GEOLOGY AND HEAVY METAL CONCENTRATION IN GROUNDWATER OF KAMPUNG IPOH, TANAH MERAH, KELANTAN

by

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A thesis submitted in fulfilment of the requirement for the degree of Bachelor of Applied Science (Geoscience) with Honours

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DECLARATION

I declare that this thesis entitled **"GEOLOGY AND HEAVY METAL CONCENTRATION IN GROUNDWATER OF KAMPUNG IPOH, TANAH MERAH, KELANTAN"** is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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APPROVAL

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

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GEOLOGY AND HEAVY METAL CONCENTRATION IN GROUNDWATER OF KAMPUNG IPOH,TANAH MERAH, KELANTAN

ABSTRACT

The main objective of present research is to produce the geological map on the 1:25,000 scale and identify heavy metal concentration in groundwater. The study area is located at Kampung Ipoh in district Tanah Merah, Kelantan, Malaysia. It is situated at the west part of Tanah Merah district which cover an area of 25 kilometer square and it lies between latitude 05°51'13.28''N to 05°48'30.98''N and longitude 102° 3'45.50''E to 102° 0'54.75''E. The methodology used were mainly based on fieldwork inputs where the fresh rock sample have been collected. Also, the drainage pattern, lithology data, structural trends of rock and the geomorphological features of the studied area also had been observed. All of the data obtained were transferred into (GIS) software before the geological and other thematic maps produced. Meanwhile, there are about twelve water sample was collected from different well in Kampung Ipoh during sampling. The in-situ parameters which have been analysed in this research was pH, temperature, turbidity, total dissolved solids and dissolved oxygen. It has been observed by using a multiparameter instrument. Also, six heavy metal was identified (Mn, Fe, Cu, Zn, Ch and Pb) in groundwater by using Atomic Absorption Spectrometry (AAS) method. Based on results after field observation and petrography analysis, schist and quartzite lithology were identified. Schist was found dominant lithology that can be found mostly at the eastern part of study area. The granitic body in the study area could be known as Kemahang Granite. Taku schist is a unit that contact with Kemahang Granite along Kampung Ipoh-Ayer Lanas road. In terms of geomorphology, the study area was classified as plain to low hill area with elevation ranges from less than 100 to 200 metres above sea level. For the heavy metal concentration in Kampung Ipoh, Tanah Merah, Kelantan, its value was compared with the guideline that has been given by WHO and MOH for drinking quality of groundwater. From the result, the parameters values of wells in Kampung Ipoh show a reading that is within the range allowed by WHO and MOH. The problem only occur for pH and turbidity parameters. Most of the groundwater in the study area has pH value less than 6.5 which are below the standard value of WHO and MOH. It is very not recommended to drink the water which pH below 6.5 since it is an acidic water. Others, the well with highest turbidity at the study area are NW 9, NW 4, and NW 12 with reading exceeding 5 NTU. Although there is a high demand for groundwater due to population growth, the groundwater in study area must be monitored regularly especially for the groundwater that has a high turbidity and pH.

Keywords: Geological mapping, Kemahang Granite, Heavy metal concentration, AAS

GEOLOGI DAN KEPEKATAN LOGAM BERAT DALAM AIR BAWAH TANAH DI KAMPUNG IPOH, TANAH MERAH, KELANTAN

ABSTRAK

Objektif utama penyelidikan ini adalah untuk menghasilkan peta geologi pada skala 1:25,000 dan mengenal pasti kepekatan logam berat dalam air bawah tanah. Kawasan kajian ini terletak di Kampung Ipoh, Tanah Merah, Kelantan, Malaysia. Ia terletak di bahagian barat daerah Tanah Merah yang meliputi kawasan seluas 25 kilometer persegi dan terletak di antara latitud 05°51'13.28"N hingga 05°48'30.98"E dan longitud 102° 3'45.50"E hingga 102 ° 0'54.75"E. Metodologi yang digunakan adalah berdasarkan input kerja lapangan di mana sampel batuan segar telah dikumpulkan. Juga, corak saliran, data litologi, aliran struktur pada batuan dan ciri geomorfologi kawasan yang dikaji juga telah diperhatikan. Semua data yang diperoleh telah dipindah ke dalam perisian GIS sebelum peta geologi dan peta tematik lain dihasilkan. Selain itu, terdapat dua belas sampel air telah diambil dari telaga yang berbeza di Kampung Ipoh semasa proses pensampelan. Parameter in-situ yang telah dianalisis dalam penyelidikan ini adalah pH, suhu, kekeruhan, jumlah pepejal terlarut dan oksigen terlarut. Ia telah dikaji dengan menggunakan instrumen multiparameter. Terdapat enam logam berat telah dikenal pasti (Mn, Fe, Cu, Zn, Ch dan Pb) di dalam air bawah tanah dengan menggunakan kaedah Spektrometri Serapan Atom (AAS). Berdasarkan keputusan selepas pemerhatian lapangan dan analisis petrografi, litologi syis dan kuarsit telah dikenalpasti. Syis didapati litologi dominan yang boleh ditemui kebanyakannya di bahagian timur kawasan kajian. Badan Granit di kawasan kajian boleh dikenali sebagai Granit Kemahang dan Taku schist adalah unit yang berhubung dengan Granit Kemahang di sepanjang jalan Kampung Ipoh-Ayer Lanas. Dari segi geomorfologi, kawasan kajian dikelaskan sebagai kawasan dataran hingga bukit rendah dengan ketinggian antara kurang 100 hingga 200 meter dari aras laut. Bagi kepekatan logam berat di in Kampung Ipoh, Tanah Merah, Kelantan, nilainya telah dibandingkan dengan garis panduan yang diberikan oleh WHO dan KKM bagi kualiti minuman air bawah tanah. Hasilnya, nilai parameter kesemua telaga di Kampung Ipoh menunjukkan bacaan yang berada dalam julat yang dibenarkan oleh WHO dan KKM. Antara masalah yang telah dikenalpasti adalah pada parameter pH dan kekeruhan. Kebanyakan air bawah tanah di kawasan kajian mempunyai nilai pH kurang daripada 6.5 iaitu di bawah nilai standard WHO dan KKM. Air yang mempunyai pH di bawah 6.5 tidak digalakan untuk dijadikan air minuman kerana ia adalah air berasid. Selain itu, telaga yang mempunyai kekeruhan tertinggi di kawasan kajian ialah NW 9, NW 4, dan NW 12 dengan bacaan melebihi 5 NTU. Oleh kerana terdapat permintaan yang tinggi terhadap air bawah tanah akibat pertambahan penduduk, air bawah tanah di kawasan kajian perlu dipantau secara berkala terutamanya bagi air bawah tanah yang mempunyai kekeruhan dan pH yang tinggi.

Kata kunci: Pemetaan geologi, Granit Kemahang, Kepekatan logam berat, AAS

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AAS	Atomic Absorption Spectrometry
CDC	Centers for Disease Control and Prevention
EPA	U. S. Environmental Protection Agency
GIS	Geographic Information System
MOH	Ministry of Health
pH	Potential of Hydrogen
PPL	Plane Polarized Light
TDS	Total Dissolved Solids
TSS	Total Suspended Solids
WHO	World health Organization
XPL	Cross Polarized Light
Fe	Iron
Mn	Manganese
Cu	Copper
Zn	Zinc
Cr	Chromium
Pb	Lead

LIST OF SYMBOLS

°	Degree
°C	Degree celcius
Km	Kilometer
Mg/l	Milligrams per liter
NTU	Nephelometric turbidity units

CHAPTER 1

INTRODUCTION

1.1 General background

Geological mapping is one of the scientific processes that can form a variety of map for a different purpose like in assessing contamination in groundwater, determining contamination risk, and knowing the hazard (David R.S, 2004). After the process of making the geological mapping is done, the geologic mapper will be form which provide an information that can give an understanding about the composition structure of geologic material that exist below and above of our earth. Generally, groundwater is an essential in human life. Groundwater can be defined as subsurface water that fills all the pore space of soils and geologic formation below the water table (Freeze & Cherry, 1979). Groundwater is a water source that come directly from the earth which is at the spaces and cracks in rocks or soil and basically it will store in the underground in the aquifers. The flows of this groundwater in the aquifer layer will be towards the point of discharge. The example of discharges area are wells, spring, and river.

Major reason that needs to make sure groundwater quality is always clean and presence in a good condition is because good quality of groundwater will protect human health since it will be use every day by human in order to sustain their life. In daily use, groundwater will be as a human's drinking water and also use in maintaining the food supplies. Nowadays, not all of the groundwater presence in a good quality. A few of them might have a heavy metal concentration like cooper, magnesium and zinc.

*(*Lentech, 2022*)*. Even though many trace element are important micronutrient for living system, somehow it can also be persisted environmental pollutant that can give a big effect to the most of living thing in our earth (Jinwal et al., 2009).

Due to the increasing demand of groundwater, the water quality underground is a major thing that should be take serious. This is to prevent the hazardous happening like soil and groundwater pollution resulting from activities performed by urban residents, industry and agricultural activities (Shirazi et al. 2015). The related studies groundwater quality globally has been conducted by many researchers, among them are Annapoorna and Janardhana (2015), Batayneh and Zumlot (2012), Kumar et al. (2014), Thousand and Jakarta (2017), Shankar et al. (2017) and Subyani and Ahmadi (2010). Meanwhile, in Malaysia, the study on groundwater quality land has been conducted in the State of Malacca (Shirazi et al. 2015), Manukan Island (Umar Kura et al. 2013), Kelantan (Hamzah et al. 2014), Terengganu (Umar Kura et al. 2013) and in the West Coast of Peninsular Malaysia (Sapari et al. 2011).

1.2 Study area

The purpose of this study is to study about the geology of the study area. The study area is a part of Tanah Merah district under district of Kelantan where known as Kampung Ipoh. It will be mainly focuses about the location, demography, land use and others.

1.2.1 Location

The geological mapping area is located at coordinate 5°51'9.52"N 102° 0'48.99"E, 5°51'10.07"N 102° 3'44.01", 5°48'25.49"N 102° 0'54.59" and 5°48'29.10"N 102° 3'41.43"E which cover 25 kilometres^2. Based on the figure 1.2, this study area is located in between two other villages which are Kampung Batang Merbau and Kampung Petai Jenerih.

1.2.2 Accessibility

In terms of accessibility, this study area is easy to access because there are a lot of road connection in that area which connect from one village to another village and all of that road can easily access by the vehicle transport like motorcycle, car, lorry and other. In terms of main road, Timur-Barat highway is a main road that connect this study area to all of the accessible area (Geographic.org. 2017). Since there is no problem in terms of road accessibility from Kampung Ipoh to another place. The resident can go to the Tanah Merah town, in order to get the basic need which only take about 20 minutes.

1.2.3 Demography

Demography is known as a study about the statistic of education, birth, religion and other aspect that represent the population of the study area. From the Table 1.1 which is the data from Jabatan Perangkaan Penduduk Negara Negeri Kelantan, it shows the number of populations of Kelantan from 2010 to 2014. The number of the population in districts of Kelantan is increasing in four years starting from 2011 until 2014. To be more specific, the estimation of population in Tanah Merah district keep on going until 2021, with the land area about 884.0 square kilometres, can accommodate about 150,766 people with a population density of 170.5 persons per kilometres square. According to the statistic, as shown in Figure 1.1, 95.6% of resident in Kampung Ipoh are Malay while other 4.4% of people are comes from other nation (City Population, 2020). This indirectly shows that the majority people who live and develop the area of Kampung Ipoh are consist of Malay people.

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

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

(Source: Jabatan Perangkaan Penduduk Negara Negeri Kelantan)

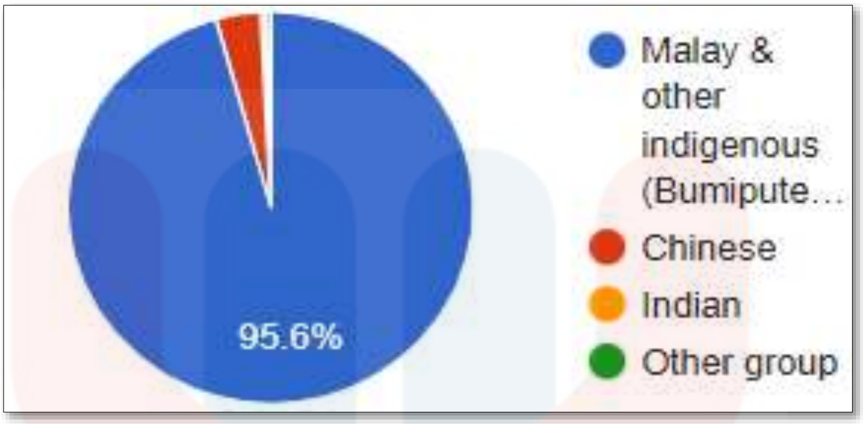

Figure 1.1: Pie chart of residence in Kampung Ipoh, Tanah Merah, Kelantan
(Source: City Population. 2020)

1.2.4 Land use

The mapping area consist of one village which Kampung Ipoh has a plains landform that mostly covered by the residential and plantation area. Plantation area consist of two types which are palm plantation and rubber plantation. Both of the plantation activities are handled by the resident around there. Instead of having plantation area, the land use of Kampung Ipoh also has an infrastructure like petrol pump, school, mosque, clinics and others which convenience to the resident.

1.2.5 Social economic

The social economic that handle by the people at that area is more focusing on business as well as medium to big business also rubber tappers. This is because, instead of having palm plantation and rubber plantation at that area, there are also other business, like food stall and petrol pump. All of this social economic indirectly can increase the economic status of the Kampung Ipoh area instead of giving the job opportunities to the resident around there.

i)

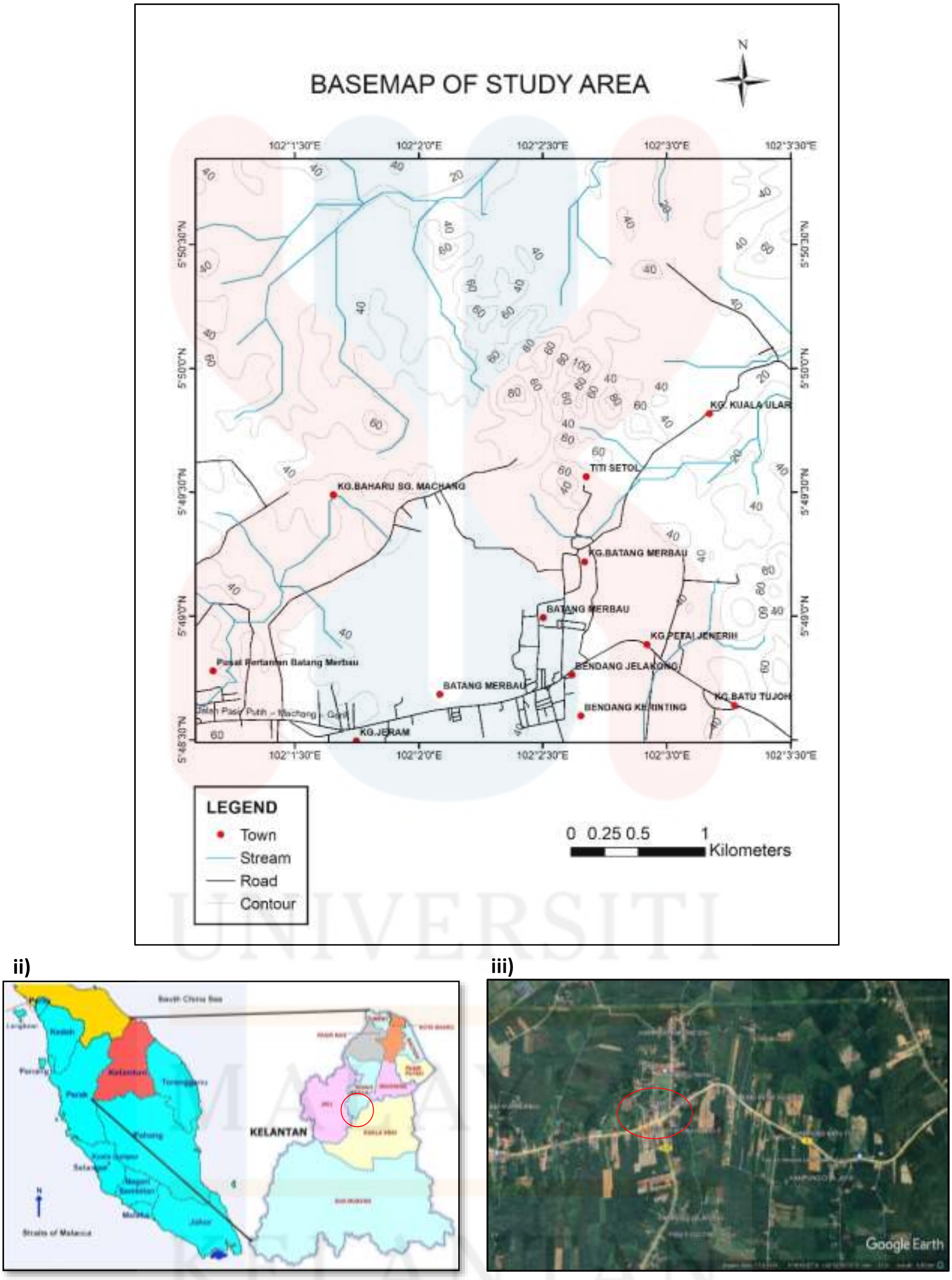

Figure 1.2: i) basemap of study area, ii) map of Kelantan, iii) terrain map of study area

1.3 Problem statement

Even though Kelantan geological map already produces by Department of Mineral and Geosciences Kelantan in 2005, the existed geological maps is un updated and the information about the climate change, geology structure and heavy metal concentration in groundwater of the study area cannot be trace by the certain organisation. It will make the contamination in groundwater of the study area become worst and give a bad effect to resident who stay there. Also, the existing geological map also come in a large scale which give a problem to focused at a specific area in order to get a precise data of study area.

Other than that, the rising in number of populations who stay in the study area and also the increasing of infrastructure will make the demand of groundwater increasing. Water is the dynamic resource that help human and other population to survive. It is necessary to always maintain the groundwater quality in the domestic well. Somehow, the groundwater at the study area also can be contaminated due to the surrounding conditions. One of the reasons that can triggered the contamination in groundwater is the presence of pesticides and fertilizers used in agriculture. When the heavy metal concentration in groundwater has been detected, it will indirectly give the chance to the certain organisation to make groundwater treatment.

1.4 Objective

1. To produce and update geological map of study area in scale 1; 25, 000.
2. To analyse the concentration of heavy metal (Mn, Fe, Cu, Zn, Cr and Pb) in groundwater

1.5 Scope of study

This study is focussing on the analysation of the concentration of heavy metal (Mn, Fe, Cu, Zn, Cr, and Pb) in groundwater of Kampung Ipoh, Tanah Merah, Kelantan. The data will be collected by taking a sample from twelve different wells in that area. In this research, Atomic Absorption Spectrometry (AAS) method is one of the methods that can be used to analyse element in solution after all of the parameter has been measure. Basically, the elements that usually presence in groundwater can be detect by using nitric acid. The nitric acid will be use as reagent in this method because most of the heavy metals and alloys can be oxidized by nitric acid (Assubaie, 2015).

In terms of geological mapping, this research will involve traversing and mapping in the study area to get the information and taking the groundwater sample from the study area. The traverse used to get information about lithology, stratigraphy and geomorphology of the area. In terms of sampling process, some of the water sample need to be taken from the study area for petrographic laboratory. The result from the sampling process will be use as a primary data and the other information can be collect from the journal, research paper and other source which can be refer as a secondary data.

