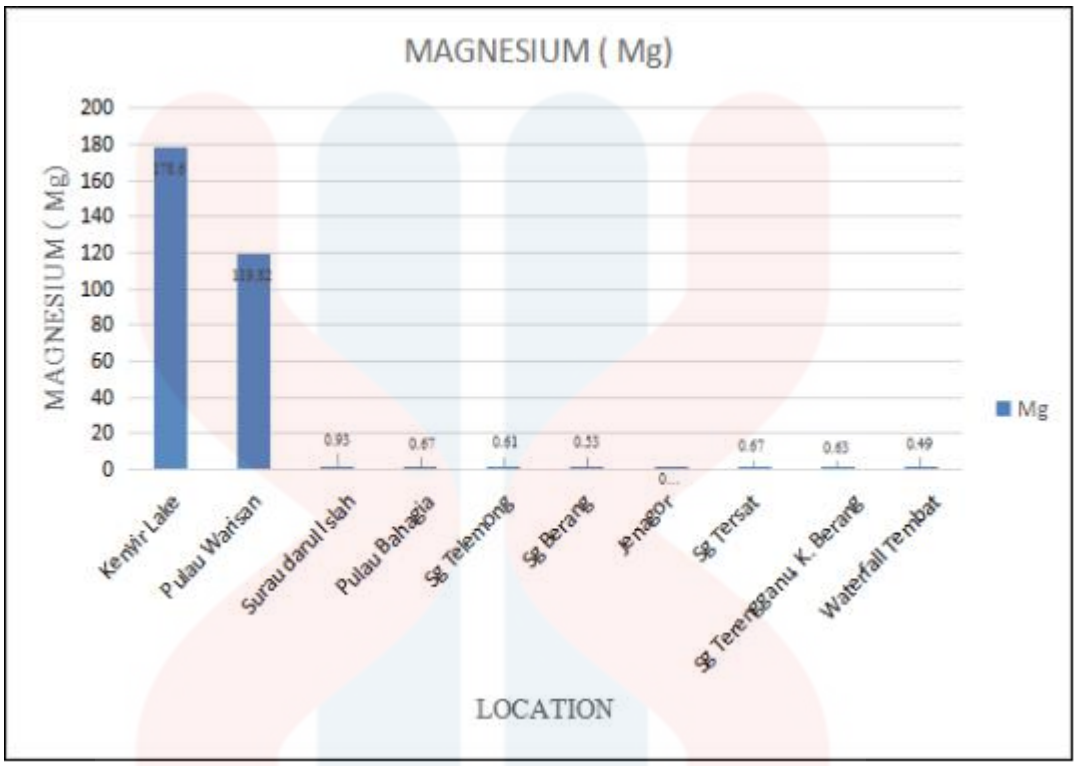


Figure 5.21 : Bar diagram show the concentration of magnesium in the study area.

d. Potassium (K)

Potassium is an important parameter. Despite the fact that potassium does not represent a human danger for continued consumption. Its concurrence can demonstrate disintegrating groundwater quality and could show different issues with water quality, with cause unfavourable effects. The most regular content of potassium in drinking water will be water softeners utilizing potassium chloride. The concentration of potassium is most likely because of silicate minerals, orthoclase, microcline, hornblende, muscovite and biotite in igneous, metamorphic rocks. Evaporitic deposit such as gypsum and sulphate discharge significant amount of potassium into groundwater. The permissable amount allowed for human consumption is 200 mg/L (WHO, 2011 and MOH, 2010). Potassium is common in many rocks. Many of these rocks are relatively

soluble and potassium concentrations in groundwater increase with time. Potassium is more likely to be evenly distributed than sodium among the aquifers. Potassium also important ions in water and are used to assess quality control for samples and laboratory analysis.

The range of potassium values of study areas are from 0.852 mg/L to 42.936 mg/L. The highest concentration of potassium are sample ID 16002 with is 42.936 mg/L while the lower concentration of concentration of potassium are at sample ID 16004 with 0.852 mg/l. All the samples have range of values within limits of WHO, 2006 . The highest value is 42.936 mg/L that indicate it might near the high fertilizer usage areas that it gives higher potassium concentration at the sampling area its also the area are the granitic rocks.

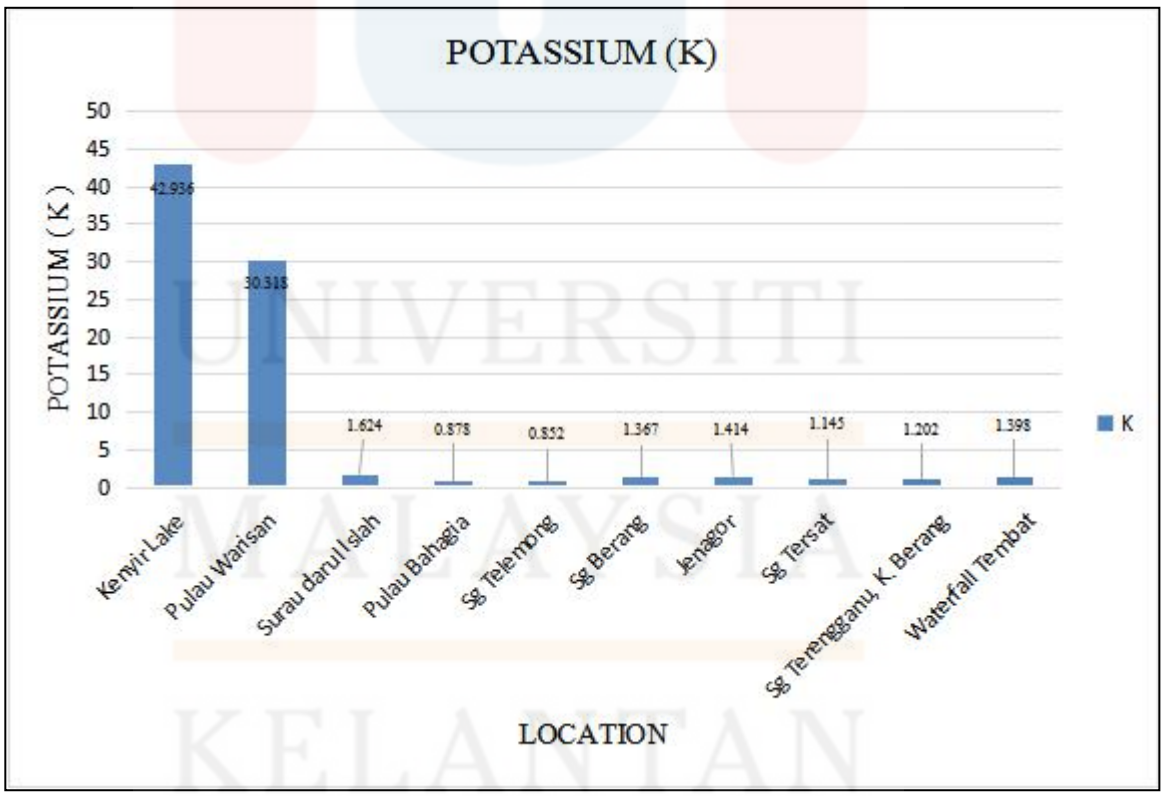


Figure 5.22 : Bar diagram show the concentration of potassium in the study area.

e. Iron (Fe)

Iron is the second most abundant metal in the earth's crust of which is account for about 5% readily combine with oxygen and sulphur containing compound to form oxides, hydroxides, carbonates and sulfides. Element iron is rarely found in nature, as the iron ions Iron (Fe^{2+}) and (Fe^{3+}) readily combine with oxygen and sulphur containing compounds to form oxides, hydroxides, carbonates and sulfides. Iron is most commonly found in nature in the form its oxides (Knepper WA., 1981).

Based on the figure 5.23, the range of iron concentration is between 0.08 mg/L to 1.25 mg/L. The higher concentration are at Sg. Telemong with 1.25 mg/L while the lower concentration is at Pulau Bahagia with 0.08 mg/L.

