GEOLOGICAL AND MAJOR ION ANALYTICAL STUDIES OF GROUNDWATER IN PASIR MAS, KELANTAN.

by

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

µS/m	Micro Siemens per Centimeter
asl	Above Sea Level
AAS	Atomic Absorption Spectrometer
bgl	Below Ground Level
EC	Electrical Conductivity
GIS	Geographic Information System
GPS	Global Positioning System
JKR	Jabatan Kerja Raya
JMG	Jabatan Mineral dan Geosains
JPS	Jabatan Pengairan dan Saliran
JUPEM	Jabatan Ukur dan Pemetaan Malaysia
meq/L	Miliequivalent per litre
mg/L	Miligram per litre
MOH	Ministry of Health
SAR	Sodium Adsorption Ratio
TDS	Total Dissolved Solids
WHO	World Health Organization

LIST OF SYMBOL

%	Percentage
Ca^{2+}	Calcium ion
Cl^{-}	Chloride ion
F^{-}	Fluoride
Fe^{2+}	Iron
HCO_3^{-}	Bicarbonate
K^{+}	Potassium ion
Mg^{2+}	Magnesium ion
Na^{+}	Sodium Ion
ºC	Degree Celcius
pH	Potential Hydrogen
SO_4^{2-}	Sulphate ion

ABSTRACT

Geological And Major Ion Analytical Studies Of Groundwater In Pasir Mas, Kelantan

Geochemical signatures of groundwater in a part of Pasir Mas district, Kelantan, Malaysia were used to identify the major ions that control hydrogeology in terms of its quality. This research is focusing on updating the alluvium map and also to analyze the major ion concentration of groundwater in order to monitor the suitability of drinking water standards in the study area and for the agricultural purposes. There are fifteen samples from groundwater wells and one river water sample that was collected from the study area. The physical parameters, such as electrical conductivity, potential hydrogen (pH), total dissolved solids (TDS), total suspended solids (TSS), turbidity and also major ion concentration such as Calcium (Ca^{2+}), Magnesium (Mg^{2+}), Sodium (Na^{+}), Potassium (K^{+}), Chloride (Cl^{-}), Bicarbonate (HCO_3^{-}), and Sulphate (SO_4^{2-}) of groundwater were taken into consideration. The method that was being used to record the physical parameters is by using YSI Multiparameter, turbidimeter and TSS portable while the chemical parameters were identified by using several methods such as gravimetric method, alkalinity titration, colorimetric method and Atomic Absorption Spectrophotometer (AAS). The concentrations of these cations and anions in the groundwater were varied spatially and temporally. The recorded data was represented through Piper trilinear diagram which concludes that the groundwater is classified as Ca-HCO_3^{-} which is typically the shallow and fresh groundwater. Therefore, there are 3 out of 16 samples were exceeding the standards set by WHO and MOH in terms of the pH value but iron (Fe^{2+}) content was exceeding the standard in all samples. Other than that, geological mapping in the form of alluvial mapping has been done with an explanation through soil analysis. Five soil samples from the alluvium in depth interval of 0 to 50 cm were being collected for analysis. The results from the soil analysis conducted conclude that the study area is comprised with interbedded clay, silt and sand which aged at Quaternary.

ABSTRAK

Geologi dan Kajian Analisis Ion Utama Air Bawah Tanah Di Sekitar Pasir Mas, Kelantan

Ciri-ciri geokimia untuk air bawah tanah yang dijalankan di kawasan kajian bertempat di daerah Pasir Mas, Kelantan, Malaysia telah digunakan untuk mengenalpasti proses kimia yang mengawal kualiti dalam air. Fokus utama kajian ini adalah untuk mengemaskini peta alluvium dan juga untuk mengenalpasti kepekatan ion utama di dalam air bawah tanah di kawasan kajian supaya ia sesuai dengan standard kualiti air minuman dan untuk tujuan pertanian. Terdapat 15 sampel air bawah tanah dan 1 sampel air sungai yang telah diambil di kawasan kajian. Ciri-ciri fizikal seperti kekonduksian elektrik, potensi hidrogen (pH), pepejal terlarut (TDS), pepejal termendap (TSS), kekeruhan air dan juga kepekatan ion-ion utama seperti Kalsium (Ca^{2+}), Magnesium (Mg^{2+}), Natrium (Na^{+}), Potassium (K^{+}), Klorida (Cl^{-}), Bikarbonat (HCo_3), and Sulfat (SO_4^{2}) di dalam groundwater juga telah direkodkan. Kaedah yang digunakan untuk memperolehi data ciri-ciri fizikal adalah dengan menggunakan YSI Multiparameter, turbidimeter dan TSS portable sementara ciri-ciri kimia air telah dikenalpasti melalui beberapa kaedah seperti kaedah gravimetric, titrasi alkaliniti, kaedah colorimetric dan Atomic Absorption Spectrophotometer (AAS). Kepekatan ion positif dan ion negatif di dalam air bawah tanah berbeza mengikut sesuatu lokasi dan juga ia bersifat sementara. Justeru, data yang telah direkodkan telah diolahkan di dalam Piper trilinear diagram yang berkesimpulan bahawa air bawah tanah di Pasir Mas adalah bercirikan $Ca\text{-}HCO_3^{-}$ di mana ia selalunya cetek dan terdiri daripada air tawar. Terdapat 3 daripada 16 sampel telah melebihi standard kualiti yang telah ditetapkan oleh WHO dan MOH untuk nilai pH, sementara kesemua sampel melebihi standard kandungan Besi (Fe^{2+}) daripada yang ditetapkan. Selain itu, pemetaan geologi untuk kajian ini adalah di dalam bentuk pemetaan alluvium yang telah disiapkan bersama penerangan tentang analisa tanah di kawasan kajian. 5 sampel tanah daripada alluvium di dalam kedalaman 0 hingga 50 sm telah diambil untuk analisa makmal. Kesimpulan daripada analisa makmal yang dapat dibuat daripada pemetaan tersebut adalah kawasan kajian mengandungi statigrafi berumur Quaternary yang terdiri daripada lapisan lempung, pasir dan kelodak.

CHAPTER 1

INTRODUCTION

1.1 General Background

This research study entitled geological and major ion analytical studies of groundwater in Pasir Mas, Kelantan. Groundwater is the water that can be found underground in cracks and voids in soil, sand and rocks. It is less polluted than the surface water because when it flows through the soil and rocks, they will filter most of the contaminants present in groundwater (Hamzah Z. et al., 2014).

Groundwater is an important source of water that is highly demand across the world including Malaysia. It plays a very important roles in our environment and in our economies since it is mainly used for domestic, industrial and agricultural purpose. Despite, according to Zaini Ujang et al. (2008), water pollution had become a global concern due to the scarcity of freshwater such as river. Furthermore, unhealthy natural resources will be led by the water quality depletion and affect the overall environment.

On top of that, present water supply is inadequate to serve as a daily basic need. Kelantan for instance, they had been using about more than 70% of groundwater for public water supply according to Jabatan Mineral dan Geosains Malaysia (JMG). Therefore, the chemistry of groundwater has to be studied since it is a vital factor to determine groundwater use either it is for domestic, industrial or agricultural purpose.

Moreover, the geochemical analyses were being used to characterize the water quality in the aquifer, in order to describe the origin and movement of ground water from recharge areas to discharge at wells and springs, and also to determine the age of water in the aquifer (Scott et al., 2009).

1.2 Problem Statement

This study is intended to analyze the major ion concentration of groundwater in the study area, which is Pasir Mas, Kelantan. Most of the local residents here are still using domestic wells as their daily basic needs, includes for the housing and agricultural area which will depends to the use of groundwater. Besides, the domestic well is confined to shallow aquifer.

There are almost of all the residence is using the same sewage system which will probably increasing the rate of contamination in their water sources. Thus, an authorized party has to be assigned in monitoring the suitability of the drinkable water standards, and also for the agricultural purposes. The major ion concentration of water will be aids the water quality records.

1.3 Research Objectives

There are a few objectives need to achieve in this research. The objectives are:

i. To update the alluvium map in Pasir Mas, Kelantan on the scale of 1:55 155.

ii. To analyze the major ion concentration of groundwater in order to monitor the suitability of drinking water standards in the study area and for the agricultural purposes.

1.4 Study Area

The study area lies on the coordinate of E 102° 5' 30" to E 102°10'0" and N 06° 0'30" to N 06° 5'10" which is approximately 80 km^2. It is located in Kelantan at Pasir Mas District as shown in the base map in Figure 1.1. The base map of the study area was digitized by using ArcGIS 10.2 based on aerial image from Google Earth in Figure 1.2 and the data source from Jabatan Ukur dan Pemetaan Malaysia (JUPEM). The study area includes the area of Bandar Pasir Mas, Kuala Lemal, Lubok Aching, Bechah Menerong, Meranti, Bakong, Lalang, Kubang Terap, Kubang Bemban, to Tasik Berangan. Most of the villagers in Pasir Mas are using domestic wells as their daily basic needs.

1.4.1 Geography

a. People Distribution

According to the Housing and Population Census recorded by the Department of Statistics in Malaysia for the year of 2010, there are a total of 180,878 residents who live in Pasir Mas. On referring to the statistics, Pasir Mas have the second largest population after Kota Bharu. Table 1.1 shows the number of population in Pasir Mas on 2010 according to their race and citizenship. Bumiputra had conquered the population in Pasir Mas among the races according to the pie chart in Figure 1.3.

We can conclude that most of the Kelantan people chose to live in Pasir Mas and Kota Bharu, is due to the economic and social factor. There are high preference on living in Pasir Mas and Kota Bharu due to the many facilities provided compared to the other areas.

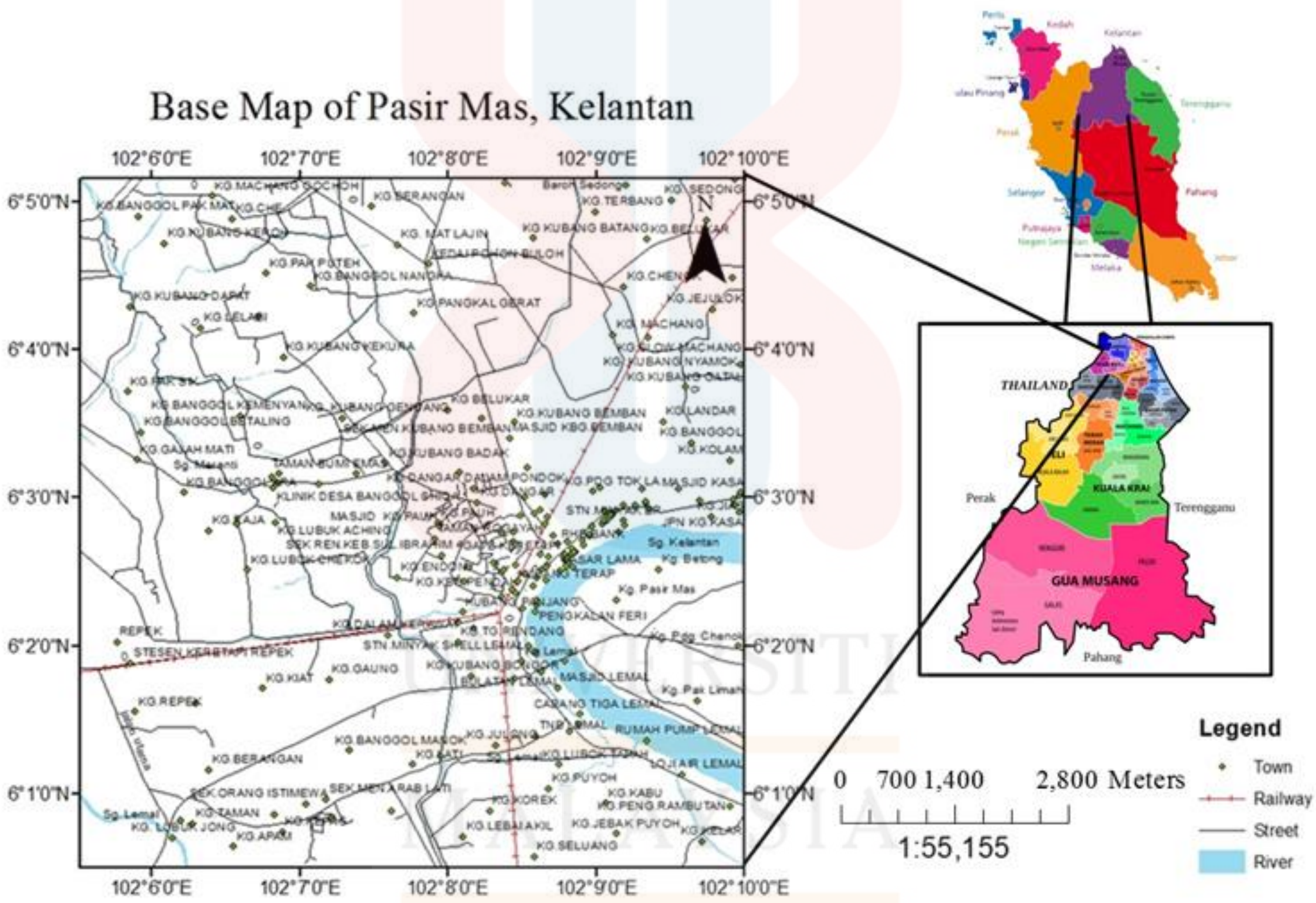


Figure 1.1: The Study Area in Pasir Mas, Kelantan

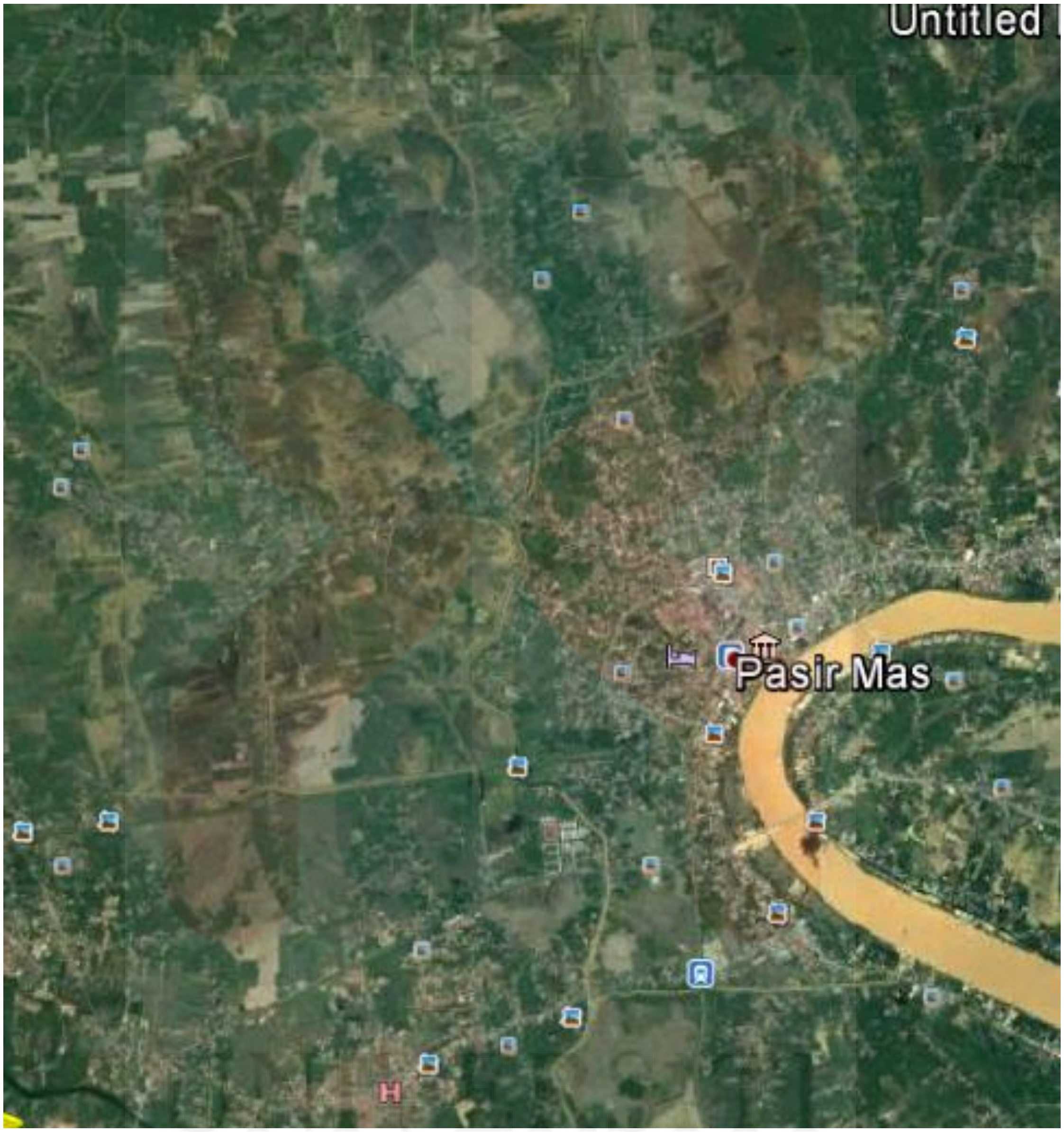


Figure 1.2: The satellite image from Google Earth in the study area.

Table 1.1: Housing and population census in Pasir Mas (Department of Statistics, 2010)

Jajahan/ Local Authority Area	**Total**	**Malaysian Citizens**							**Non-Malaysian Citizens**
		Total	Bumiputera			Chinese	Indians	Others	
			Total	Malay	Other Bumiputera				
M.D Pasir Mas	180,878	177,487	173,162	173,094	68	3,560	26	739	3,391
Gual Periok	1,031	1,018	1,003	1,003	-	15	-	-	13
Pasir Mas	11,899	11,841	11,089	11,063	26	731	9	12	58
Rantau Panjang	3,864	3,706	3,556	3,555	1	127	3	20	158
Tok Uban	2,990	2,981	2,959	2,959	-	22	-	-	9
Remainder of M.D	161,094	157,941	154,555	154,514	41	2,665	14	707	3,153

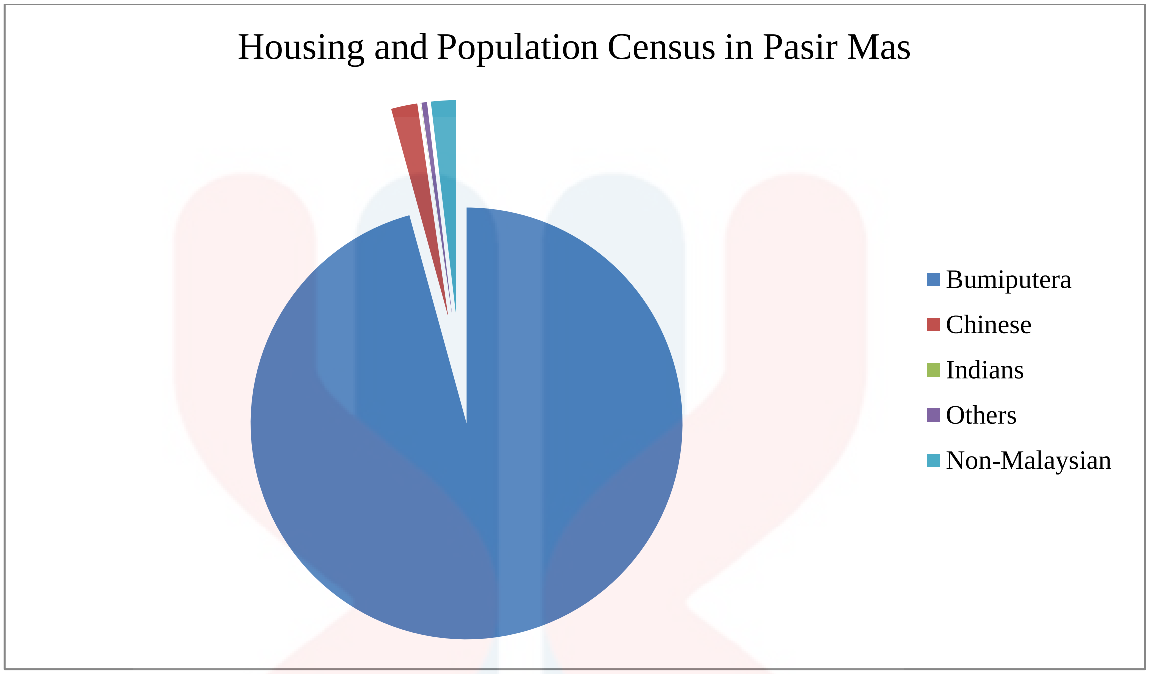


Figure 1.3: Pie chart of housing and population census in 2010

b. Rain Distribution

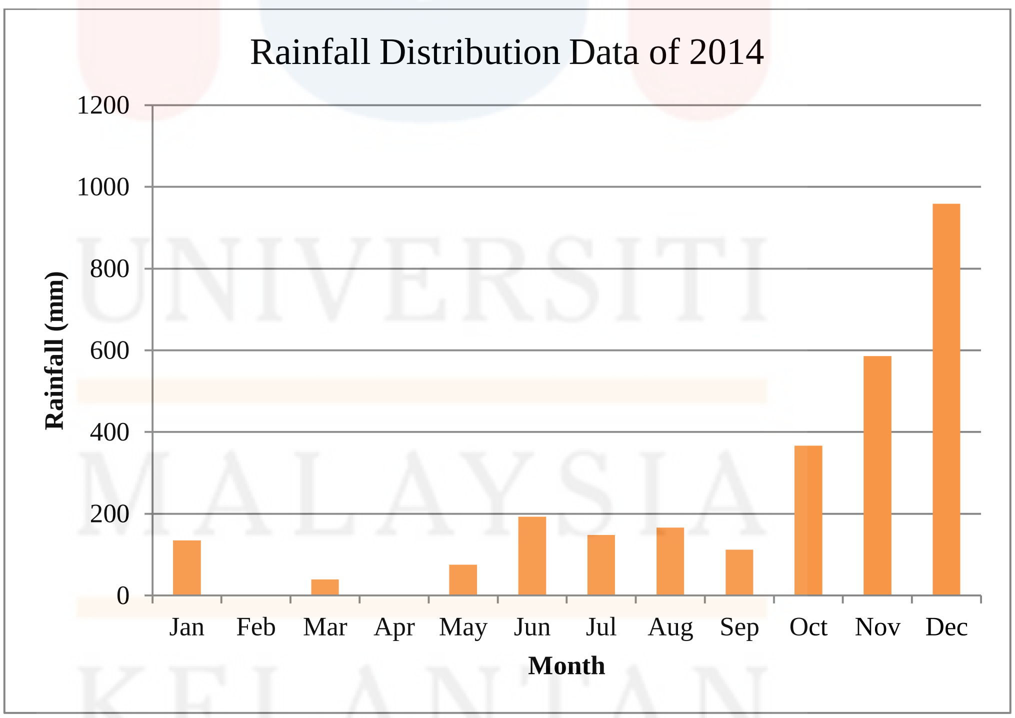


Figure 1.4: Rainfall distribution data of 2014 in Pasir Mas, Kelantan. (JPS Kelantan)

For rain distribution, the recorded data is represented in bar chart in Figure 1.4 to show an increment rainfall distribution pattern from the month of January to December. The highest rainfall distribution recorded is in December where the monsoon season was taking place during the month. Malaysia's monsoon season starts from October to March in every year. Starting from April which is the post-monsoon season, the rainfall distribution began to stabilize until the month of September. Rainfall will affect the precipitation of water, where the rainfall precipitation became low to moderate during post-monsoon season.

c. Soil Use

Good physical and chemical characteristics can be identified in alluvium soil which is beneficial for cropping purpose. According to Figure 1.5, the.major land use in Pasir Mas is the cultivation of paddy and several other agricultural crops like sundry tree cultivation and rubber plantations. There are many rubber plantations in the rural area along the road that connecting Pasir Mas and Rantau Panjang.

d. Social Economic

Major economic activities in Pasir Mas are agricultural based, mainly the cultivation of paddy, rubber, and oil palm. One of the implication of the fluctuation of rainfall distribution data is that, it will be able to affect the economy of an area. Paddy is a plant that is relatively grow with the water movement. The condition of soils in Pasir Mas is suitable enough to the crops like paddy since it is high in its moisture.