1.6 Significance of study

The important of this study is to update the geological map of Kampung Ipoh, Tanah Merah, Kelantan as references to others for geology mapping purpose. By completing this study, the new geological map will be produces and update with scale 1; 25, 000 after the mapping process. This study also will be meaningful to the future research in order to make a new well and construction as an essential for future planning for mining, urbanization and others plan.

For the specification part, the heavy metal concentration in groundwater of Kampung Ipoh will be analyse through AAS method. It might give an information about the groundwater that has been contaminate at that area to the certain organisation in order to purify it. Generally, the groundwater quality and heavy metal concentration in groundwater really need to be consider. This is because the groundwater that occurs in this world is very important not only for human need but also for others. For example, for industrial uses, wildlife habitat and recreational. If the groundwater quality is not good it will contribute to the water quality issues to the human and their neighbours.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter will represent the result of the research based on the literature review and previous research such as thesis, journal and past report about the study area. This literature review needed to be done in order to understand the geological features of Kampung Ipoh, Kelantan. All the previous study will be part of the references to this research. This chapter is very important as the starting point to ensure the working or the flow of the research can be done in the right ways, smoothly and accurate.

2.2 Regional geology and tectonic setting

Kelantan is located at the Malay Peninsula eastern coast where located between latitude 04^o 45'' and 06^o 25” north and longitudes 101^o 30” and 102^o 40” east. Kota Bharu is the central business district of Kelantan. Kelantan coast line was estimated about 15,000 kilometres^2 with total land border line approximately to 576 kilometres and the longest width stretching from the eastern towards the western part is 96 kilometres (Metcalfe, 2000). During the Peninsular Malaysia ranges, the systems that occurred in this era is from 570 million years to 10,000 years with major systems dated from Cambrian period until Quaternary ages.

Besides, the regional geology of Kelantan is central zone of sedimentary and metasedimentary rocks (Goh.S. et al, 2006*)*. It has been divided by border which stated on the west and east. Within two central zone there are a windows of granitic intrusive presence (Heng,et al ,2006). The nearest windows of granitic intrusive from the study area is Kemahang pluton. Geologically, this granite and country rock belts consist of north-south and it come from the northern continuation of north Pahang regional geology. The belt continued to the south Thailand in west and central part of Kelantan.

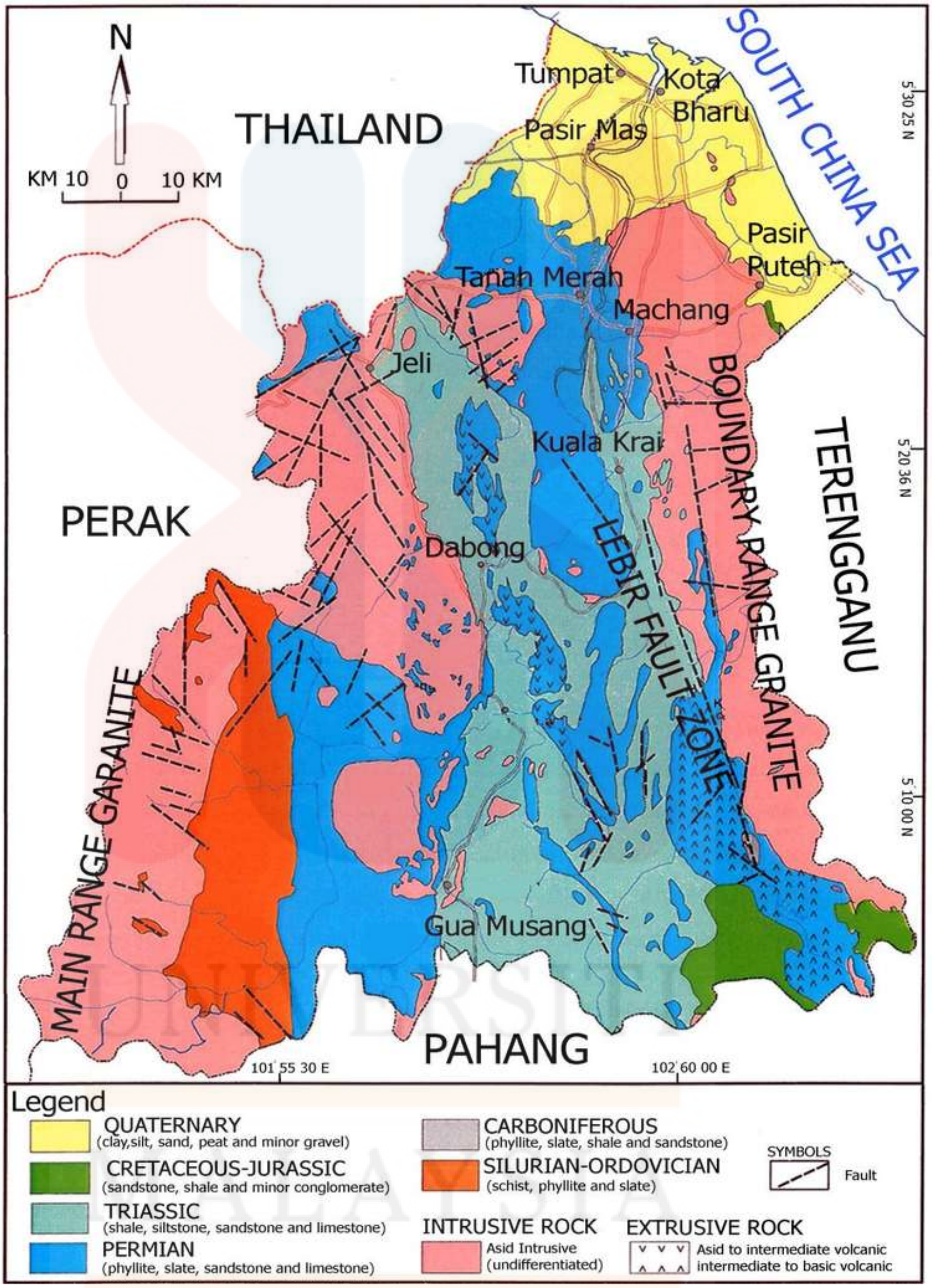

Figure 2.1: Geological Map of Kelantan (Hasim,2017)

2.3 Stratigraphy

Stratigraphy can be defined as a branch that describe about the correlates and interpret the stratified rocks and stratified sediment on and in of the earth (Southard, 2007). Since the environmental conditions in our earth change, the depositional processes will keep on going over time. The sediments are compacted and cemented into sedimentary rock over time. The geological time scale can explain the age of each layer.

Peninsular Malaysia is made up in two separate basins. One of them are known as Main Range. The Main Range is made up of numerous nearly horizontal lava flows, mostly of basalt, that erupted between 25 and 22 million years ago during the Tertiary period, gradually forming a complex and elongate volcano. There are also some prominent trachyte flows in the sequence. The larger of separate basins that made up the Peninsula Malaysia is the one that occur in a continuous outcrop along the axial belt of the Peninsula running from the north in the state of Kelantan to the south in the state of Johor. However, the smaller one is at the extreme northeast, in three separate outcrops aligned north to south, 17 from Kedah to south Perak. This continues into southern Thailand.

The stratigraphy of Kelantan can be explained more by referring the three belt that exist in Peninsular Malaysia, which are central, eastern and western. All of them formed in a different zone which are boundary of eastern and western form in Lower Palaezoic and central basin exist in Permian and Mesozoic age. During the Palaezoic era, the formation that happened in Peninsular Malaysia are Gua Musang Formation and Aring Formation in the south of Kelantan. The rocks that presences in this era are consist of argillaceous, volcanic facies and calcareous and arenaceous facies. (Lee, 2004).

However, the formation will be change in another era. The middle belt that forms the north south trending belt extending away from the intercontinental boundaries with Thailand in the north. Also, at the south of Singapore it subjugated by the Mesozoic formation. The type of rock that presence at this era also different from before which are argillaceous, marble, and some tuff and andesite.

In terms of lithology, most of the rocks that exist at this study area which is Kampung Ipoh, Tanah Merah, Kelantan are quartz-rich schist and quartz-mica schist (Afiq.M, 2018). Most of the quartz-rich schist that occur at that study area composed of a few minerals like quartz and layered with other mineral like biotite and muscovite. The quartz that exists in the sample can be seen by naked eyes because it is presence as a coarse grain.

2.4 Structural Geology

This study which covered about the geology and heavy metal concentration in groundwater is located at the Kampung Ipoh, Tanah Merah, Kelantan. In the past, Kelantan state was also known as Tanah Serendah Sekebun Bunga. The name Kelantan is thought to be a corruption of the Malay name for the Melaleuca Leucadendron tree.

Geologically, Kelantan is divided into four provinces by the Pattani federal government which are East Kelantan, West Kelantan, Legeh, and Ulu Kelantan.

In terms of geology structure of Kelantan, type of landform in Kelantan area are different in each place. Some areas might be a hilly landform, and other are alluvium landform. Generally, the differences of landform are influenced by climate element like rainfall, temperature, and wind plays a significant role in the evolution of landforms.

Also, climate change is one of the factor that trigger the hydrogeological condition of a specific area during its development. Types of climates in Kelantan basically humid and tropic, and it is typical of Peninsula Malaysia. It is distinguished by high temperatures, high humidity, and heavy rainfall (Ibadullah.M, et al, 2018).

2.5 Historical geology

Kelantan geological formations is divided into three main ages. There are Paleozoic, Mesozoic and Cenozoic. The Paleozoic formation in Kelantan was found in the central belt of Peninsular Malaysia. In the upper paleozoic era, the sediment consist of marine Permian layer which form a linear belt.

The granitic body in the study area can be known as a Kemahang Granite. This Kemahang granite basically contact with other four units. One of them is Taku schist. Kemahang granite will have the contact with Taku schist along Kampung Ipoh-Ayer Lanas, road (Afiq.M, 2018). The Kemahang granite of MacDonald (1967) is a granitic mass of batholitic dimension which situated at the North-West Kelantan. The example of sediment that occur at Kemahang Granite area are slate, phyllites and marble (Khoo.T.T. 1980).

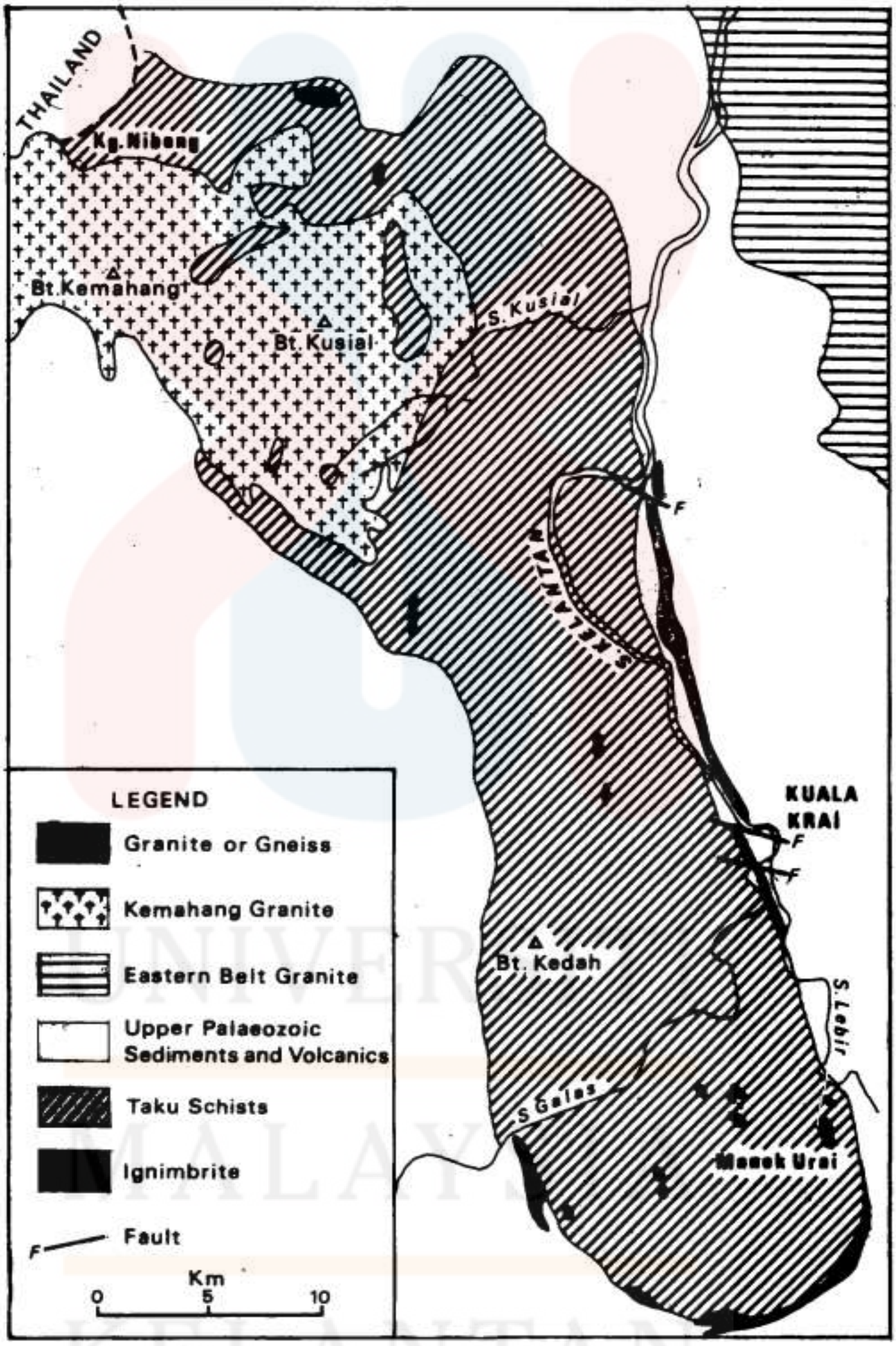

Figure 2.2: The location of Kemahang Granite and Taku Schist
(Source: Afiq, M, 2018)

2.6 Groundwater and hydrogeology

Generally, groundwater is an alternative fresh water source for the human in Kelantan. Groundwater development in Kelantan was occur since 1900's. Based on the previous study (T.Eng et al, 2022), there are about 24 wells has been drilled at the Northern parts of Kelantan in 1998. All of the groundwater will be supplied to the residents that live at the certain area like in Kota Bharu, Bachok and also Tumpat.

As mentioned before, groundwater usually stored in aquifer. An aquifer can be defined as a formation or a geological structure which has good permeability to supply sufficient quantity of water to a well or spring. Instead of un-consolidated sedimentary formations like gravel and sand which form an excellent aquifer, fractured igneous and metamorphic rocks and carbonate rocks with solution cavities also form good aquifers.

Most of the groundwater that exist at Kelantan has a good quality of groundwater. Instead of that, it also can be recharged quickly and most of the wells are shallow. So, the shallow aquifer is preferred for development because it has low construction and pumping costs.

The quality of groundwater always described in terms of hardness and salinity. The water quality is an important thing that must be considered when evaluate the water or groundwater. It can be measure by using a set of physicochemical parameters of the water. The hardness of groundwater quality is referred to the amount of calcium and magnesium content. Yet, in groundwater quality, not only calcium and magnesium exist as a heavy metal, the other material also might be presence because the water will move through the hydrologic cycle which interact with the atmosphere and soils. All of them will give an effect to the chemical composition of groundwater. (Zamri.W, 2011).

In due course, the amount of heavy metal is very useful and important for domestic and industrial purpose. However, some of the groundwater will be contaminated because of some precipitation infiltrates the ground. It also may happen when hazardous substances come into contact and dissolved in the water that has soaked into the soil. This condition usually happened in agriculture area. The magnitude of any pollution problem will depend on the size of the area which affected and the amount of the pollutant involve.

These pollutants could be dissolved solutes or a separate liquid phase like gasoline. Cadmium is one of the heavy metals that always presence in groundwater which can come by the wastewater from the chemical industry. Chromium, mercury, lead, and arsenic are the other example of the compound that always exist in the contamination in groundwater (Gao,J, 2021)

Other than that, a study about groundwater often associated with the hydrogeology. Hydrogeology can be defined as a movement of water through the subsurface geologic environment or known as a groundwater recharge (Direct.S (2018). For example, the way groundwater flow into the ground and bedrock. It will can be correlate with heavy metal concentration in groundwater of Kampung Ipoh, Tanah Merah Kelantan because in hydrogeology part, it also will explain more about the analysis of water chemistry.

The analysis process of groundwater can be done by making an investigate of the transit and fate of contaminants that penetrate the subsurface environment, as well as the measurement of water chemistry changes along a subsurface flow path.

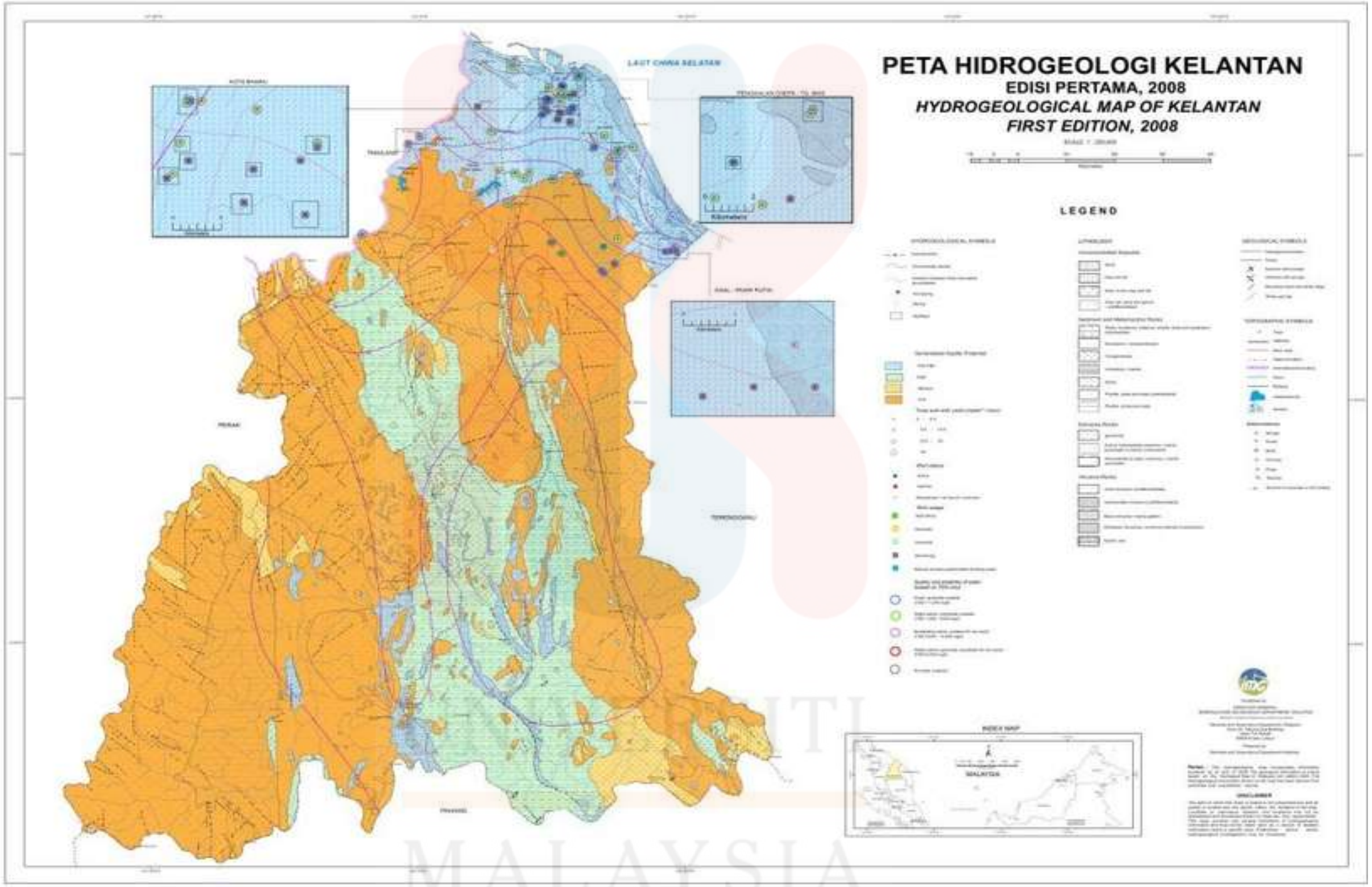

Figure 2.3: Kelantan Hydrogeology Map (Source: Din, A. 2008)

2.6.1 Heavy metal

Heavy metal can be defined as a metallic chemical element that have high density and can presence as a toxic at low concentrations (Lentech. (2022). Copper and zinc are the example of heavy metal that usually presence in groundwater. All of the heavy metal are naturally occur in our earth crust. Basically, it cannot be degraded and will remain persistent in our environment.