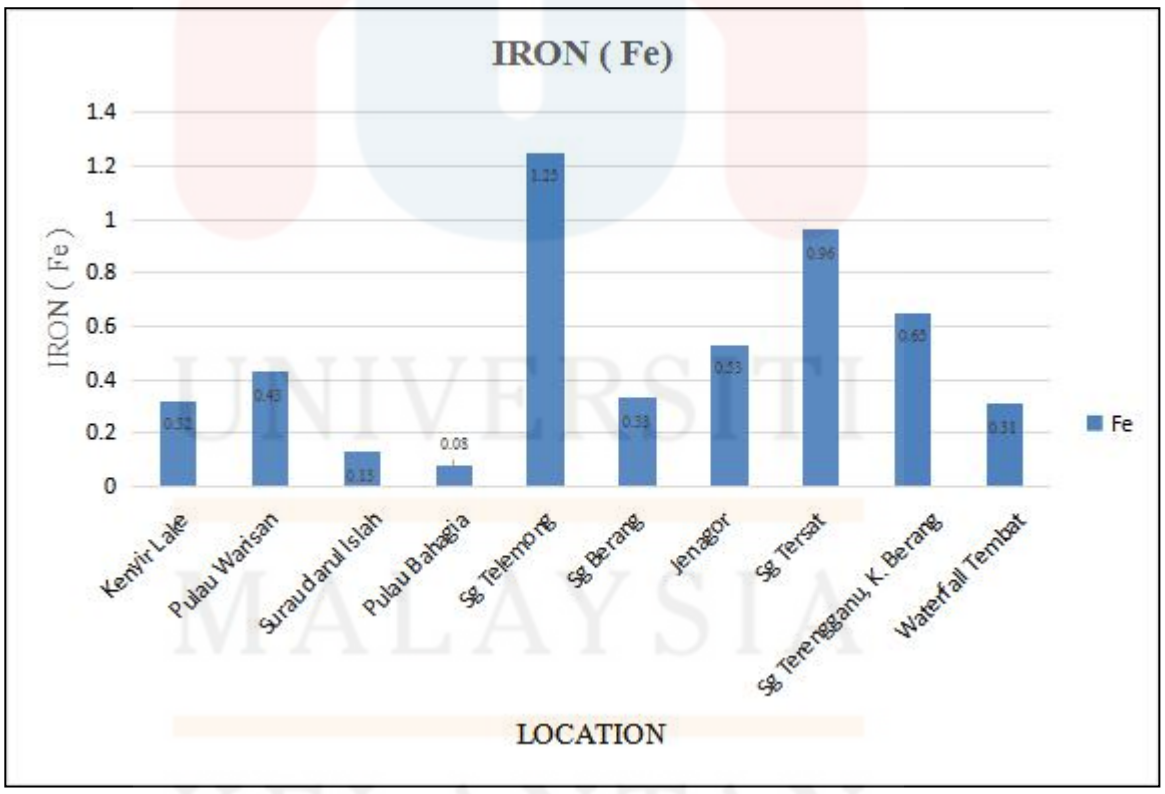


Figure 5.23 : Bar diagram of concentration of ion iron (Fe) in the study area.

f. Manganese (Mn)

Manganese (Mn) is a mineral naturally occurring in rocks and soils and is a normal constituent of the human diet. Its exist in well water in CT as a naturally occurring groundwater mineral, but may be also present due to underground pollution sources. Manganese become noticeable in tap water at concentration at concentration greater than 0.05 milligrams per liter of water (mg/L) by imparting a color, odor, or taste to the water. However, health affect from manganese are not a concern until concentration are approximately 10 times higher.

The ranges of concentration of manganese <0.01 mg/L to 0.11 mg/L. The higher concentration of manganese are 0.11 while the lower concentration of manganese are 0.01.

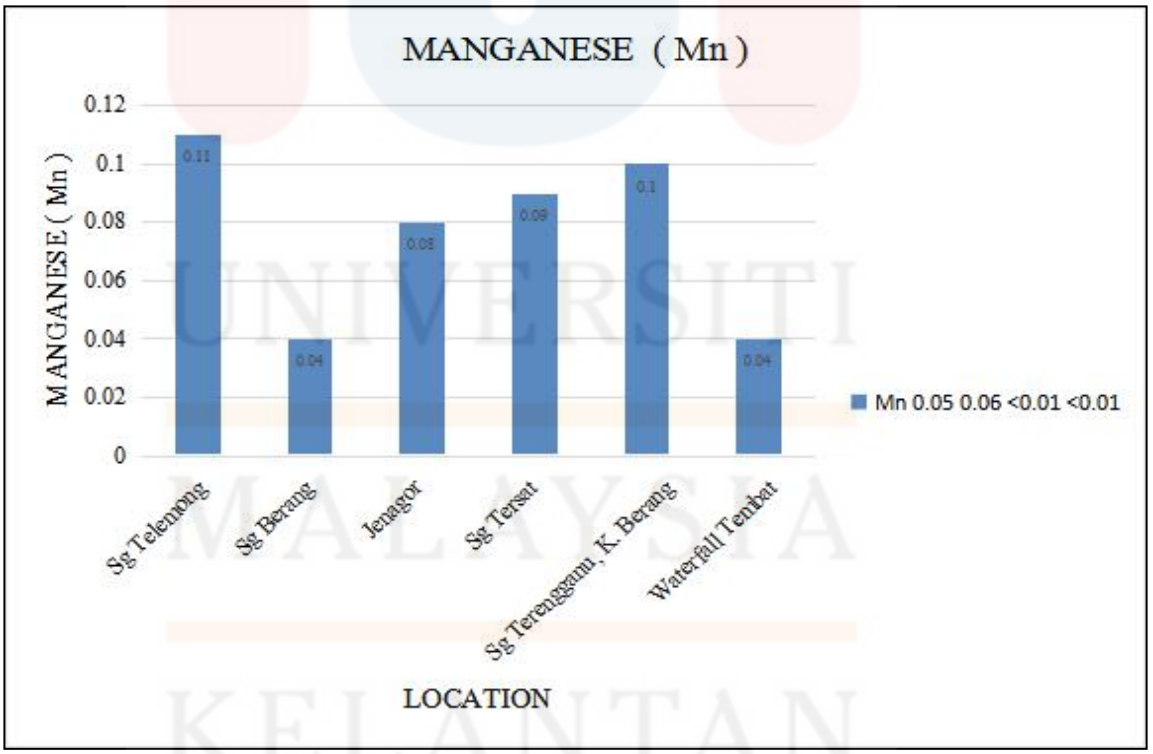


Figure 5.24 : Bar diagram of the concentration of manganese in the study area.

g. Copper (Cu)

Copper is a reddish metal with a face-centered cubic crystalline structure. It reflects red and orange light and absorbs other frequencies in the visible spectrum, due to its band structure, so it as a nice reddish color. It is malleable, ductile, and an extremely good conductor of both heat and electricity. It is softer than zinc and can be polished to a bright finish. It is found in group Ib of the periodic table, together with silver and gold. Copper has low chemical reactivity. In moist air it slowly forms a greenish surface film called patina; this coating protects the metal from further attack.

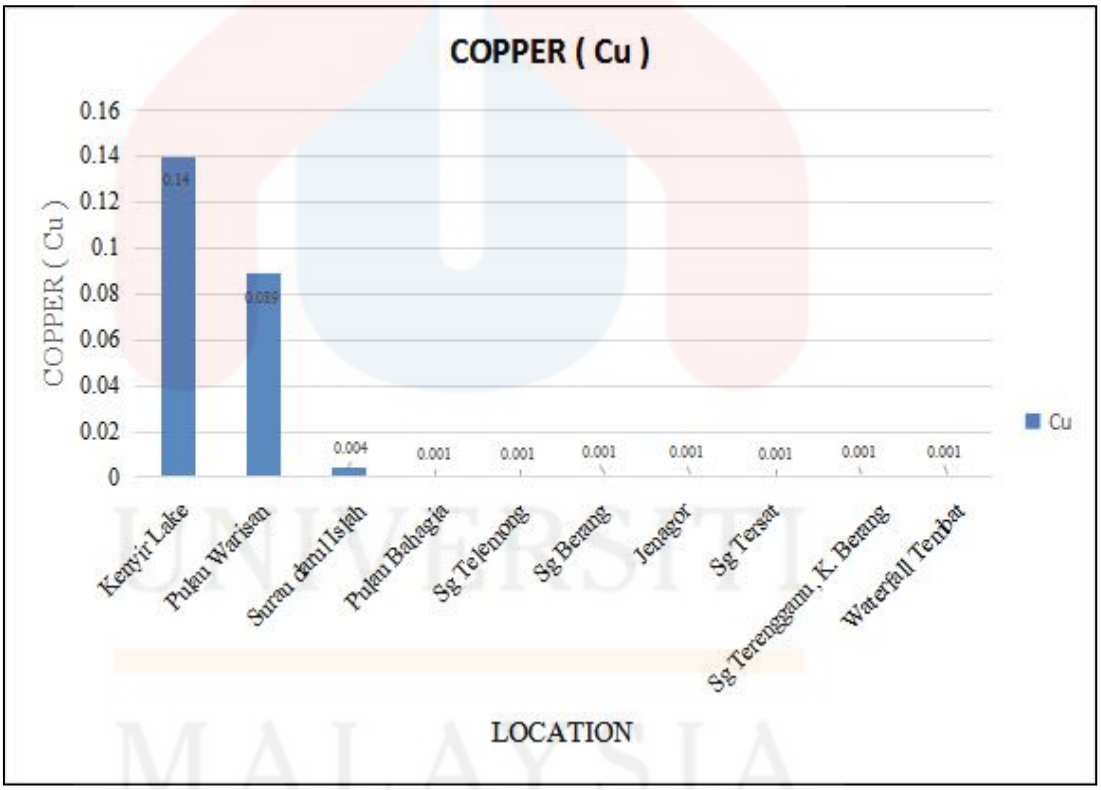


Figure 5.25 : Bar diagram show the concentration of copper in the study area.

h. Zinc

Zinc is a chemical element with the symbol Zn and atomic number 30. It is the first element in group 12 of the periodic table. In some respects zinc is chemically similar to magnesium: both elements exhibit only one normal oxidation state (+2), and the Zn^{2+} and Mg^{2+} ions are of similar size. Zinc is the 24th most abundant element in Earth's crust and has five stable isotopes. The most common zinc ore is sphalerite (zinc blende), a zinc sulfide mineral. The largest workable lodes are in Australia, Asia, and the United States. Zinc is refined by froth flotation of the ore, roasting, and final extraction using electricity(electrowinning).