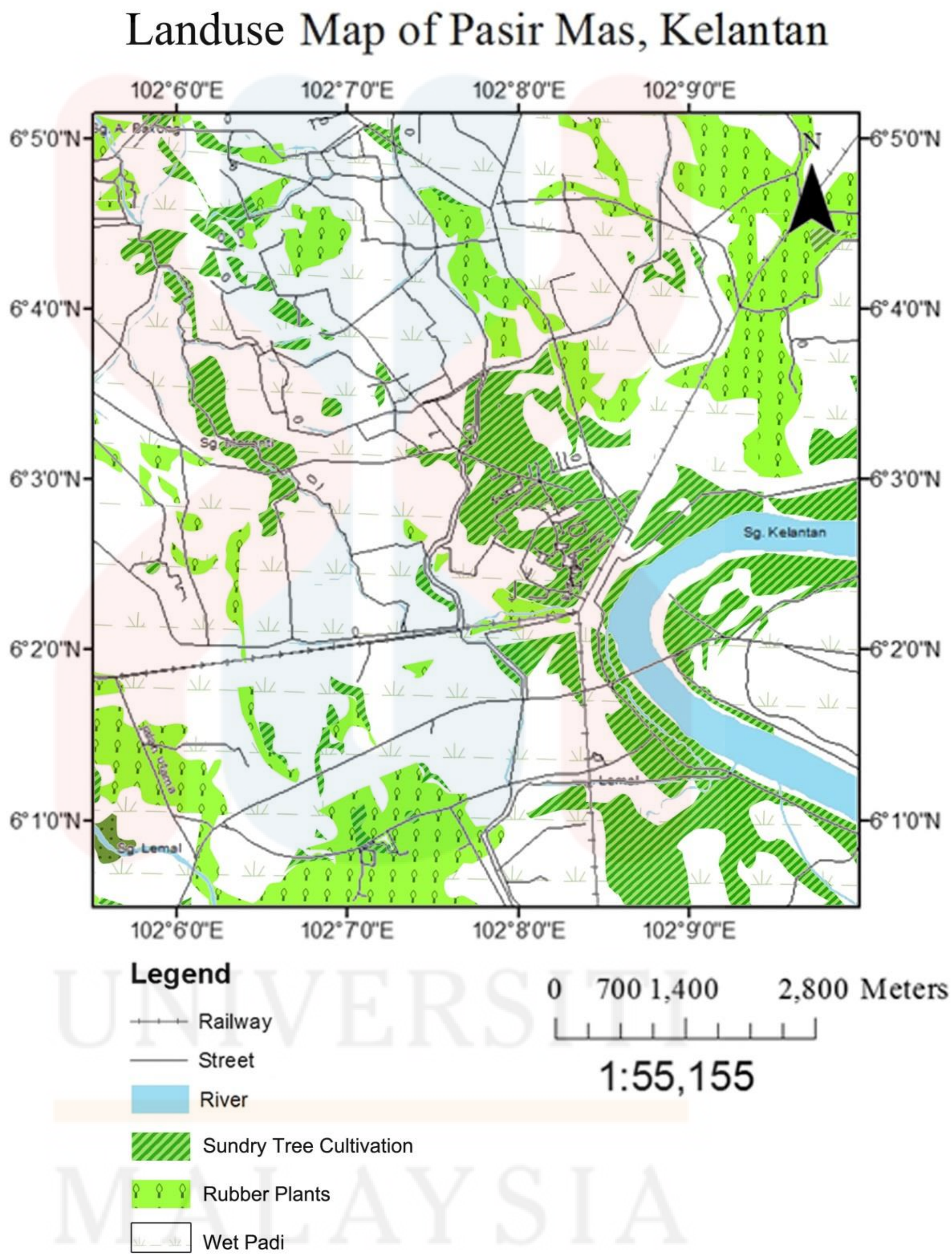


Figure 1.5: Landuse map of Pasir Mas, Kelantan

e. Road Connection

Based on the map on Figure 1.6, the road connection in the study area is accessible from all direction due to the well development of the district. Despite there are some paddy field and rubber plant, the road is still well connected along the way from Pasir Mas to Meranti. The road development of the district is being monitored by the authorities like Jabatan Kerja Raya (JKR).

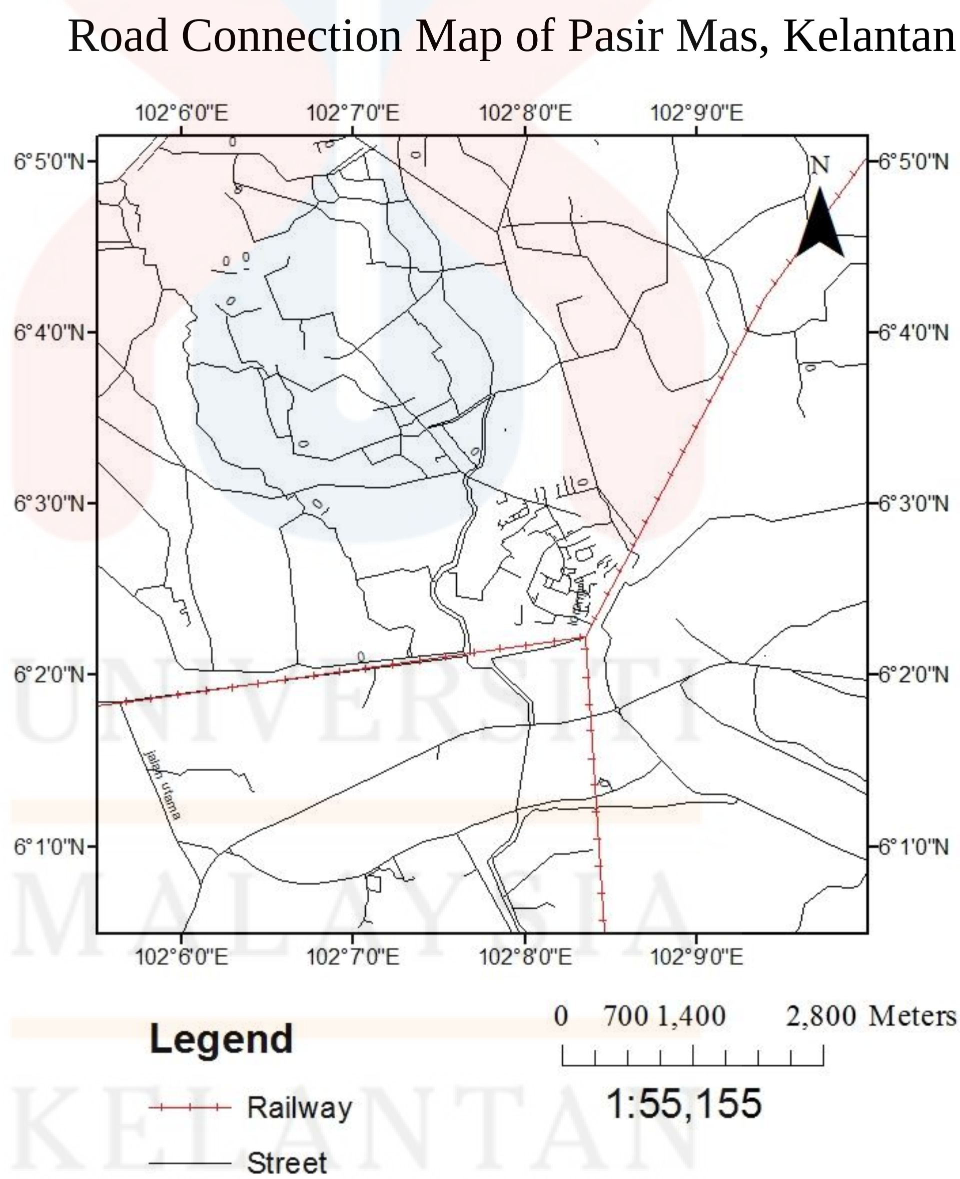


Figure 1.6: The road connection around Pasir Mas, Kelantan.

1.5 Scope of Study

The research study covered about 80 km^2 of the areas around Pasir Mas, Kelantan. Alluvium mapping and water sampling will be collected in this area. In order to do this research study, in-situ parameter will be done for water sampling to record their physical properties such as total dissolved solids (TDS), total suspended solids (TSS), electrical conductivity (EC), resistivity, temperature, pH, and turbidity.

The water sample then will be brought to laboratory for further analysis. In this case, the study of geochemistry is included. According to Fetter (2000), the chemical properties of water are as important as physical properties and available quantity. There are more than 90% of the dissolved solids in ground water can be attributed to eight ions; Na^+, Ca^{2+}, K^+, Mg^{2+}, SO_4^{2-}, Cl, HCO^{3+} and CO_3^{2-}.

Alluvium mapping will be conducted in the study area including the study of geomorphology, stratigraphy, and hydrology. In order to do the alluvium mapping, the sampling of soil will be done. Geomorphology will be focusing on the study of the landform by explaining thoroughly about their origin, evolution, formation, and distribution across the physical landscape. While the stratigraphy will be focusing on the study of its rock strata and its layering.

1.6 Research Importance

The importance of this research is to generate the latest alluvium map for Pasir Mas, Kelantan besides focusing onto the major ion analytical studies of groundwater in the study area. In addition, we will also get to know the geological reasons which might be contributing to the concentration of the major anion and cation of groundwater of the area. This study will monitor the suitability of drinking water standards and agricultural purpose in the area. On the other hand, this study will be really helpful for different organization in order making a decision.

1.7 Chapter's Summary

This chapter is about the geological and specification in which major ion analysis is conducted in Pasir Mas, Kelantan. There are many modern technology applied to analyze the major ion including conducting the alluvium mapping. This study intended to update the alluvium map in Pasir Mas, Kelantan on the scale of 1:55 155 and also to analyze the major ion concentration of groundwater in order to monitor the suitability of drinking water standards and agricultural purpose in the study area. The geography of the 80km^2 of targeted area is characterized through the people distribution, rain distribution, soil use, and social economic also the road connection.

CHAPTER 2

LITERATURE REVIEW

2.1 Regional Geology and Tectonic Setting.

Kelantan's regional geology consists of a central zone of sedimentary and metasedimentary rocks bordered on the west and east by granites of the Main Range and Boundary Range respectively (Goh Swee Heng et al., 2006). Besides, the abundance of the common rock-forming minerals controlled the background levels of trace metal in rocks (Garrett, 2000). It will conclude that major and minor ions are difference from place to place, depending on the chemical composition of the rocks through which the groundwater flow and also based on the human activities at that place (Hamzah Z. et al., 2014).

2.1.1 Kelantan

Malaysia suffers from water shortage problems surface only during extended dry weather periods (Zaini Ujang et al., 2008). Despite, the state of Kelantan with the total area of 15,099 km2 still relies on well water and boreholes for drinking and domestic purposes (Hamzah Z. et al., 2014). On the other hand, the concentration of cations and anions in well water in Kelantan generally is not within the WHO permissible levels. Hence, the consumption of the water for drinking may require treatment (Hamzah Z. et al., 2014)

2.2 Stratigraphy

The thickness of unconsolidated sediments, which is referred as alluvium are known of over 200 m along the west coast of West Malaysia (Koopmans, 1965). The alluvium in the Kelantan delta increase in thickness eastwards, with the deepest bedrock encountered at a depth of 150m (Bosch, 1986). The sediments consist of coarse gravelly sand and a depth of 50 to 60 m of of thin clay beds, although a 10-m thick clay layer occurs at a depth of 130 m (C.S Hutchison et al., 2009). In Pasir Mas, which to the south of the area, lies the sedimentary rocks of Triassic and Permian age (Dawson et al., 1967). Schists and granite, in that order, occur to the south of the formation. To the southeast of the plain lies a large mass of granite outcrops of Mesozoic age according to Figure 2.1.

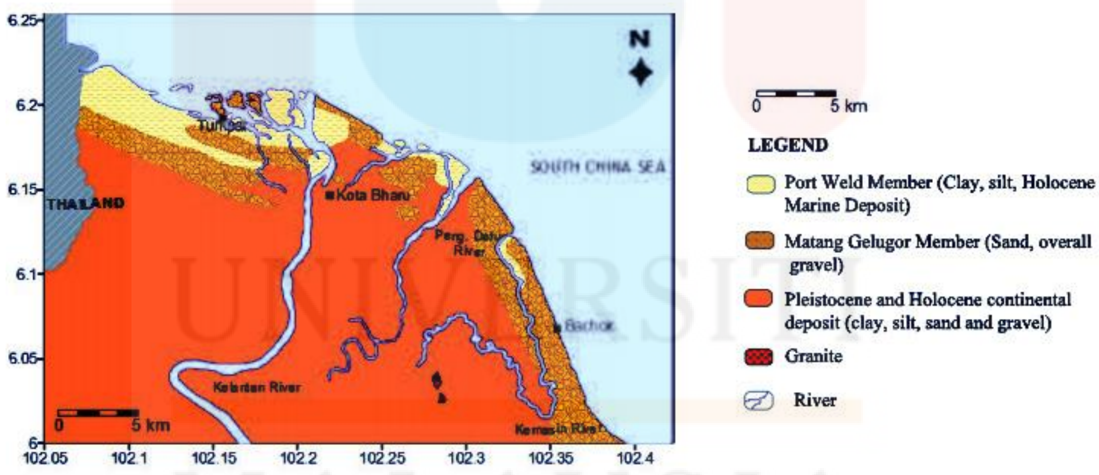


Figure 2.1: Geological Map of Northern Part of Kelantan (Nur Hayati Hussin,2011)

2.3 Research Specification Review

2.3.1 Hydrogeology

The degree of connection between a river and an aquifer has become a significant determining factor of the flux of water between a river and an aquifer as controlled by the material characteristic of the river bed and river bank sediments and the extent to which the channel of the river intersects the saturated part of the aquifer (Kevin M. Hiscock et al., 2014)

2.3.2 Groundwater

Groundwater defined as the sciences of the occurrence, distribution, and movement of water below the surface of the Earth (D.K. Todd, 2006).Groundwater plays an important part in petroleum engineering and as the sources of water supply throughout the world. Hence, the use of groundwater in irrigation, industries, municipalities, and rural homes continue to increase.

2.3.3 Aquifer

The groundwater of the first aquifer is relatively fresh and it is a good source of water supply for the north Kelantan area (A.Rahim Samsudin et al., 1997). On the other hand, in order to make sure that each well can produce enough quantity of water according to its design capacity, all of the production wells should be monitored and maintained each year (Fauzie et al., 2014)

2.3.4 Hydrochemistry

The chemistry of atmospheric precipitation, mineralogy of the rocks encountered along the flow path, residence time of the surface or groundwater, topography and climate can be the factors of the chemical composition of natural water (Mokthar et al., 2009). The presence of minerals like major ions in very low concentrations could pose a risk to individuals who consume this water on a regular basis (A. Zaharin Aris et al., 2013). Therefore, major and minor ions in drinking water are very crucial to human health since these ions are very significant in serving several functions in human body (Hamzah Z. et al., 2014).

2.3.5 Groundwater Quality

According to Mahirah Kamaludin et al., (2013), a study done by the Association of Water and Energy Research Malaysia (2011) stressed on some cases in Kelantan with low coverage performance, dirty and smelly water supply and frequent unscheduled interruption. One of the factors that which are putting the pressure on water resources are high growth rates in population, increasing water consumption, and water pollution (Mahirah Kamaludin et al., 2013). According to Zaini Ujang et al. (2008), water pollution has become a global concern due to the scarcity of freshwater such as river. Furthermore, unhealthy natural resources will be led by the water quality depletion and affect the overall environment (Zaini Ujang et al. 2008).

CHAPTER 3

MATERIALS AND METHODOLOGY

3.1 Introduction

This chapter is about the discussion of the materials and method that is needed throughout this research study. Figure 3.1 indicates the brief flow of the whole research study from the start to the end of the study.

3.2 Preliminary Researches

Before undergoing this research, a preliminary study about the hydrology specification has been done in order to get the whole overview of the specification. The previous study of the area is also significant to be linked with this research. Topographical map will be collected and digitized by using ArcGis 10.2, a map digitizing software. Data collection from articles, journals and other reference has been studied in order to get more information about major ion concentration in groundwater of Pasir Mas, Kelantan.

3.3 Materials and Methods

One of the most important things to have during fieldwork is the base map of the study area. Base map of the study area was produced by ArcGIS 10.2 using the data from JUPEM. It is used for the plotting or presentation of specialized data from the fieldwork. By having a base map, the plotting of data such as the coordinate of the wells and the rock distribution is required in order to get a record on aiding the alluvium mapping of the study area. Other field equipment that was used throughout this fieldwork is as shown in Table 3.1 listed with each of the equipment's function.

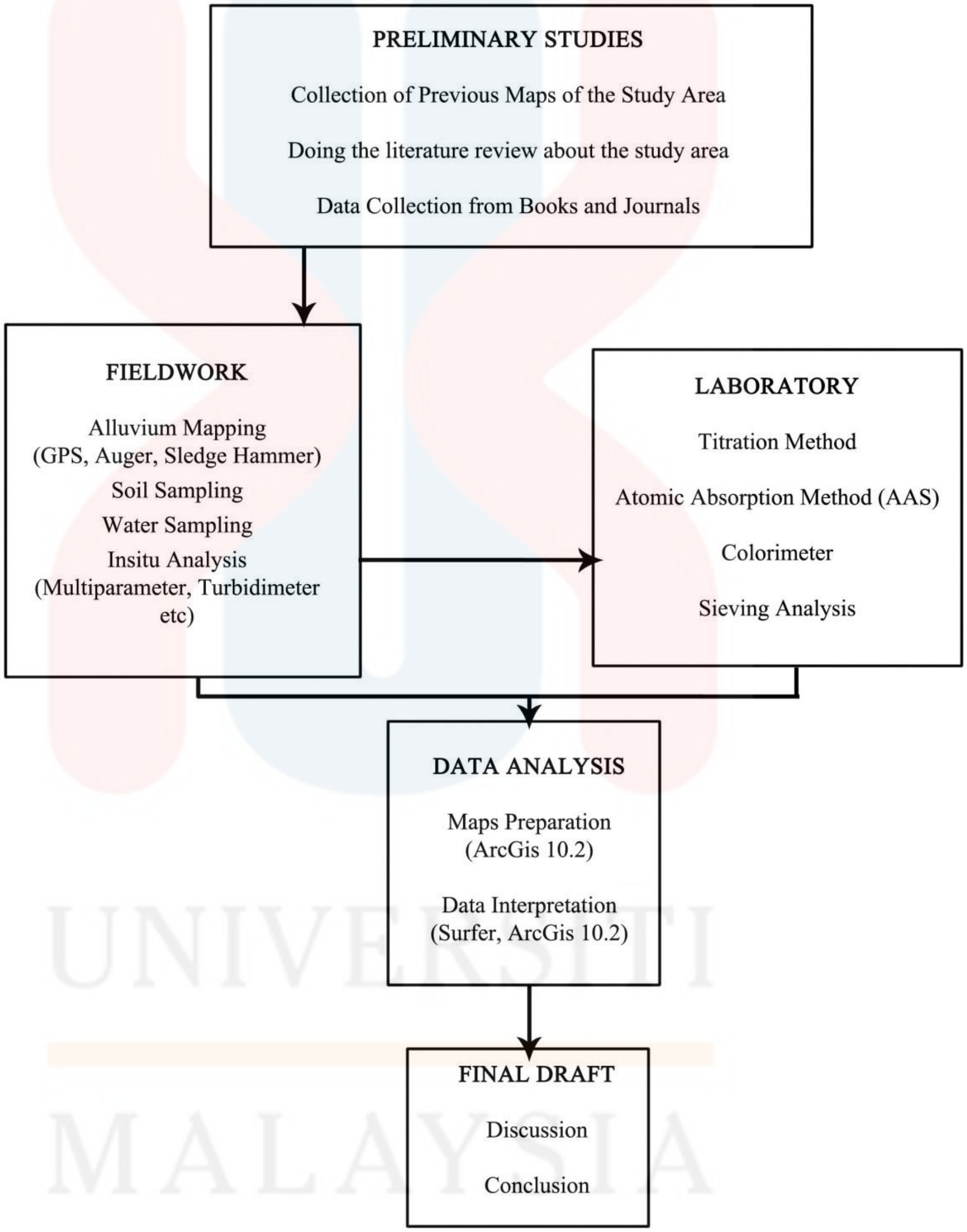


Figure 3.1: Research flow chart

3.3.1 Field Equipment

EQUIPMENTS	USES
i. Garmin Global Positioning System (GPS) 	This tools provides location of the study area and time information in all weather conditions. The data collected by this tools will be utilized to determine the distribution of water contours on map.
ii. Water Level Meter 	This water level meter is used to measure the well height, water level and also the depth of the water in the wells.
iii. Sledge Hammer 	This tool aids the soil collection by hammering it to auger to the soils.

iv. Auger 	Used for boring holes on the ground. A custom-made auger has been made in order to get a 50cm undisturbed texture of soil.
v. Portable pH meter 	This tools measure the hydrogen-ion concentration in a solution, indicating its acidity or alkalinity.
vi. Portable TSS. 	To measure the total suspended solids in the water.

vii. YSI Multi Parameter 	This tools measure the multi characteristic of water such as pH, DO, salinity, TDS, and conductivity.
viii. Turbidity meter 	Measure and comparing the turbidity of liquids.
ix. Poly Ethlene (PE) Bottle for Water Sampling (1L) 	This bottle is used for collecting waters for further chemical analysis. The bottle was wrapped fully with aluminum foil to prevent the penetration of lights to the water.
x. Ziploc Plastic Bag 	This A4 sized plastic bag is used for soil sampling for soil analysis.

Table 3.1: The field equipment needed on field

3.3.2 Field Studies

a. Alluvium Mapping

A detailed mapping has been conducted in the study area which is in Pasir Mas including the study of geomorphology, and hydrogeology. The equipment in the fieldwork that has been used was Garmin Global Positioning System (GPS), sledge hammer, auger, YSI multi-parameter, portable TSS, portable turbidimeter, poly-ethlene bottle. During the mapping, soil and water sampling has been collected for undergoing the chemical analysis.

In order to inspect the distribution of the alluvium in the study area, grain size of each soil sample has been inspected by using a sieve and its shaker. Soil sampling is undergone by using 1 meter auger that was designated sharp at the tip so that it's easier to collect the sample.

b. In situ Analysis

Next, an in situ analysis of physical parameter of the groundwater such as identification of temperature, pH measurement, electrical conductivity (EC), total dissolved solids (TDS), water turbidity, and total suspended solids has been done by using YSI Multiparameter, TSS, and turbidity meter. Other than that, water level meter also needed in order to measure the height of the well and the water level. The recorded data was interpreted by using software such as Surfer 8.

c. Laboratory Investigations

Firstly, water sampling was conducted for further analysis in laboratory. The method that has been used in laboratory was Atomic Absorption Spectrophotometer (AAS), Colorimetric method and Titration method. From the water sampling, the results showed the ion exchange reactions in groundwater that can vitally influence the natural groundwater chemistry and are an important consideration in predicting the migration contaminants such as heavy metals and polar organic chemicals (Kevin et al., 2014).

The data analysis according to Table 3.2 has been done in laboratory by using the equipment like Atomic Absorption Spectrophotometer (AAS) and colorimeter. Other than that, this research used the titration methods such as gravimetric and alkalinity, and also sieving method for soils. The methods were applied to the sample and analyzed the particular major ion except for the sieving method which will be analyzing the grain of the samples.