2.6.2 Concentration of heavy metal

Mn, Fe, Cu, Zn, Cr, and Pb heavy metal are come in a various group in periodic table. Like others, heavy metal also has its pros and cons. A small amount of concentration of heavy metal in groundwater did not give any effect to human since they use to sustain their live. It still safe to use as a drinking water and other purpose. In spite of that, if the level of heavy metal is high in groundwater, it will become toxic and has a possibility to damage the function of human organs like kidney, lungs and other.

a) **Manganese, Mn**

Manganese is an active element. It will reactive when it is pure and presence as a powder. When the reaction with the water (H_2O) occur, the manganese will rust like iron and dissolve in dilute acid. This element is very abundant in soils. It presents as an oxides and hydroxides (Lentech, 2022)

b) **Iron, Fe**

Iron is a common problem in rural groundwater supplies, with concentrations ranging from 0 to 50 mg/l. Despite the fact that iron occurs naturally in the aquifer, dissolution of ferrous borehole can raise iron levels in groundwater. Iron-bearing groundwater is frequently orange in colour and has a bad taste when drinking and cooking (Lentech, (2022)).

c) **Copper, Cu**

Copper is an element that classed in group 11. Copper can be one of the heavy metals that presence in the groundwater because of the absorption of this heavy metal from the plumbing material. The copper will leach with the water in the pipes, fitting. Basically, the copper concentration in groundwater will depends on acidity, the period of water stays in the pipes, and amount of mineral in water.

d) **Zinc, Zn**

The amount of zinc that should have in groundwater is about 1 milligram per liter of water (mg/L). Basically, the groundwater contamination can happen due to the presence high amount of zinc in waste water from industrial plant. It will make the groundwater become more acidic

e) **Chromium, Cr**

Chemical element chromium can be categorised as a transition metal. Usually, a small amount of chromium are present in rocks and soils naturally, and some of it is released into the water environment through weathering and erosion processes.

f) **Lead, Pb**

If water corrodes a lead-containing material, such as lead pipes, lead solder, or brass fittings, lead heavy metal can dissolve. The greatest lead solubility potentials were found in groundwater with low pH, alkalinity, and phosphate concentrations.

2.6.3 Sources of heavy metal

There are a few factors that can be as a source of heavy metal concentration in groundwater either from anthropogenic sources or natural sources.

First of all, the heavy metal can come from a solid waste from industrial activity. An industrial solid waste including oil-contaminated wastes and paint residue which contain arsenic and mercury. It will dissolve with rainwater and reaches to the aquifer system and indirectly contaminate the groundwater (Mohankumar, et al, 2016).

Other than that, it can also presence from the agriculture activities. The presence of heavy metal like Cooper (Cu) will directly come from the pesticides, fertilizers and herbicides which known as a chemical that can leach through the soil profile and contaminate. Pesticides transported to groundwater mostly by recharge resulting from rainfall or irrigation within agricultural where they are use. Run off of pesticides, fertilizers and herbicides will adds toxins and excess nitrogen and phosphorus in groundwater. High phosphorus leads to increased risk of heart attack and stroke for human.

Also, the presence of heavy metal concentration in groundwater can happened from natural sources like erosion of natural deposits. The rocks and soils that occur underground might contain with inorganic chemicals like chromium, iron, lead, and manganese. Instead of that, the other natural sources that may triggered the presences of heavy metal in groundwater is by weathering of mineral, forest fires, and biogenic sources.

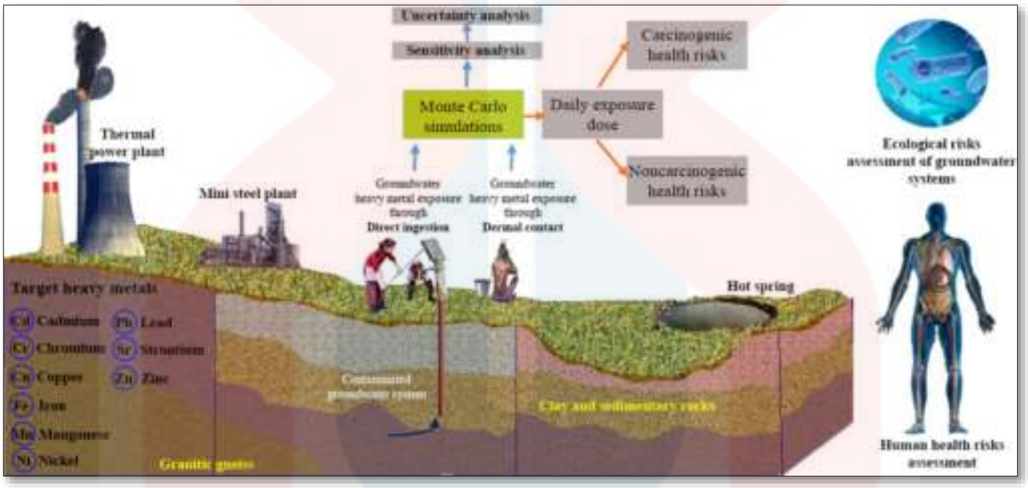

Figure 2.4: A conceptual schematic of contamination of heavy metals.
(Source Mukherjee., et al, 2020)

2.7 Previous study

Based on the previous study, most of the groundwater in Tanah Merah contaminate because of the industrial development and suburbanization (Mathialagan,et al, 2018). Instead of assess the major ion chemistry of the groundwater in Tanah Merah, an assessment in terms of physical parameter also has been done. Physical parameter will be referred to the World health Organization (WHO) and Ministry of Health (MOH) guidelines.

For the other places in Kelantan, like Bachok, most of the domestic well at that area contain a toxic element. For instance, As and Pb (Pillai, K. R,2020). It also has other heavy metal that can risk the human health. Chromium is the example of the element that have a good and bad effect. It depends on the intake rate. Human might get the hypertension due to the high amount of this element in the body and if the intake rate still under control, it will regulate the glucose metabolism in the human body system.

According to Khan et al., (2017) who also conducted a study about the distribution of heavy metal in groundwater at the study area of Bachok which conducted near the Beris Lalang, Kelantan landfill, there are about eleven groundwater samples and two surface water samples has been taken in order to investigate by using AAS method. By using this method, the heavy metal like lead (Pb), manganese (Mn), copper (Cu), zinc (Zn), iron (Fe), and Chromium (Cr) was identified.

CHAPTER 3

MATERIAL AND METHODOLOGY

3.1 Introduction

This chapter discuss about the materials and equipment that were used in this study to achieve all the objectives. The application of GIS has been used as a tool for the interpretation of data in analysation of heavy metal concentration in groundwater.

3.2 Equipment/Material

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

Table 3.1: Equipment and material

EQUIPMENT/ MATERIAL	FIGURE	FUNCTION
Garmin *GPSMAP 64s*		Provide an information about location, navigation, tracking and also timing
Brunton Compass		To obtain directional with degree measurements. It also can be uses to measure the geological structure such as the strike and dip of sedimentary beds.

Hammer		To break the rock in order to get the fresh surface.
Specimen Bottle		To put the sample during transportation to the laboratory for data analysis.
Sample (Water)		To make it as a sample in order to know the heavy metal concentration.
Instruments a. AAS b. Microscope c. YSI multi parameter	 	AAS instrument used to investigate the heavy metal that occur and the concentration of metal in water sample. YSI multi parameter use to assess the physical parameter of the water sample during sampling process.

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

1) Arc GIS software

ArcGIS is a software that use to digitize maps, sorting data and perform spatial analysis and build a perfect map. Based on the map that has been generate, we can carry out reconnaissance study to interpret the lithology, landform and other map of the study area. By using ArcGIS, all of the maps are created before and during the programme. The maps that need to provide by the researcher in order to do the mapping is base map, contour map, drainage map, geological map, lineament map, lithology map, landform map and land use map.

3.3 Methodology

3.3.1 Research flowchart

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

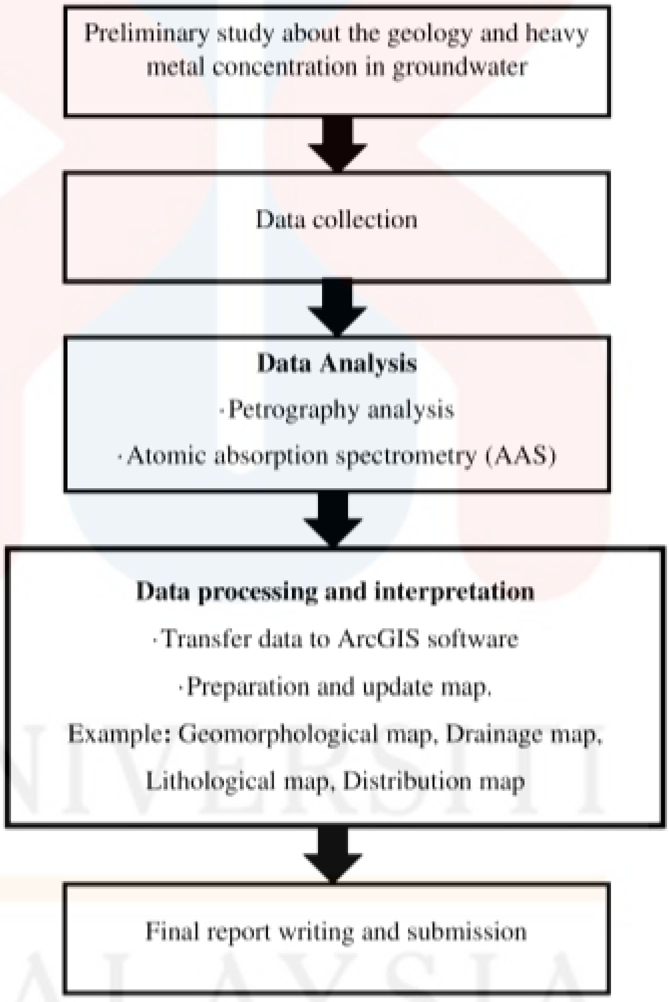

Figure 3.1: Research flow chart

3.3.2 Preliminary studies

Preliminary study was made by making the research either by collect the information by using a secondary data or go for preliminary fieldwork. In order to analyse the heavy metal concentration in groundwater at the study area, the information can be gets by go through the previous research. There are a few research papers, journal and also books will be collected to get an information about the heavy metal concentration in groundwater at the potential area instead of to know its method as well.

3.3.3 Field studies

a) Geological mapping

Geological mapping will be made by referring terrain and base map in order to get a precise information as well as updating. To make the geological mapping success, it need to be conduct using field activities. All of the process are including traversing, sampling, and observation at the study area. Traversing is a crucial thing that need to be done in geological mapping to make sure all the pathway are marked during the mapping. It can also be as traversing evidences when the mapping process has been done. For the sampling, sampling is one of the methods that need to take a sample in order to make an observation. In this research, the fresh outcrop needs to be identified in order to know about the structure geology and lithology of the study area. Structure geology is a process of identification and distinguish the geological structure that exist at the study area. For example, faults, lineament that exist in the study area. After all of the sample has been collect, the geological map will be produced.

b) Water sampling

Next, to proceed the data collection process, a geological mapping process need to be complete. This is to make sure the primary data can be collect. So, the basic step of geological mapping is by taking water samples instead of making an observation and measurement. The water sample need to be take at the different shallow domestic well. In order to get the primary data, not only water sample need to be collect, the other information like collection of rock sample drainage data, geomorphology and also lithology data also need to be collect to generate map.

3.3.4 Laboratory work

Laboratory work will be process by referring to the primary data. Laboratory work are including the process of AAS method, petrographic analysis in order to get the firm data before proceed with the interpretation by using the ArcGIS software.

3.3.5 Data processing

a) Geology mapping

After all of the mapping process has been complete, which include traversing and collecting the sample, the ArcGIS software will be use. It will completely interpret the data that has been collect. From this, all of the preparation and update map process, like geomorphological map, lithological map, cross section map can be carried out.

b) Research specification

Heavy metal concentration data will be compiled and interpret in the ArcGIS. The example of the data that can be interpret by using the data that we get from the water sample collection data is distribution map of heavy metal concentration in the study area. Also, all of the percentage of heavy metal concentration in the study area will be compiled together and send to the nearest water treatment plant before make a journal.

3.3.6 Data analysis

a) Geology mapping

Petrographic analysis is one of the process of data analysis. It will go through two processes. The first step is by making a hand specimen analysis which involve the macroscopic observation. Microscope will be uses as an equipment in order to observe the mineral clearly. Then the petrography process will be continued with the thin section analysis. The rock sample will be cut and thin on the glass slide. The objective of making this process is to identify the mineral texture and composition.

b) Groundwater

In situ analysis measurement need to be take action to measure all of the physical and chemical parameters in a water body. The groundwater also will be replicates for two time. Parameters that will be observe are including temperature, TDS, hardness and pH. Basically, the temperature of the water at the study area will be change (Senoro,et al. 2021). Other than that, hardness is defined as water that is high in calcium, magnesium, or both. The properties of water substance raise the boiling point of groundwater. Hard water reduces the likelihood of harmful processes occurring in pipeline structures by reduce the heavy metal from entering the pipeline system (Trivedy & Goel, 1984).

In terms of pH, acidic water will contain more free hydrogen (H+) ions than hydroxide (OH+) ions, whereas alkaline water contains extra free hydroxide (OH+) ions than hydrogen (H+) ions. The pH of water can change depending on the presence of air and temperature changes, such as acid rain falling from the sky and seeping into the subsurface and eventually reaching the aquifer (Trivedy & Goel, 1994). In most portable groundwater systems, the carbonate system is the primary control. So, this analysis is valid to do in order to get an accurate data measured in a laboratory. In situ data are often required to aid the interpretation of other water quality results.

The method will be continued with the data processed that can be done by using the AAS method. The water sample will go a preservation process before AAS analysis start. For preservation process, the water sample will be dilute with 5% nitric acid for preservation. The purpose of preservation is to maintain the quality of the water sample and avoid the heavy metal from destroy. Moreover, in order to make sure the sample well maintain, the bottle need to be seal with the aluminium foil before placed in the ice box or refrigerator. This is to prevent the water sample exposed to the direct sunlight or air that can disturb the quality of sample and heavy metal or ion inside. It must to make sure the water sample always kept cool even in laboratory until they can be analysed.

After preservation, the samples need to be filter by using micron micropore membrane filter 0.45 μm before transfer into four centrifuge tube to avoid clogging of the burner capillary. Then, all of the four centrifuge tubes will be labelled as A,B,C and D.

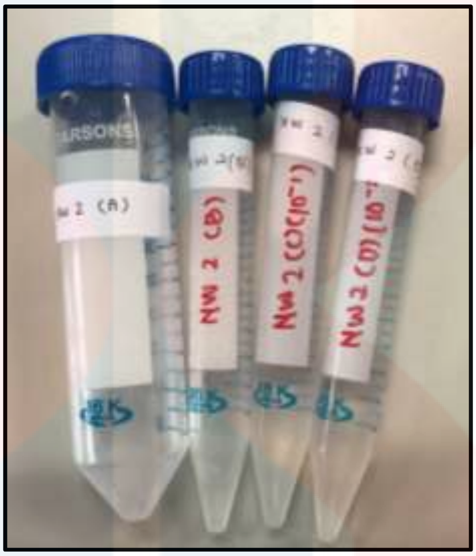

Figure 3.2: The example of centrifuge tube labelled as A,B,C,D for NW2

In centrifuge tube A, a pure water sample will be put. 15 mililiters sample from centrifuge tube A must be transfer into centrifuge tube B. The process continues by taking a C’s centrifuge tube and mix 13.5 mililitres of 5% nitric acid with 1.5 water sample from centrifuge tube B. Centrifuge tube C need to be shake slowly to make sure it completely dilute. Last step before AAS analysis, 13.5 mililitres of 5% nitric acid also need to be fill in centrifuge tube D. A dilution of 13.5 mililitres sample and nitric acid in centrifuge tube C will be fill in centrifuge tube D. This process needs to be done in order to enrich the heavy metal concentration.

After all of that process has been done, the Atomic Absorption Spectrometry (AAS) analysis can start by run the distilled water as blank and continue with analysing standard heavy metal solutions for the standard curve (Pushkar.D.B. (2020).

CHAPTER 4

GENERAL GEOLOGY

4.1 Introduction

The general geology of study area Kampung Ipoh, Tanah Merah, Kelantan were discussed in this chapter. A several components of general geology which consist of accessibility, settlement, forestry, geomorphology with its classification and drainage pattern, lithostratigraphy, structural geology and historical geology will be explain in detail at this chapter.

Geomorphology can be defined as the study of the landform and its processes related to the origin of the Earth and about the evolution of the Earth. It includes the study from topography, drainage pattern and the weathering process which occur in the study area. However, stratigraphy is another part of geology that concerned with the order and relative position of strata that correlate with the geological timescale. Stratigraphy basically will explain in detail about a lithostratigraphy in terms of its stratigraphic position and the explaination about its unit.

Furthermore, a structural geology will be carried out by making an analysis of structure that was found on the outcrops during mapping process. The example of geological structure consists of joint, fractures, fault, and fold. The structural mechanism was done to determine the major forces that deformed in the study area. Part of the historical geology also discussed about the historical formation of the study area by compare the sequence of the lithology found and the history of deformation during the formation of the area.

4.1.1 Accessibility

This study area is easy to access because there are a lot of road connection that can be access easily by the vehicle transport like motorcycle and car. Timur-Barat highway, constructed by the Malaysian Public Works Department is a main road that give an access to this study area.

Furthermore, from the mapping process, the Eastern part of the study area is believed to be a road connection to a rubber plantation area while at the Northern part is a road connection to palm plantation. At the South part area of the Kampung Ipoh, most of the road was used by the resident to go from one village to others because there are residential areas along the road. Some of the area that located at the Western part cannot be reach because it has been covered by electric fence for agriculture purpose.

4.1.2 Settlement

A settlement or community who live at the study area can be classify by using their pattern which are isolated, dispersed nucleated and linear. Kampung Ipoh and Kampung Batang Merbau are the settlement that can represent the settlement of the study area since the number of community that presence at that two villages is high.