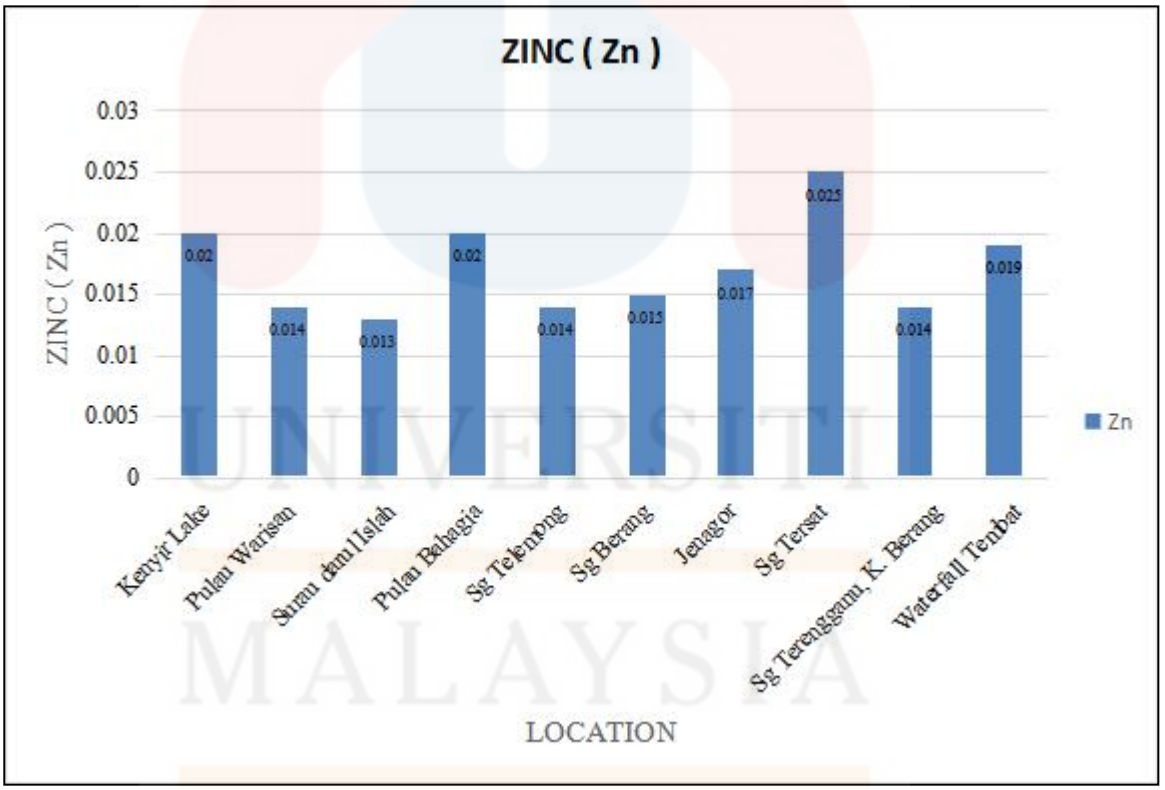


Figure 5.26 : Bar diagrams of concentration of zinc in the study area.

5.3.2 Major anions

Bicarbonate (HCO_3), Chloride (Cl), Fluoride (F), Sulphate (SO_4) and Nitrate (NO_3) were determined as the major anions (Table 5.6) present in groundwater of the islands. The distributions of these major elements is as follows:

a. Bicarbonates (HCO^-_3)

Bicarbonates are generated by the movement of carbon dioxide in water on carbonates rocks. For instance, limestone and dolomite, bicarbonate and carbonate create a soluble environment. Bicarbonates of calcium and magnesium deteriorate in steam boilers and boiling point where its forms scales and discharges destructives carbonic corrosive gas. In a blend with calcium and magnesium, they form carbonate hardness. Bicarbonates is of little significance in the public supplies except in substantial sums; the taste is altered or where the alkalinity influences the destructiveness of water.

The figure 5.27 shows the bicarbonates concentrations that are contains in the water at the study area. Bicarbonates (HCO_3) concentration in the ranges 166.67 mg/L to 383.33 mg/L with average of 222 168 mg/L. Bicarbonates concentration is obtained by titrate the sample with strong acid (HCl). The result of titration method is to known the capacity of the water sample to neutralize a strong acid by means of the bicarbonates alkalinity.

The highest value for bicarbonates is present in sample ID 16006 that is 383.33 mg/L. The possible sources that make water sample has high bicarbonate is when carbon dioxide gas dissolved in water to from acid. Carbon dioxide in water originates from the atmosphere and also from the oxidation of organic matter by bacteria. These bacteria can come from the septic tank that is near to the river and has high elevation from the river.

The sewage from septic tank can flow or infiltrate to the river by high elevation to low elevation due to gravity.

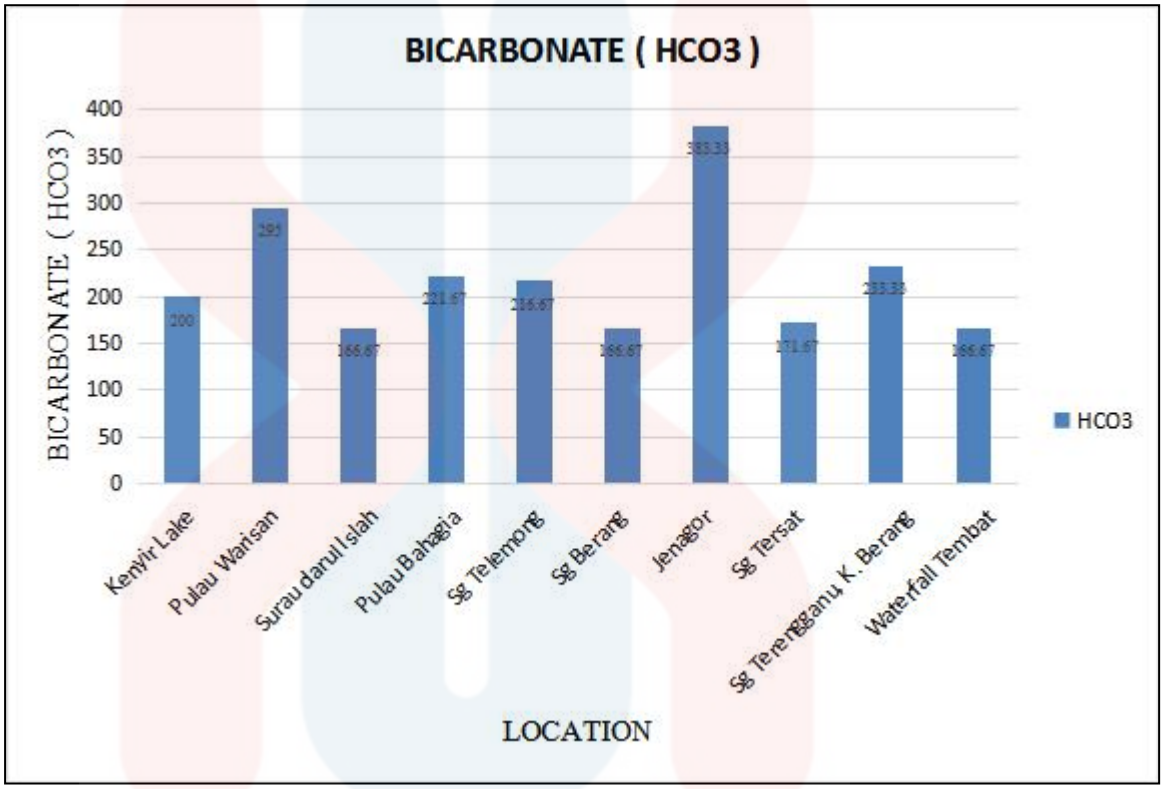


Figure 5.27 : Bar diagrams show concentration of bicarbonate in the study area.

b. Chloride

The residences of the chloride in drinking water sources can be associated to the dissolution of salt precipitates, effluents from chemicals industries, oil well services, sewage, irrigation seepage, ignored leachetes, volcanic vapors, sea spray and seawater interference in coastal areas. All these sources may end up in regional contamination of surface water and groundwater. The chloride ion is extremely mobile and is ultimately carried into restricted basin or to the shores. Chloride occurs naturally in all types of water.