Table 3.2: The equipment with its analyzed major ions.

EQUIPMENTS	MAJOR ION ANALYZED
Atomic Absorption Spectrophotometer An analytical technique that measures the concentrations of elements.	Major Cations : Sodium (Na^+), Potassium (K^+), Calcium (Ca^{2+}), Magnesium (Mg^{2+}).
Colorimeter Method The device used to test the concentration of a solution by measuring its absorbance of a	Major Anions : Nitrate (NO_3^-), Fluoride (F^-).

specific wavelength of light.	
Titration (Alkalinity) Method A titration method that measuring alkalinity of an aqueous solution in prior to its quantitative capacity to neutralize the acid.	Bicarbonate (HCO_3^-), Chloride (Cl^-)
Gravimetric Method Describes a set of methods in analytical chemistry for the quantitative determination of an analyte based on the mass of a solid.	Sulphate ($SO4^{2-}$)

d. Data Analyses and Interpretation

The data collected using the equipment was interpreted by using Piper-Trilinear Diagram on Figure 3.2. Arthur M.Piper (1944) invented the points plotted in the central diamond-shaped field may have areas proportional to total concentrations, and are located by extending the points in the anion and cation triangle to the points of intersection.

To use the Piper-Trilinear Diagram according to Zaporozec A. (1972), the percentage plotting of cations and anions had been plotted separately in the triangle

(Figure 3.2). The intersection of lines extended from the points to the central rectangular field gives a point representing a type of water. From that point, lines drawn to adjacent rectangles give points showing total concentration scale in mg/l or g/l and any other optional characteristic constituent of the water in mg/l. Ions of lesser importance to the problems studied are usually located at the vertices of triangles farther from the central field.

3.4 Report Writing

The format is given during the writing of this report. As all of the properties of a scientific writing, they must be accurate, coherent and concise since a scientific writing can be a reference to further and other scientific study. Most importantly, a scientific report should have clearly stated the objectives, discussions and the applications of results also the conclusions of the study too.

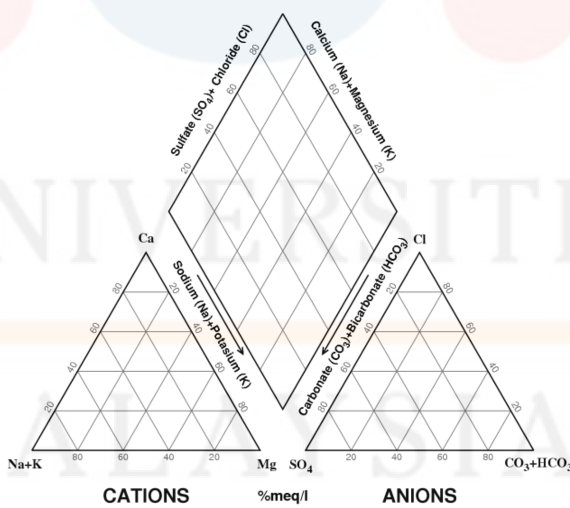


Figure 3.2: Piper-Trilinear Diagram

CHAPTER 4

GENERAL GEOLOGY

4.1 Introduction

Geology appeared to be an investigation on the history of evolution in a particular area from the past until the recent status (Nur Hayati Hussin, 2011). This chapter will describes further about the general geology of the study area with regard to geomorphology, alluvium mapping, soil analysis, and Quaternary stratigraphy. A traversing map in Figure 4.1 has been produced by using ArcGIS 10.2. The map shows the coverage of study area throughout the field mapping period. Most of the waypoints marked in the map is the point where the water and soil samples collected.

4.2 Geomorphology

According to Osterkamp, W. R. (2008), geomorphology is the study of landforms including investigations into the processes that cause and change onto landforms especially in the present times. The geomorphology of this study area comprises from topography, drainage, and weathering and erosion.

4.2.1 Topography

According to the classification of topographical units based on mean elevation made by Raj (1982) that is shown in Table 4.1, the study area has two classes from the unit which is low lying that has mean elevation less than 15m and rolling which has mean elevation of 16 to 30m. The topographical map in Figure 4.2 shows the distribution of the topographic units.

Table 4.1: Topographic unit based on mean elevations (Raj, 1982)

Topographic Unit	Mean Elevation (metres above sea level)
Low Lying	Less than 15
Rolling	16 – 30
Undulating	71 – 75
Hilly	76 – 300
Mountainous	More than 300

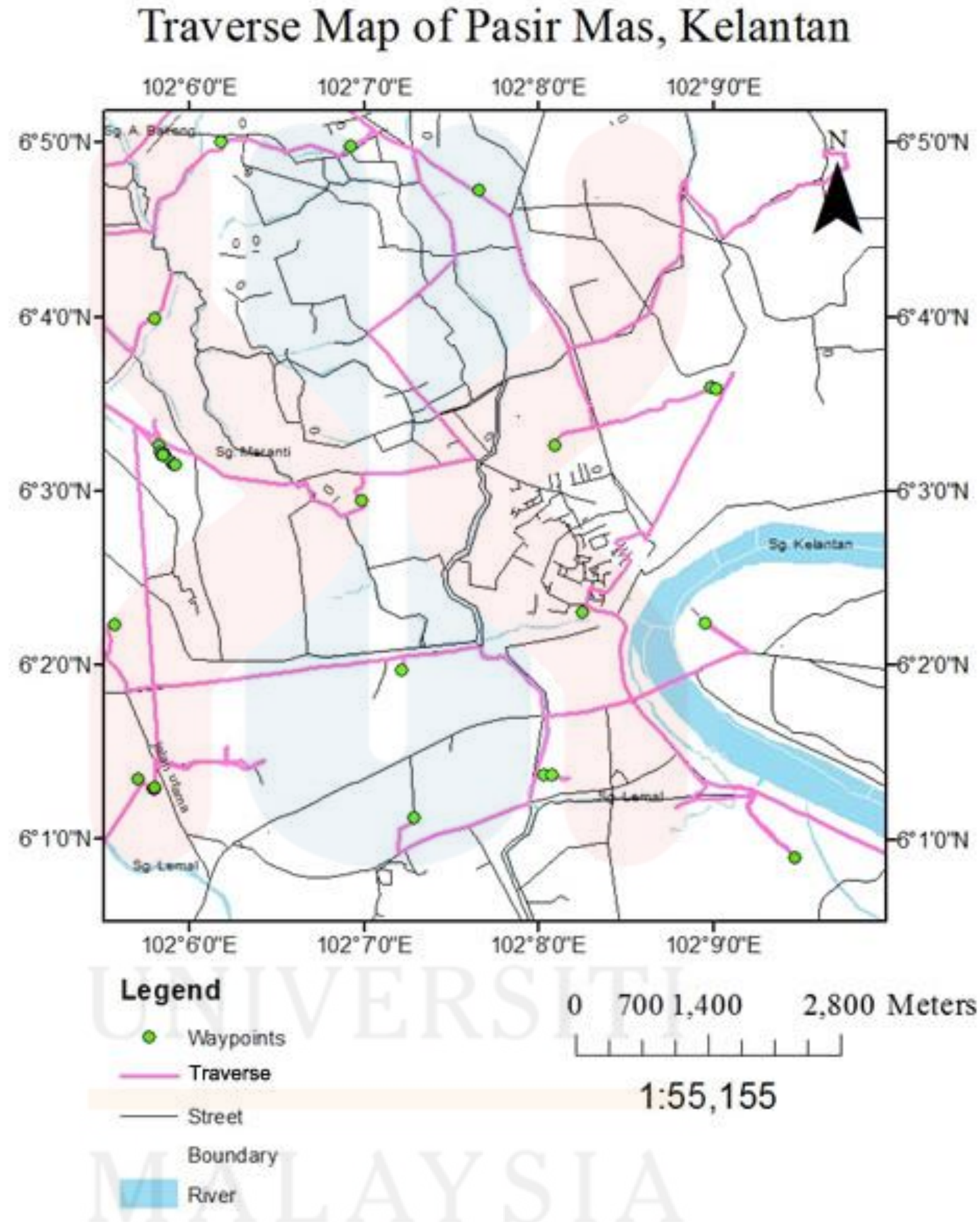


Figure 4.1: Traverse Map of Pasir Mas, Kelantan

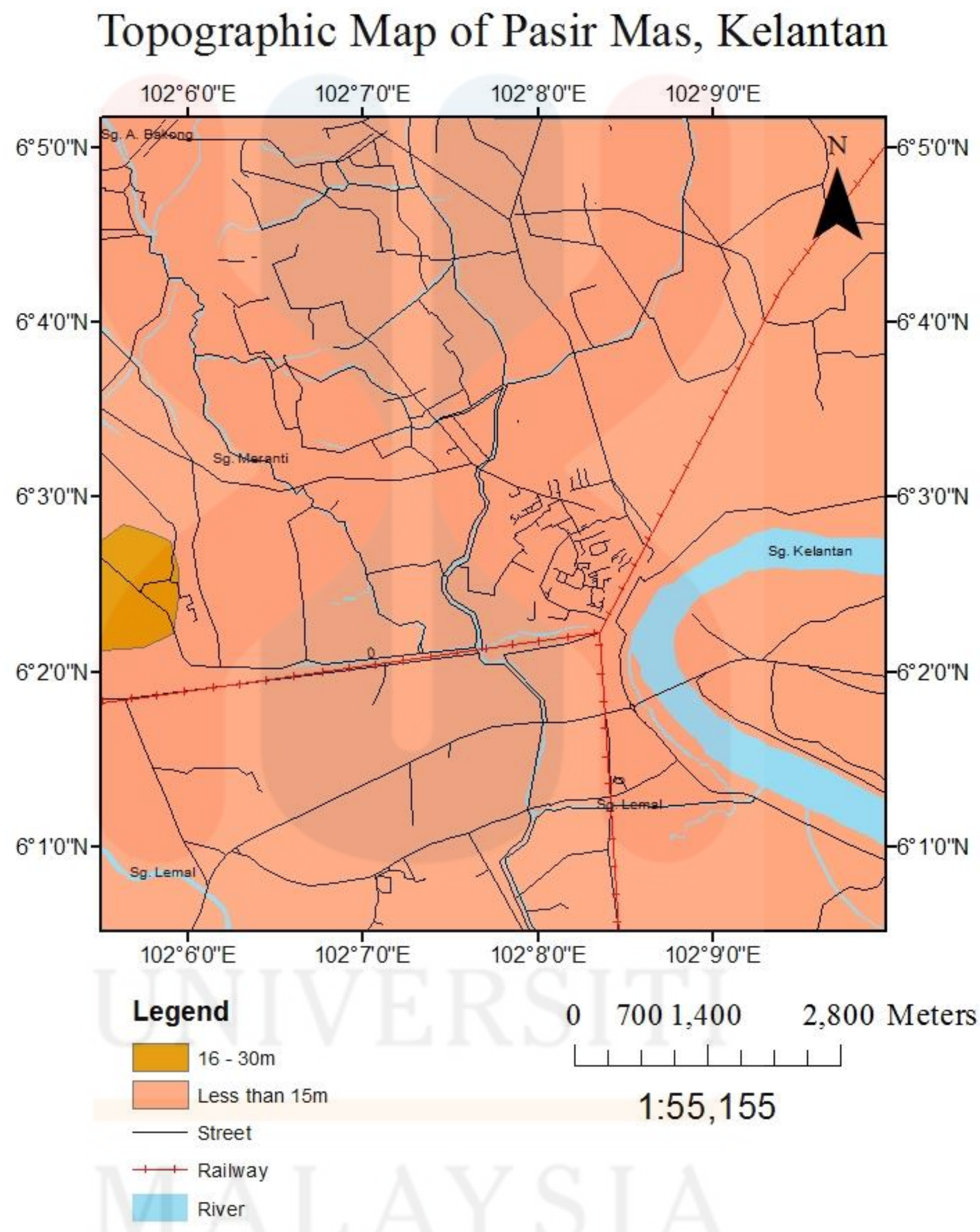


Figure 4.2: Topographic Map of Pasir Mas, Kelantan

4.2.2 Drainage Pattern

There are a number of drainage pattern relatively to the main river which is Sungai Kelantan that can be found in the study area. Based on Figure 4.4, we can see that the connection river shows meander forms and dendritic pattern. A detailed figure of the pattern is shown in Figure 4.5.

4.2.3 Weathering and Erosion

In accord to C.S Hutchison and D.N.K Tan (2009), Kelantan has been part of East Coast where they are facing to South China Sea without any protective barrier. In prior to that, Kelantan is dominated by several linear stretches of sandy beach of different width. There are both chemical and physical weathering occurs in Pasir Mas Kelantan. One of the weathering agents involved is water. The increasing velocity of flowing river water might be affecting the river banks and later it's eroded into smaller grains like sand and silts. The result of the weathered river banks will widen the river valley causing the meandering of river. Then, the sediments will be deposited from the eroded highland area to the lowland area cause the formation of flood plain and alluvial plain. Figure 4.3 shows the geomorphology of flood plain and sand bar in Sungai Kelantan, Pasir Mas. As for geomorphology of sand bar, it is formed in water caused by currents or tides of the river. The next weathering agents will be the temperature of the surrounding. The changes in temperature will be causing a thermal stress onto the alluvium. Hence, alluvium's outer layer will be started to fall off due to the changes of high to low temperatures.

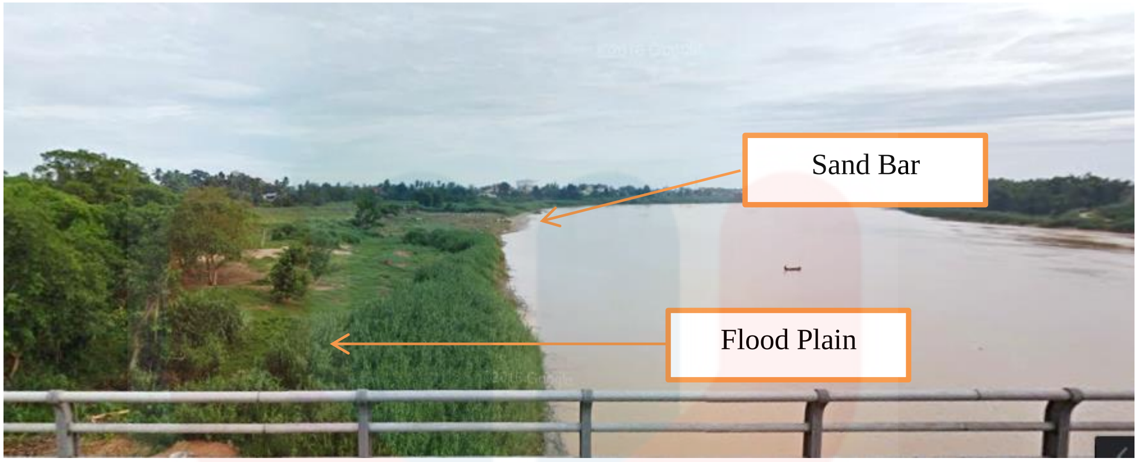


Figure 4.3 : Flood Plain and Sand Bar of Sungai Kelantan (Source: Google Maps)

4.3 Alluvium Mapping

The alluvium mapping is conducted by collecting the soil sample from depth intervals of 0cm to 50cm in the location as listed in Table 4.1. By doing sieving analysis, it will be easier to inspect the grain of each soil sample. Hence, a soil profile can be made in prior to the soil colour, grain size and soil moisture as shown in Table 4.2. Figure 4.7 shows the updated alluvium map of Pasir Mas Kelantan that consists of interbedded clay, silt, sand and gravels.

The collected data was then interpreted by using ArcGIS 10.2 based on the data provided by JUPEM. The previous map in Figure 4.6 indicates that the current morphology of the river has been eroded and widen its valley even more.

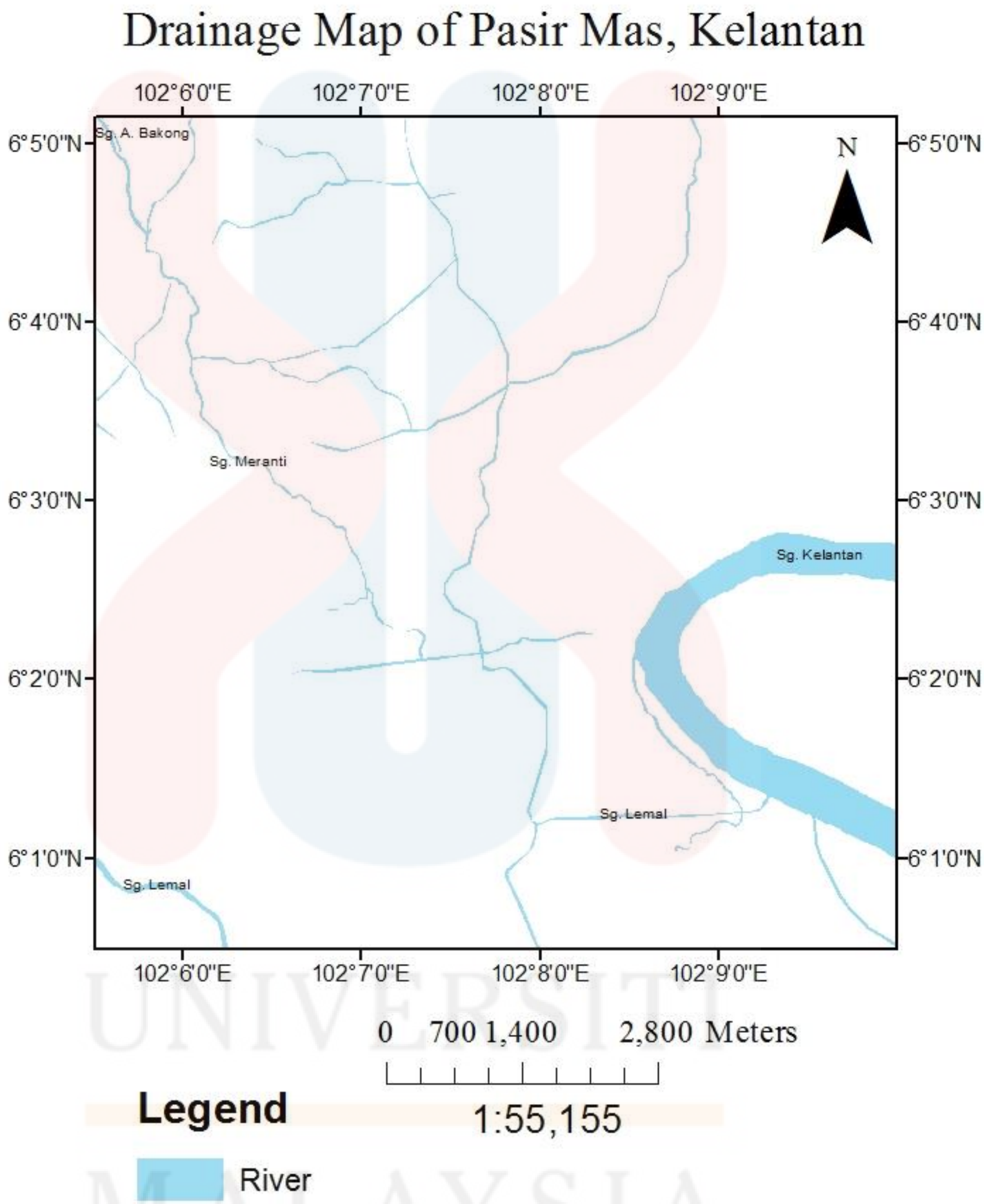
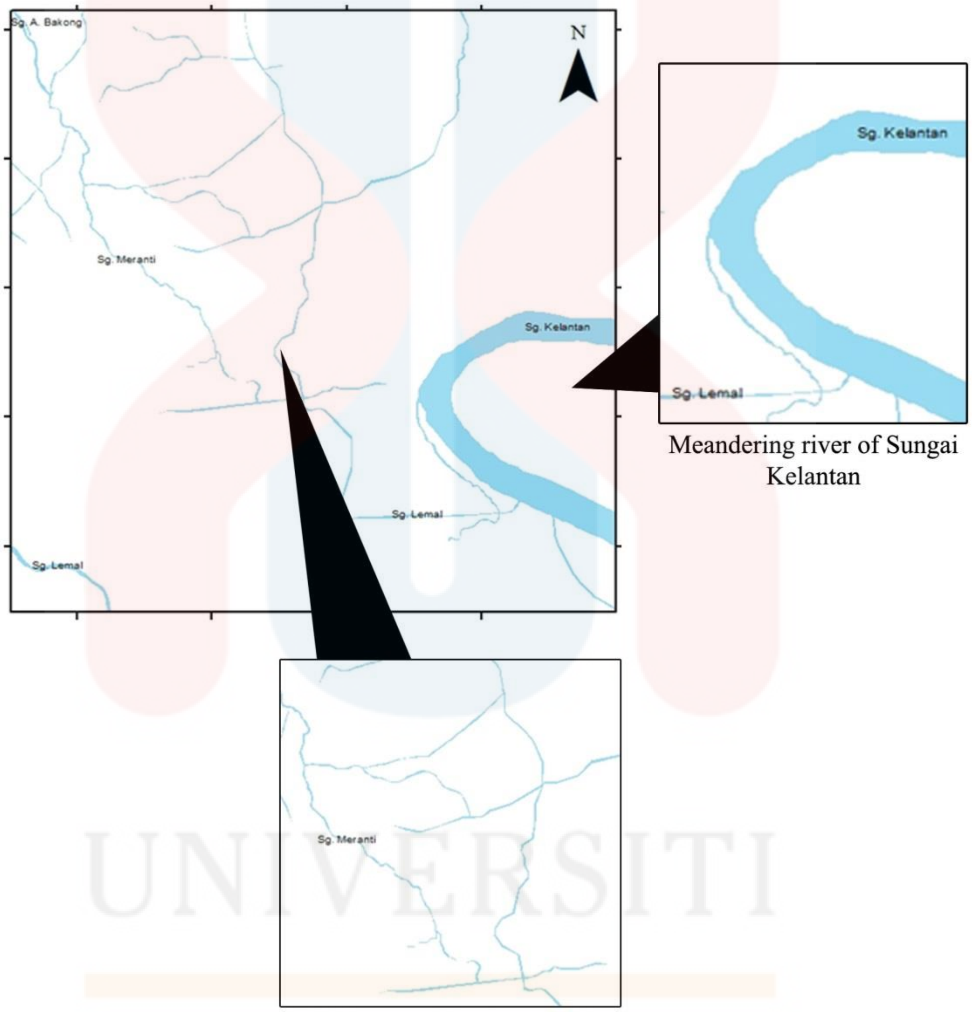


Figure 4.4: Drainage Map of Pasir Mas, Kelantan



Dendritic Pattern of Drainage in Pasir Mas

Figure 4.5: Detailed of Drainage Forms and Pattern in Study Area

Table 4.2: Soil Sampling Location

Station ID	Latitude	Longitude	Location	Elevation (m)
Soil 1	N 06º0’53.6”	E 102º09’28”	Kampung Jebak Puyoh	13
Soil 2	N 6º3’35.4”	E 102º8’59.1”	Kg. Kubang Bemban	17
Soil 3	N 6º4’58.5”	E 102º6’54.3”	Kg Kubang Kekura	18
Soil 4	N 6º3’12.4”	E 102º5’50.6”	Kg Gajah Mati	19
Soil 5	N 6º1’17.6”	E 102º5’48.1”	Kg. Lubok Jong	20