There are a several settlements that can be identify in the study area. The first settlement is in Kampung Ipoh. The pattern of settlement can be considered as linear pattern. It can be proved when the houses in the area form a straight line that follow the line of road.

For the Kampung Batang Merbau, the settlement can be classify as a dispersed pattern or scattered settlements since the buildings are spaced across a wide area. Instead of having a few houses, there are also other building that occur there, such as mini mart, school and also government health clinics.

4.1.3 Vegetation

The land that has been cover by the plant is known as a vegetation area. There are about 80% of the land in the study area is used for agriculture. The types of vegetation which cover that area are palm plantation which mostly located at the Northern part of the study area. While the rubber plantation was cover the Eastern part and at the Western part of the study area has been covered by electric fence since that agriculture part are new establish and it need to be restrict by human and animal to avoid the destruction.

Figure 4.1: Example of vegetation types in the study area i) palm plantation ii) rubber plantation, iii) agriculture place which covered by electric fence in study area

4.2 Geomorphology

4.2.1 Geomorphologic classification

Geomorphology can be defined as a study of landforms which explain more about the process and evolution of landscape at the surface of the earth. Basically, the geomorphology of the study area will be identify based on the landform and topography. An arrangement of the physical distribution of the Earth's surface like an elevation and shape is the example of topography. It can be represented in a map which known as topographic map that included the elevation of the area by referring Van Zuidam (1985) classification.

Table 4.1: Landform classification of the study area based on Van Zuidam

Relief/ Landform	Elevation (m)
Low plain area	<50
Plain area	50-100
Low hill area	100-200

(Sources: Van Zuidam, 1985)

According to Van Zuidam (1985), the type of landform divided into seven classes based on its elevation. They are <50 meters above sea level, 50-100 meters above sea level, 100-200 meters above sea level, 200-500 meters above sea level, 500-1,000 meters above sea level, 1,000- 1,500 meters above sea level, and >1,500 meters above sea level. A landform that has an elevation less than 50 meters above sea level can be classify as a low plain area while for the area with elevation 50-100 meters, it consider as plain area. Geologically, plain area or known as flat land is a major landform that occur on Earth. For the low hill, the elevation range is about 100 – 200 metres while hilly area is from 200 – 500 metres in range and high hill 500 – 1500 metres above sea level.

The elevation of the study area ranging from 20 to 100 meters above sea level. According to Van Zuidam classification, Kampung Ipoh is 90% covered by low plain area. It can be proved by looking and observe the pattern of topography that shows the lines of contour is far away. This means the topography of the study area is low area. Low area which covered with plain landforms are extremely important for agriculture like in Kampung Ipoh, Tanah Merah. The sediments that made up by the various types of plain landforms contribute significantly to fertility, allowing for excellent crop growth like palm plantation, rubber plantation in the study area and a grass land that provide good grazing for livestock. So, a geomorphology analysis is done at the study area.

Figure 4.2: An illustration views of the study area which represent surface features of the area

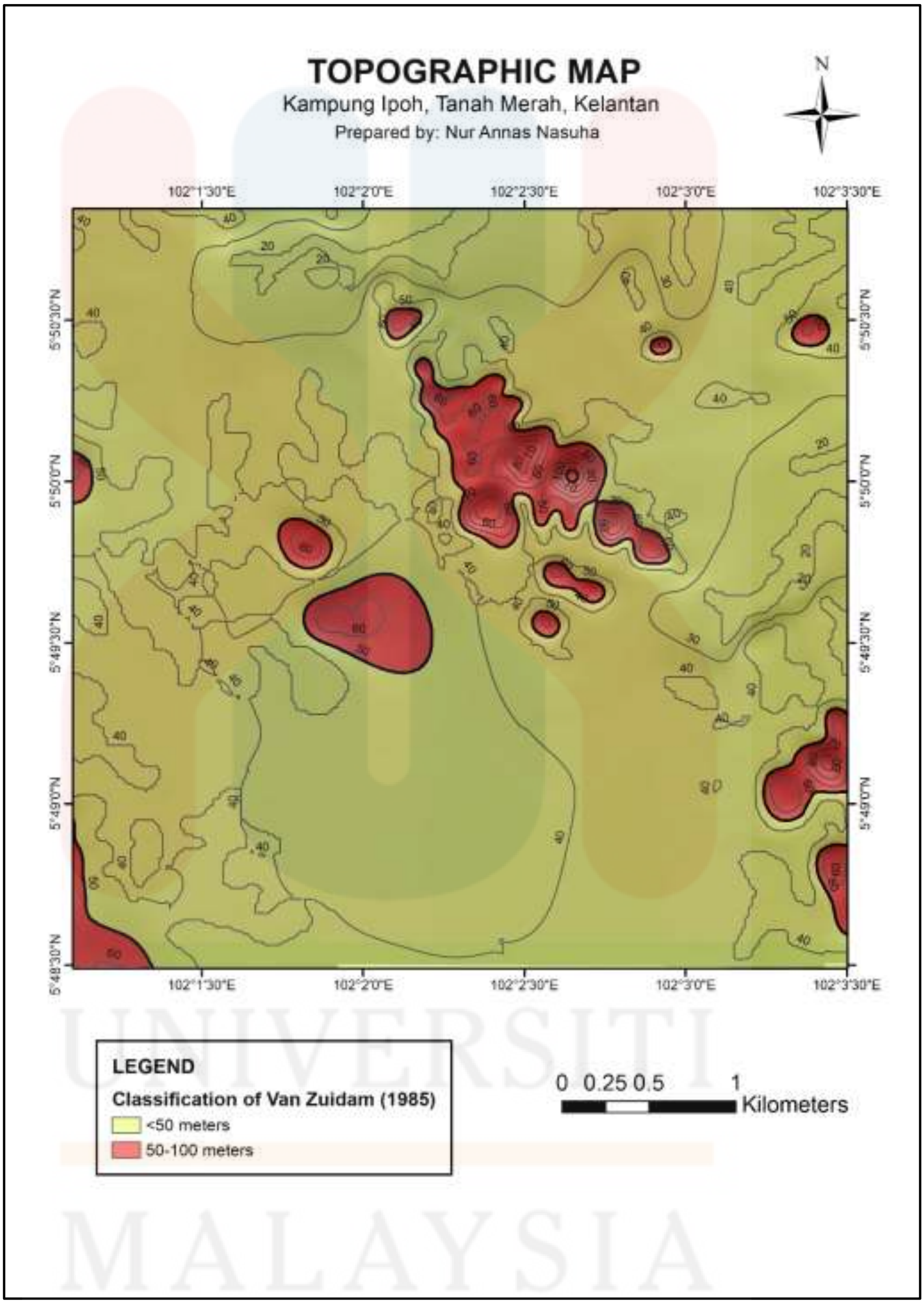

Figure 4.3: Topographic map of the study area

4.2.2 Drainage pattern

The arrangement of streams on the surface of Earth that follow a drainage system is known as drainage pattern. The pattern creates by stream, rivers, and lakes in a particular drainage basin. Topography of the land in terms of gradient of the land or type of rock at the region will give an effect to the drainage pattern. There are two types of drainage pattern that can be observed from the study area. They are dendritic pattern and rectangular pattern.

Dendritic pattern can be identified based on its shape which looks like branching shape of tree roots. This type of drainage pattern form at an unconsolidated material or rock like granite, gneiss, and volcanic rock that occur at beneath the stream in order to make sure it can be eroded equally in all directions. Dendritic drainage pattern found in almost part of the study area especially at the northwest part. According to Ritter (2006), the dendritic drainage pattern form or appear in areas underlain by homogeneous material. The tributaries join to the larger streams at acute angle which is less than 90 degrees. But, for the rectangular drainage pattern, this type of drainage occurs when the rock structure leads a streams into a parallel course, with contribute joint occur at almost in every angle.

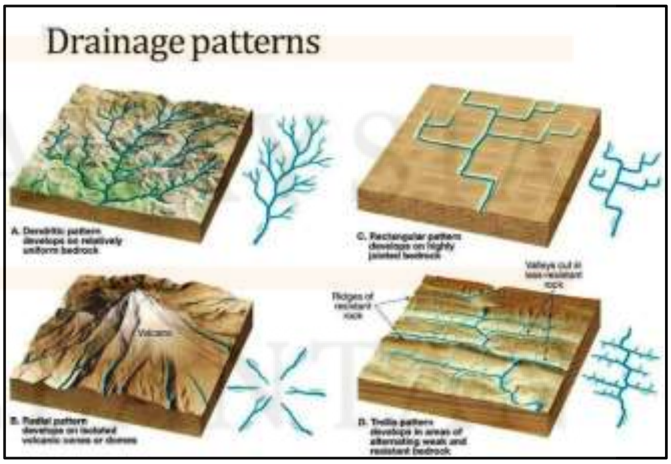

Figure 4.4: Example of drainage pattern

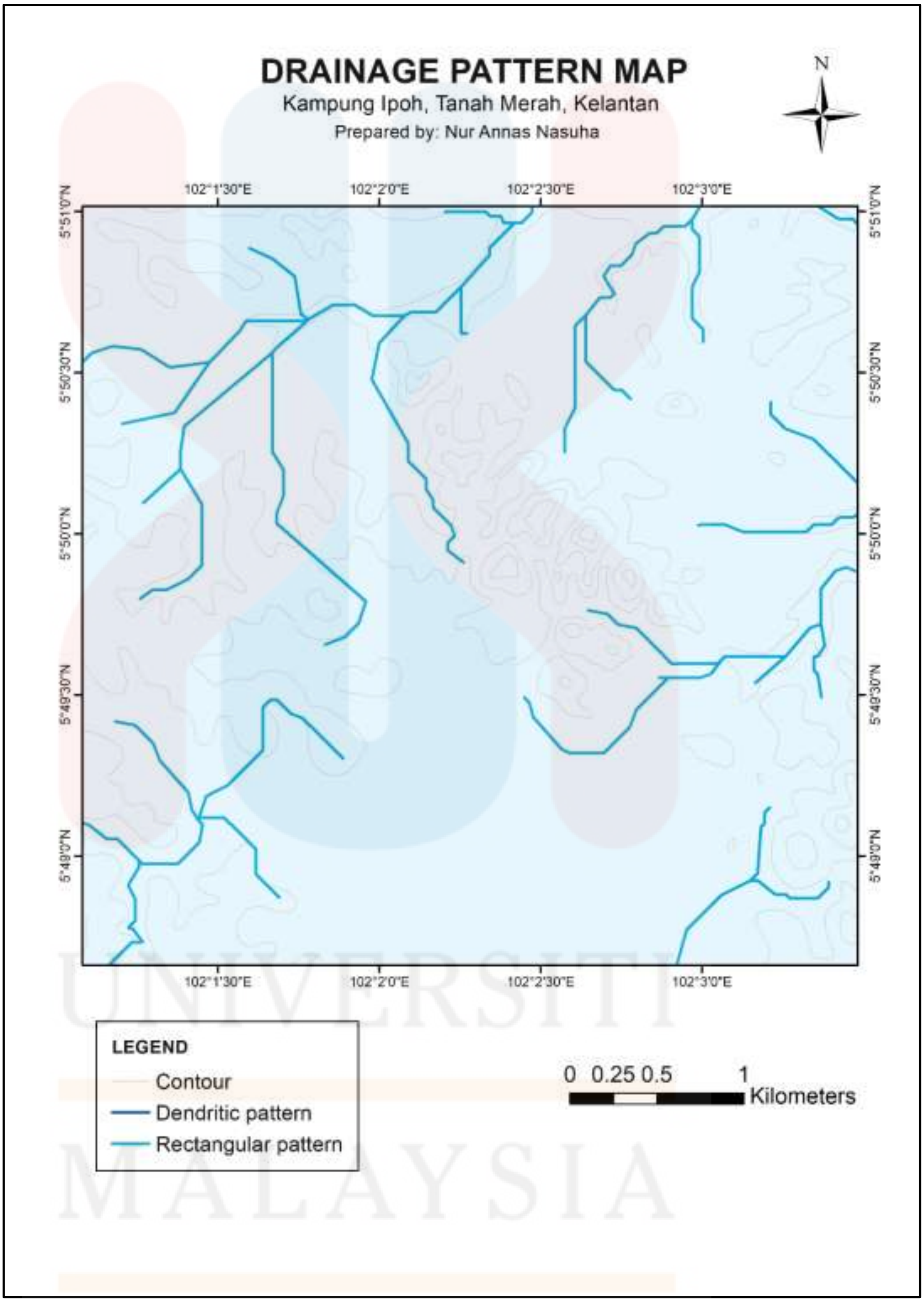

Figure 4.5: Drainage map of the study area

4.2.3 Weathering

Weathering can be defined as a process of breaking down or dissolving of rocks and mineral. The weathering process will give an effect to the chemical decomposition and mechanical disintegration of soil and rock. There are three types of weathering process which are mechanical weathering or basically known as physical weathering, chemical weathering and biological weathering. These types of weathering process can be happened due to the presence of agents like water, ice, wind and others.

Mechanical weathering is a process which the rock will disintegrate and easy to crumble because of the temperature, pressure and other force which occur on the rock without change the chemical composition of the rock. However, for the chemical weathering, it will divide into four types, solution, hydration, oxidation and carbonation. When the water interacted with the mineral, a different types of chemical reaction happen and change the chemical composition of the rock. This process on going rapidly with the presence of water and high temperature.

On the other hand, biological weathering is the disintegration process of rock by animals or microbes and mostly occur because of plants. Plant's root biologically weathered the rocks by growing within the rock cracks and fractures which can lead to the rock breakage happen.

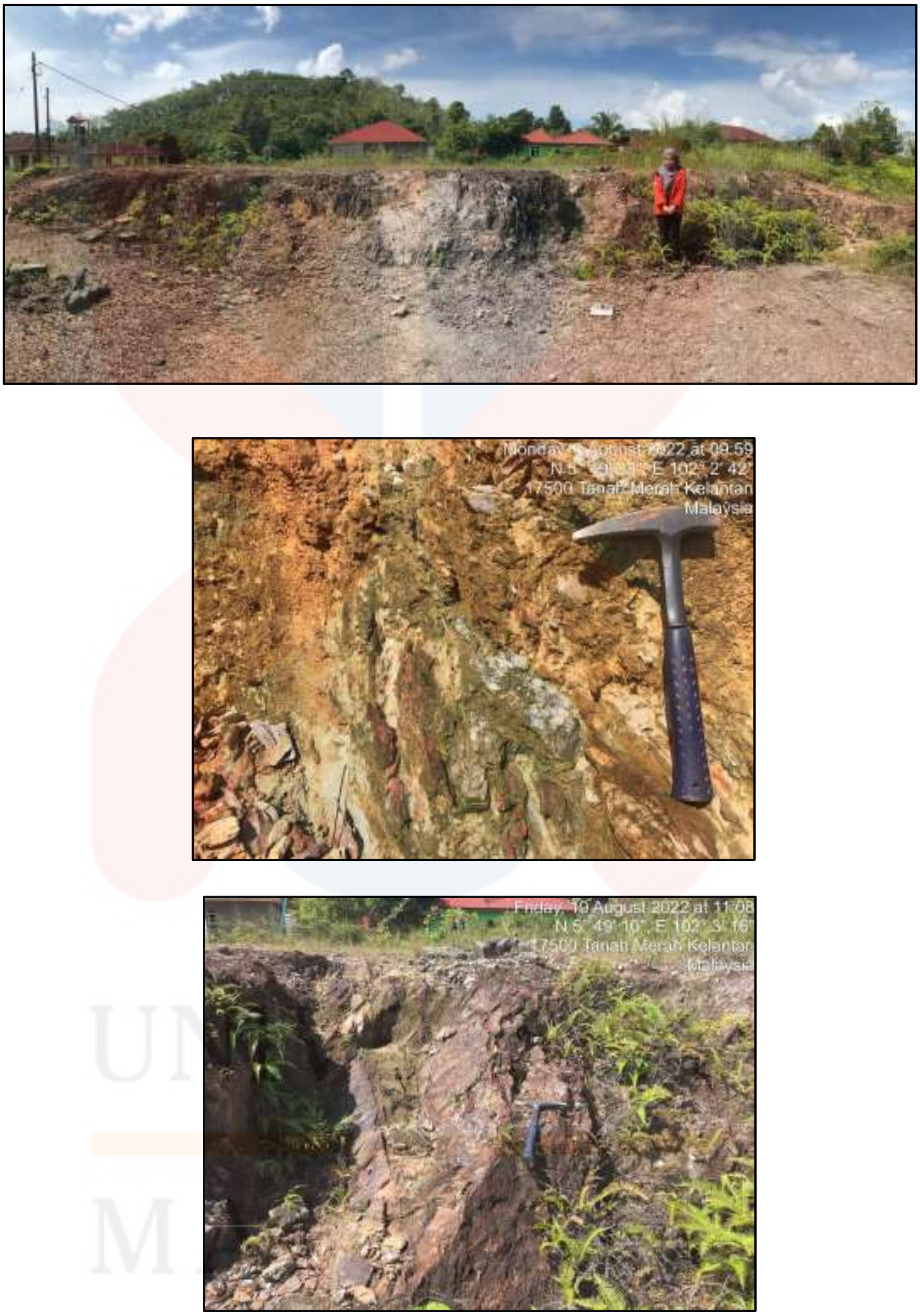

Figure 4.6: Example of weathering in study area

Type of weathering will be classified based on its grade of weathering by making an identification in terms of rock colour, the way of rock disintegrated and others.

To be more specific, there are six grades of weathering are occur starting from grade I until grade VI. Grade I is the fresh rock where there is no weathering occur while the worst weathering is in grade VI when all of the rocks are completely ruin and can be crumble by hand easily. Geologically, different outcrop will have a different type of grade due to its physical and chemical condition. From the geological mapping, most of the outcrop at the study area are consist of grade II to grade V weathering classification.

VI	Residual Soil	A soil formed by weathering in place but with original texture of rock completely destroyed.
V	Completely weathered rock	Rock wholly weathered but rock texture preserved No rebound from N Schmidt hammer Slake readily in water Geological pick easily indents surface when pushed
IV	Highly weathered rock	Rock weakened so that large pieces can be broken by hand Positive N Schmidt rebound value up to 25 Does not slake readily in water Geological pick cannot be pushed into surface Hand penetrometer strength index greater than 250 kPa Individual grain may be plucked from surface
III	Moderately weathered rock	Completely discolored Considerably weathered but possessing strength such that pieces 55mm diameter cannot be broken by hand N Schmidt rebound value of 25 to 45 Rock material not friable
II	Slightly weathered rock	Discolored along discontinuities Strength approaches that of fresh rock N Schmidt rebound value greater than 45 More than one blow of geological hammer to break specimen
I	Fresh rock	No visible signs of weathering or discolored

Figure 4.7: The weathering classification

4.3 LITHOSTRATIGRAPHY

Lithostratigraphy is known as a classifying of rock bodies. It can be classified by making an observation in terms of lithological properties of the strata and their relative stratigraphic positions, (Davies et al., 2020). From the stratigraphy observation, all of the information about the processes, geographical distributions, and others can be develop. Geologically, the stratigraphy can also provide an information about the geological events over a wide area.

4.3.1 Stratigraphic position

According to previous research, the sequence of the rock that occur at the study area are schist and quartzite.