The concentrations for chloride ions are under suitable level for human consumption,

where ranges 2 mg/L to 3 mg/L. The others two sample of water are exhibits high amount in chloride compared to other sample such as sample ID 16001 and 16002 with the concentration values.

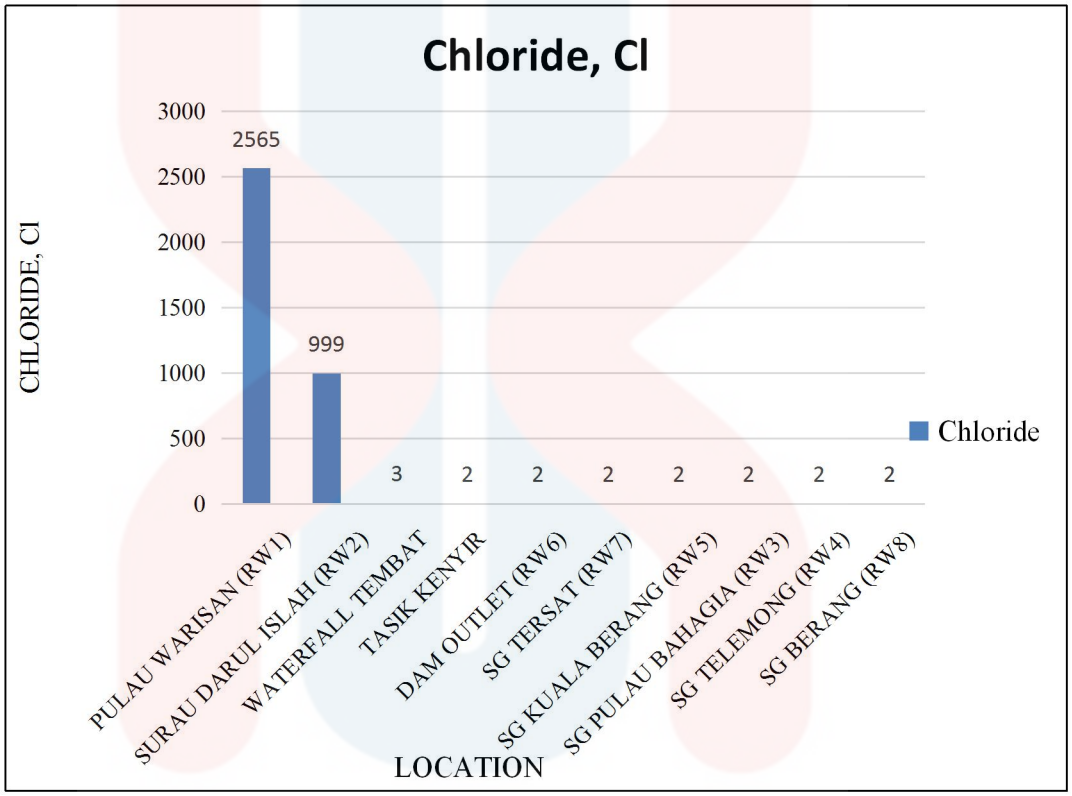


Figure 5.28 : Bar diagram show the concentration of chloride ion in the study area.

c. Fluoride

Fluoride occurs as fluorspar or fluorite, rock phosphate, triphite, phosphate crystals in nature. Among factors which control the concentration of fluoride are the climate of the area and the presence of accessory minerals in the rock mineral assemblage through which the groundwater is circulating. In this study, fluoride concentration of all samples lies within the normal range of the permissible limit of WHO. Samples from study areas show a range of 0.08 to 0.17 mg/L for the fluoride and it is all within the range of

drinking water quality guideline. Hence, is suitable for drinking purposes.

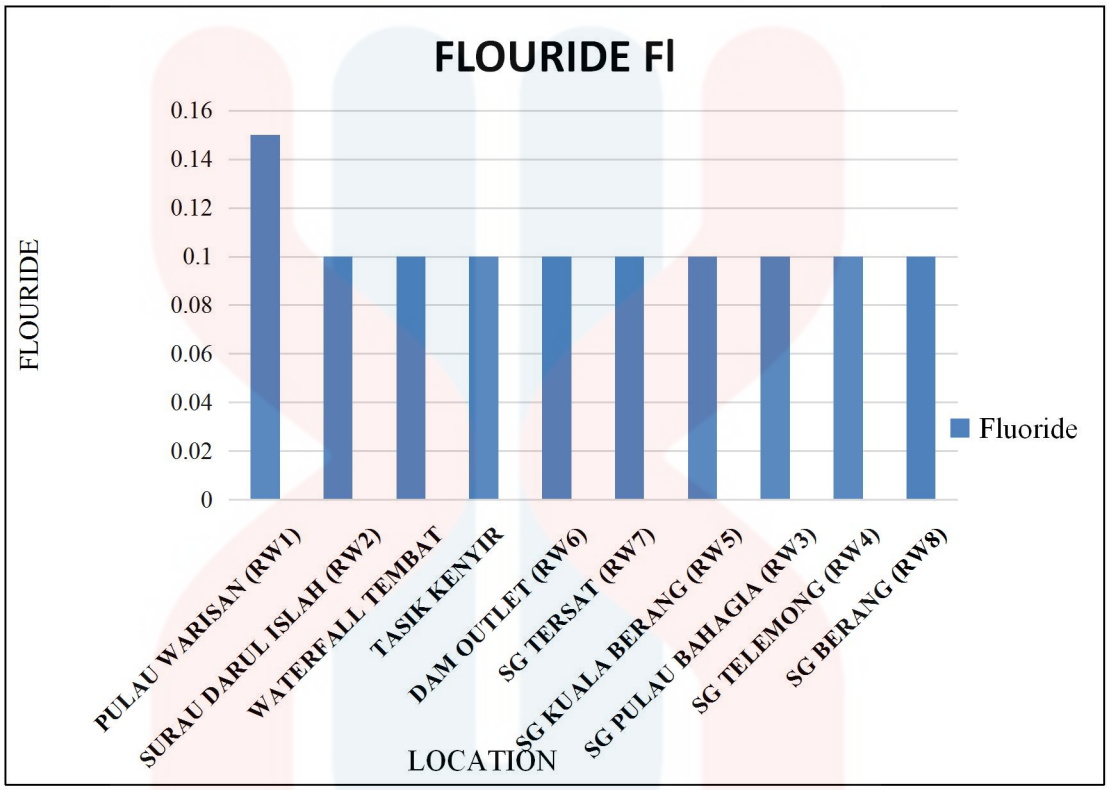


Figure 5.29 : Bar diagram of concentration of flouride at study area.

d. Sulphate

Source of sulphate is normally due to the oxidation of sulphide ores, gypsum and anhydrite. In addition to its role as a plant nutrient, high concentrations of sulphate can be problematic as they make the water corrosive and are capable of being reduced to hydrogen sulphide which is known as a toxic, foul-smelling gas. When zero dissolved oxygen conditions prevail in the water body. The WHO,2011 guideline value for sulphate in drinking water is 500 mg/L. The range for sulphate in the study areas varies from 1.83 to 8.99 mg/L and it is all lies within the WHO, 2011 guideline limit. Hence, the water is in good condition to be consumed.