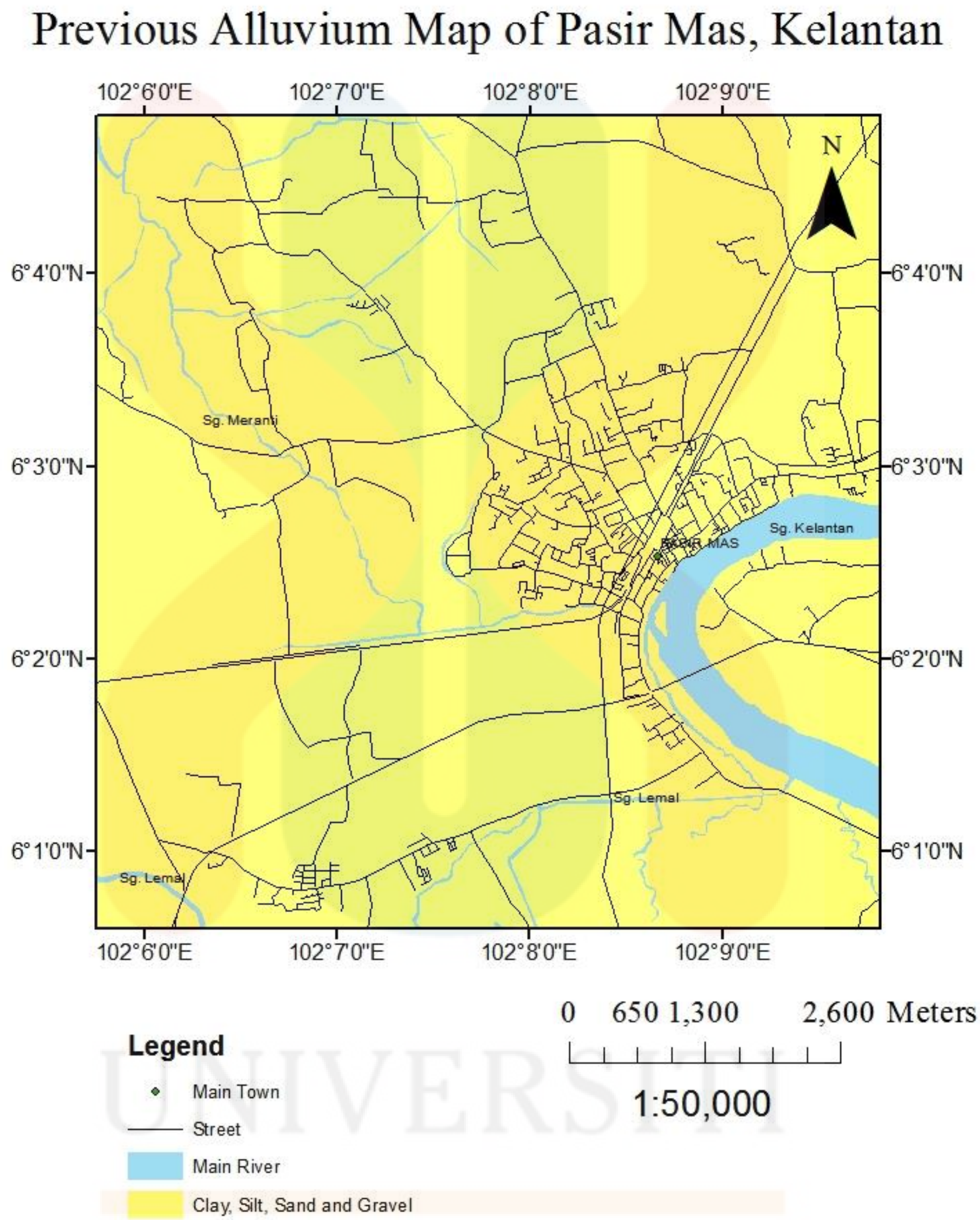


Figure 4.6 : Previous alluvium map of Pasir Mas, Kelantan (Source : JUPEM)

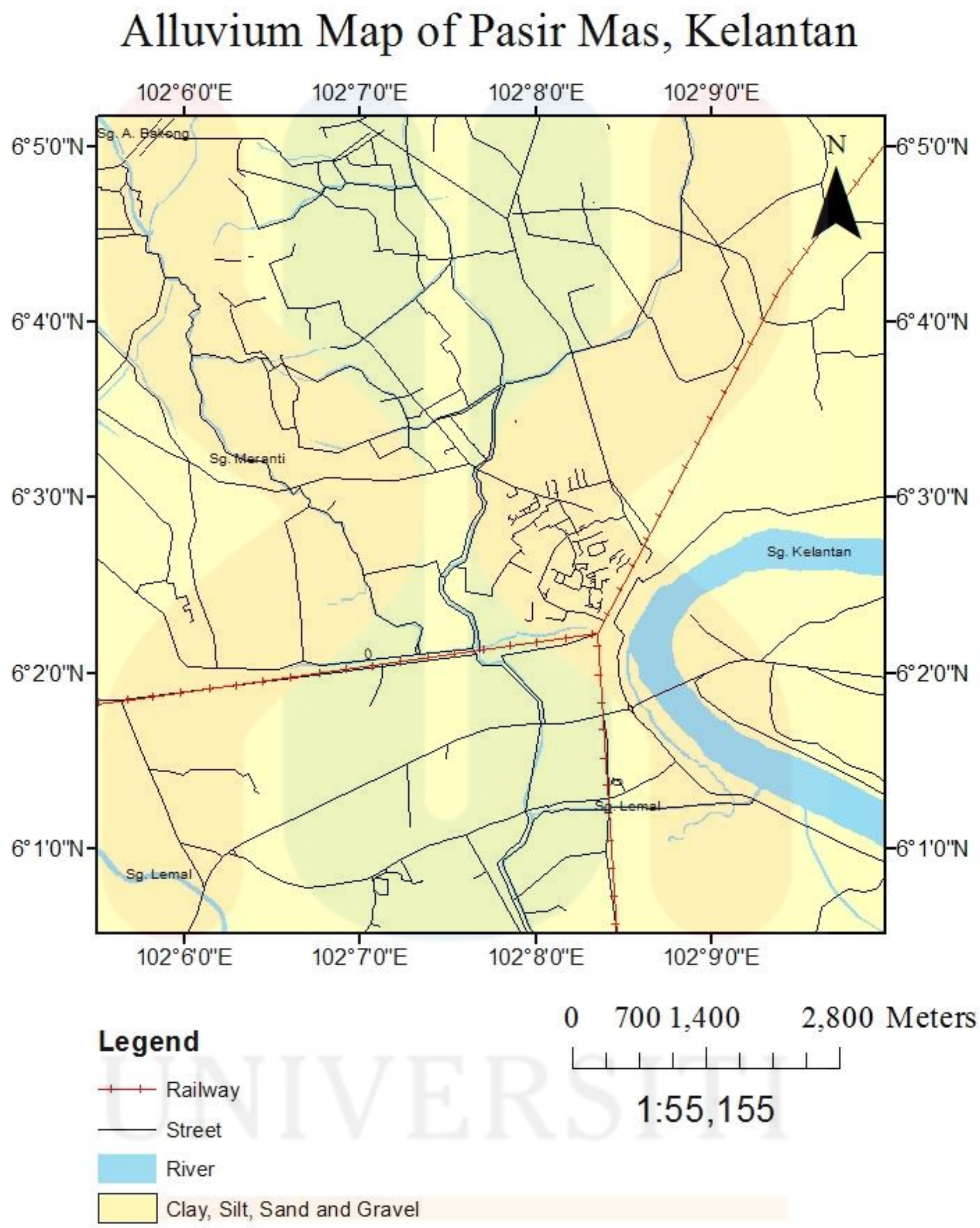


Figure 4.7: Updated alluvium map of Pasir Mas, Kelantan

4.4 Soil Analysis

Soil Analysis was conducted by interpreting the recorded data to the profile of soil samples with each was drilled in the depth interval of 0cm to 50cm. The depth at every 10cm intervals clearly shows the change of colour, grain size and moisture together with pH. Table 4.2 shows the soil profile with each properties. The collection of soil sample was drilled at unharvest land to avoid any textural changes to the sample collected.

According to Kresic. N (2006), there are four significance of grain analysis in hydrogeological practice. One of the significance is to help to determine the uniformity coefficient of the soil. Other than that, it helps to determine the effective grain size which become the main factor of groundwater flow in soil. Moreover, it is important in designing the gravel pack around the well screens and drains. Last but not least, grain analysis helps to obtain the hydraulic conductivity of the soil.

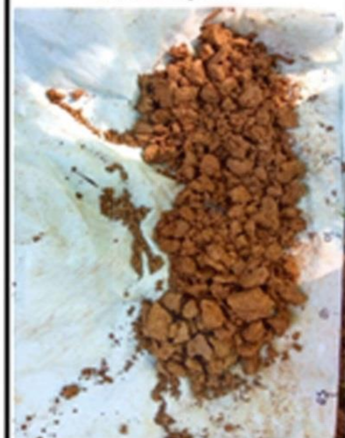
In accord to Azlan et al. (2012) that has done a study on the correlation between soil content and the percentage of water content, the findings had concluded that the higher the clay compositions, the higher the water content. The relationship is significant to the water holding capacity of clay which is the porosity. Clay has small pores that concluding them to have a high water holding capacity which is good in agricultural industry since it influences the humidity needed for bacterial growth. However, according to Raymond Jr L. S (1988), clay is not good for water source since it has really small pores that will create friction and abrupt the water movement. Therefore, clay can be a good confining layer that will protect from surface contamination.

A previous study of soil analysis in Kelantan has been made by M.Saleem et al. (2010). This research study is about Boron, B content for samples collected in paddy growing areas around Kelantan. Paddy field has comprised many percentage of the land use in Pasir Mas, Kelantan. The study shows there are no soils collected contains higher than 1mg of Boron. Thus, the soil may be deficient in B status according to Bingham (1982). Heavy rainfall could affect Boron deficiency because of leaching losses. Thus, leaching through the vadose zone to the water table might be a great concern due to the implication towards low groundwater quality if the content exceeds the optimum standard made by the authorize party.

4.5 Quaternary Stratigraphy

Pasir Mas, Kelantan is among places that ages at Quaternary which is mainly consisting riverine alluvium. This can be shown by the study of Nur Hayati Hussin (2011) in the geological map of northern part of Kelantan in Figure 4.8. The quaternary deposit in northern part of Kelantan can be classified into two deposits which is Pleistocene and Holocene deposit as been mapped by Bosch (1986). Both of the quaternary deposits contain clay, silt, sand and gravel. The study area represented by the green box in this figure shows that it has been categorized as Pleistocene and Holocene deposit which is classified under Simpang/Beruas Formation.The depositional environment is fluvial in accord to Suntharalingam & Teoh (1985) and Loh (1992) based on Nur Hayati Hussin (2011).

Table 4.3: Soil Profile

Soil Sample	Depth	Colour	Grain Size	pH	Moisture
Soil Sample 1 	0 cm – 20 cm	Light Red	Silt Clay	6.8	1
	20 cm – 50 cm	Dark Red			
Soil Sample 2 	0 cm – 20 cm	Red	Silt Clay	6.9	3
	20 cm – 50 cm	Brown			
Soil Sample 3 	0 cm – 20 cm	Light Yellow	Silt Clay	6.9	4
	20 cm – 50 cm	Dark Red			

Soil Sample 4 	0 cm – 20 cm: Grey 20 cm – 50 cm: Dark Grey (0 cm, 10 cm, 20 cm, 30 cm, 40 cm, 50 cm)	Silt Clay Sand	6.6	3
Soil Sample 5 	0 cm – 20 cm 20 cm – 50 cm (0 cm, 10 cm, 20 cm, 30 cm, 40 cm, 50 cm)	Silt Clay Sand	6.8	3

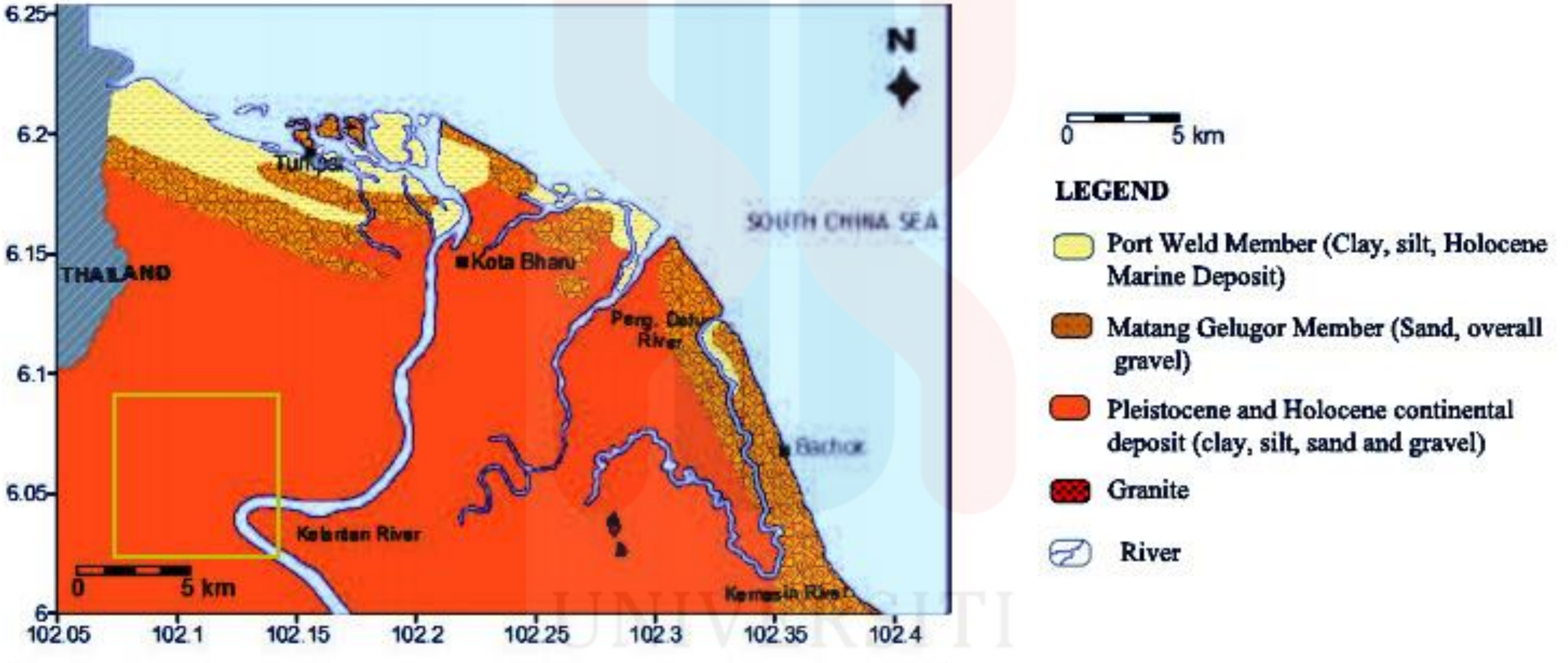


Figure 4.8: Geological map of northern part of Kelantan (Nur Hayati Hussin, 2011)

CHAPTER 5

RESULTS AND DISCUSSION

5.1 Introduction

Solutes and gases content as well as suspended matters can be determined in order to achieve the result of water quality (Fetter C.W., 2000). Hence, by studying the major ion concentration of the water, we can conclude the suitable water quality is ready to be consumed. Groundwater can be used for many purposes including irrigation, domestic, and even for drinking. Each of the purposes has its own standard water parameters which have been classified by the authorities such as World Health Organization (WHO) and Ministry of Health (MOH).

An analytical study of major ion has been made through a comparison assessment with the parameter standards set by WHO and MOH through the sample collected in Pasir Mas, Kelantan as shown as in in Figure 5.1 and listed in Table 5.1. The sample is collected by using grid systems. The base map of the study area has been divided into 16 grid section in order to cover the whole study area. Major ions like Na+, K+, Ca2+, Mg2+, HCO3-, Cl-, SO2-4, NO3- and F- has been analyzed by using several methods such as Atomic Absorption Spectrophotometer (AAS), Alkalinity and Gravimetric Titration, and also Colorimetric Method. The result of the chemical analysis is as shown in Table 5.2 while the in-situ analysis result is as shown in Table 5.3.

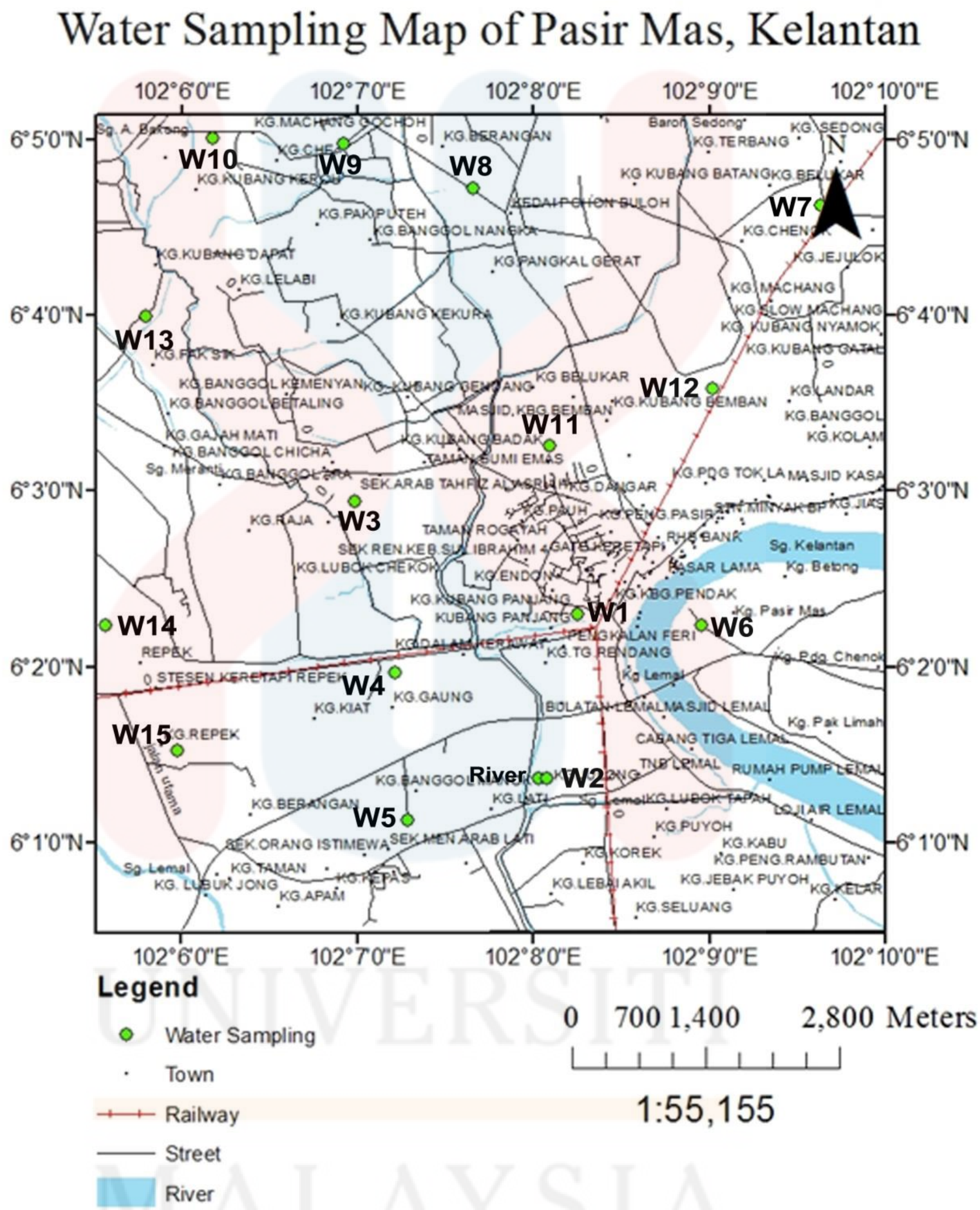


Figure 5.1: Water Sampling Location Map of Pasir Mas, Kelantan.

Table 5.1: Water sampling location in Pasir Mas, Kelantan.

Station ID	Location Name	Latitude	Longitude	Elevation (m)
Well 1	Kg. Lemal	N 6º2’17.9”	E 102º8’15.2”	14
Well 2	SK Lati	N 6º1’21.7”	E 102º7’59”	13
Well 3	Banggol Chicha	N 6º2’56.5”	E102º6’59.2”	10
Well 4	Kg Gaung	N 6º1’58”	E 102º7’12.9”	10
Well 5	Kg Banggol Manok	N 6º1’7.4”	E 102º7’17.2”	13
Well 6	Kg. Seberang Pasir Mas	N 6º2’14.2”	E 102º8’57.5”	15
Well 7	Kg. Tanjung Chenak	N 6º4’39.9	E 102º9’42.3”	14
Well 8	Kg. Mat Lazim	N 6º4’43.5”	E 102º7’39.4”	8
Well 9	Kg Machang Gochoh	N 6º4’58.5”	E 102º6’55.2	8
Well 10	Kg. Kubang Hakim	N 6º5’0.3”	E 102º6’10.7”	10
Well 11	Kg. Dangai	N 6º3’15.6”	E 102º8’5.6”	13
Well 12	Slow Machang	N 6º3’35.1”	E 102º9’0.9”	15
Well 13	Kg. Gajah Mati	N 6º3 20.5”	E 102º5’47.81”	12
Well 14	Kg. Repek	N 6º2’13.9”	E 102º5’34.4”	16
Well 15	Kg. Tiong Chandi	N 6º1’ 32.64”	E 102º5’42.03”	15
River	Nearby SK Lati	N 6º1’21.9”	E102º8’01.9	10

Table 5.2: Physical Water Quality Parameters in Pasir Mas, Kelantan.

Station ID	Temperature (C°)	pH	DO (mg/l)	Conductivity (µS/cm)	TDS (mg/l)	Hardness (mg/l)	Salinity (mg/l)	TSS (ppm)	Turbidity (NTU)
Well 1	28.78	7.18	2.65	0.332	0.201	64.18	0.15	4	4.09
Well 2	29.30	6.9	1.84	0.143	0.086	8.83	0.06	3	1.65
Well 3	28.95	6.69	2.17	0.334	0.208	30.55	0.15	2	1.93
Well 4	28.11	6.00	0.35	0.115	0.071	7.99	0.05	7	25
Well 5	29.54	5.41	1.95	0.039	0.023	2.60	0.01	4	3.72
Well 6	28.00	6.28	1.22	0.371	0.229	6.59	0.17	3.8	-
Well 7	28.14	5.93	0.50	0.141	0.092	12.13	0.07	2	1.58
Well 8	28.29	6.02	0.22	0.232	0.142	12.54	0.10	16	12.4
Well 9	29.46	6.4	1.00	0.74	0.104	13.93	0.07	14	-
Well 10	28.39	5.87	1.29	0.137	0.084	6.51	0.06	6	1.15
Well 11	28.99	6.27	0.34	0.144	0.087	17.50	0.06	5	7.2
Well 12	28.06	6.37	1.25	0.173	0.107	6.49	0.08	4	4.05
Well 13	28.62	6.02	0.32	0.134	0.082	5.92	0.06	48	42.2
Well 14	29.44	5.92	1.42	0.123	0.074	4.31	0.05	3	4.11
Well 15	28.79	5.55	1.10	0.078	0.047	2.18	0.03	2	0.92
River	29.98	5.96	3.12	0.028	0.017	4.48	0.01	1.21	-

Table 5.3: Chemical Water Quality Parameters in Pasir Mas, Kelantan.