Table 4.2: Stratigraphy column of the study area

LITHOLOGY	TYPE OF ROCK	AGE	DESCRIPTION
	Schist	Late Cretaceous	The biotite mineral from schist enclaves within Kemahang Granite and it go through the metamorphism process.
	Quartzite	Late Triassic	Mainly consist of quartzite that made up by a quartz as a major mineral.

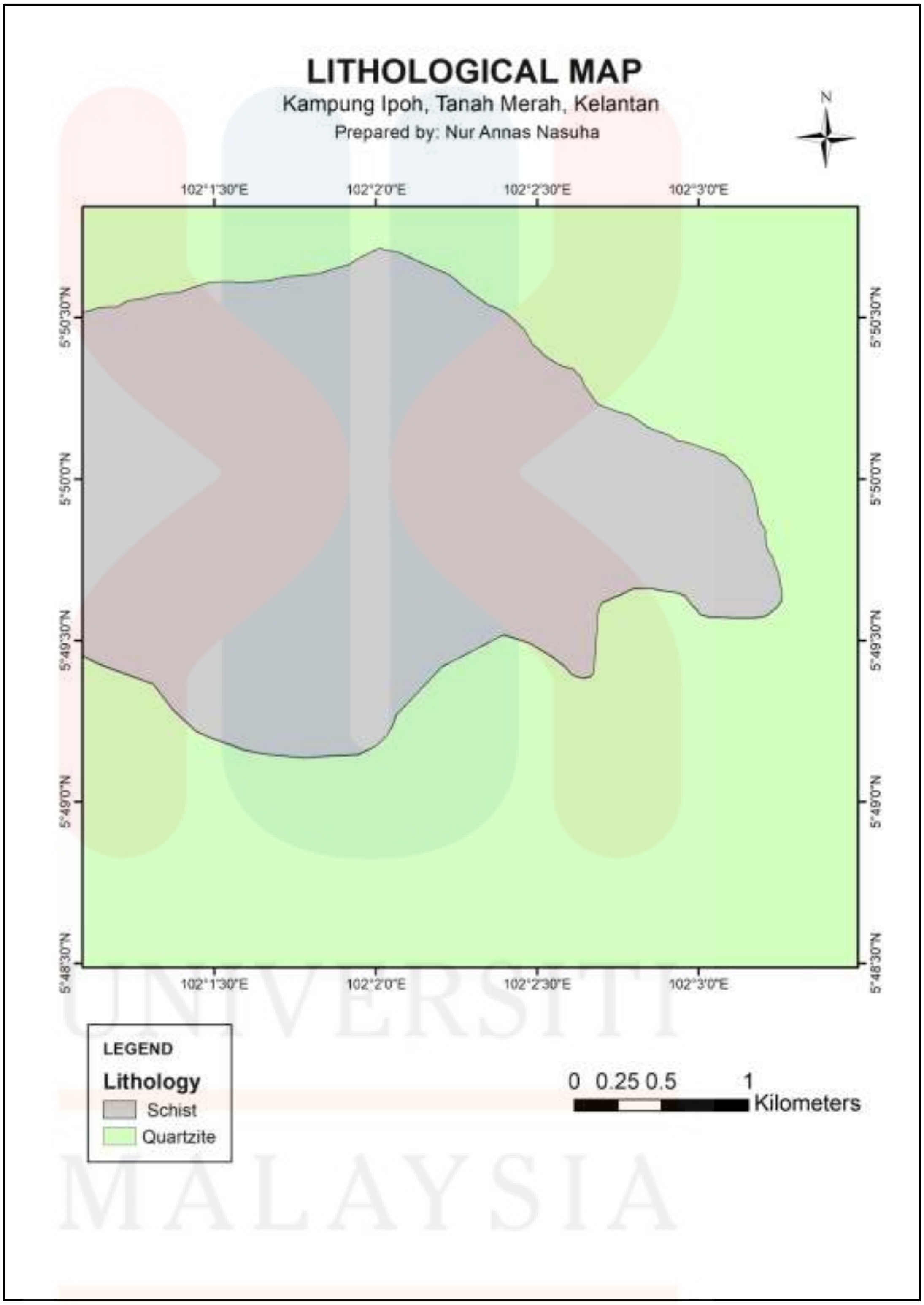

Figure 4.8: Lithological map of the study area

4.3.2 Lithology

Most of the study area are covered by schist. And the other 1/4 area is quartzite area. The characteristic of each rock after making an analysis is mostly same because of the rock classification. Under this subtopic, the explanation about the hand specimen and thin section analysis will be elaborate in detail in terms of its physical characteristic and mineral composition in each rock sample.

Field and Hand specimen analysis

Schist

i) First hand specimen and outcrop

Figure 4.9: Hand specimen of the first sample (schist)

Figure 4.10: Outcrop of the first sample (schist)

One of a fresh schist outcrop was found and hand specimen was collected in the study area at coordinate 05°50'35.2" N 102° 01'19.6"E. As usual, schist presence in sheet-like and comes with physical properties of schist which can be seen with naked eyes and in terms of its colour, its presence as black in colour.

There are a few parts of the outcrops and hand specimen turns to green colour. It was occurs because of its formation under particular temperature and pressure which trigger distinction of the greenschist facies in the mineral facies (Science, G., 2022) Other than that, this hand sample comprised of talc minerals, and also have abundant amount of quartz. In terms of its grain size, it would be considered has a medium to fine grain.

ii) Second hand specimen and outcrop

Figure 4.11: Hand specimen of the second sample (schist)

Figure 4.12: Outcrop of the second sample (schist)

The figure above shows the schist rock which occur at the other outcrop that has been weathered. Obviously, the biological weathering can be seen when the subsequent disintegration of rock by plants occurred and destroy the physical properties of rock sample in terms of its colour, texture and so on. Due to high grade (grade V) of weathering, mineral composition of the hand specimen cannot be investigate based on our naked eyes but can only see under thin section analysis.

Grade V shows a completely slightly weathered rock which all of rock material did not show its colour and some of them are converted to soil. It can be seen clearly from the figure when there still has a small rock which not been disintegrate yet and some of the rock can be crumbled by hand easily.

Quartzite

i) First hand specimen and outcrop

Figure 4.13: Hand specimen of the first sample (quartzite)

Figure 4.14: Outcrop of the first sample (quartzite)

At coordinate 05°50'43." N 102° 01'22."E one quartzite hand specimen has been collected. The physical properties of this rock sample can be seen in a various way in terms of its grain size, hardness, textured and also colours. It has a medium grain size. Geologically, the presence of quartz crystals can be easily identified with the naked eye. Quartz in the rock sample that can easy to be distinguish because it shows its crystalline properties. Other feature of this sample is it has a gritty texture with a black colour.

In terms of hardness, the sample come with a high hardness even the outcrop slightly weathered. The outcrop might be weathered by the presence of water as a primary agent since it located near to the stream. Other than that, the weathering also occurred due to the presence of biological weathering. At the top of the outcrop there are a plant that grow on it and the root intrude into the outcrop.

ii) Second hand specimen and outcrop

Figure 4.15: Hand specimen of the second sample (quartzite)

Figure 4.16: Outcrop of the second sample (quartzite)

For the second hands specimen and outcrop of quartzite, the outcrop much more fresh. It has been proved when the outcrop only has a low grade of weathering classification and its original mass structure are still preserved. The outcrop only have a little bit discoloration at the joint area. Since it need to be broken by using a geological hammer it gave a ringing sound when it is struck. The hand specimen can be considered as fresh through its colour, hardness and also mineral composition. Pure quartzite occur in a white colour and have a high level of hardness. Also, it might be more scratch resistant, but it cannot be considered as a scratch proof. In terms of mineral composition, it is dominated by quartz. Due to highly metamorphosed process, the minerals bond together tightly.

Thin section Analysis

a) Schist

i) First thin section

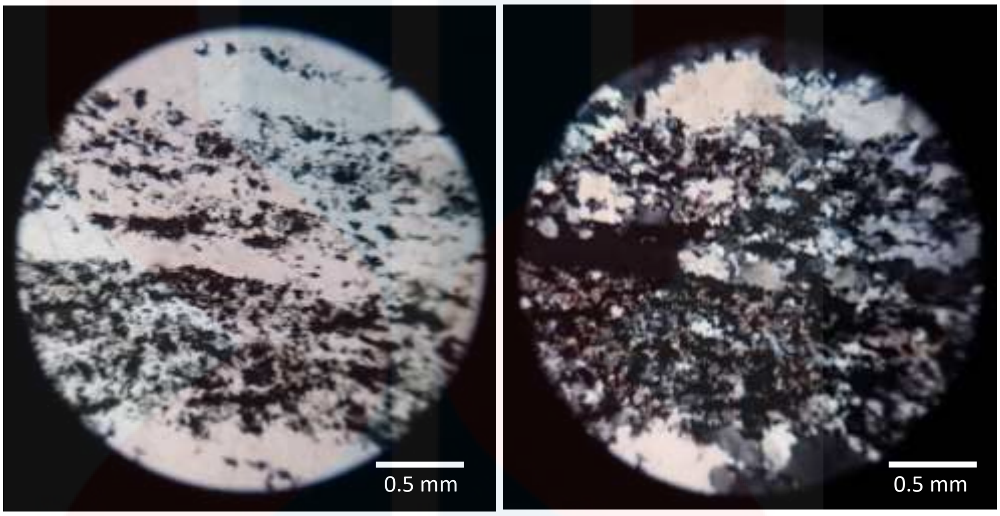

Figure 4.17: Left- Plane Polarized Light (PPL); **Right-** Cross Polarized Light (XPL) first sample of Schist photomicrograph thin section

According to the photomicrograph of thin section in sample above, it was made up by 70% of quartz mineral. The mineral shows a characteristic with low relief and have a foliation structure (schistose) that can be seen clearly under the microscope with 10x and 5x magnification. It comes with a range size from <1/256 to 1 millimeters. Quartz mineral was identified come as an anhedral crystal texture with no evidence of pleochroism and cleavage. Under Cross Polarized Light (XPL), quartz was identified based on its first order interference colour of white to grey. The other characteristic of quartz under XPL is it did not have any twinning.

Instead of quartz, talc also mixed together to made up this sample. It has an anhedral crystal texture under Plane Polarized Light (PPL). On the other hand, this mineral shows a low relief and also did not have any cleavage like quartz. It different in terms of interference color. Under cross polarized light (XPL), talc mineral presence in third order interference colour of blue to yellow. When the polar light across during analysis, there is no twinning appear in talc mineral. Moreover, an opaque mineral seen across thin section as a black interference colour. Its crystal texture more euhedral and just a little bit of it comes in anhedral crystal texture.

ii) Second thin section

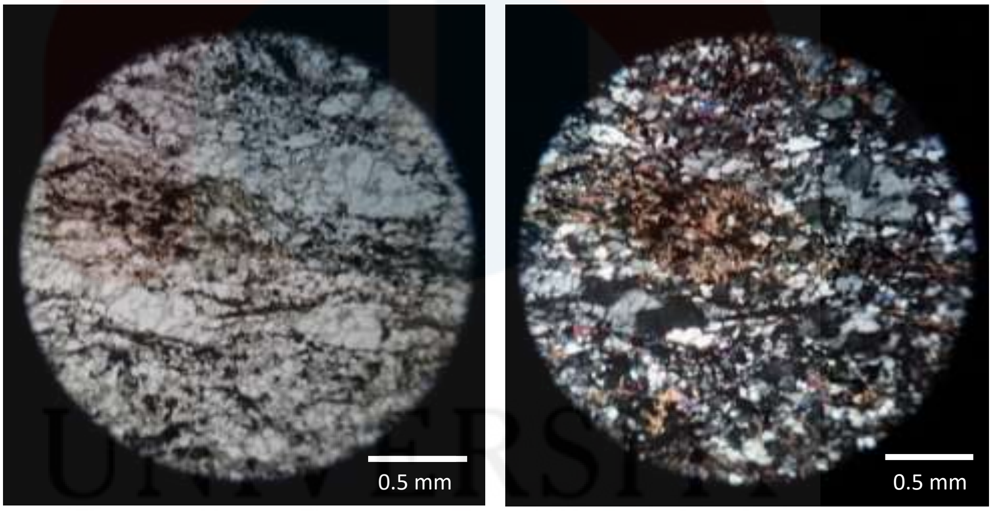

Figure 4.18: Left- Plane Polarized Light (PPL); **Right-** Cross Polarized Light (XPL) second sample of Schist photomicrograph thin section

For the second sample of Schist photomicrograph thin section, it shows a foliation but come with palimpsest texture and all of the mineral are well sorted. This thin section is different with the previous in terms of its mineral composition. Talc, quartz and opaque mineral still mix together to form schist but it has an addition mineral of clay.

Under Cross Polarized Light (XPL), quartz was identified based on its first order interference colour of white to grey. The other characteristic of quartz that has been identified is it did not have any twinning. In Plane Polarized Light (PPL), quartz come as an anhedral crystal texture with no evidence of pleochroism and cleavage. It is very distinguishable as quartz mineral exhibit a colourless colour.

Talc mineral has an anhedral crystal texture under Plane Polarized Light (PPL). Also, it comes in a low relief and pleochroism. In terms of interference color, talc mineral presence in third order interference colour of blue to yellow. When the polar light across during analysis, there is no twinning appear in talc mineral.

Other than that, there are about 10% of clay mineral composed of a micron of silicate material has been found during analyses. A mineral appeared to be brownish under Plane Polarized Light (PPL) while in XPL it shows the interference colour of dark grey to black. On the other hand, opaque mineral which have a crystal texture are more euhedral and just a little bit of it comes in anhedral crystal texture found in this second thin section of schist.

b) Sample Quartzite

i) First thin section

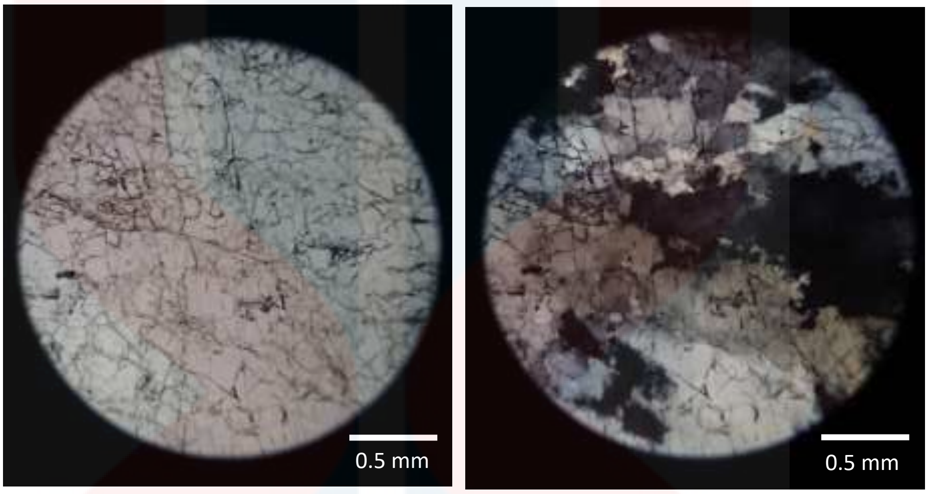

Figure 4.19: Left- Plane Polarized Light (PPL); **Right-** Cross Polarized Light (XPL) first sample of Quartzite photomicrograph thin section

This thin section is mainly consist of two mineral composition which are quartz and opaque mineral. Through microscopic observation of 10x ocular magnification and 5x objective ocular, there is no foliation occur for this sample. The texture is medium sorting and mostly they are granoblastic with size <1/64 to >2 milimetres. Based on photomicrograph of plane polarized light (PPL), opaque mineral presence in a euhedral crystal texture with absence of pleochroism.

By referring the mineral relief categories, this mineral can be classified as low relief with refractive index below than 0.04 different from surrounding medium. Quartz mineral can be distinguished easily through plane polarized light (PPL), since it appears to be colourless with low relief and pleochroism. Under Cross Polarized Light (XPL) microscopic, opaque mineral presence in first order interference colour of black and not showing any twinning in this section similarly to quartz. Quartz mineral appear in first order interference colour of white to grey.

ii) Second thin section

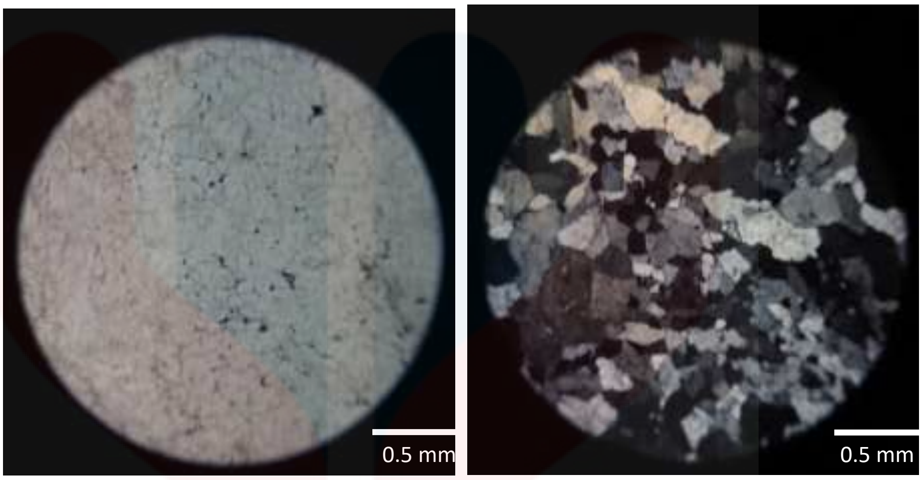

Figure 4.20: Left- Plane Polarized Light (PPL); **Right-** Cross Polarized Light (XPL) second sample of Quartzite photomicrograph thin section

According to the photomicrograph of Quartzite thin section, it is non foliation and have a granoblastic texture. The mineral of this thin section is different to the previous one because the mineral is well sorted. From the thin section analysis, there are about 99% of quartz mineral occur. Quartz mineral appear in first order interference colour of white to grey through Plane Polarized Light (PPL) and shows a low relief with no pleochroism under Cross Polarized Light (XPL). However, for the opaque mineral, the grade of interference also first order but with a black color. In PPL microscopic also, opaque mineral did not show any twinning. The other characteristic that obvious during analysis is its lack of cleavage and pleochroism.

4.4 Structural geology

4.4.1 Lineament analysis

Lineament is a linear line that represent a pattern in map or model of earth's surface or subsurface of earth. The line also should be continuous, well expressed and related to features of the solid earth. A lineament can be form by a fault zones, shear zones, valley, fault or fold-aligned hills, streams and coastlines, (Caran et al. (1981)). This type of structural geology can be in two types. They are positive and negative lineament. A linear line that represents ridge and range is known as positive lineament while negative lineament is a line of streams, faults and valleys.

Lineament analysis may be used in regional synthesis to define the structural fabric of a terrane and to focus attention on domain boundaries or zones of weakness instead of knowing it principles strength. Also, the other purpose of making a lineament analysis is to locate buried structures, map fractures, and interpret the regional structure.