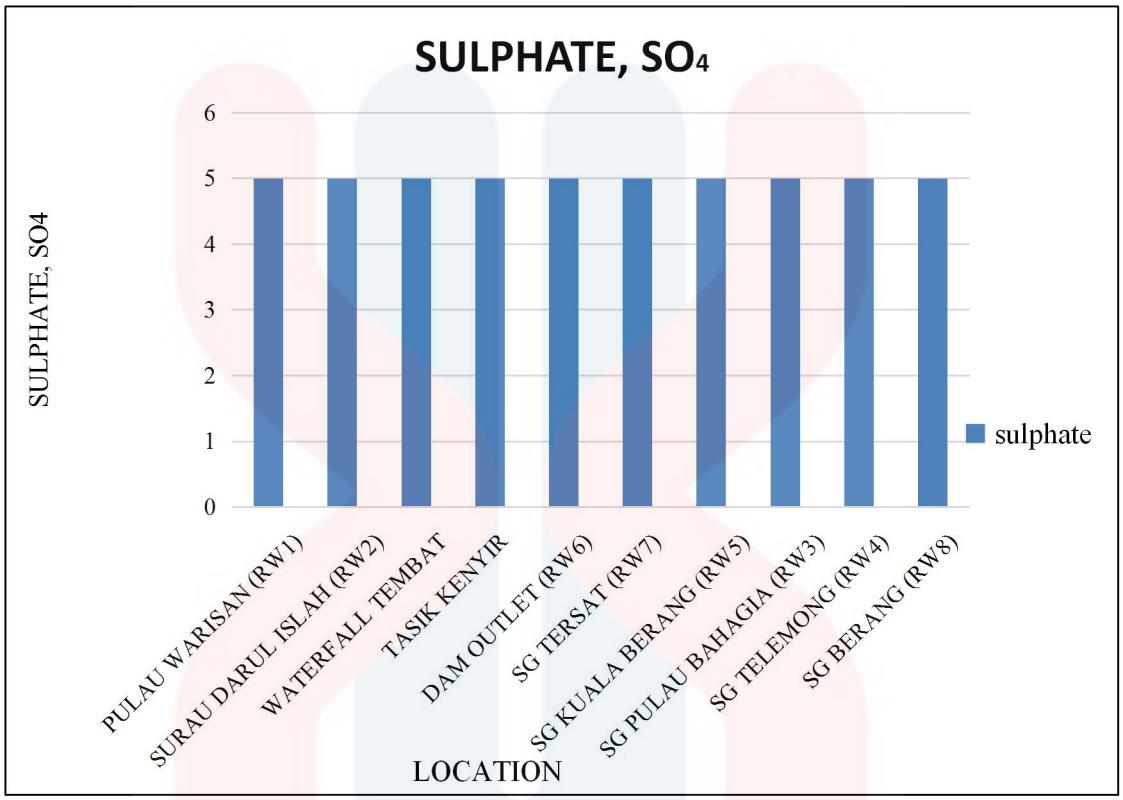


Figure 5.30 : Bar diagrams of concentration of sulphate in the study area.

5.4 Classification of Water

5.4.1 Piper Trilinear Diagram

Chemical data of the respective sample rm the sudy area was presented by plotting them on the Piper Trilinear Diagram (Piper, 1944). This is to infer hydrochemical facies in order to recognize and distinguish the suitability of water composition in different classes as well as to bring out the chemical relationship in more accurate term rather than other possible plotting techniques. These diagrams revealed the analogies, dissimilarities and types of various water in the study area. Futhermore, the waters were grouped into hydrochemical facies indicating water types based on the subdivisions of the Piper-Trilinear Diagram suggested by Back (1961) and Hanshaw (1965) that were

displayed in the figure 5.31.

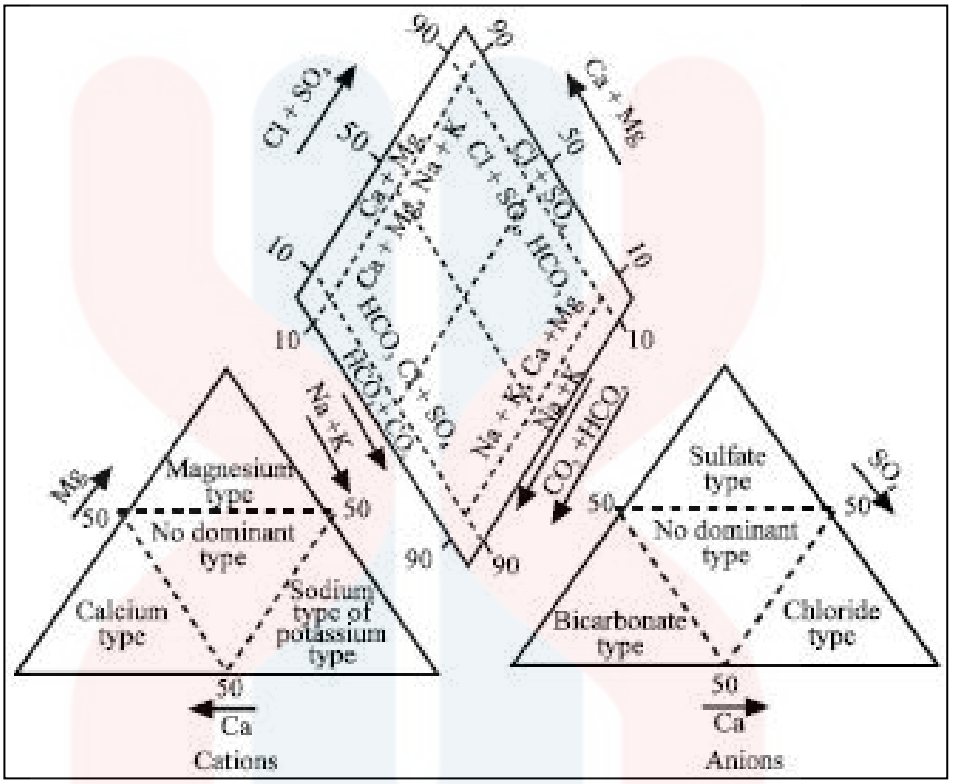


Figure 5.31 : Classification diagram for anion and cation facies in the form of major-ion percentages (Back, 1961; Hanshaw, 1965).

Piper Trilinear Diagram consist of three distinct fields, two triangular fields and one diamond shaped fields. Anion are plotted on the right and cations are plotted on the left triangular fields are representing the percentages of anions and cations. From the triangular fields, the chemical contains on the groundwater can be classified by the percentages of the anions and cations. The triangular fields are divided into six part types of major ions.

The advantages of using Piper Trilinear Diagram compared other indications are first, many water analyze can be plotted on the same diagram, can be used to classified waters, and can be used to identify mixing of waters.

Based on the figure 5.32 below shows the Piper Trilinear Diagram which represented the classification of water types in study area. From the result of plotting in the piper diagram, it show that the major ions represent is in three types. The different types of water is classify as :

I. Ca + Mg – Cl + SO_4 type

II. Mixed Ca + Mg – Cl + SO_4 type

III. Ca + Mg – HCO_3 type

Most of the water sample is in the Ca + Mg – Cl + SO_4. Mixed Ca + Mg – Cl + SO_4 types is not dominant in the study area. The water sample has high content of Ca + Mg ions.

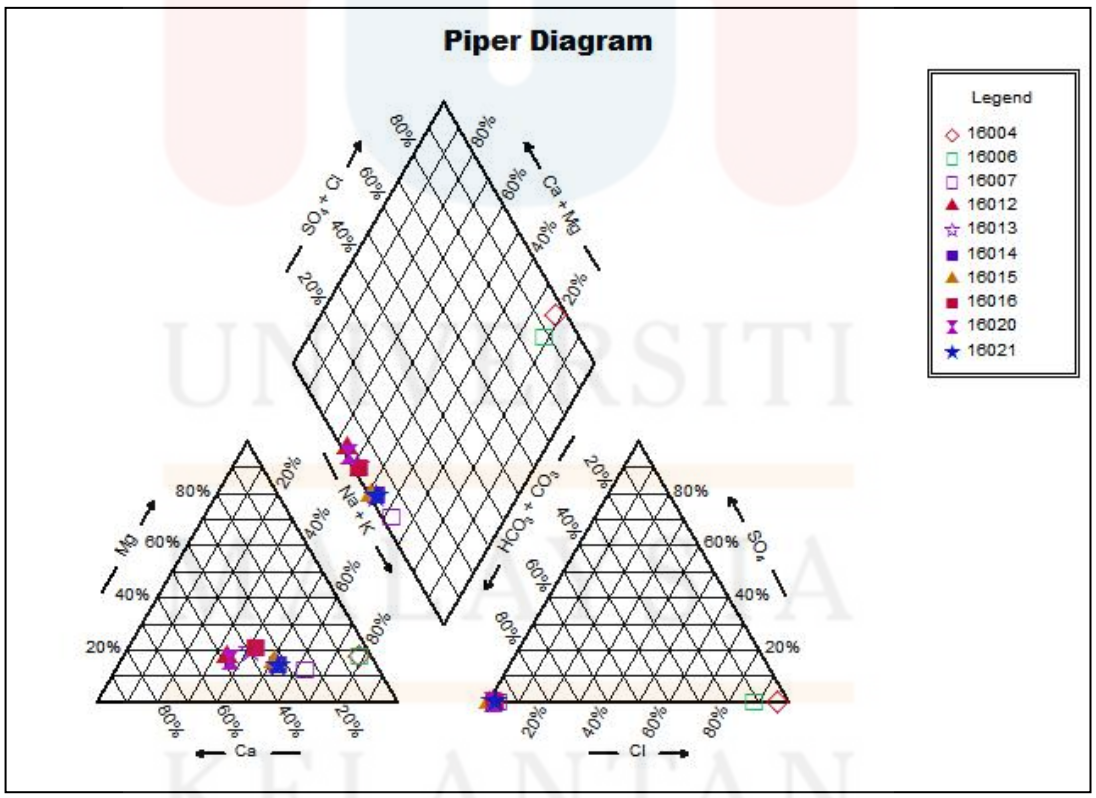


Figure 5.32 : The piper trilinear diagram plot of study area.