Station ID	HCO_3^- (mg/l)	Cl^- (mg/l)	SO_4^{2-} (mg/l)	F (mg/l)	NO_3^- (mg/l)	Na^{2+} (mg/l)	K^+ (mg/l)	Ca^{2+} (mg/l)	Fe^{2+} (mg/l)	Mg^{2+} (mg/l)
Well 1	212.50	80.94	2.10	0.48	0	14.89	9.857	22.94	3.636	1.658
Well 2	97.50	46.86	1.22	0.48	0	5.777	6.105	0	3.664	2.143
Well 3	425.00	74.55	2.25	0.44	1.4	15.09	9.865	7.540	3.887	2.839
Well 4	110.00	51.12	2.73	0.20	2.9	12.90	8.122	0	4.443	1.939
Well 5	95.00	60.35	3.34	0.28	0	7.823	6.932	0	4.124	0.631
Well 6	112.50	71.00	5.36	0.32	2.9	13.25	3.568	0	4.205	1.599
Well 7	287.50	51.12	5.98	0.21	0	14.76	8.832	0	4.242	2.943
Well 8	137.50	59.64	4.60	0.32	0	15.14	9.227	0	4.507	3.043
Well 9	462.50	46.86	1.39	0.32	1.2	5.389	9.993	0	4.107	3.380
Well 10	60.00	58.93	3.37	0.16	0	13.34	9.070	0	3.850	1.580
Well 11	210.00	51.12	2.42	0.48	0.6	14.54	6.220	0	4.259	4.247
Well 12	340.00	54.67	3.38	0.24	0.9	13.19	5.114	0	4.119	1.576
Well 13	65.00	56.80	5.30	0.48	0.7	9.167	9.504	0	4.091	1.436
Well 14	105.00	46.15	3.31	0.36	0	11.70	6.068	0	4.327	1.045
Well 15	155.00	41.18	4.00	0.43	0	7.985	6.026	0	3.642	0.528
River	60.00	54.67	1.31	0.26	0	3.813	2.212	0	5.279	1.087

Table 5.4: Water Level in Pasir Mas, Kelantan.

Station ID	Location Name	Latitude	Longitude	Well Depth (m)	Elevation (m asl)	Well height from surface level (m)	Depth to water level (m bgl)	Water Contour (m)
Well 1	Kg. Lemal	N 6º2'17.9"	E 102º8'15.2"	6.18	14	1.08	1.78	12.22
Well 2	SK Lati	N 6º1'21.7"	E 102º7'59"	4.6	13	0.97	1.63	11.37
Well 3	Banggol Chicha	N 6º2'56.5"	E102º6'59.2"	4.63	10	0.93	1.25	8.75
Well 4	Kg Gaung	N 6º1'58"	E 102º7'12.9"	4.54	10	0.64	1.23	8.77
Well 5	Kg Banggol Manok	N 6º1'7.4"	E 102º7'17.2"	4.34	13	0.74	0.51	12.49
Well 6	Kg. Seberang Pasir Mas	N 6º2'14.2"	E 102º8'57.5"	15	15	0.9	7.1	7.9
Well 7	Kg. Tanjung Chenak	N 6º4'39.9	E 102º9'42.3"	3.22	14	0.9	0.59	13.41
Well 8	Kg. Mat Lazim	N 6º4'43.5"	E 102º7'39.4"	2.16	8	0.73	0.11	7.89
Well 9	Kg Machang Gochoh	N 6º4'58.5"	E 102º6'55.2	3.87	8	0.8	0.59	7.41
Well 10	Kg. Kubang Hakim	N 6º5'0.3"	E 102º6'10.7"	4.35	10	0.68	2.05	7.95
Well 11	Kg. Dangai	N 6º3'15.6"	E 102º8'5.6"	0.78	13	3.83	-2.9	11.1
Well 12	Slow Machang	N 6º3'35.1"	E 102º9'0.9"	3.44	15	1.1	0.53	14.47
Well 13	Kg. Gajah Mati	N 6º3 20.5"	E 102º5'47.81"	3.85	12	0.74	0.46	11.54
Well 14	Kg. Repek	N 6º2'13.9"	E 102º5'34.4"	4.68	16	0.63	0.84	15.16
Well 15	Kg. Tiong Chandi	N 6º1' 32.64"	E 102º5'42.03"	4.96	15	1.26	0.53	14.47

5.2 Groundwater Movement

There are laws that controlled the groundwater flow, which is law of physics and thermodynamics (Fetter C.W., 2000). The direction of groundwater flow is from high elevation to the lower elevation. A water contour and water level map was done by using the data from Table 5.4 that shows the water level and water contour recorded from the wells in the study area. Hence, the groundwater movement will be shown in the both maps in Figure 5.3 and Figure 5.4 respectively.

5.2.1 Water Level

According to the recorded data listed in Table 5.4, Figure 5.2 shows the distribution of water level height in 3D map. From the map, we can see the pattern of the water level that indicates the recharge and discharge of the water.

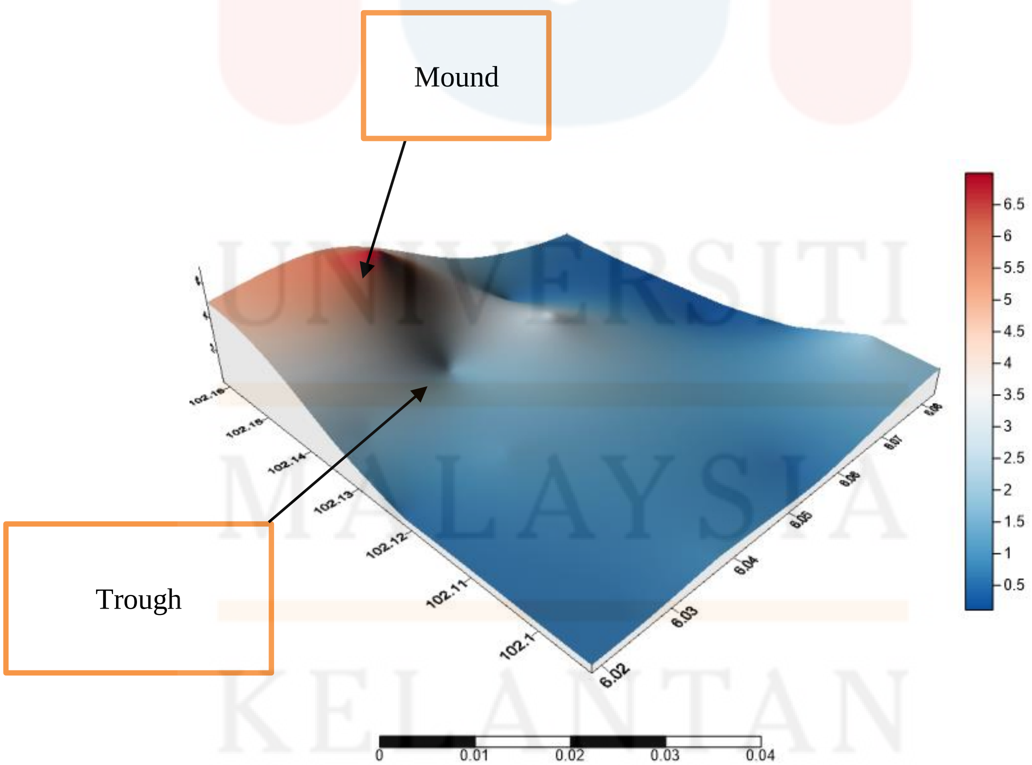


Figure 5.2: 3D Water Level Map

5.2.2 Water Contour Map

In order to produce a water contour map, the elevation of location's surface is subtracted to the depth to water. The data is then interpreted by using Surfer 8 software as shown in Figure 5.3 and its 3D map in Figure 5.4. The arrow shown in the both figures indicates the movement of groundwater from higher elevation to the lower elevation. From the movement of groundwater in the study area, we can conclude that it is gaining stream since it is discharged towards the river located at the east of the map.

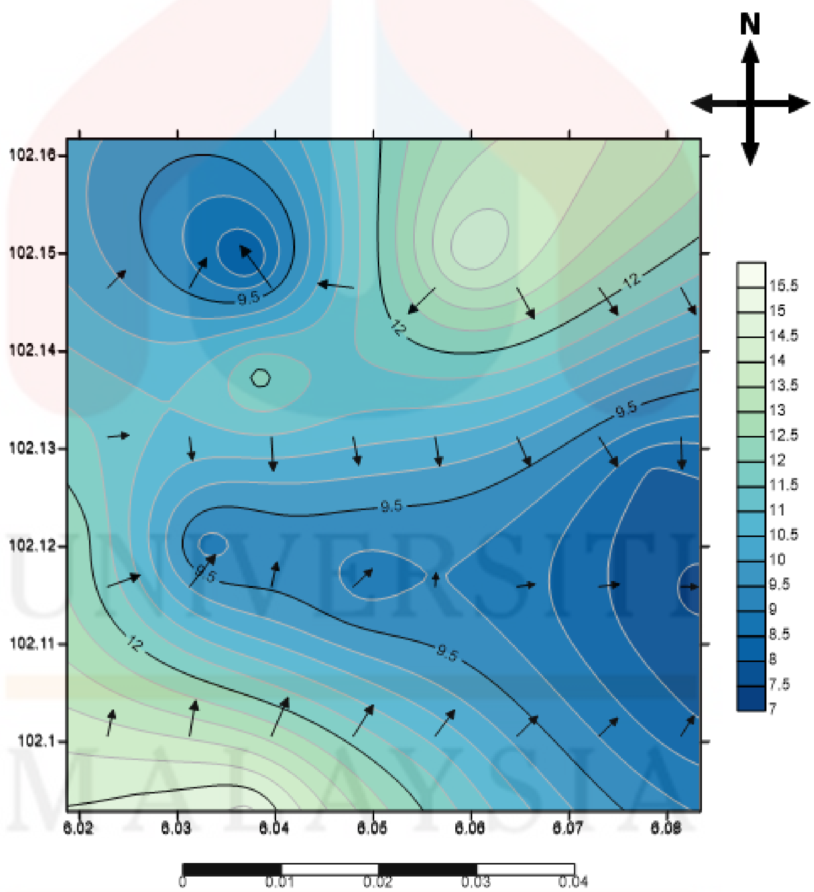


Figure 5.3: Water Contour Map

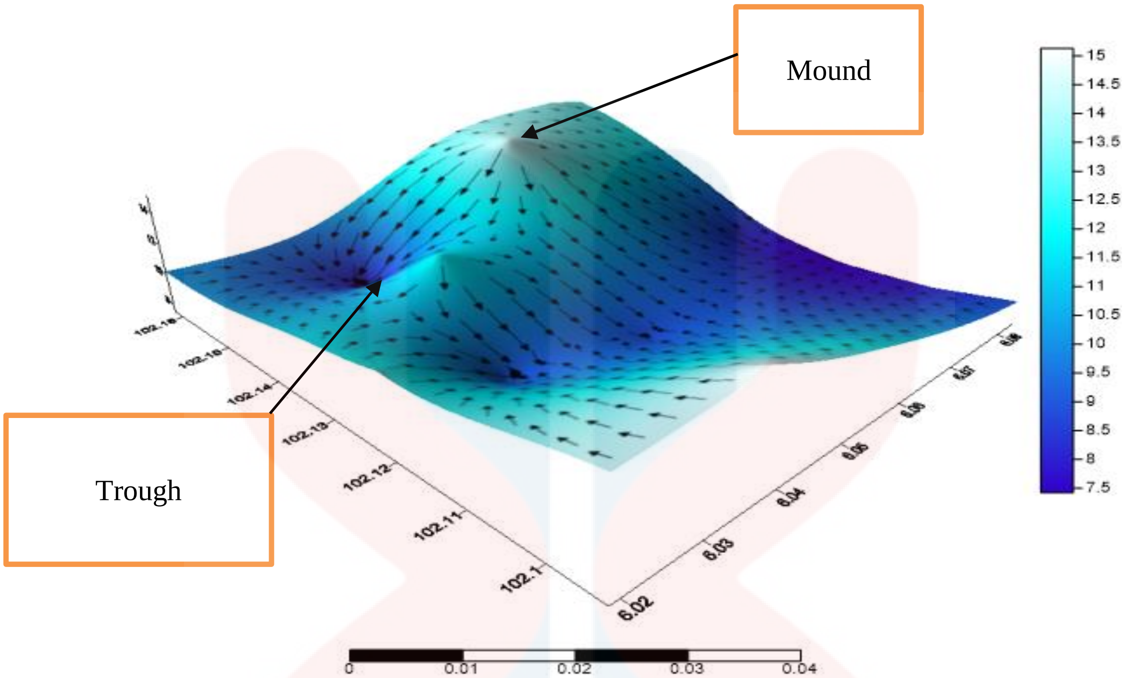


Figure 5.4: 3D Water Contour Map

5.3 Physical Parameter

There are a total of seven physical parameter of water that had been analyzed in this research study. They are the potential hydrogen (pH), temperature, electrical conductivity, total suspended solids, turbidity, salinity and the total dissolved solids (TDS). These parameters were all analyzed by using YSI Multi-Paramater, and TSS Portable, and HACH Turbidimeter.

5.3.1 Potential Hydrogen (pH)

Potential Hydrogen (pH) is one of the vital properties for the standard of water quality which could give an indirect impact to our health. The fundamental of pH is being classified in two, which is alkaline where the pH value has more than 7 while for acidity has the pH value of less than 7. The optimum pH that has been standardized by

World Health Organization (WHO) is ranging from 6.5 to 8.5 whilst based on Minister of Health (MOH) standard lies between 6.5 to 9.0.

Based on Figure 5.5, the highest pH among the Well Sample recorded is Well 1 which is 7.18, categorized as alkaline while the lowest pH value is 5.41, which is categorized as acidic. The highlighted cells in Table 5.2 indicates the Well Sample that is not following MOH and WHO guidelines. According to WHO (2003), the lower pH values will lead to the corrosion which will indirectly affect the consumer's health.

To conclude, the only well sample that is within the MOH and WHO standards for pH value is Well 1, 2 and 3 while the other well samples and one sample from river nearby SK Lati is below the standards.

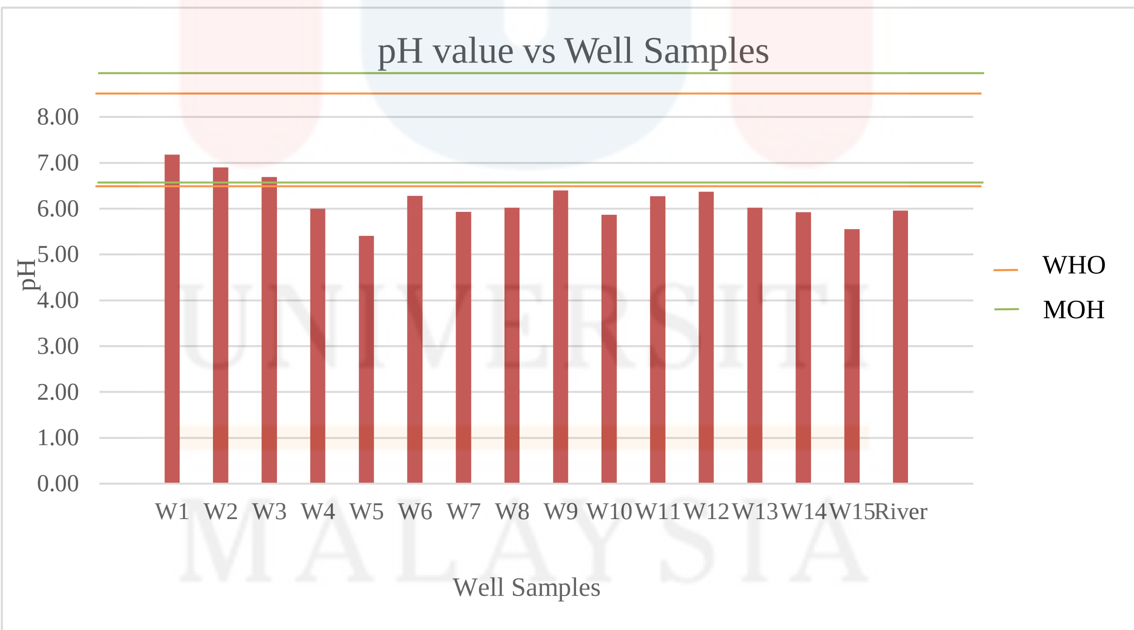


Figure 5.5: The pH values versus Well Location

5.3.2 Temperature

Temperature is one of the most important parameter in water since it could change their physical and chemical properties. The increasing of water temperature is usually will be influenced by the sunlight or heat transfer from the atmosphere. Thus, the highest temperature recorded in the study area based on the chart in Figure 5.6 is water sample from river as it is the most possible sample that has higher exposure towards sunlight and the atmosphere. While among the lowest temperature of water sample in the study area is W4, W6, and W12 since the wells is placed inside of the house of the well owner and as a result it will lower the exposure towards the atmosphere and sunlight.

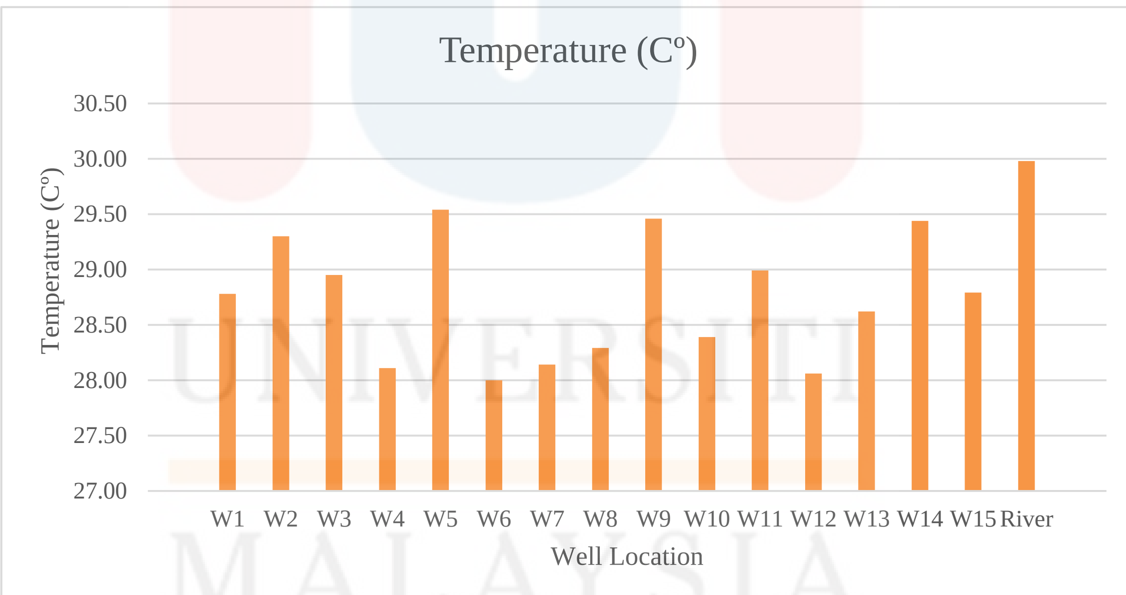


Figure 5.6: Temperature versus the Well Locations.

5.3.3 Electrical Conductivity (µS/cm)

The electrical conductivity (EC) in water is determined by the ability of the electrical flow to pass through the water. This happened since water contains ion that has conductive properties such as chlorides, sulphate, and also carbonates. Hence, the level of EC will be highly dependent on the content of the ions stated. Other than that, temperature also can be the factor of the alteration of EC reading. Based on Figure 5.7, the finding shows that Well 9 has the highest EC. In correlation with the content of its chloride and sulphate, both of the ions concentrate at high value. In addition, the sample from river should have high in EC due to the exposure to the atmosphere such as rain. This is because of rainwater always has high conductivity than fresh water.

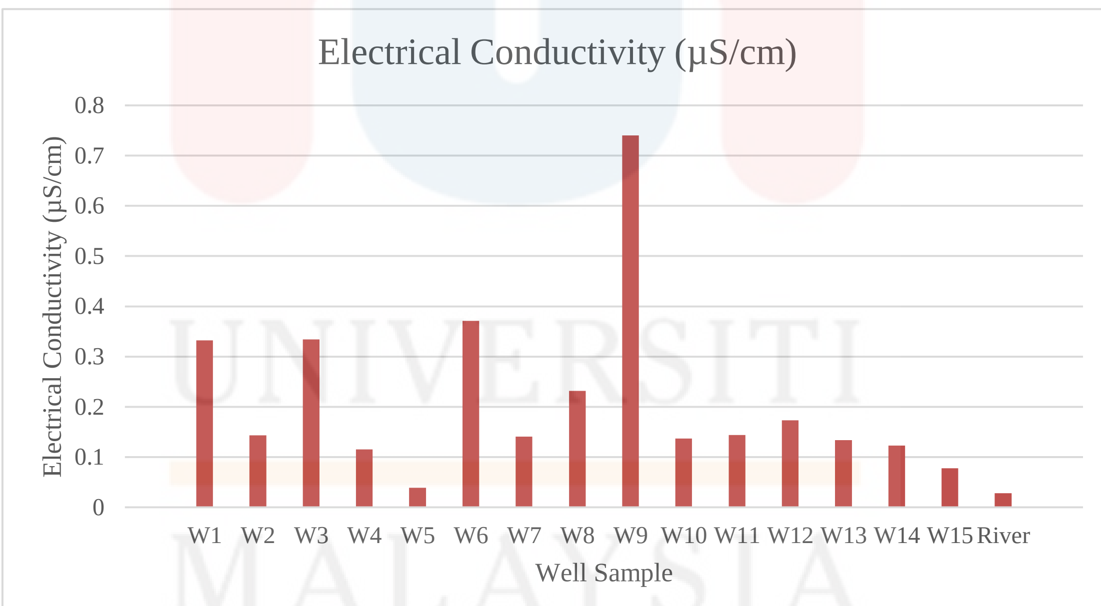


Figure 5.7: Electrical Conductivity versus Well Samples

5.3.4 Total Dissolved Solids

Total Dissolved Solids in the water could adding water palatability if its level is less than 600 mg/l. If the water has TDS level greater than 1000 mg/l, it could cause great scaling in pipes in household. Based on Figure 5.8, the water sample that has highest value of TDS is in Well 6 while the lowest value is in the river. The distribution of TDS value in 2D and 3D based on Figure 5.9 and Figure 5.10 respectively is higher from south to north direction. This can be correlated with the water movement which is directed from north to east according to higher elevation to lower elevation. It indicates that the TDS value will be high at the low elevations and low value at high elevations. However, none of the well contains more than the optimum level standardized by MOH and WHO, which is 900 mg/l and 1000 mg/l respectively.