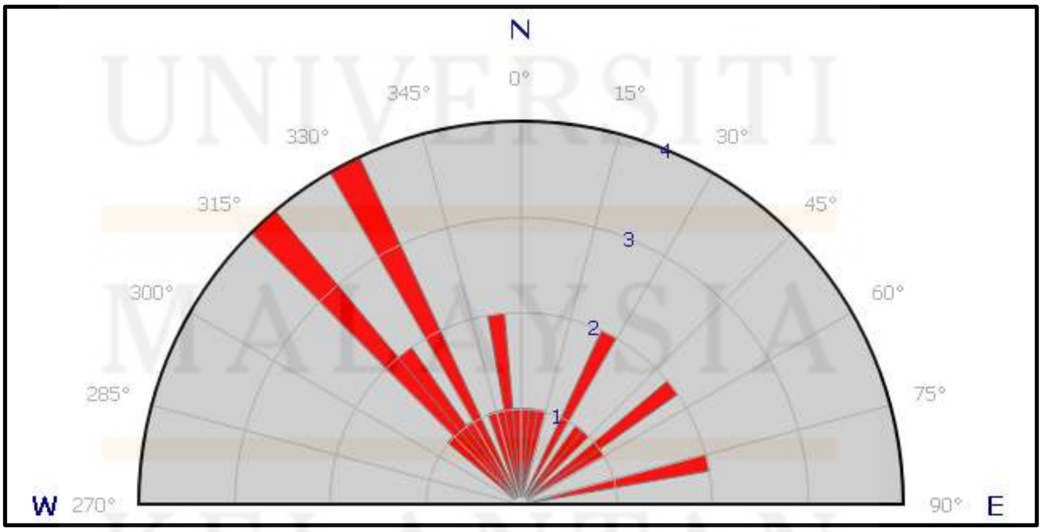

Figure 4.21: Rose diagram based on lineament analysis

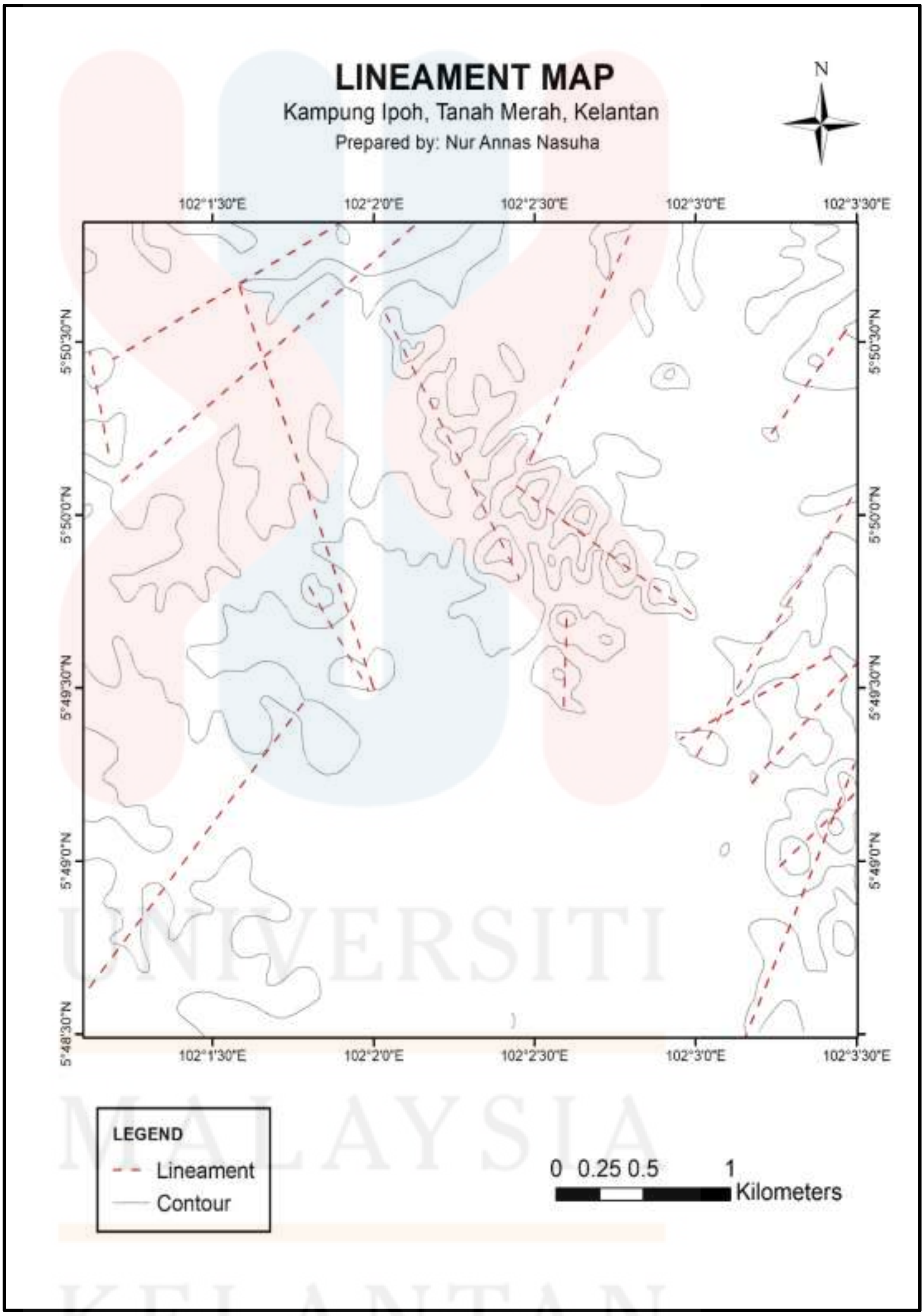

Figure 4.22: Lineament map of the study area

4.5 Historical geology

Taku Schist formation form near to suture zone by on going the process of high-grade metamorphism. From the convergence of the Sibumasu continental block and Sukhothai Arc, Taku schist form a few parts of an Indosinian orogenic.

In research from Aminuddin, the type of lithology of this formation are consist of greenschist's metamorphism into amphibolite facies. It has been proved when an observation has been done near the Triassic and Cretaceous intrusions of the Kemahang Granite. The evolution process of the rocks can be correlate with the interactions between a contact and regional metamorphism, (2021).

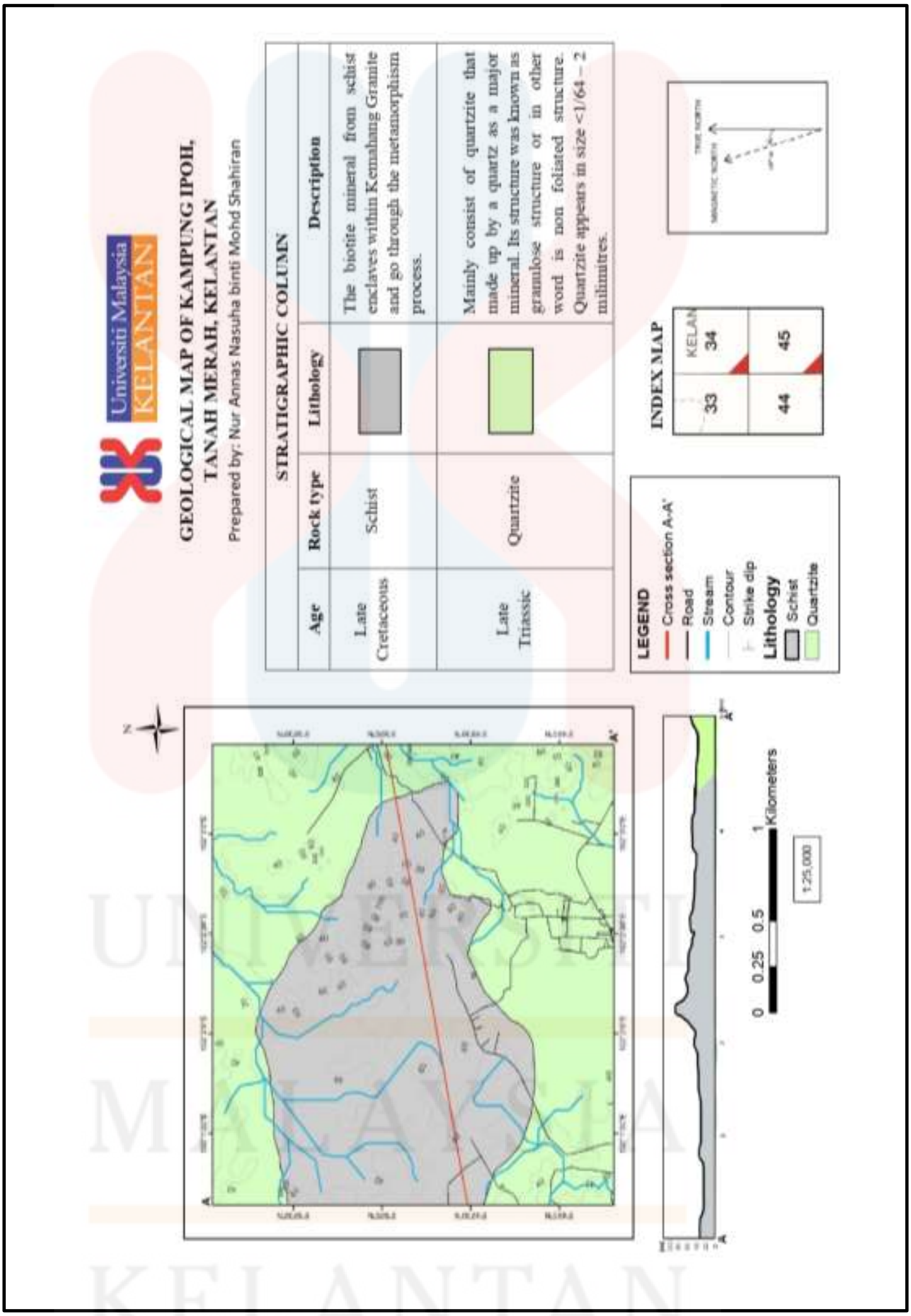

Figure 4.23: Geological map of the study area

CHAPTER 5

HEAVY METAL CONCENTRATION IN GROUNDWATER OF KAMPUNG IPOH, TANAH MERAH, KELANTAN

5.1 Introduction

Groundwater was usually found contaminated with heavy metal concentrations. The level of contaminated can be measure when the concentration of heavy metal in groundwater exceeding the WHO and MOH limit for drinking water. Strong correlation can be observed between the level of contamination with heavy metal concentration between Mn, Fe, Cu, Zn, Cr and Pb. In this chapter, the results and interpretations of groundwater samples data from 12 different wells around Kampung Ipoh, Tanah Merah, Kelantan will be discussed in detail. Heavy metal concentration in groundwater is discussed based on the analysis that was made by using AAS method.

5.2 Hydrogeology of Kelantan

Hydrogeology of Kelantan basically consist about 70% of groundwater as a water supply at the Lower Kelantan River Basin. The groundwater resources can be extracted from the aquifer body reservoir in deeper settings (Daud et al., 1985). There are about 10 meter to 30 meter depth of the groundwater occur depend on the depth of the aquifer. Kelantan river is one of the major rivers in Malaysia which commands about 85% of the Kelantan area and has four main tributaries which are known as Nenggiri River, Galas River, Lebir River and Pergau River.

Kelantan River is the example of the tributaries and the principles source of water for both irrigation needs as well as the portable water demand for the state of Kelantan. The North Kelantan River Basin is topographically dominated by the flat coastal plain with elevation less than 75 meters above mean sea level and mainly covered by Quartenary sediments or alluvium formation and constituents the reservoir in this region.

5.3 Data acquisition

As mentioned before, the data sampling was taken from twelve different well around Kampung Ipoh, Tanah Merah, Kelantan. Figure 5.1 shows the location of groundwater sampling and the Table 5.1 shows the information about all of the wells.

Figure 5.1: Sampling location map (Source: Google Earth)

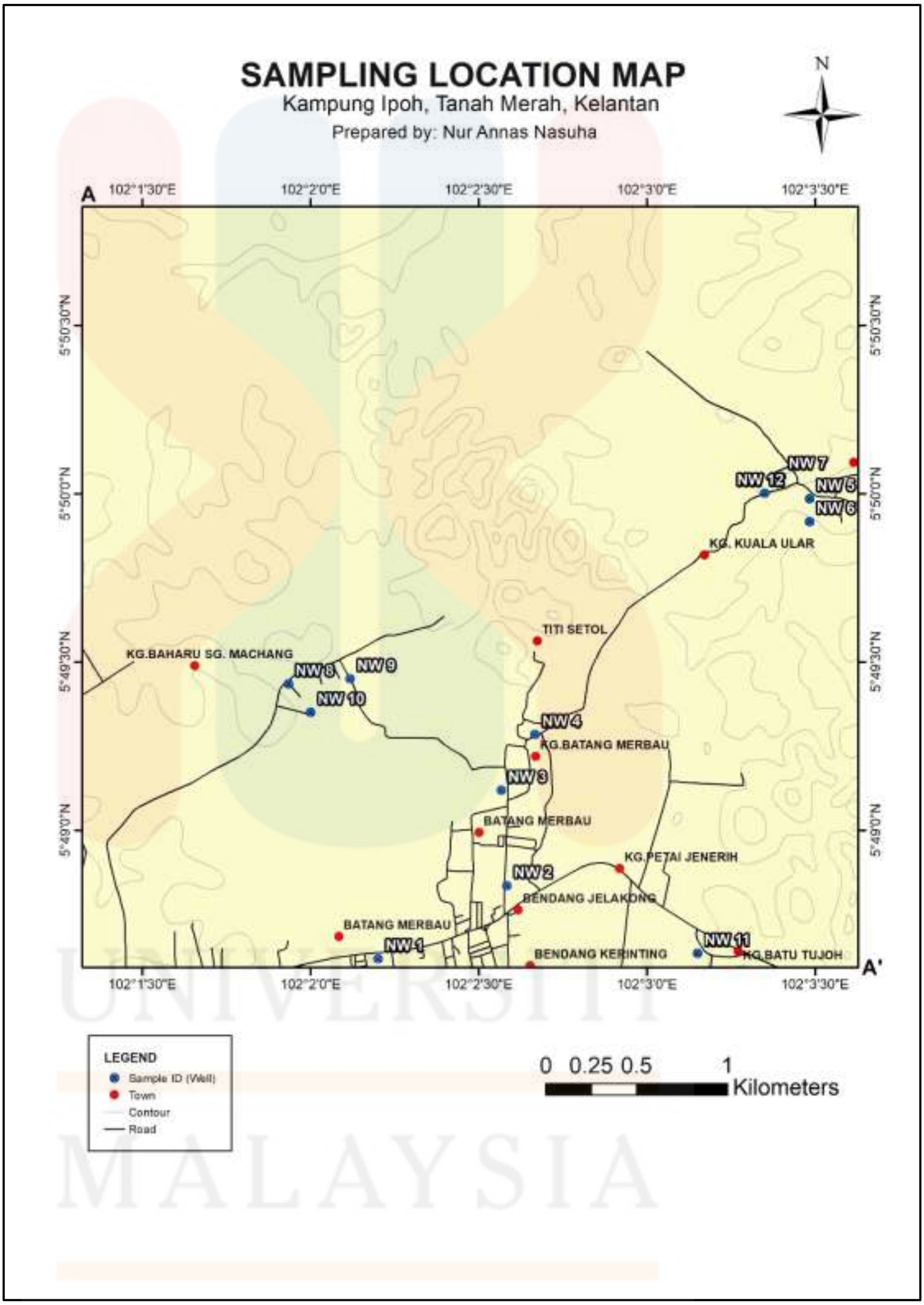

Figure 5.2: Sampling of the study area

Table 5.1: Groundwater samples location

Sample ID	**NW1**
Location	Kampung Ipoh
Coordinate	05°48'37.1"N 102° 02'12.07"E
Elevation	29 meters
Time//date	11.15am // 27/7/2022
Type of well	Domestic well
Sample ID	**NW 2**
Location	Kampung Ipoh
Coordinate	05°48'50.7"N 102° 02'35.0"E
Elevation	28 meters
Time//date	12.05pm // 27/7/2022
Type of well	Domestic well
Sample ID	**NW3**
Location	Kampung Batang Merbau
Coordinate	05°49'07.9"N 102° 02'34.4"E
Elevation	30 meters
Time//date	12.29pm // 27/7/2022
Type of well	Domestic well
Sample ID	**NW 4**
Location	Kampung Batang Merbau
Coordinate	05°49'17.5"N 102° 02'40.4"E
Elevation	26 meters
Time//date	12.44pm // 27/7/2022
Type of well	Domestic well

Sample ID	**NW 5**
Location	Kampung Bendang Nyor
Coordinate	05°49'59.6"N 102° 03'29.3"E
Elevation	29 meters
Time//date	1.19pm // 27/7/2022
Type of well	Domestic well
Sample ID	**NW 6**
Location	Kampung Bendang Nyor
Coordinate	05°49'55.0"N 102° 03'29.1"E
Elevation	29 meters
Time//date	1.24pm // 27/7/2022
Type of well	Domestic well
Sample ID	**NW 7**
Location	Kampung Bendang Nyor
Coordinate	05°50'03.6"N 102° 03'24.3"E
Elevation	34 meters
Time//date	1.41 pm // 27/7/2022
Type of well	Domestic well
Sample ID	**NW 8**
Location	Kampung Air Machang
Coordinate	05°49'26.5"N 102° 01'56.8"E
Elevation	45 meters
Time//date	11.51am // 28/7/2022
Type of well	Domestic well

Sample ID	**NW 9**
Location	Kampung Air Machang
Coordinate	05°49'27.0"N 102° 02'07.4"E
Elevation	39 meters
Time//date	12.04 pm // 28/7/2022
Type of well	Domestic well
Sample ID	**NW 10**
Location	Kampung Air Machang
Coordinate	05°49'21.1"N 102° 02'00.4"E
Elevation	37 meters
Time//date	1.15 pm // 28/7/2022
Type of well	Domestic well
Sample ID	**NW 11**
Location	Kampung Batu 7
Coordinate	05°48'38.2"N 102° 03'09.6"E
Elevation	47 meters
Time//date	1.45 pm // 28/7/2022
Type of well	Domestic well
Sample ID	**NW 12**
Location	Kampung Bendang Nyor
Coordinate	05°50'00.4"N 102° 03'21.4"E
Elevation	30 meters
Time//date	2.20 pm // 28/7/2022
Type of well	Domestic well

The data that has been obtained was including all of the physical and chemical parameters like pH, dissolved oxygen, temperature, turbidity and others. In terms of chemical parameters, it will be measure based on the concentration of heavy metal that contain in groundwater sample in twelve wells in Kampung Ipoh, Tanah Merah. All of the parameters will be compared with the guidelines that has been provide by Ministry of Health Malaysia and World Health Organization.