5.4.2 Schoeller Diagram

These semi-logarithmic diagrams were developed to represent major ion analyses in meq/l and to demonstrate different hydrochemical water types on the same diagram. This type of graphical representation has the advantage that, unlike the trilinear diagrams, actual sample concentrations are displayed and compared.

The Schoeller diagram can be used to plot all samples in the open database or selected sample groups only. Up to 10 different parameters can be included along the x-axis and the symbols representing the sample points can be customized according to shape and color. The highlighted lines indicate specific samples that are selected in the database and are also highlighted on all other open graphical displays.

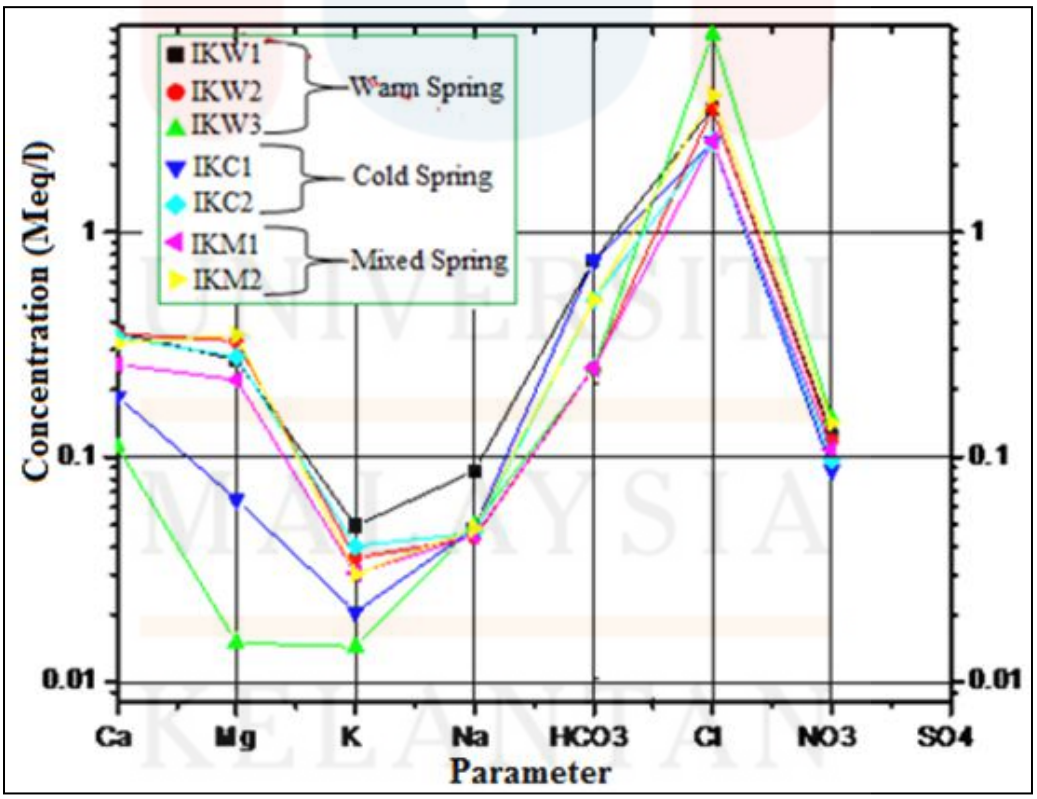


Figure 5.33 : The diagram show the Schoeller Diagram for classify the water type.

Based on the figure 5.34 below shows the Schoeller Diagram which represented the classification of water types in study area. From the result of graphing using Schoeller diagram, it show that the major ions represent is in three types. The different types of water is classify as :

Most of the water sample is in the Ca + Mg – Cl + SO_4. Mixed Ca + Mg – Cl + SO_4 types is not dominant in the study area. The water sample has high content of Ca + Mg ions.

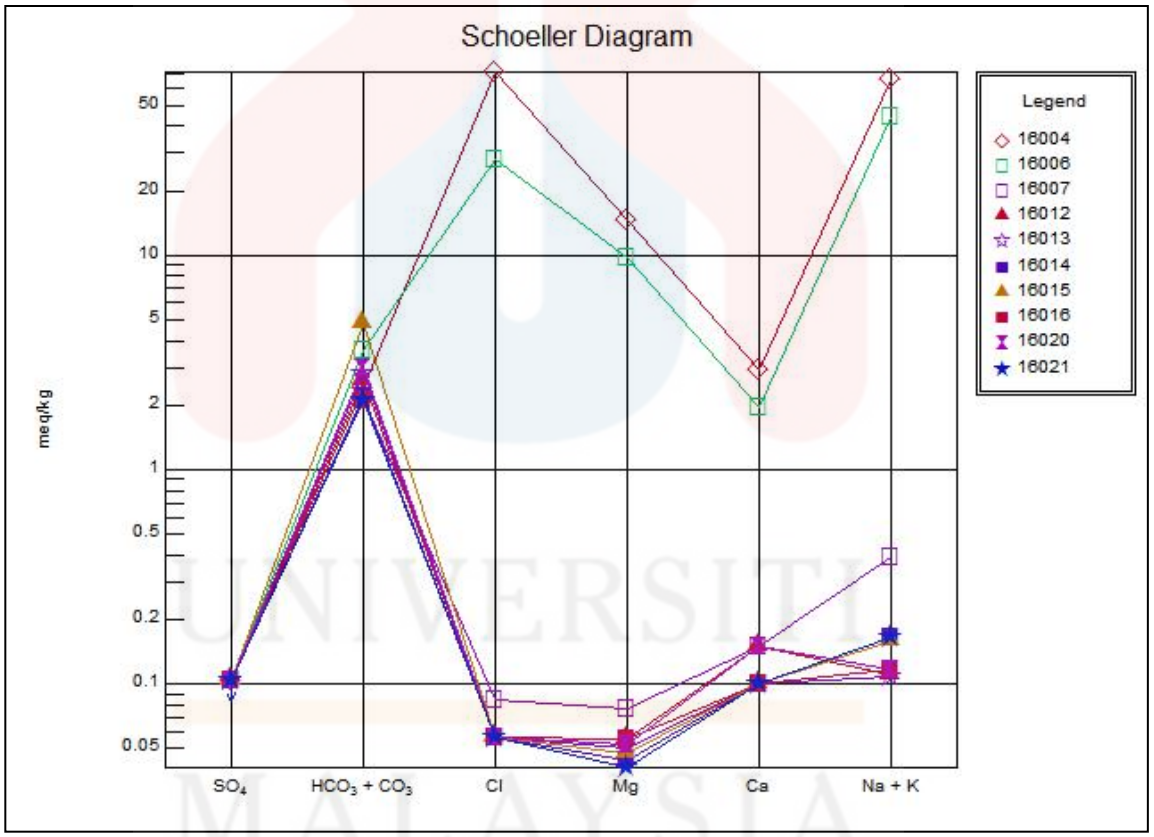


Figure 5.34 : The graph of Schoeller Diagram that shows the classification of water types.

5.5 Evaluation of analytical data

5.5.1 Anion-Cation Balance

Analytical data for each parameter was checked for validation and converted into

reportable value. The evaluation is conducted to through Anion-Cation Balance as shown in figure 5.35. The cation and anion are calculated in meq/L using balancing equation nd the value calculated should be below 5%. If more than 5% it indicates the sample have high suspended solid which need to be remove frequently through filtering. From the figure, the anion-cation balance was 0,68 providing a valid data since it is below 5%.