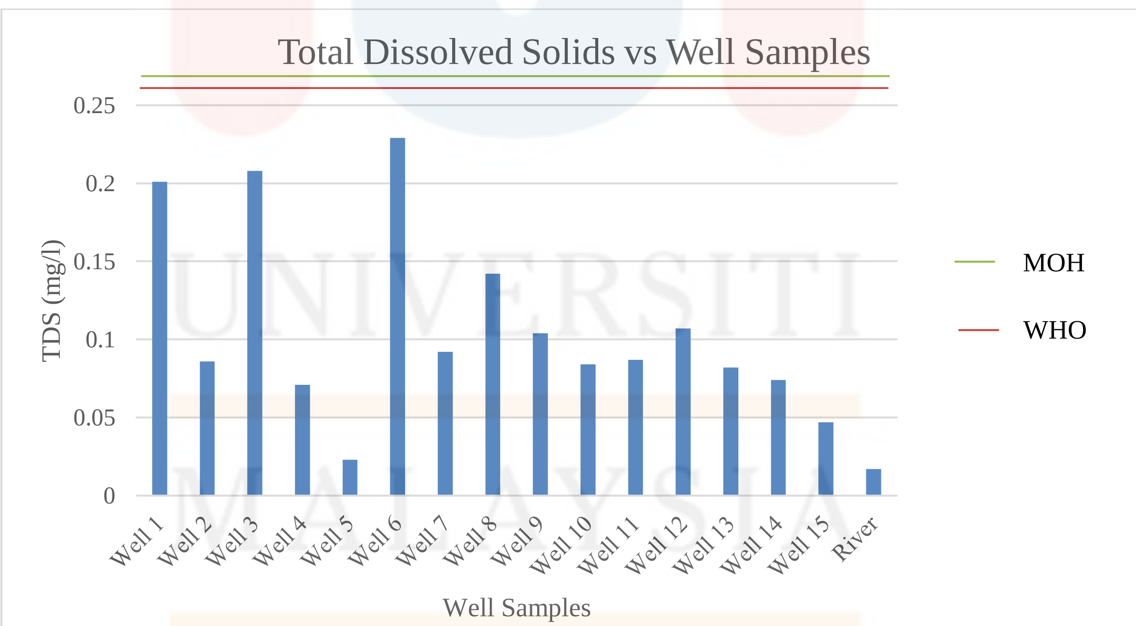


Figure 5.8: TDS value vs Well Samples

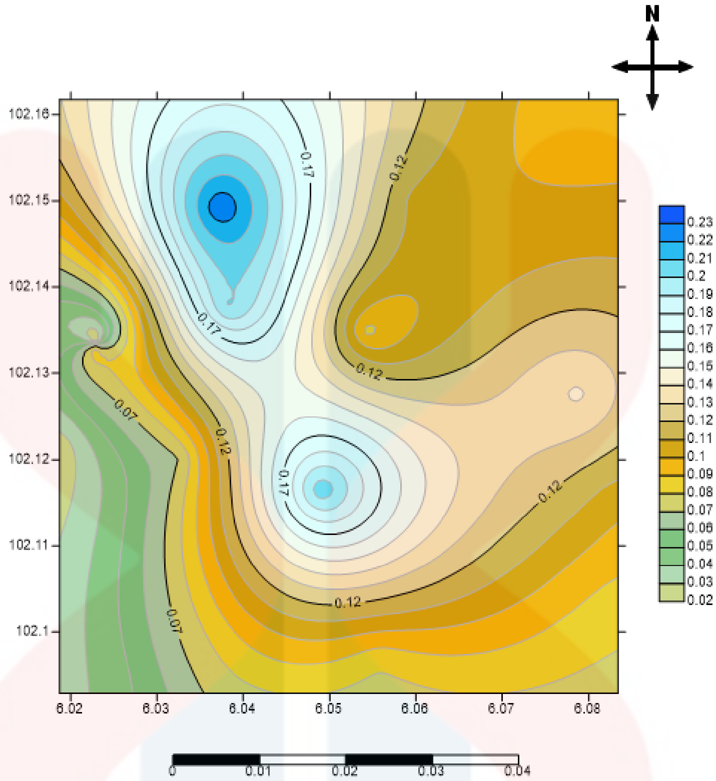


Figure 5.9: 2D Map of TDS Distribution

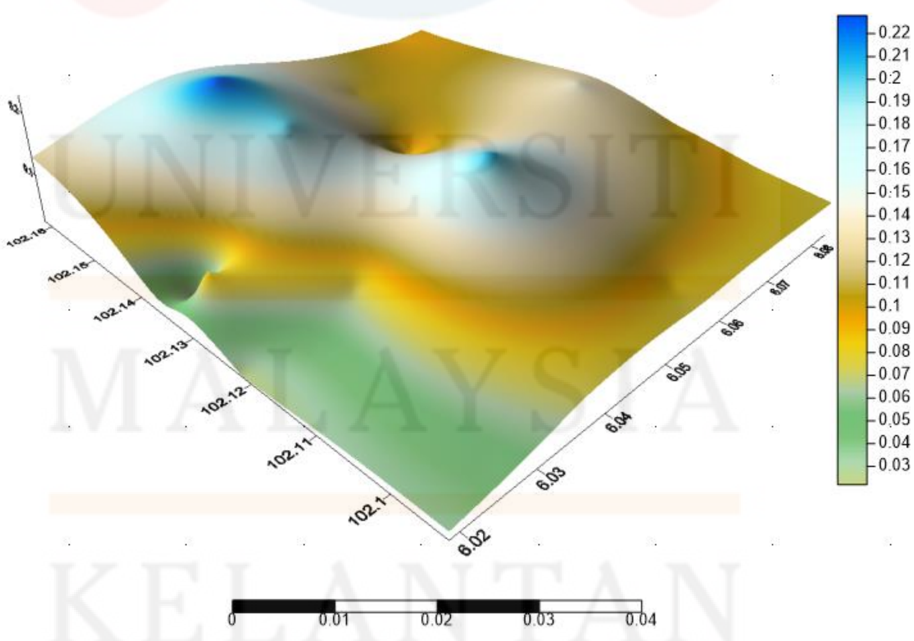


Figure 5.10: 3D Map of TDS Distribution

5.4 Major Ions

5.4.1 Anion

There are five anions that has been analyzed in this research study. They are bicarbonate, sulphate, chloride, fluoride and nitrate.

a. Bicarbonate (HCO_3^-)

High carbonate, CO_3 and bicarbonate, HCO_3^- increases the Sodium Adsorption Ratio (SAR) index more than 3-4meq/l or less than 180 to 240mg/l. This is because bicarbonate and carbonate ions combined with calcium or magnesium will precipitate as calcium carbonate (CaCO3) or magnesium carbonate (MgCO3) when the soil solution concentrates in drying conditions. The concentration of Ca and Mg decreases relative to sodium and the SAR index will be bigger. This will cause an alkalizing effect and increase the pH. Therefore when a water analysis indicates high pH level, it may be a sign of a high content of carbonate and bicarbonates ions. It the study area, the chemical analysis shows that three wells have concentration of bicarbonates more than 300 mg/l. They are Well 3, Well 9 and Well 12 while the well with lowest concentration is Well 10 based on Figure 5.11. While in Figure 5.12, the 2D map which is represented according to the recorded data shows that the distribution of bicarbonate concentration in groundwater of Pasir Mas, Kelantan is higher from east to west direction.

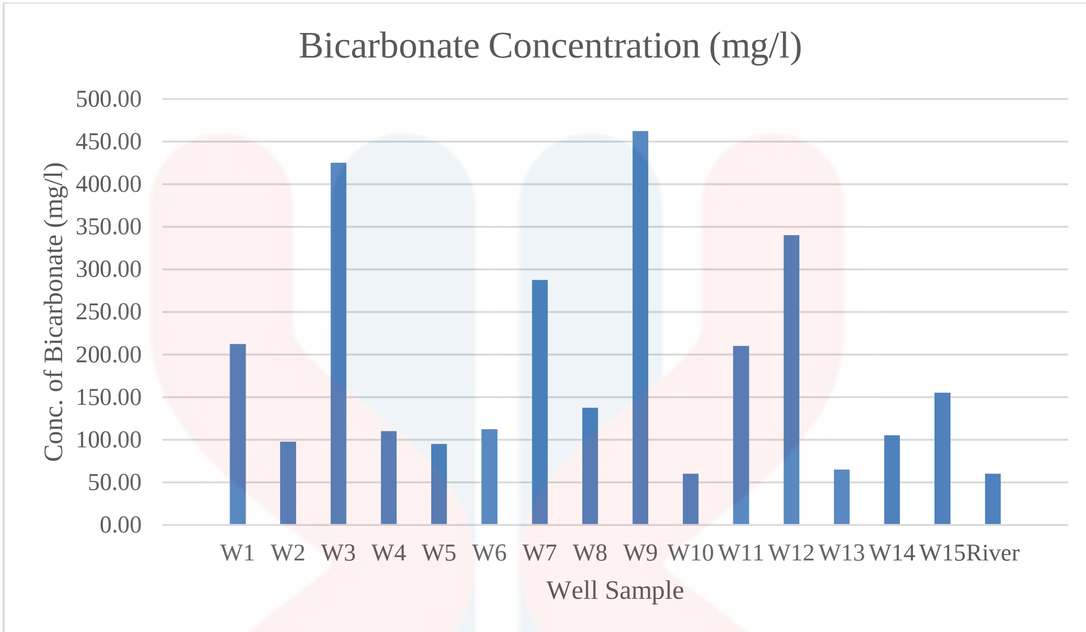


Figure 5.11: Bicarbonate Concentration versus Well Sample.

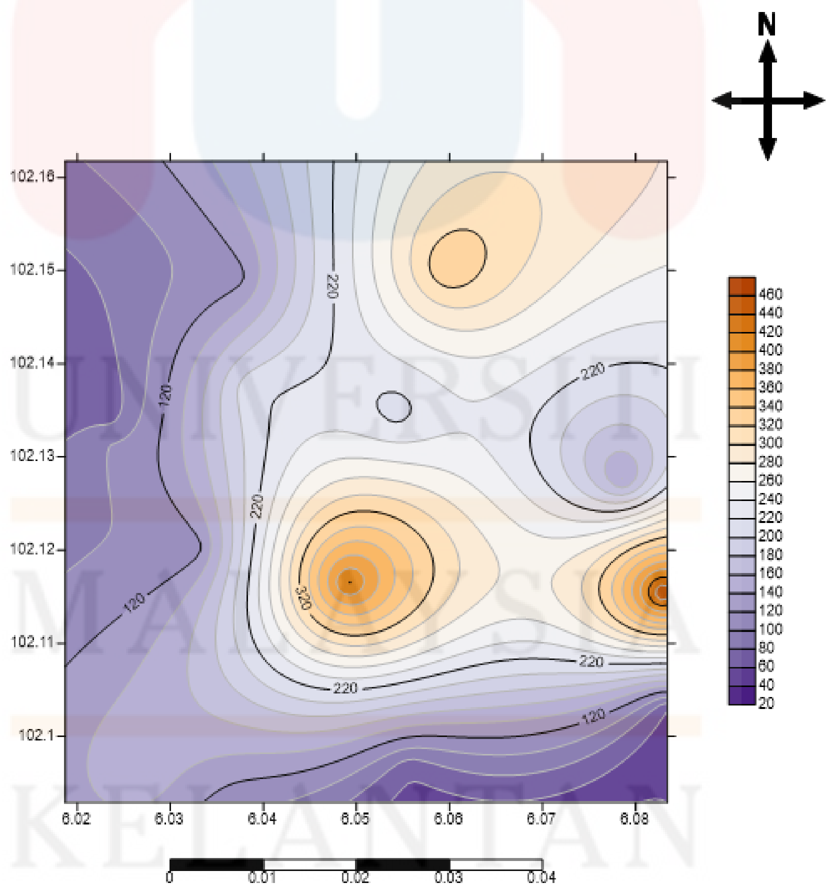


Figure 5.12: Bicarbonate concentration distribution in groundwater of Pasir Mas.

b. Chloride (Cl^-)

Almost all natural waters contain chloride ions. Their concentrations varied considerably according to the mineral content of the earth in any given area. If it is in small amounts they are not significant but in large concentrations they would present problems. Usually chloride concentrations in waters are low. Low to moderate concentrations of both chloride and sulphate ions will add palatability to water. Normally, uncontaminated water will have chloride levels range below 10 mg/l and sometimes below 1 mg/l (WHO, 2003e). Based on Figure 5.13, it is noticed that Well 1 have the highest concentration of chloride while Well 15 recorded the lowest reading. According to Figure 5.14 the distribution is higher from east to west. However, there are none of the sample exceeds the concentration standard by MOH which is 250 mg/l.

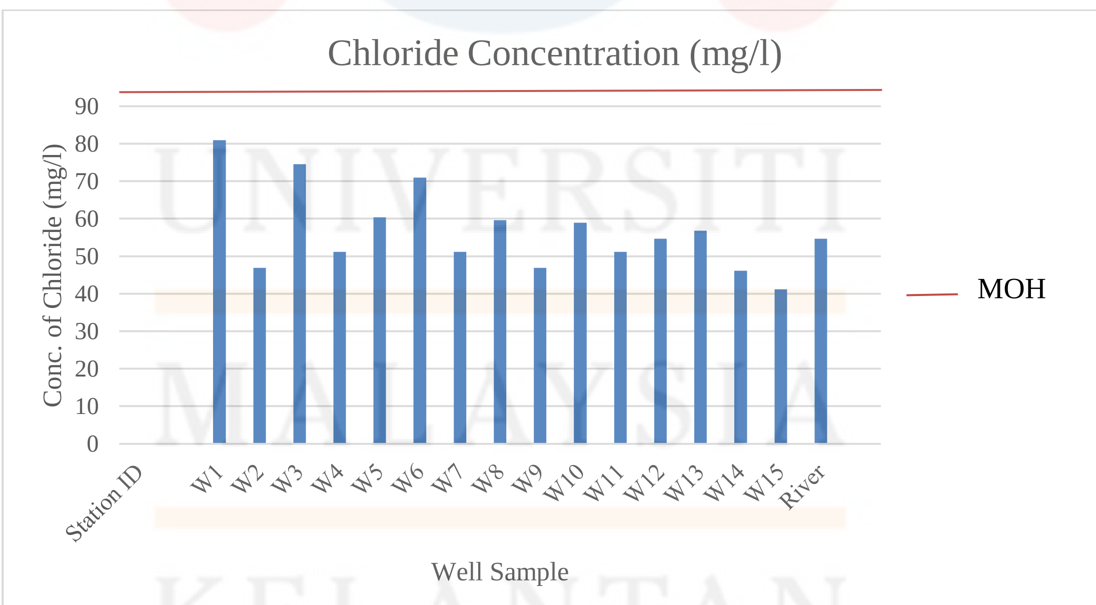


Figure 5.13: Chloride Concetration against Well Sample

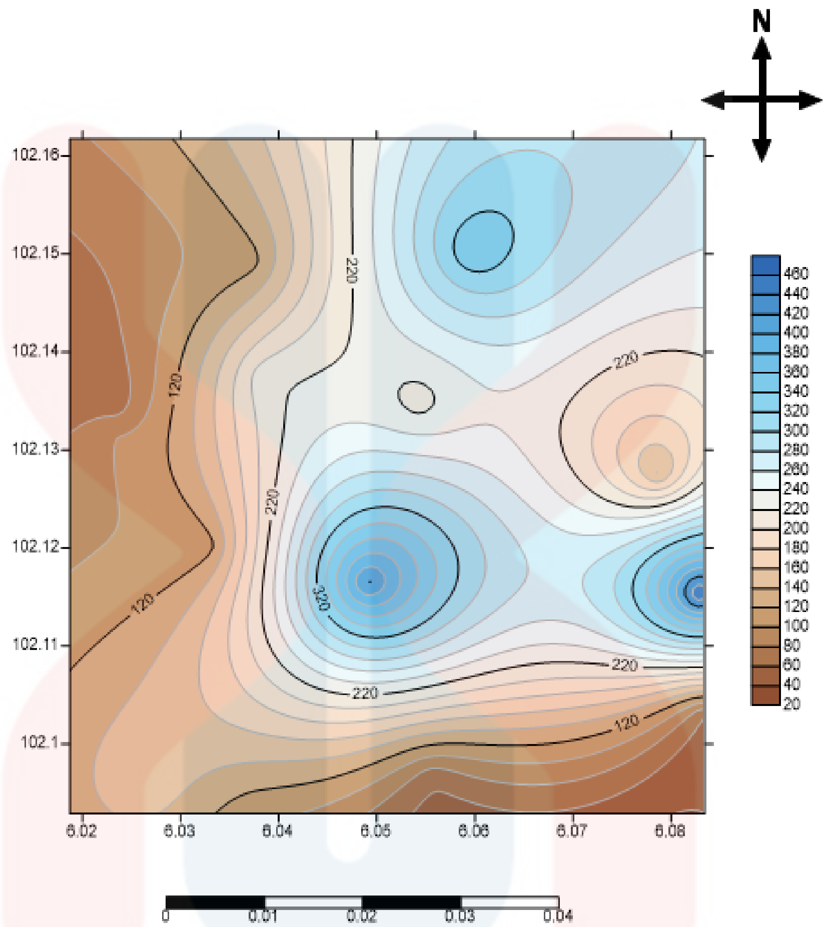


Figure 5.14: Chloride concentration distribution in groundwater of Pasir Mas.

c. Sulphate (SO_4^-)

Sulphate is a constituent of TDS and may form salts with sodium, potassium, magnesium, and the other cations. Sulfate is commonly found in nature and can be present at concentrations of a few to several hundred milligrams per liter. Water containing calcium sulphate ions is likely to have a characteristic taste somewhat bitter and astringent. In fact, it has been compared to the way of a dissolved gypsum might taste in water. When 30 to 40 grains per gallon of calcium sulphate are dissolved in water, most people are able to detect the taste. Based on the Figure 5.15, sulphate concentration is found the highest in Well 7 and the lowest is from Well 2. The distribution of sulphate ion as shown in Figure 5.16 indicates that the direction is higher from south to north. In correlation to TDS, both distributions show higher concentration towards the same direction. However, there are none of the sample exceeding the standard value where WHO is at 500 mg/l and MOH at 250 mg/l.

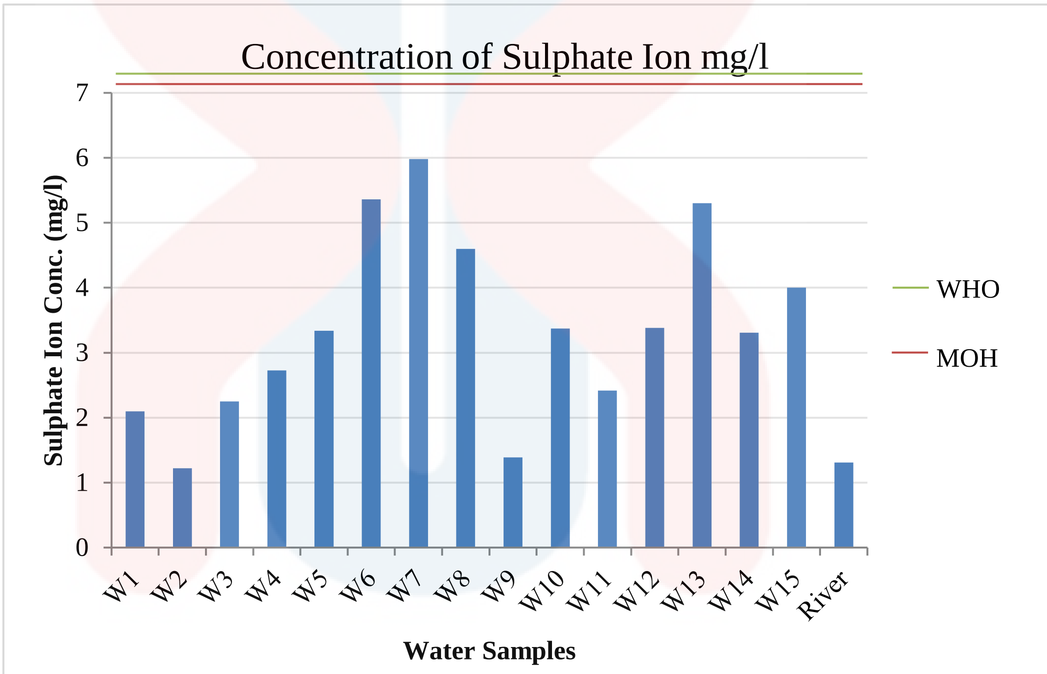


Figure 5.15: Concentration of Sulphate againts well sample

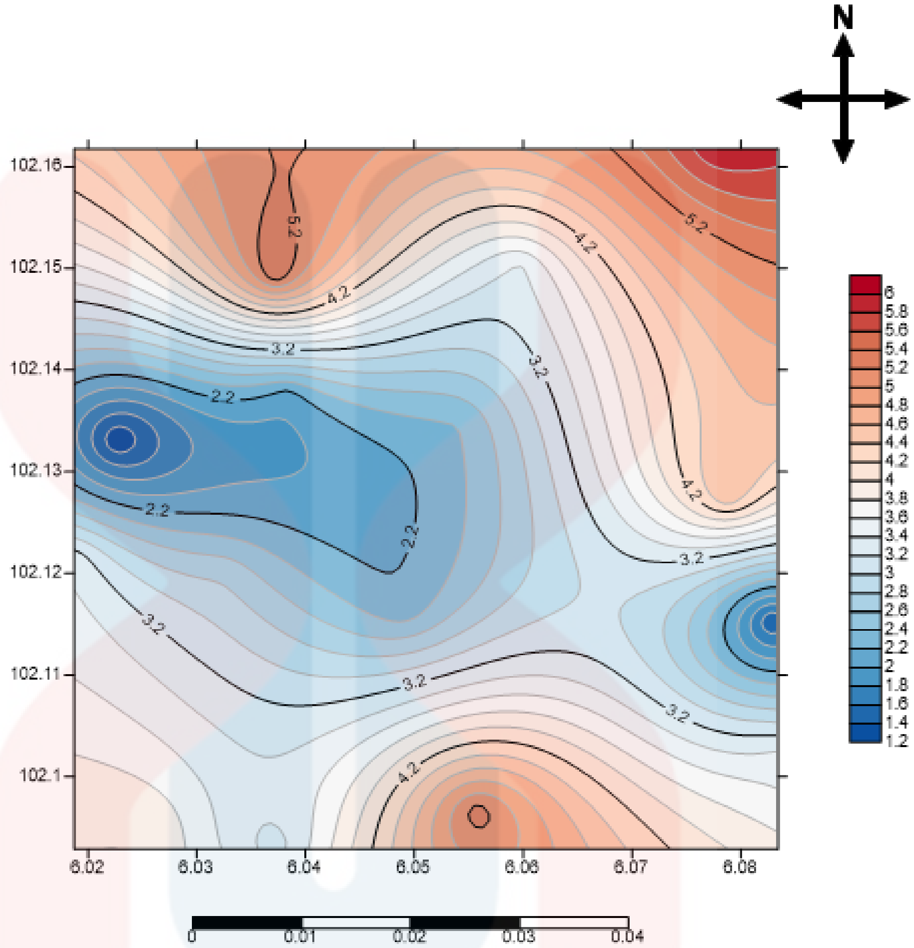


Figure 5.16: Sulphate distribution of groundwater in Pasir Mas

d. Fluoride (F^-)

Fluoride is found in all natural waters at some concentration. Seawater typically contains about 1 mg/l of fluoride ion while rivers and lakes generally exhibit concentrations of less than 0.5 mg/l. In groundwater, however, low or high concentrations of fluoride can occur, depending on the nature of the rocks and the occurrence of fluoride-bearing minerals. Concentrations in water are limited by fluoride solubility, so that in the presence of 40 mg/l calcium it should be limited to 3.1 mg/l. High fluoride concentrations may therefore be expected in groundwater from calcium-poor aquifers and in areas where fluoride-bearing minerals are common. Fluoride concentrations may also increase in groundwater in which cation exchange of sodium for calcium occurs. From Figure 5.17, Well 1, Well 2, Well 11 and Well 13 noted the highest readings in the concentration of fluoride. However, Well 10 noted the lowest fluoride concentration. To conclude, all the samples are not exceeding the standards of MOH and WHO which is 0.5 mg/l and 0.4 to 0.6 mg/l respectively. Figure 5.18 shows the fluoride concentration in 2D map which distribute mainly from north to south direction.