Table 5.2: A guidelines for drinking water quality by Ministry of Health Malaysia and World Health Organization

Parameters	**Unit**	**WHO (2011) Guideline Value**	**MOH (2004) Guideline Value**	**Value in study area**
pH	-	6.5-8.5	6.5 - 9.0	4.7-6.9
Temperature	°C	NA	NA	25.3- 28.3
Turbidity	NTU	NA	5	0.13-25.2
Total dissolved Solid	mg/L	1000	1000	10.40-164.45
Dissolved Oxygen	mg/L	NA	NA	3.25-7.34
Iron, Fe	mg/L	0.1	0.3	0.022-0.850
Manganese, Mn	mg/L	0.4	0.1	0.002-0.083
Zinc, Zn	mg/L	NA	3	0.020-0.497
Chromium, Cr	mg/L	0.05	0.05	0.001-0.014
Lead, Pb	mg/L	0.01	0.01	NA
Cooper, Cu	mg/L	NA	1.0	0.004-0.052

(NA= not available)

Table 5.3: Insitu parameters of groundwater samples

Sample ID	Coordinate	pH	Temperature	Total Dissolved Solids(TDS), mg/L	Dissolved Oxygen, (DO), mg/L	Turbidity, NTU
		Parameters				
NW1	05°48'37.1"N 102° 02'12.07"E	5.7	27.5	29.90	4.57	1.81
NW2	05°48'50.7"N 102° 02'35.0"E	4.7	28.3	63.05	6.26	1.87
NW3	05°49'07.9"N 102° 02'34.4"E	5.1	27.8	28.60	5.24	3.05
NW4	05°49'17.5"N 102° 02'40.4"E	5.3	27.7	90.35	7.34	18.3
NW5	05°49'59.6"N 102° 03'29.3"E	5.4	25.3	144.30	3.40	0.77
NW6	05°49'55.0"N 102° 03'29.1"E	5.1	27.6	63.05	5.40	0.13
NW7	05°50'03.6"N 102° 03'24.3"E	4.9	27.4	10.40	3.25	4.66
NW8	05°49'26.5"N 102° 01'56.8"E	5.1	28.0	20.15	4.99	1.23

		Parameters				
Sample ID	Coordinate	pH	Temperature	Total Dissolved Solids(TDS), mg/L	Dissolved Oxygen	Turbidity, NTU
NW9	05°49'27.0"N 102° 02'07.4"E	6.5	27.0	164.45	6.41	25.2
NW10	05°49'21.1"N 102° 02'00.4"E	5.9	27.3	72.15	6.04	7.33
NW11	05°48'38.2"N 102° 03'09.6"E	4.9	27.5	41.60	6.14	3.59
NW12	05°50'00.4"N 102° 03'21.4"E	6.9	26.9	118.30	4.97	13.8

Table 5.4: Heavy metal concentration of groundwater samples

Sample ID	Coordinate	Parameters					
		Manganese(Mn), mg/l	**Iron (Fe), mg/l**	**Copper (Cu), mg/l**	**Zinc (Zn), mg/l**	**Chromium (Cr), mg/l**	**Lead (Pb), mg/l**
NW1	05°48'37.1"N 102° 02'12.07"E	0.014	0.054	0.009	0.023	0.014	ND
NW2	05°48'50.7"N 102° 02'35.0"E	0.021	0.026	0.004	0.030	0.001	ND
NW3	05°49'07.9"N 102° 02'34.4"E	0.011	0.022	0.006	0.026	0.001	ND
NW4	05°49'17.5"N 102° 02'40.4"E	0.083	0.081	0.052	0.092	ND	ND
NW5	05°49'59.6"N 102° 03'29.3"E	0.018	ND	0.006	0.028	ND	ND
NW6	05°49'55.0"N 102° 03'29.1"E	0.047	0.039	0.013	0.020	ND	ND
NW7	05°50'03.6"N 102° 03'24.3"E	0.014	0.005	0.007	0.497	ND	ND
NW8	05°49'26.5"N 102° 01'56.8"E	0.008	0.203	0.011	0.062	0.002	ND

		Heavy metal concentration					
Sample ID	Coordinate	Manganese(Mn), mg/l	Iron (Fe), mg/l	Copper (Cu), mg/l	Zinc (Zn), mg/l	Chromium (Cr), mg/l	Lead (Pb), mg/l
NW9	05°49'27.0"N 102° 02'07.4"E	0.002	0.026	0.006	0.020	ND	ND
NW10	05°49'21.1"N 102° 02'00.4"E	0.023	0.012	0.006	0.029	ND	ND
NW11	05°48'38.2"N 102° 03'09.6"E	0.030	0.014	0.009	0.029	0.009	ND
NW12	05°50'00.4"N 102° 03'21.4"E	0.018	0.850	0.005	0.030	ND	ND

(ND = not detected)

5.4 Result and analysis

Based on the in-situ analysis and Atomic absorption spectrometry (AAS) analysis, a new result has been carried out to determine the heavy metal concentration in groundwater of Kampung Ipoh, Tanah Merah. The concentration of heavy metal depends on the several factor. Based on World Water Quality Alliance research, one of the governing factors that give an effect to the quality of groundwater is a contaminant sources from anthropogenic contamination (2021). For this research, the analysis was done by analysed the graph which represent the result.

5.4.1 In-situ parameters

i) pH

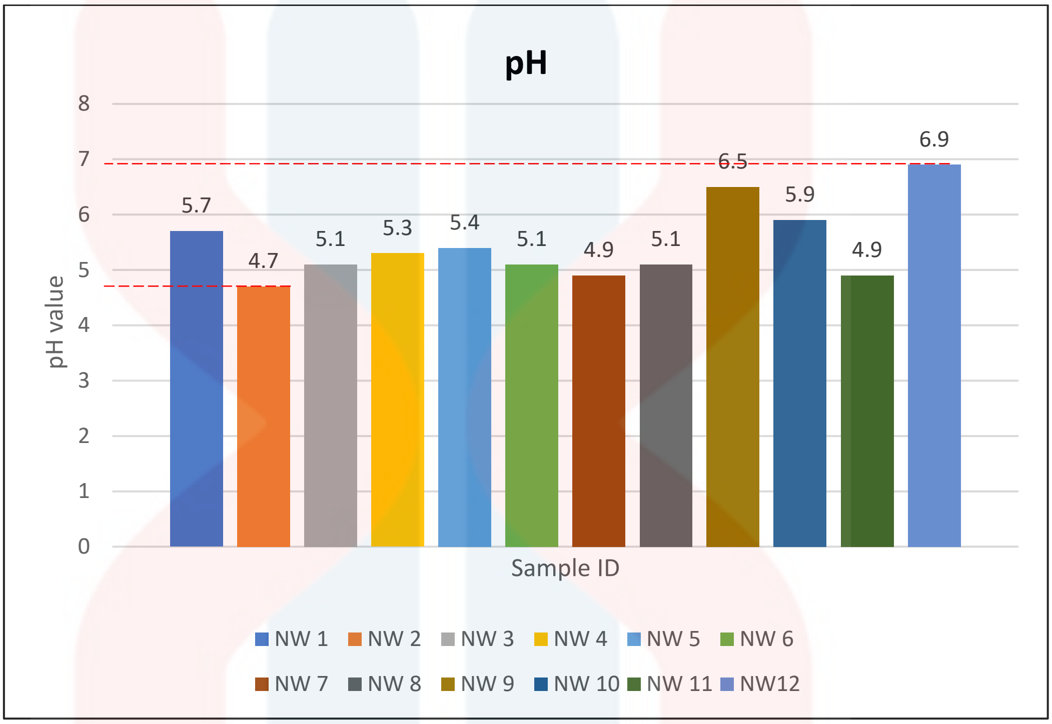

Figure 5.3: pH value in groundwater samples

pH stands for a potential of hydrogen. The pH can presence in range from 0 to 14. If the pH is less than 7 is can be classified as an acidic solution. However, if the solution with a pH greater than 7, it can consider as alkaline. Based on the graph, pH range of the study area is from 4.7 to 6.9. Most of the groundwater samples pH value are above the permitted value that has been given by World health Organization (WHO) and Ministry of Health (MOH). Only two wells which are NW 9 and NW 12 have a pH within the range and exceed the permitted. An acidic water with a pH of less than 6.5 is unsafe to drink. This is because it might be contaminated with pollutants or maybe has been corrode by metal pipes (Cirino, et al. 2019).

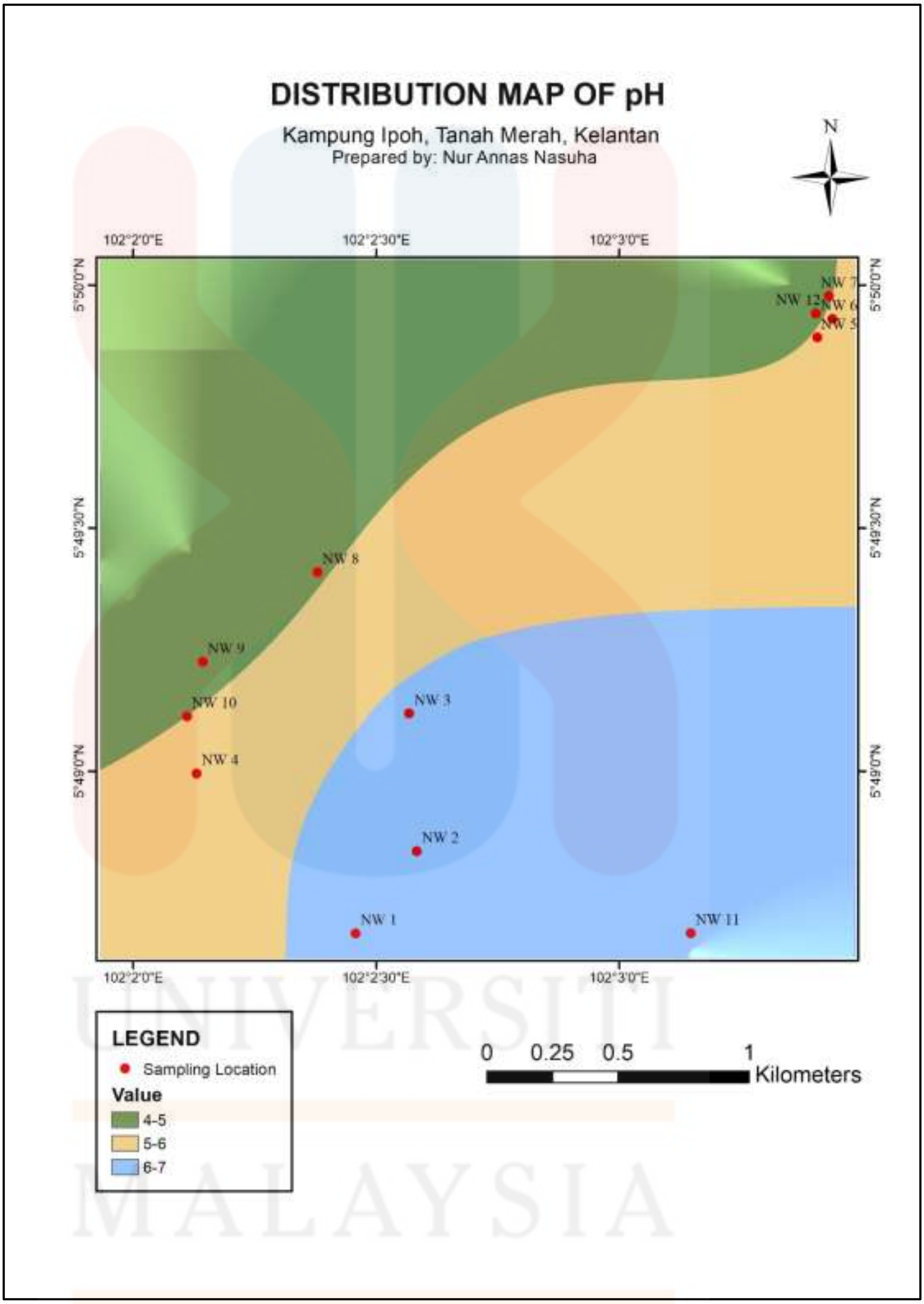

Figure 5.4: Distribution map of pH

ii) Dissolved Oxygen

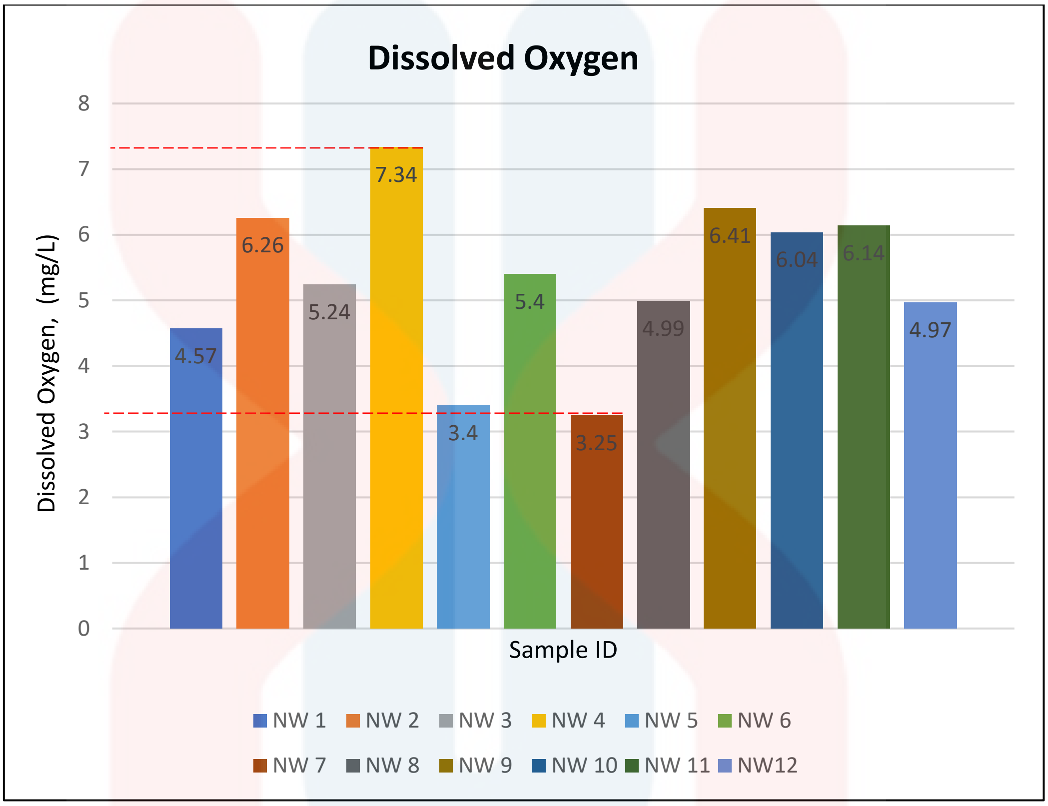

Figure 5.5: Dissolved oxygen value in groundwater samples

For the dissolved oxygen, there is no guideline value is provided. The dissolved oxygen content in groundwater around the study area is between 3.25-7.34 mg/l. 3.25 mg/l, the lowest reading represent NW 7 and the highest amount of dissolved oxygen is NW 4 with reading 7.34 mg/l. This insitu parameter basically influenced by a few factors for example the chemical or biological processes which take place in the distribution system of groundwater. It can also happen because an increasing volume of iron concentration in solution. Even there is no standard value has been provided, a high contains of dissolved oxygen not recommended for drinking water.

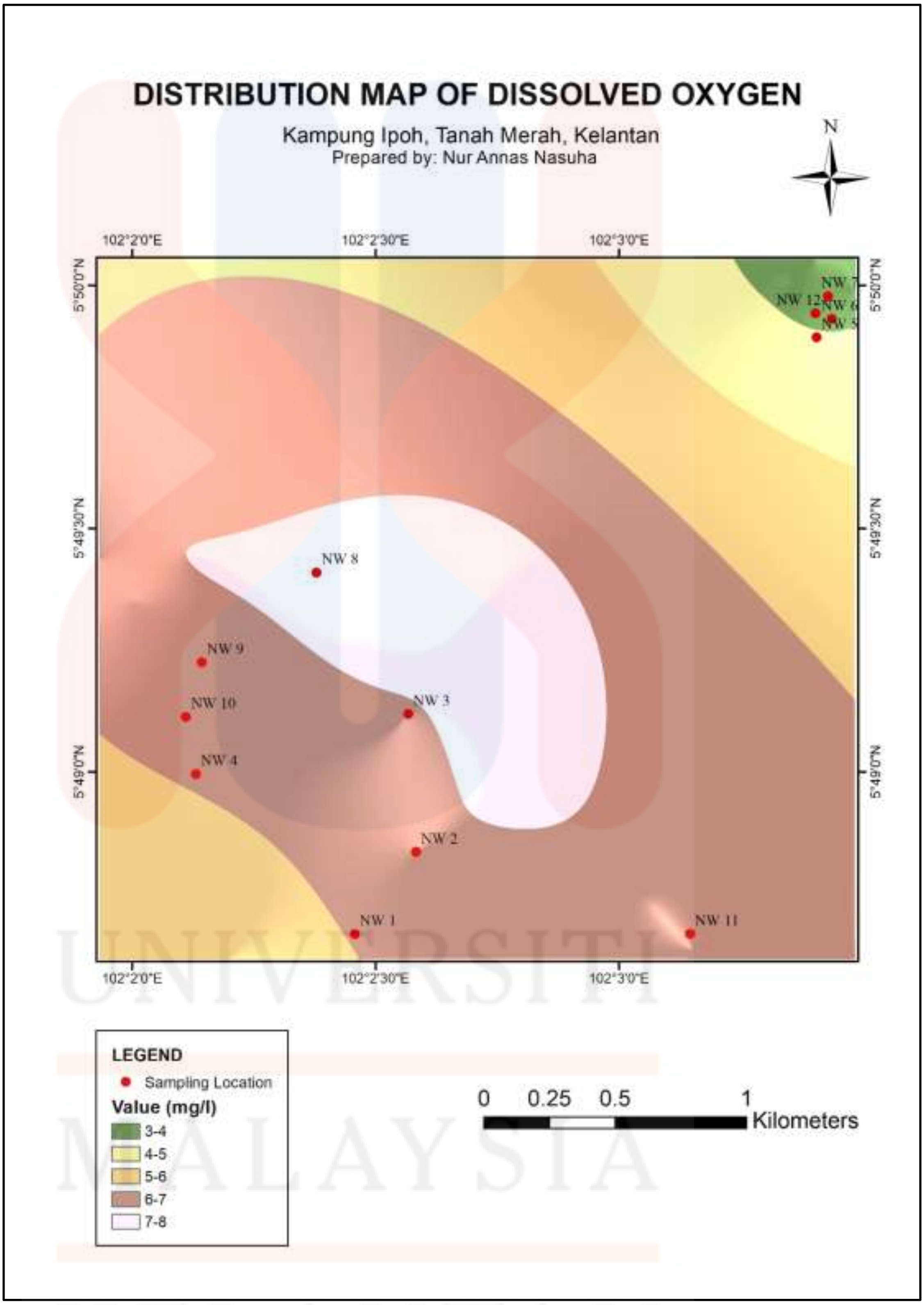

Figure 5.6: Distribution map of dissolved oxygen

iii)   Temperature

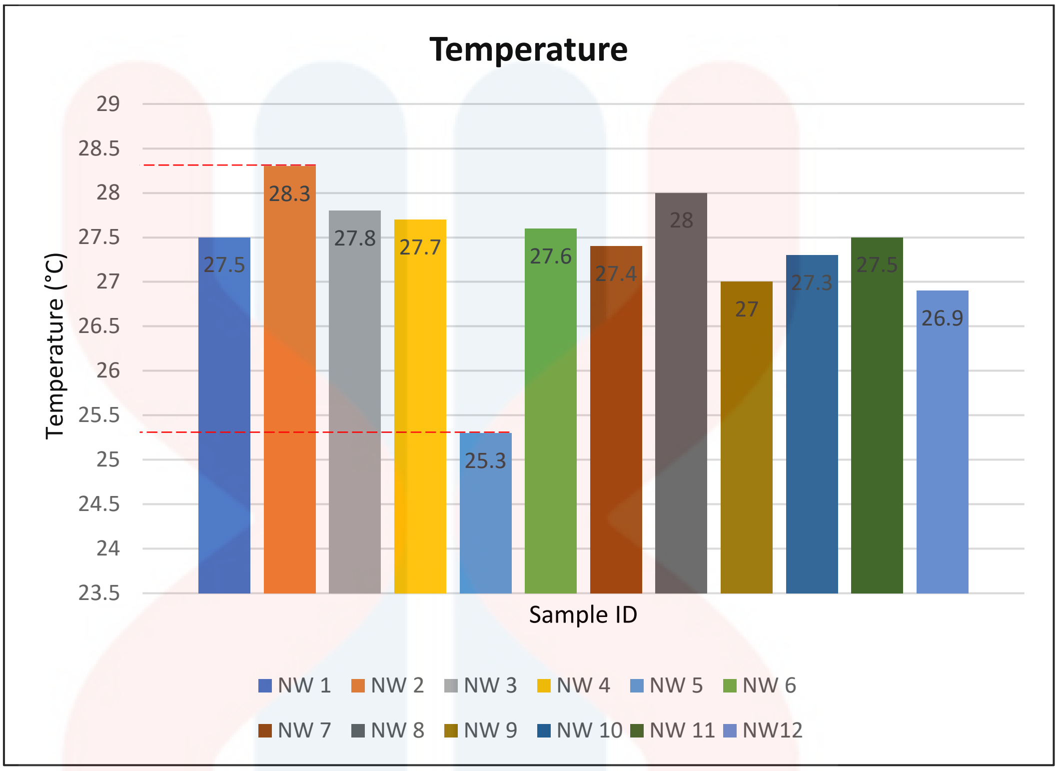

Figure 5.7: Temperature value in groundwater samples

Temperature is a physical quantity that represent quantitatively the perceptions of hotness and coldness. According to National Ground Water Association, the average of groundwater temperature is same as the mean air temperature above the land surface (2022). Based on the graph above, the highest temperature recorded is 28.3°C which located at the second well (NW 2) of Kampung Ipoh while the lowest temperature is 25.3°C represent the temperature of the fifth well (NW 5).