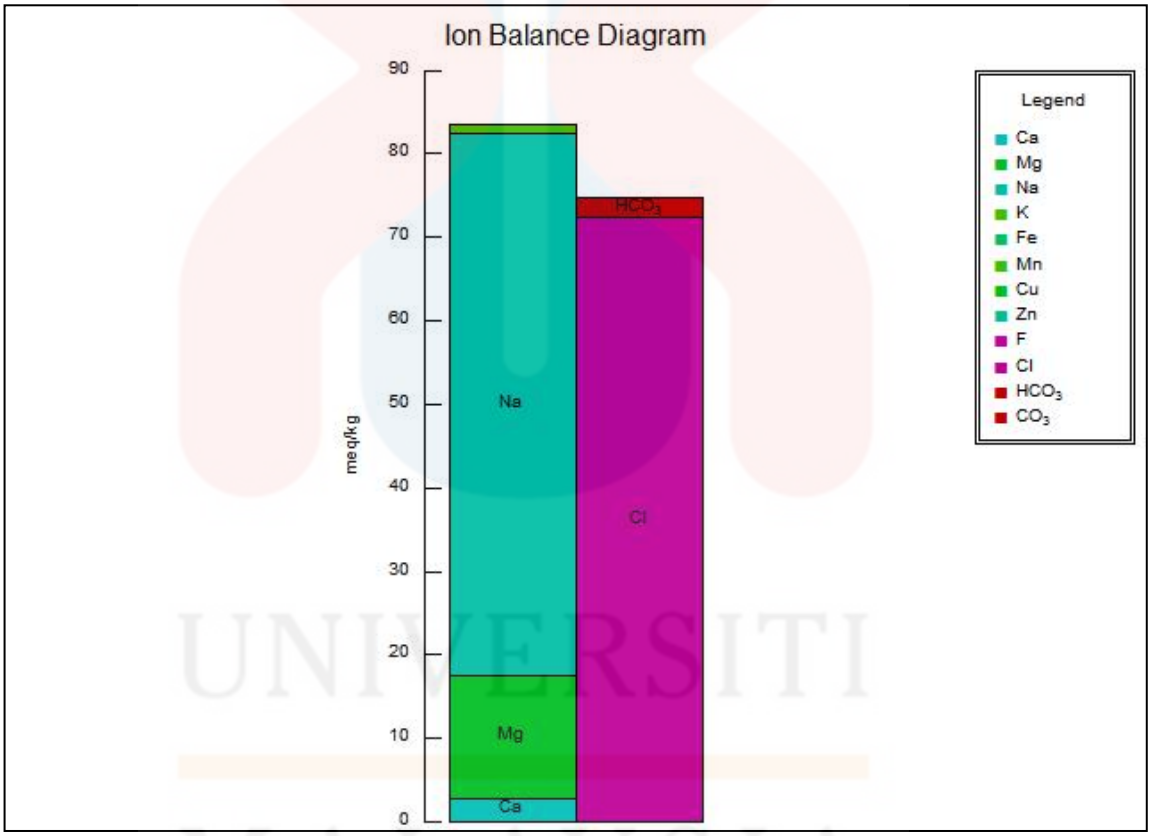


Figure 5.35 : The graphe show the ion balancing in the study area.

5.5.2 Water Quality

Based on figure 5.36, 5.37, 5.38 shows the concentration of anions and cations and the relationship between anions and cations. Based on graph below, it can be shows that

the content of the ion along the Terengganu river basin suitable for drinking water follow the guidelines WHO 2011 and MOH 2010. But it also have a certain river need to be monitor the level of ions likes sodium is highest.

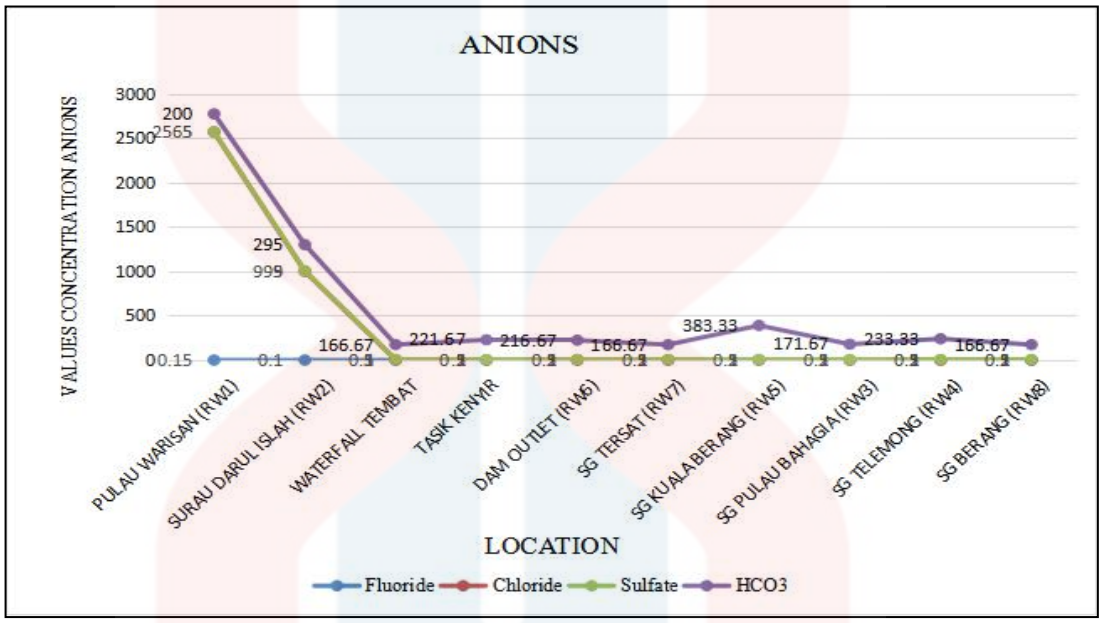


Figure 5.36 : The figure shows the concentration of all anions

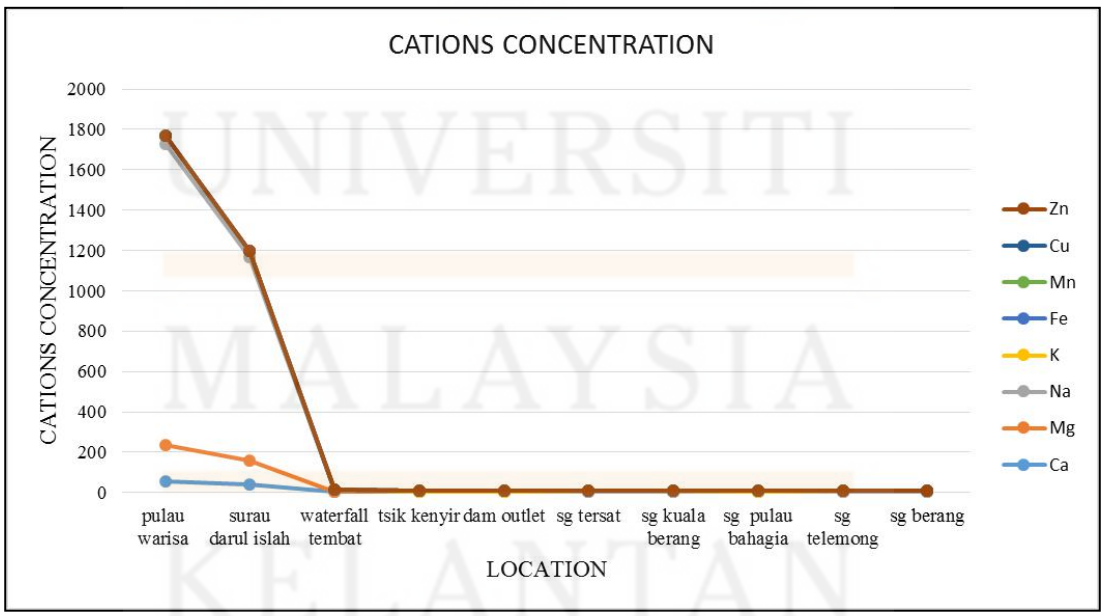


Figure 5.37 :The figure shows the concentatrion of all cations

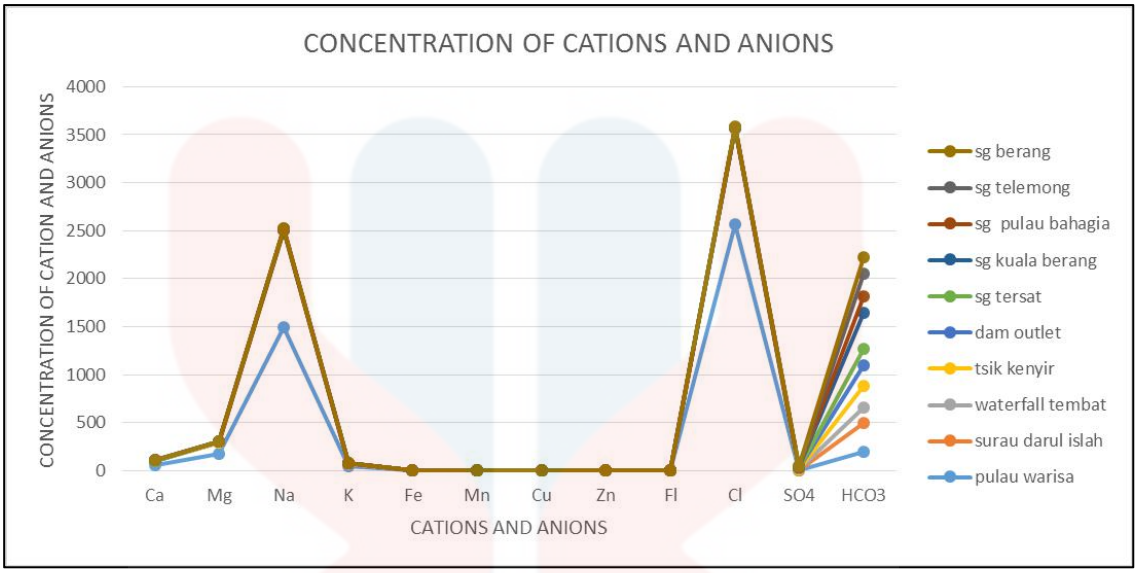


Figure 5.38 : The concentrations of cations and anion

CHAPTER 6

CONCLUSIONS

6.1 : Introduction

The present research is a part of the basic degree with titled " General Geology and Water Geochemistry of Gua Bewah, Tasik Kenyir, Hulu Terengganu, Terengganu. This study focuses mainly geological mapping and in-situ physical and chemical parameter of area. For this study the three objectives were selected to achieve this research.