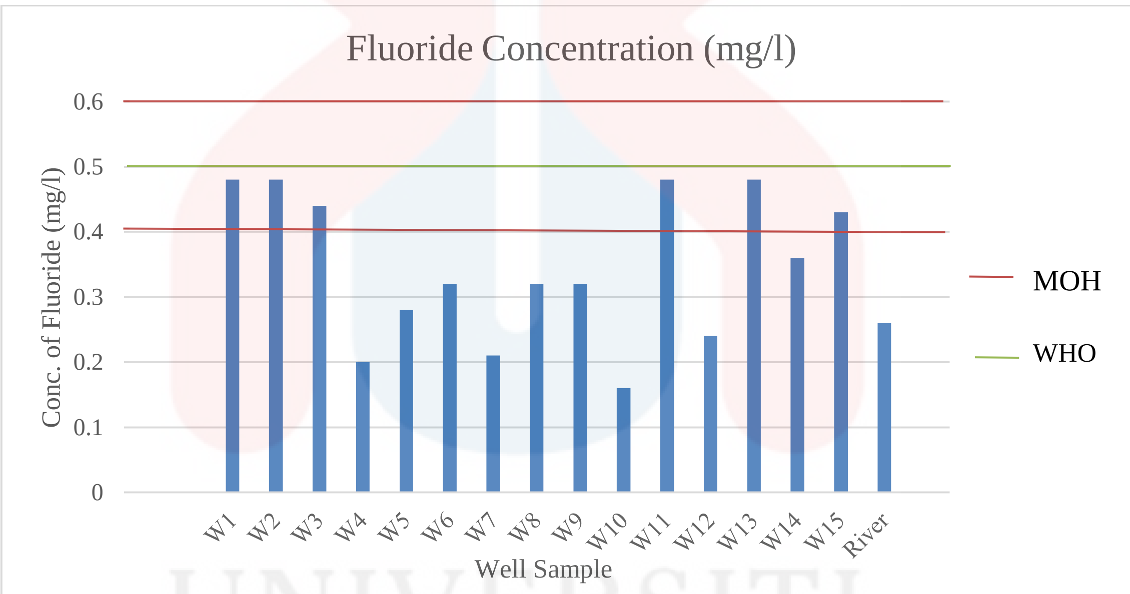


Figure 5.17: Fluoride Concentration versus Well Sample'

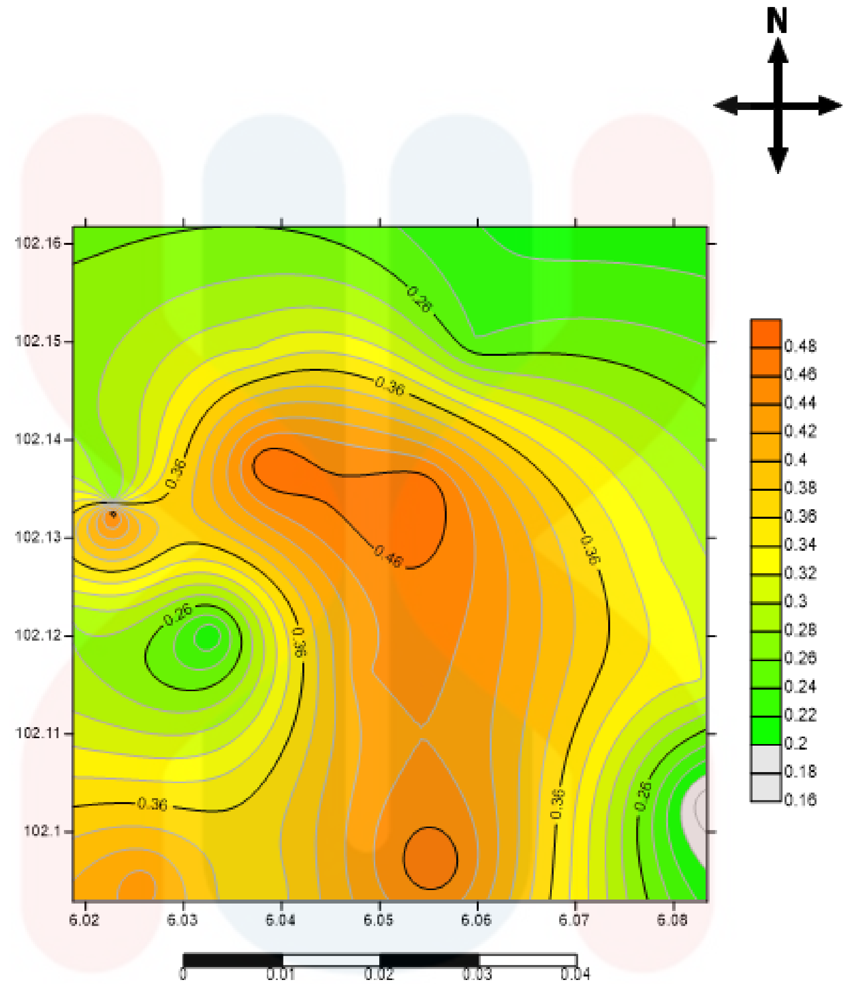


Figure 5.18: Fluoride concentration distribution in groundwater of Pasir Mas

e. Nitrate (NO_3^-)

According to WHO (2011b), nitrate has been used widely in inorganic fertilizers. Due to detrimental biological effects, treatment and prevention methods must be considered to protect groundwater aquifers from nitrate leaching and high concentrations. Based on Figure 5.19, the nitrate concentration has the highest number recorded in the study area is by Well 4 and Well 6. However, there is zero amount of nitrate concentration in Well 1, Well 2, Well 5, Well 7, Well 8, Well 10, Well 14, Well 15 as well as river water samples. The distribution of nitrate concentration based on Figure

5.20 is directed mainly from east to west region. The guideline values from WHO is 50 mg/l while from MOH is 10 mg/l. Therefore. none of the samples exceeding the standards.

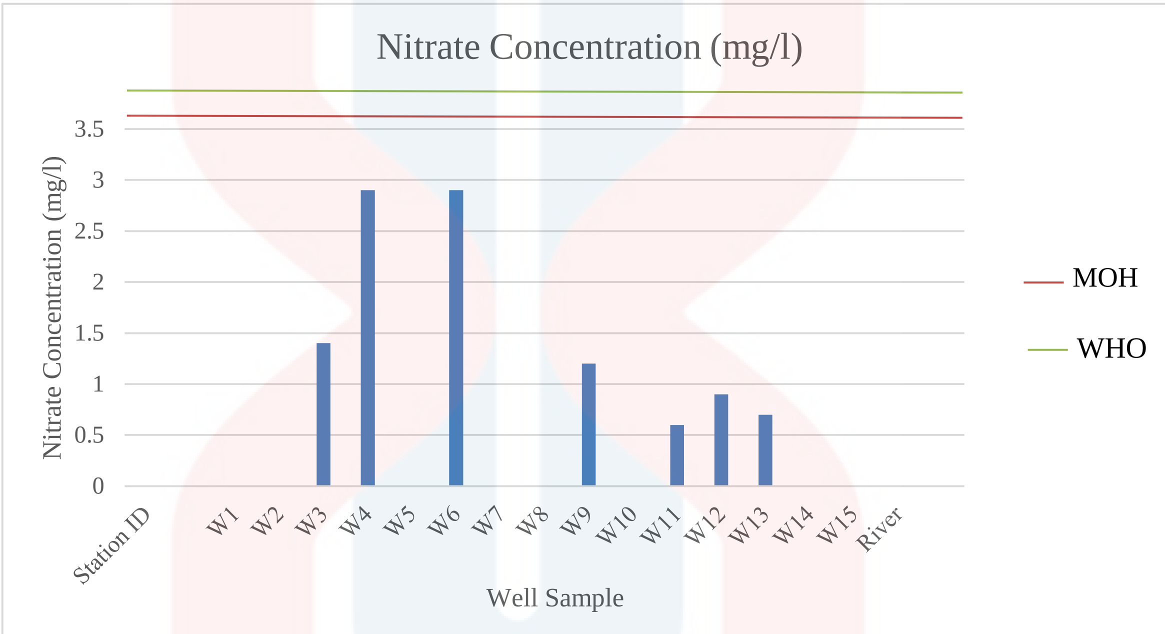


Figure 5.19: Nitrate Concentration versus Well Sample.

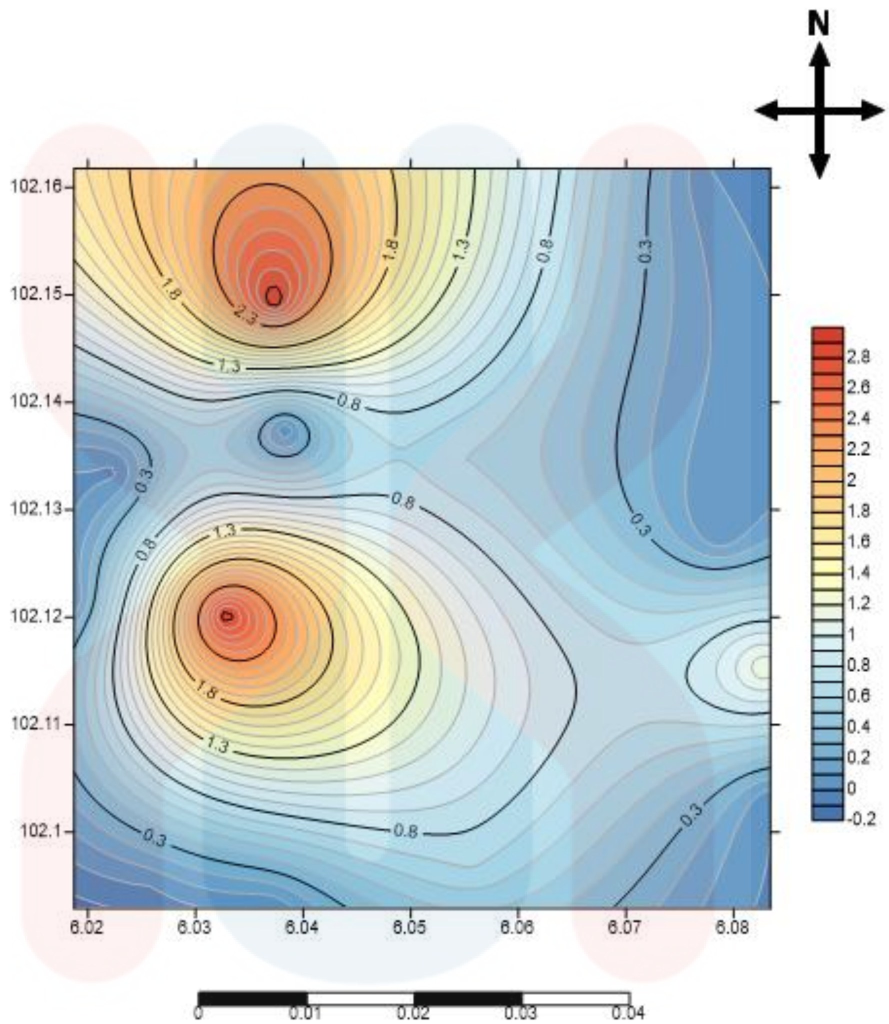


Figure 5.20: Nitrate concentration distribution in groundwater of Pasir Mas

5.4.2 Cation

The cation that has been analyzed in this research is Sodium, Potassium, Magnesium, Calcium, and Iron.

a. Sodium (Na^+)

The water that has high amount of sodium together with chloride will tastes salty (Weight.W.D, 2008). High content of sodium ion will cause foam to form in boilers. Not only that, it's also limited to use for irrigation. According to the Figure 5.21, the well that contains highest sodium content is Well 1, Well 3, Well 7, Well 8 and Well 11. Whilst the lowest sodium content in this study area is in the sample collected from river. The standard amount of sodium both by WHO and MOH is 200 mg/l. None of the well sample has exceed the standard. The distribution of sodium concentration in Figure 5.22 shows that it has higher concentrations from west to east direction.

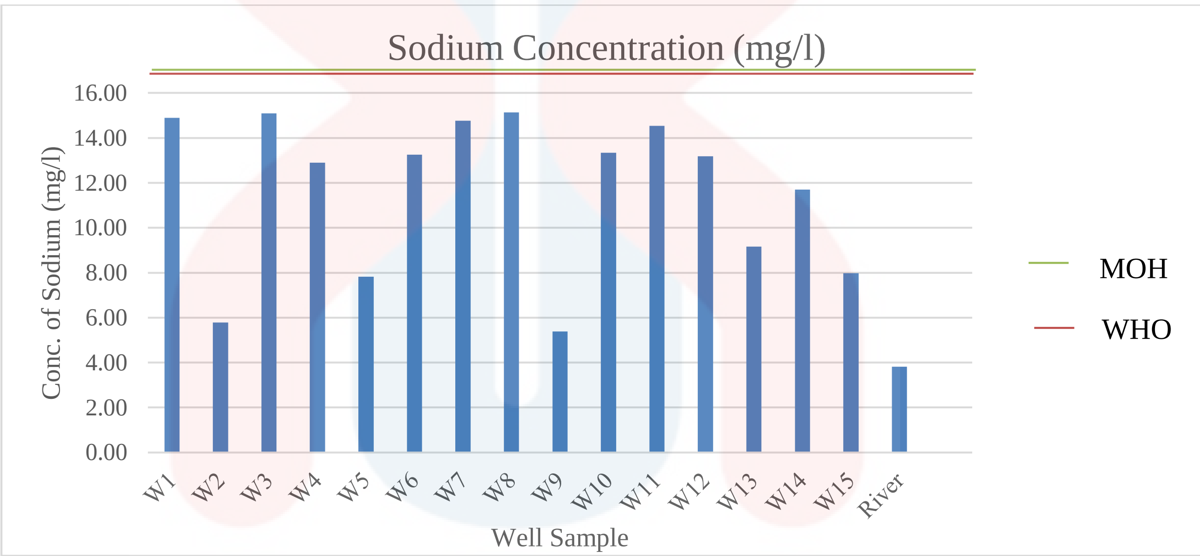


Figure 5.21: Sodium Concentration versus Well Sample

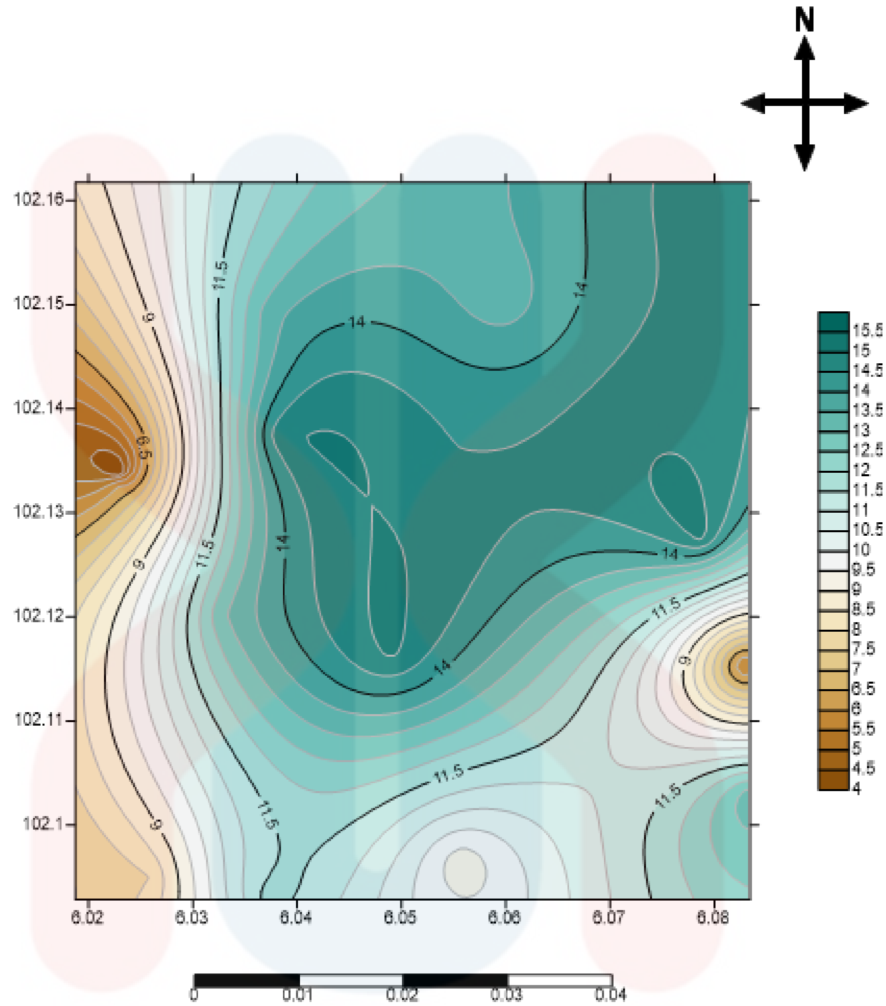


Figure 5.22: Sodium concentration distribution of groundwater in Pasir Mas

b. Potassium

According to WHO (2009), potassium does not pose threats in human yet it is an important nutrition to our body. Moreover, it also can be used as water softeners. However, it might pose threats to the high-risk groups such as individuals with dysfunction kidneys. Based on Figure 5.23, the highest content of potassium is at Well 1, Well 3, and Well 9. While the lowest content of potassium is the water sample in the river. None of the samples have exceeding the MOH and WHO standard which is 20 mg/l and 10 mg/l respectively. The 2D map in Figure 5.24 shows the distribution of potassium that is mainly directed from south to north-west.

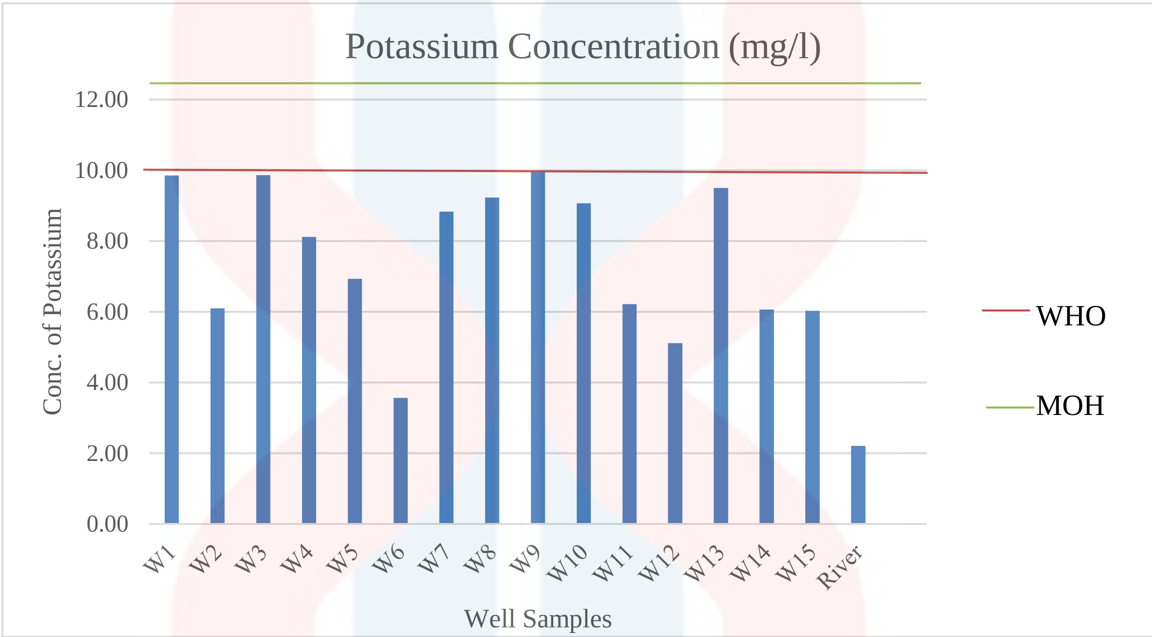


Figure 5.23: Potassium Concentration versus Well Sample

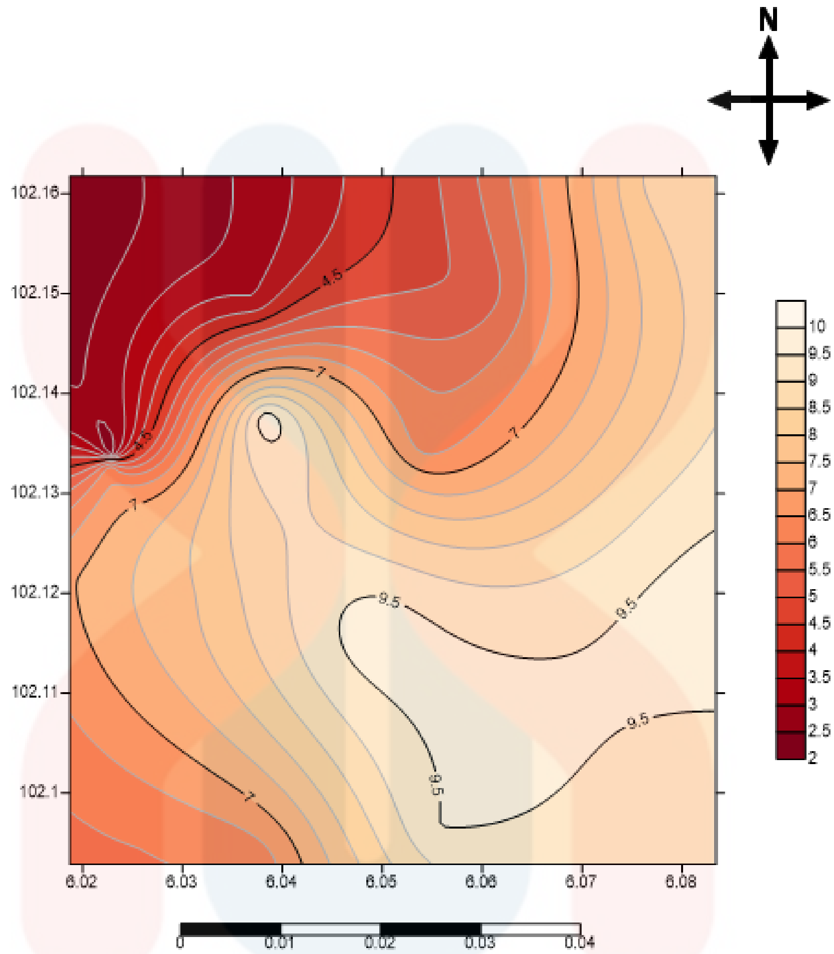


Figure 5.24: Potassium concentration distribution of groundwater in Pasir Mas

c. Calcium

According to Weight. W.D (2008), calcium ion can be originated from rocks like limestone and dolomite and gypsiferous sediments. Water that contain high calcium together with magnesium might cause the hardness of the water increase. Based on Figure 5.25, there are only 2 well sample that contain calcium which is W1 and W3. While the other well samples have negative values due to the below detection limit of AAS. However none of the samples exceed the guideline from WHO which is 50 mg/l.

Figure 5.26 shows the distribution of calcium ion which mainly highly concentrated in almost of the centre of the study area.