The study area is part of the Hulu Terenggnau, which lies at 5° 09" 01.92" N 102° 31" 36.33" E, 5° 09" 51.16" N 102° 56" 46.66" E and longitude 4° 48" 53.29" N 102° 32" 06.16" E, 4° 48" 56.65" N 102° 56" 53.03" E. The area covered by 64 km2 which the land use is plantation that covered by Hutan Simpan Tembat, Tasik Kenyir. The road connection moving towards NorthWest is the road to Dungun-Kuantan, while the road connection moving towards SouthEast is the main road to Gua Musang. The majority citizens in Hulu Terengganu showed that Malay race is the majority citizens by 67,942 peoples followed by 310 peoples of Chinese race and non-Malaysian is 2,083 peoples that may consist of different types of foreigner. Besides that, the minority of the population in Hulu Terengganu others indigenous that is only by 335 peoples. The study area is typically is flat area that is covered by majority 90% agricultural activities which are palm plantation, rubber trees. The soil composition of the land also affected to activities around the citizens of the area because of alluvium type of soil made the citizens from decades ago develop in agricultural activities. The updated land use map reveled that increasing

of agricultural activities that most of the area covered plantation than land use.

6.2 Conclusion

The study concerning hydrogeology, major ions concentration in water were observed and analyzed. 1O sample along the Terengganu river were chosen and the later it was analyzed. The movement of river in the study area it moves from the high gradient to lower gradient.

Based on the result and discussion, it can be concluded that the majority of the parameters from the river when compared with WHO 2011 and MOH 2010 standard drinking guidelines, it stll admissible and safe for drinking purpose. Except for carbonate ion. Bicarbonate ion of Surau Darul Islah gives concentration highest. However, the overall quality of the water in the study area is reliable for drinking purpose.

6.3 : Recommendation

Water monitoring is very essentials in the study area. Though the water quality of groundwater is suitable it is very important for envolving a sustainable development strategy and water balance study in the area. From the observation, the area covered by granite bedrocks that has low buffer capacity. The monitoring of groundwater monitoring water level measurement applied sampling monitoring. Some recommendations were required for a better water management :

- Water monitoring : To determine the water quality and chemistry of a region and spesific water-supply and the study area have not being investigations by any agencies.

- Further studies and investigations : Physical and chemical properties required and dependent on variation of time

- Water quality : Water are essential as in the study area the local still use a fresh water sources.

- Waste management : The waste product from the building and houses at there and the septic tank that can affect the water quality in reservoir

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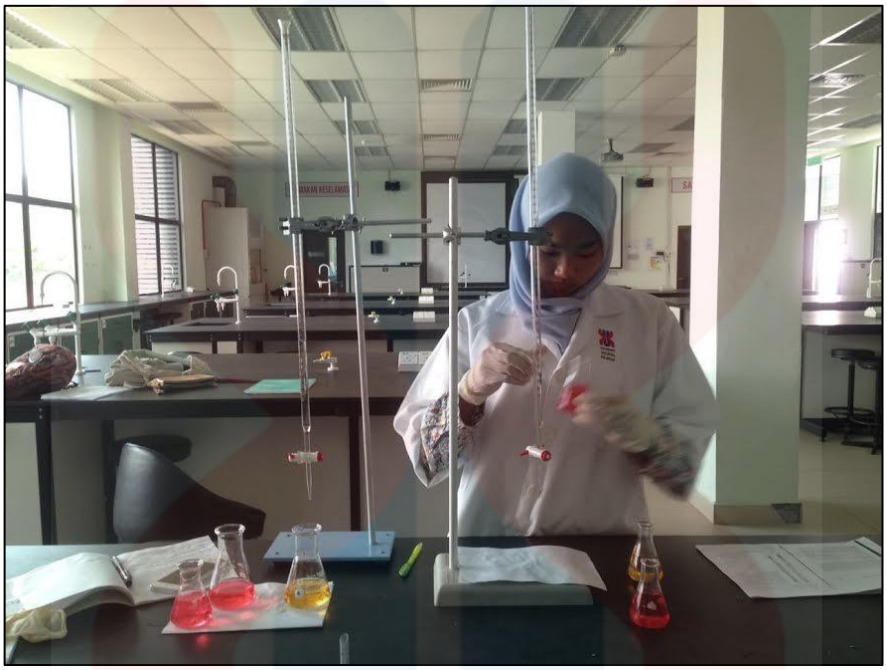
APPENDICES



Sample ID	Location Name	Latitude	Longitude	Water Types
16001	Tasik Kenyir	5° 08" 22.4' N	102° 48" 06.7' S	LK
19002	Pulau Warisan	5° 19" 55' N	103° 07" 52' S	RW1
16003	Pulau Darul Islah	5° 19" 33.5' N	103° 07" 13.9' S	RW2
16004	Pulau Bahagia	5° 16" 00.7' N	103° 03" 32.1' S	RW3
16005	Sungai Telemong	5° 12" 30.8' N	103° 01" 50.6' S	RW4
16006	Sungai Berang	5° 01" 23.7' N	103° 03" 01.2' S	RW5
16007	Jenagor	5° 01" 4.2' N	102° 55" 04.9' S	RW6
16008	Sungai Tersat	5° 01" 39.6'N	102° 59" 27.8' S	RW7
16009	Sg, Terengganu, Kuala Berang	5° 04" 23.1' N	103° 00" 25.4' S	RW8
16010	Waterfall Tembat	5° 11" 43.9' N	102° 47" 06.3' S	WF

*LK : Lake
RW : River water
WF : Waterfall

Sample ID	Temperature (C°)	pH	Conductivity (µS/cm)	TDS (ppm)	Hardness (mg/L)	Salinity (ppt)	TSS (g/L)	Turbidity (NTU)	EC (µS/cm)
16001	30.7	6.7	29.4	16.29	905.365	0	29.4	2.37	2870
16002	32.4	6.74	287	8024	590.4425	1.2	-	3.93	5948
16003	32.8	6.92	5948	4518	12.668	1.4	-	5.98	42.9
16004	30.5	6.75	27.9	16.95	10.5481	0	159	11.9	29.4
16005	31.9	6.9	28.62	17.34	7.5642	0	31.9	6.01	30.3
16006	31.3	6.93	31.1	18.9	7.175	0	29.8	2.92	34.6
16007	28.8	6.87	30.28	18.55	7.3807	0	34	2.05	31.1
16008	30.9	6.83	29.58	17.97	7.7533	0	33	6.61	27.9
16009	30.6	6.89	31.1	18.99	10.2482	0	72.1	5.21	28.6
16010	27.7	6.89	42.85	26.55	7.0104	0	9.81	9.81	31.1

Sample ID	HCO_3^- (mg/L)	Cl^- (mg/L)	SO_4^{2-} (mg/L)	F (mg/l)	Mn (mg/L)	Na^{2+} (mg/L)	K^+ (mg/L)	Ca^{2+} (mg/L)	Fe^{2+} (mg/L)	Mg^{2+} (mg/L)	Cu^{2+} (mg/L)	Zn2+ (mg/L)
16001	200	2565	<5	0.15	0.05	1490	42.936	58	0.32	0.05	0.14	0.02
16002	295	999	<5	<0.1	0.06	1008	30.318	39	0.43	0.06	0.089	0.014
16003	166.67	3	<5	<0.1	<0.01	8	1.624	3	0.13	<0.01	0.004	0.013
16004	221.67	2	<5	<0.1	<0.01	2	0.878	3	0.08	<0.01	0.001	0.02
16005	216.67	2	<5	<0.1	0.11	2	0.852	2	1.25	0.11	0.001	0.014
16006	166.67	2	<5	<0.1	0.04	3	1.367	2	0.33	0.04	0.001	0.015
16007	383.33	2	<5	<0.1	0.08	3	1.414	2	0.53	0.08	0.001	0.017
16008	171.67	2	<5	<0.1	0.09	2	1.145	2	0.96	0.09	0.001	0.025
16009	233.33	2	<5	<0.1	0.1	2	1.202	3	0.65	0.1	<0.001	0.014
16010	166.67	2	<5	<0.1	0.04	3	1.398	2	0.31	0.04	<0.001	0.019