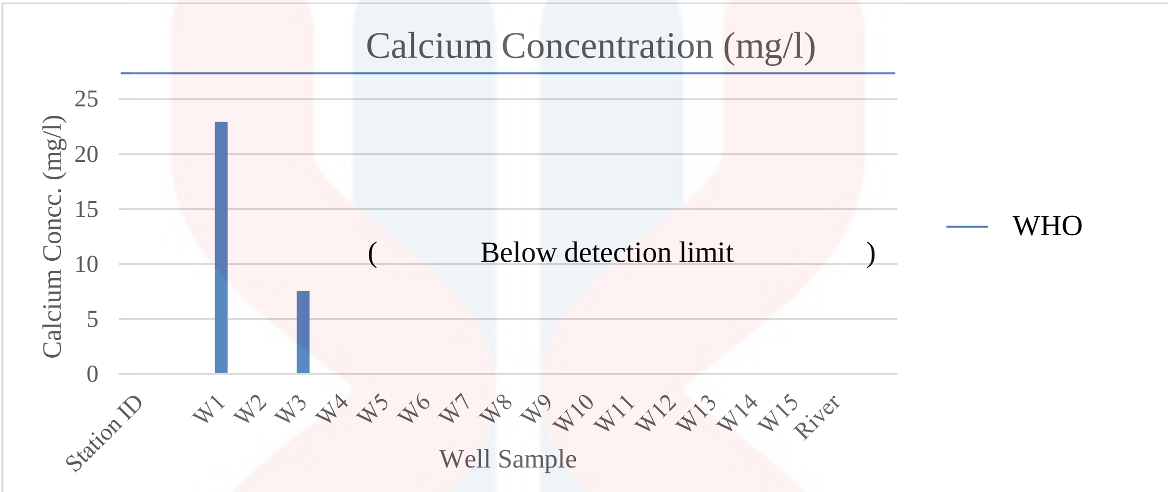


Figure 5.25 Calcium Concentration versus Well Sample

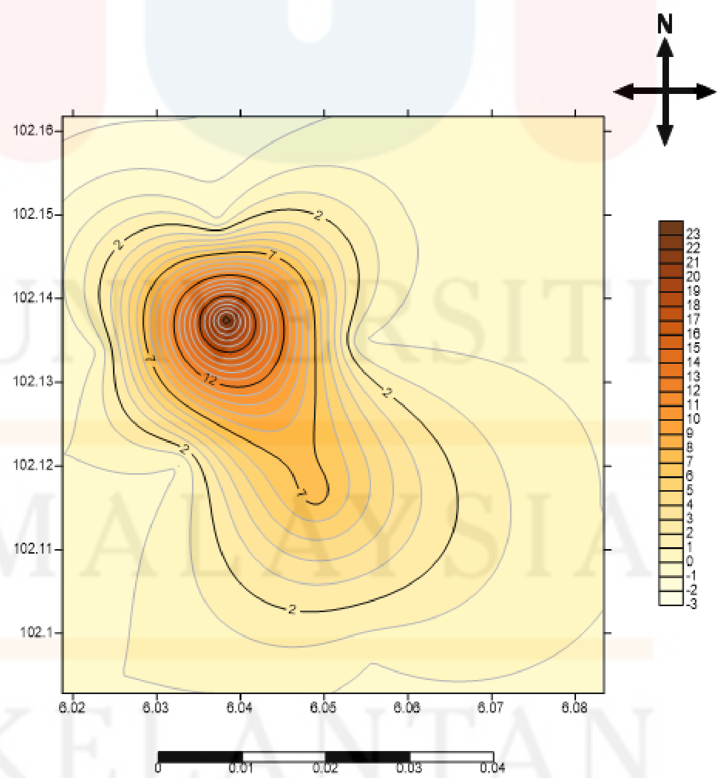


Figure 5.26: Calcium concentration distribution in 2D map

d. Iron

Weight W.D (2008) states that iron in groundwater will be oxidized to reddish brown sediment if the iron ion is exposed to the air. The larger quantities of iron with manganese will cause iron bacteria to form that will results to slimy coating in piping, but fortunately it does not affect our health. Iron can be removed through the treatment of water in the aeration process. According to WHO (2003a), the high iron concentration might came from the constructional material used in piping making. Based on Figure 5.27, the water sample from river has the highest content. The optimum level of iron content in water is 0.03mg/l by WHO and 0.3 mg/l by MOH. To conclude, all of the well samples are exceeding the standard guidelines. The iron concentration distribution based on Figure 5.28 and 5.29 shows that the direction of iron towards higher concentration is from south to north which is urban areas.

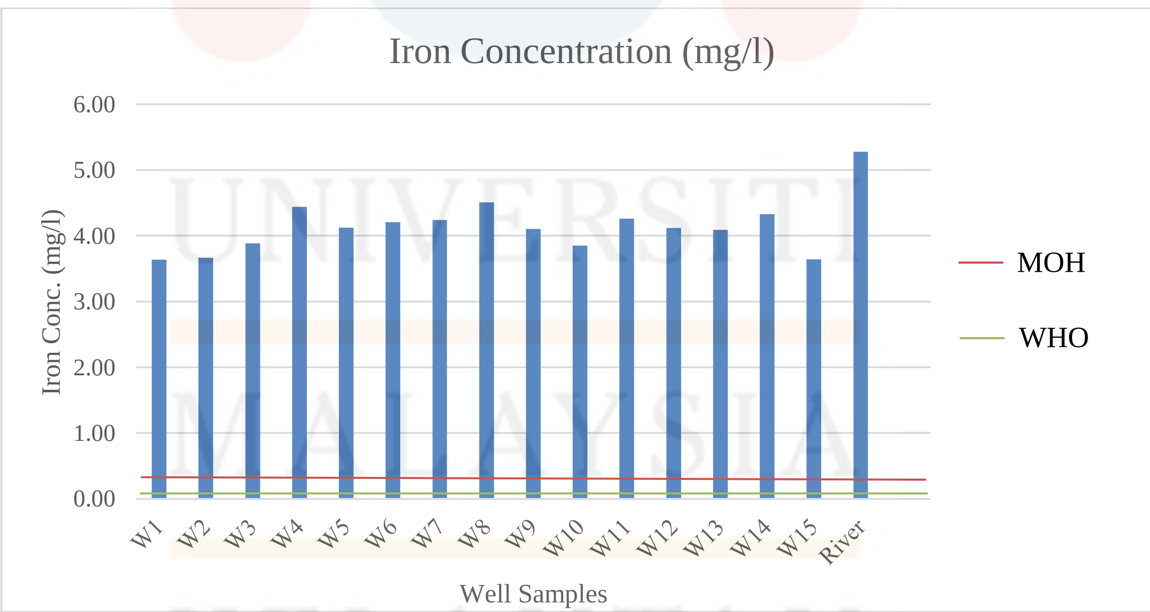


Figure 5.27: Iron Concentration versus Well Sample

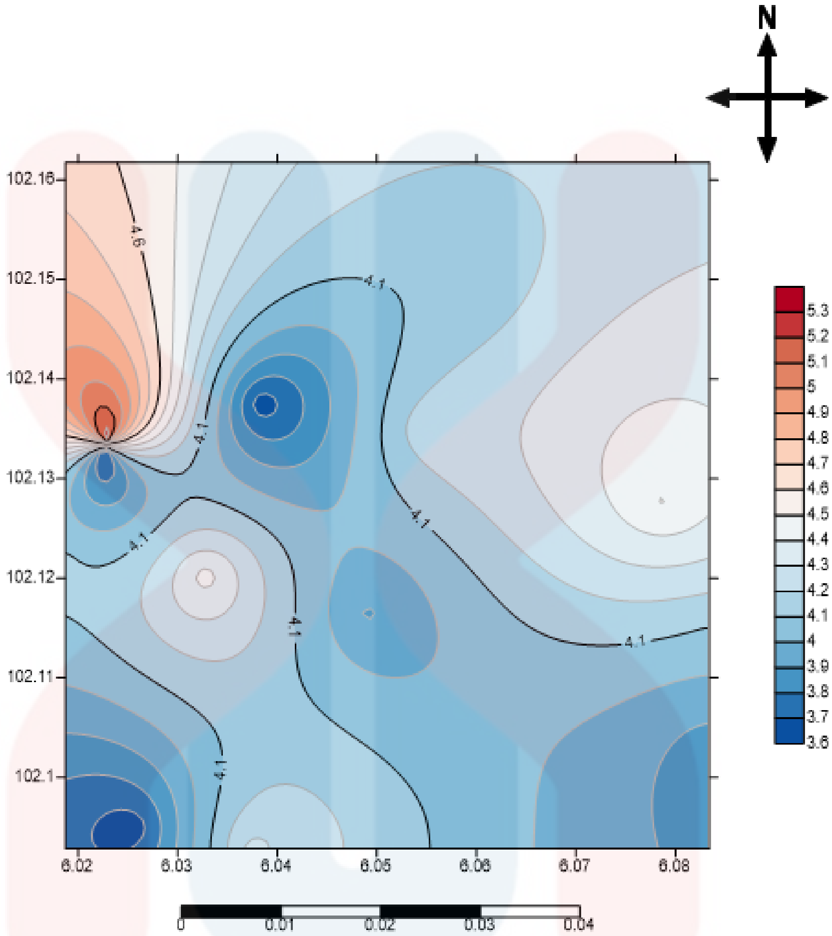


Figure 5.28: Iron concentration distribution in 2D map

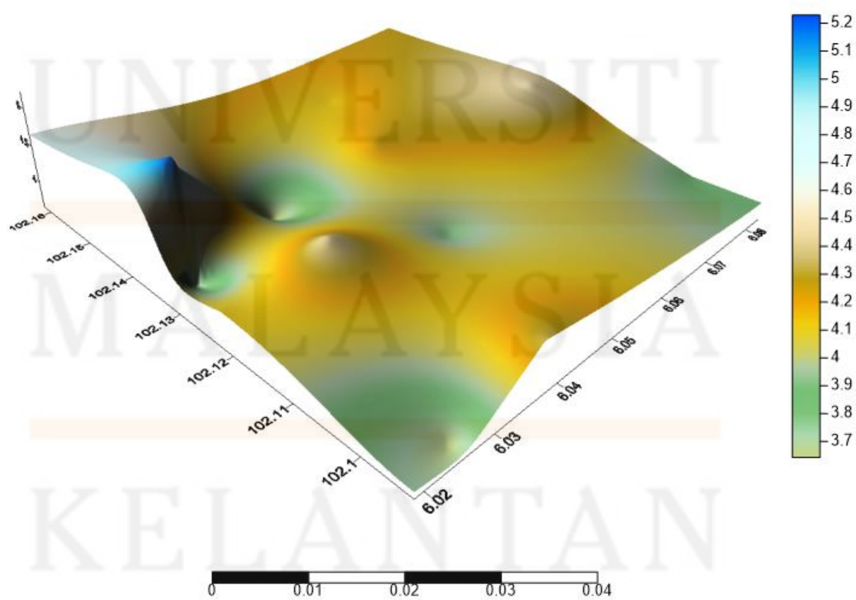


Figure 5.29: Iron concentration distribution in 3D Map.

e. Magnesium

High content of magnesium and calcium might cause to high of water hardness. The optimum level of magnesium ion in water is 30 mg/l by WHO and 150 mg/l by MOH. However, it is restricted to only 10 mg/l and lesser for magnesium ion that has to be in a drinking water. Nonetheless, none of the sample exceeds the optimum level of magnesium ion content. The distribution of magnesium concentration in the study area is highly concentration from west to east direction.

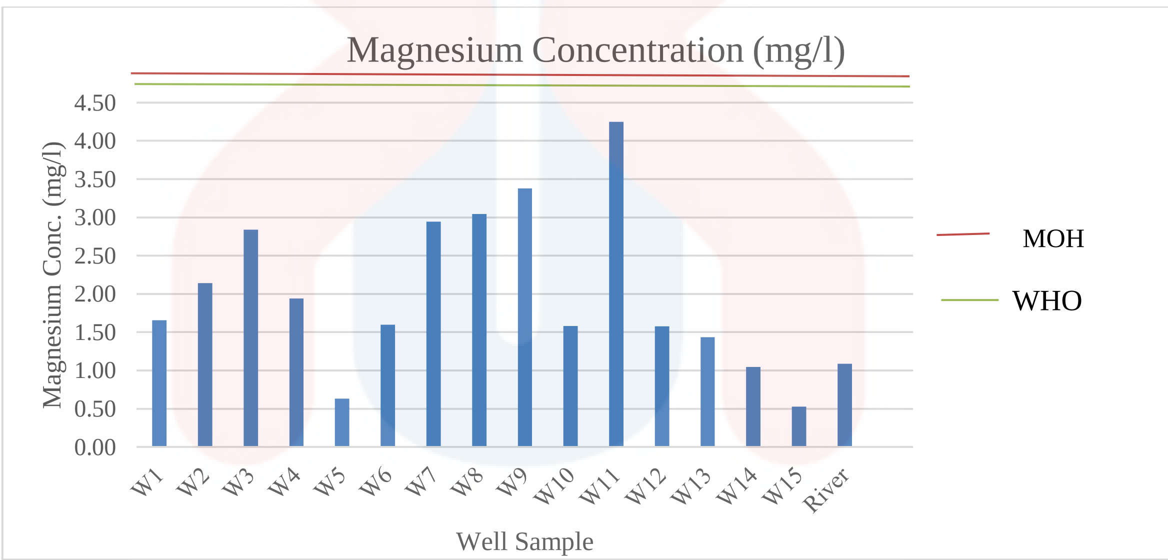


Figure 5.30: Magnesium Concentration versus Well Sample

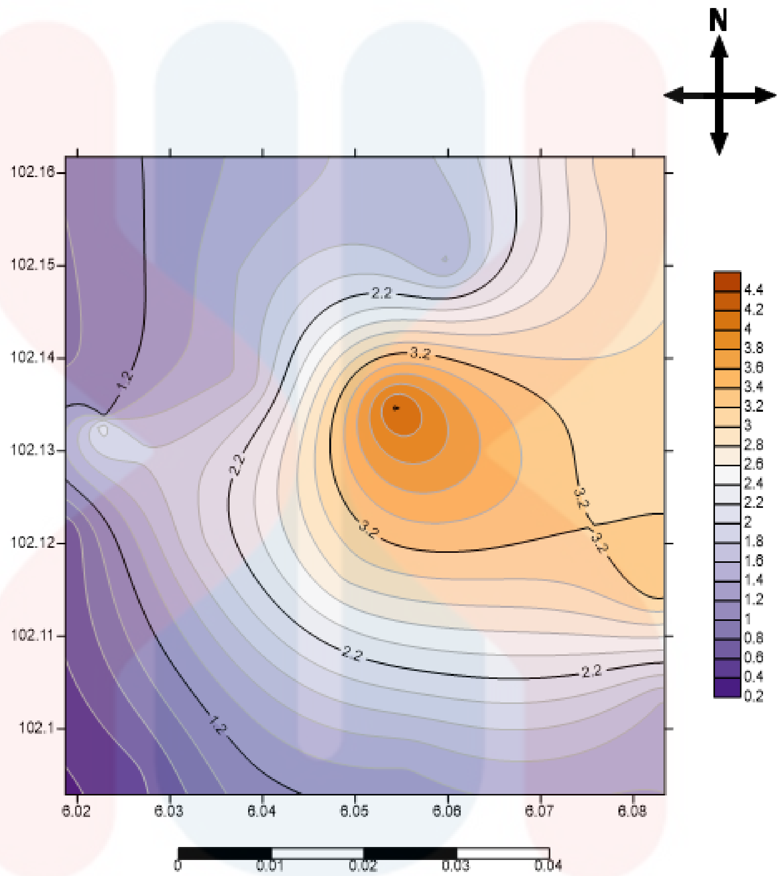


Figure 5.31: Magnesium concentration distribution in 2D map

5.5 Hardness

Water is considered hard when it has high concentration of both magnesium and calcium. The implication of having higher hardness in water is it will cause stains on surfaces somewhat like a porcelain. The standard concentration of hardness from MOH and WHO is 500 mg/l and 120 mg/l respectively. Based on Figure 5.32, there are none of the well samples and river exceed the optimum level of hardness. The distribution of hardness of the water in 5.33 shows every direction towards the centre of the study area.

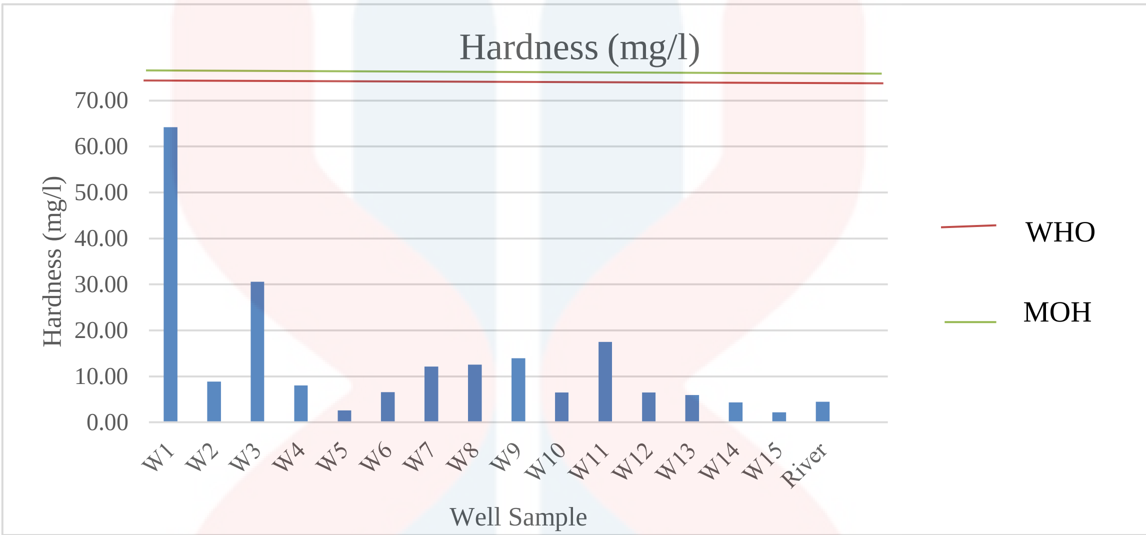


Figure 5.32: Water Hardness versus Well Sample

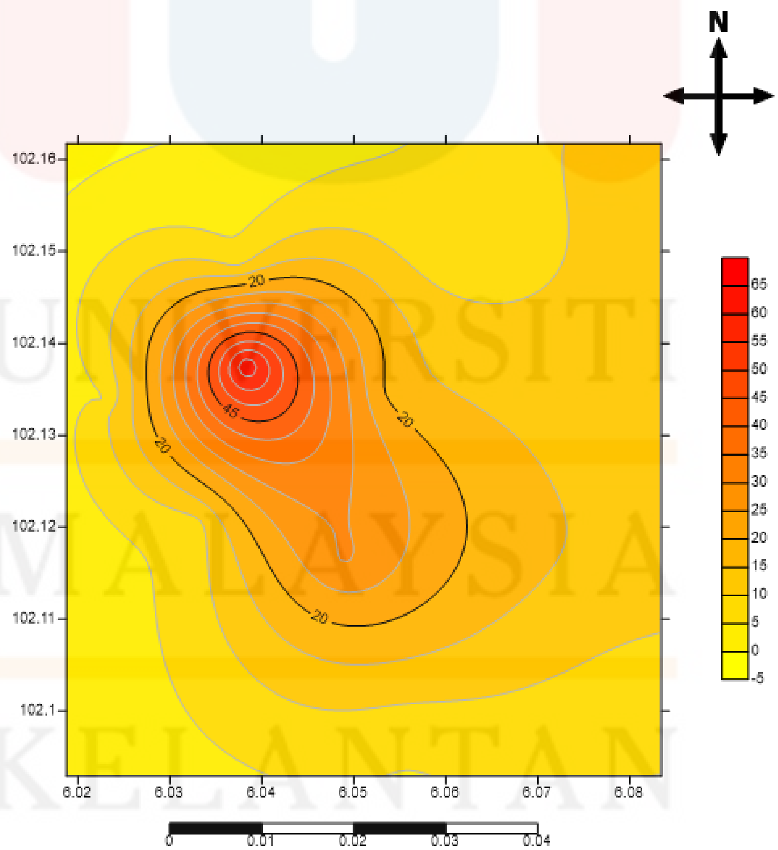


Figure 5.33: Water hardness distribution in 2D map

5.6 Piper Trilinear Diagrams

In accord to Zaporozec A. (1972), Piper-Trilinear Diagram is the percentage plotting of cations and anions that has been plotted separately in a triangle. The intersection of lines extended from the points to the central rectangular field gives a point representing a type of water. From the recorded data, the type of groundwater in Pasir Mas is Ca-HCO_3 which is typical of shallow and fresh groundwaters. Figure 5.34 shows the represented data which concludes the type of groundwater.

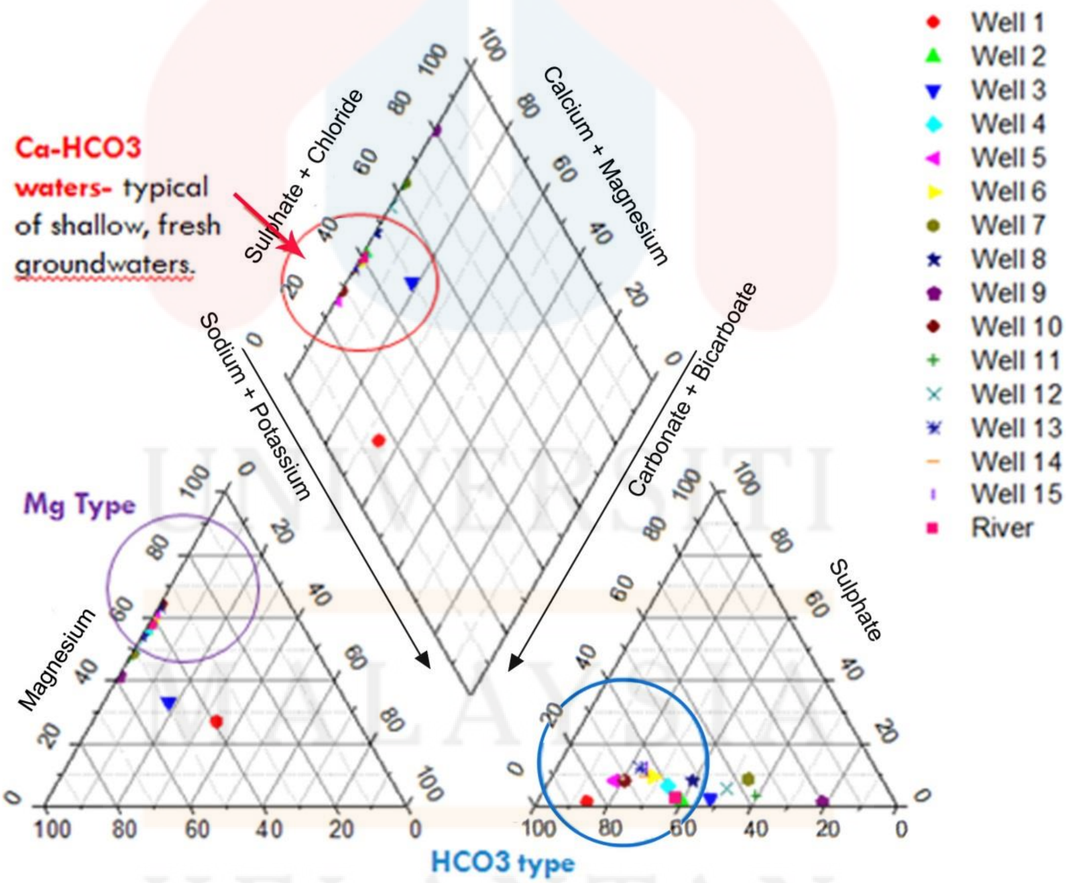


Figure 5.34: Piper Trilinear Diagram shows the type of groundwater in Pasir Mas, Kelantan

CHAPTER 6

CONCLUSION

6.1 Introduction

This research is mainly about the geological and analytical studies of major ion of groundwater in Pasir Mas Kelantan where almost all of the residence use well as their daily water source. This research is conducted based on two objectives which is to update the alluvium map with the scale of 1:55 155, and to analyze the major ion concentration of groundwater in order to monitor the suitability of drinking water standards in the study area and for the agricultural purposes.

6.2 Conclusion

The alluvium map has been successfully updated and digitized by using ArcGIS 10.2 after conducting a fieldwork to observe the current geomorphology of the study area. The updated version is varied from the oldest version in terms of the more weathered features at the river bed and banks making the river widen its valley and forming sandbars. The updated map is then used for observing the distribution pattern of each major ion concentration in the study area by using Surfer 8.

By doing the comparison assessment to data derived from conducting the laboratory experiment, and also from in-situ parameters, we can conclude that all of the 16 samples are not exceeding the standards set by WHO and MOH except for the pH value for the other than Well 1, 2 and 3 and the iron ion in all samples. The distribution of iron concentration in groundwater of Pasir Mas is higher at the urban area. This might be the factor of high developmental area is highly exposed to the well-built of steel piping. While the lower pH values might be the factor of the photosynthesis going on in the water. Carbon dioxide might be one of the factor for the pH of the water to drop. The lower of pH will lead to the corrosion which will indirectly affect the consumer's health (WHO, 2003).

6.3 Recommendations

In order for the residency to have a good water source, they should propose an application to the authorize party to take an action for regular monitoring to the well. Alternatively, the consumer can build water filter in their house but this solution is a bit costly and needs maintenance for a certain period. Furthermore, the local resident can improve the water quality by clearing the surrounding area, improving the canal system and increasing the depth of the well. Last but not least, a further research study on major ion analysis can be made by using a special instruments like ICP-MS instead of AAS, since the result of ion reading in water sample is much efficient than in the AAS.

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