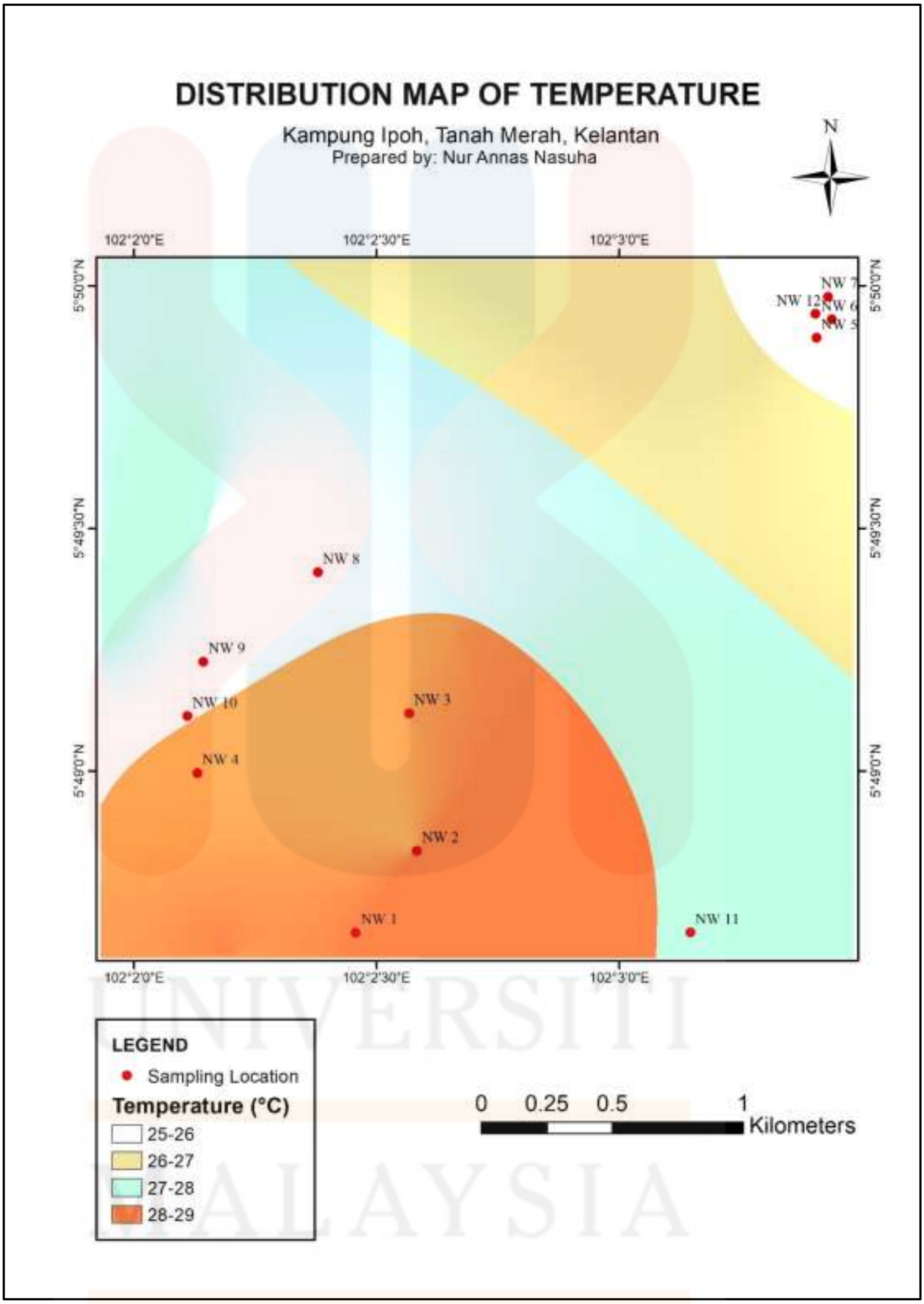

Figure 5.8: Distribution map of temperature

iv) Turbidity

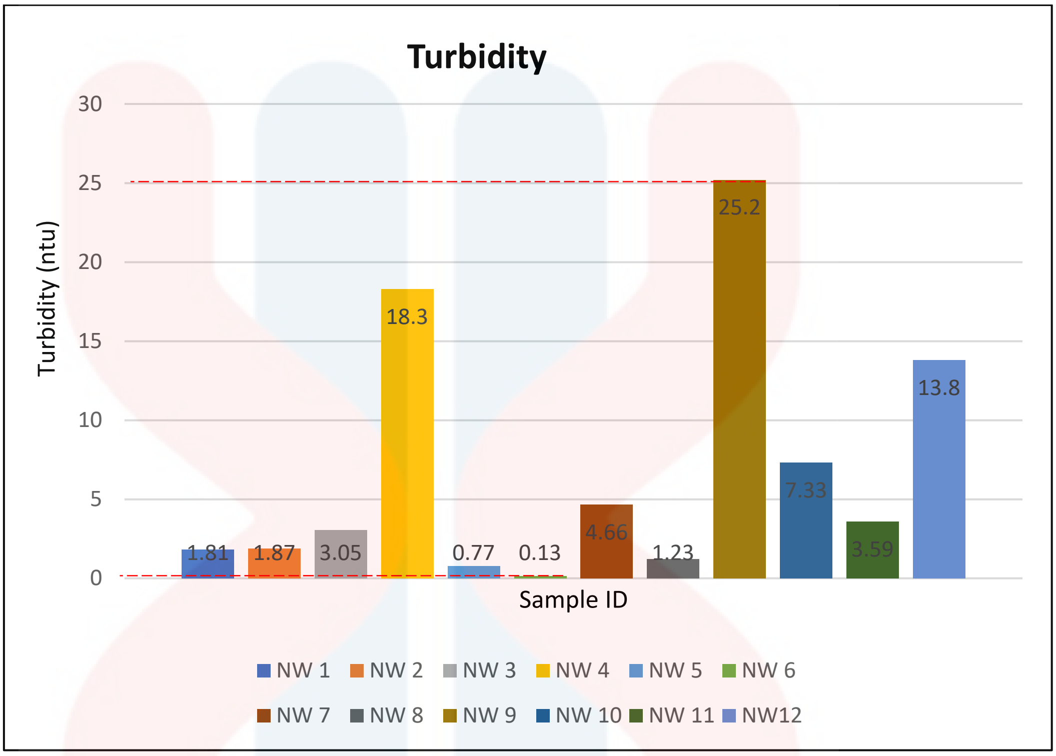

Figure 5.9: Turbidity value in groundwater samples

Turbidity is used to identify the relative clarity of a liquid. The highest turbidity in the water sample of the study area is in NW 9 with the reading 25.2 NTU. Instead of that, there are others two well that exceed World health Organization (WHO) and Ministry of Health (MOH) standard turbidity which are NW 4 and NW 12. With reading 18.3 NTU and 13.8 NTU. According to MOH guideline value, the turbidity must not exceed 5 NTU. So, even that three groundwater samples have high turbidity, it can be used for daily used. But not for drinking purpose.

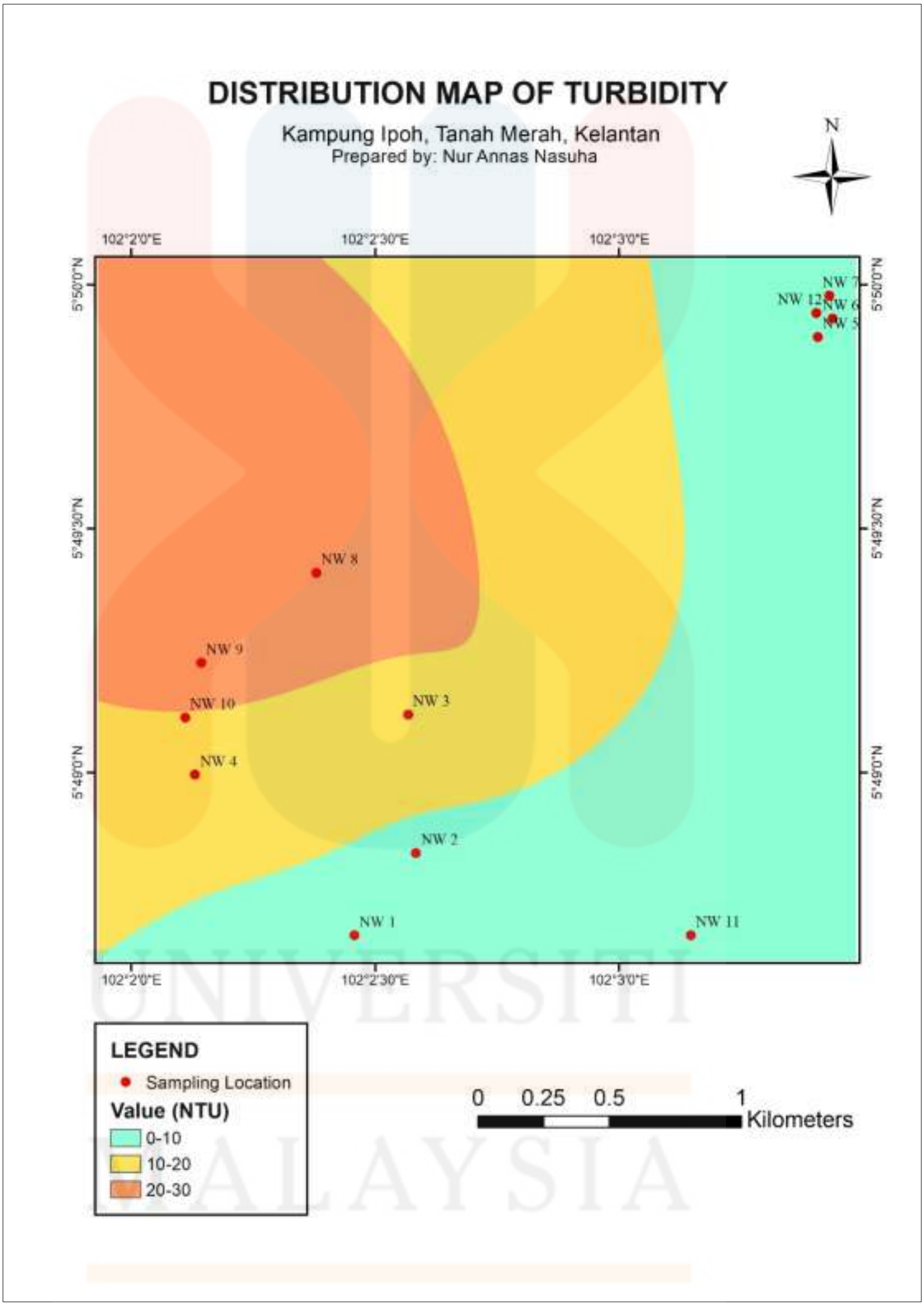

Figure 5.10: Distribution map of turbidity

v) Total Dissolved Solid

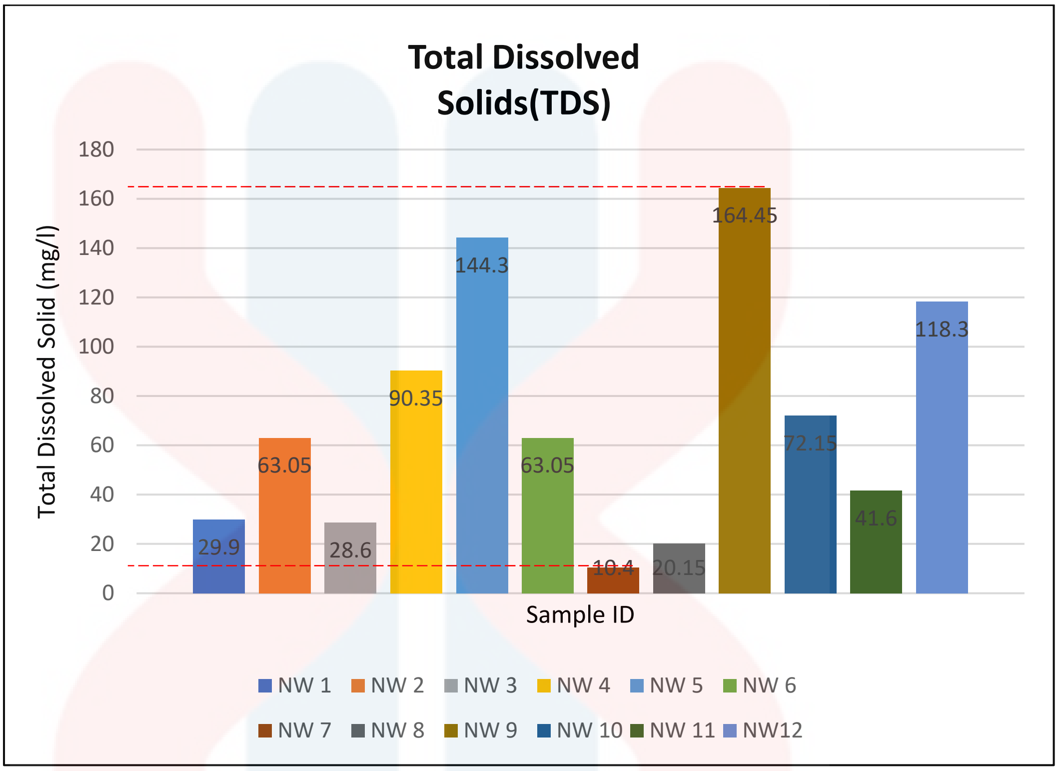

Figure 5.11: Total dissolved solid (TDS) value in groundwater samples

WHO and MOH put the standard value for Total Dissolved Solids is not must pass by than 1000 mg/l. From the graph above it shows the value of Total Dissolved Solids in twelve different domestic wells. The highest value of Total Dissolved Solids is in NW9 which is 164.45 mg/l while the sample from NW 7 has the lowest reading which is 10.4 mg/l. However, all of twelve well of the study area not exceed the standard that permitted by MOH and WHO and suitable for drinking and other purpose. To be more specific, since all of the water sample's total dissolved solid is under 1000 mg/l it consider as freshwater or non-saline water.

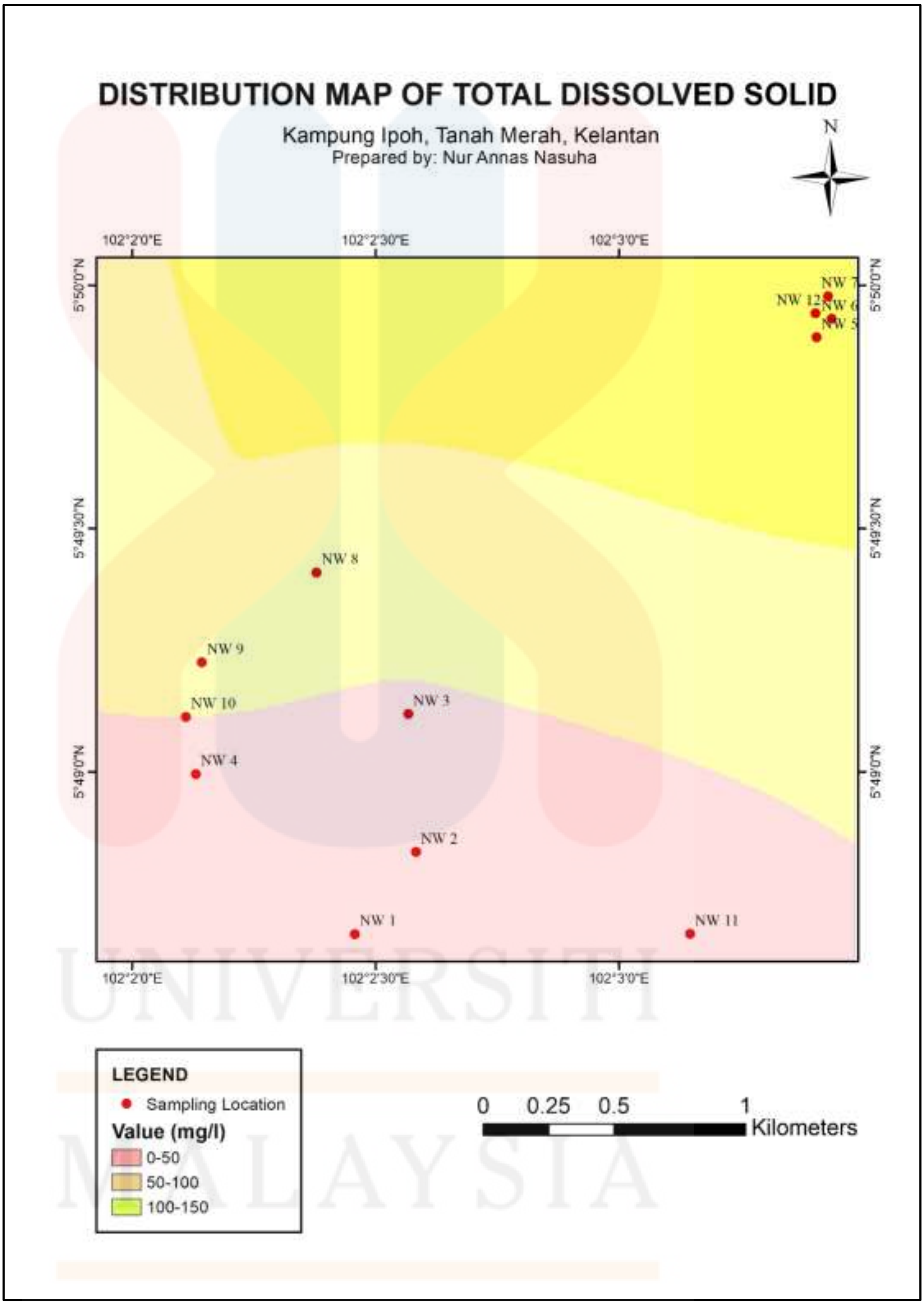

Figure 5.12: Distribution map of Total dissolved solid (TDS)

5.4.2 Heavy Metal concentration

i) Manganese

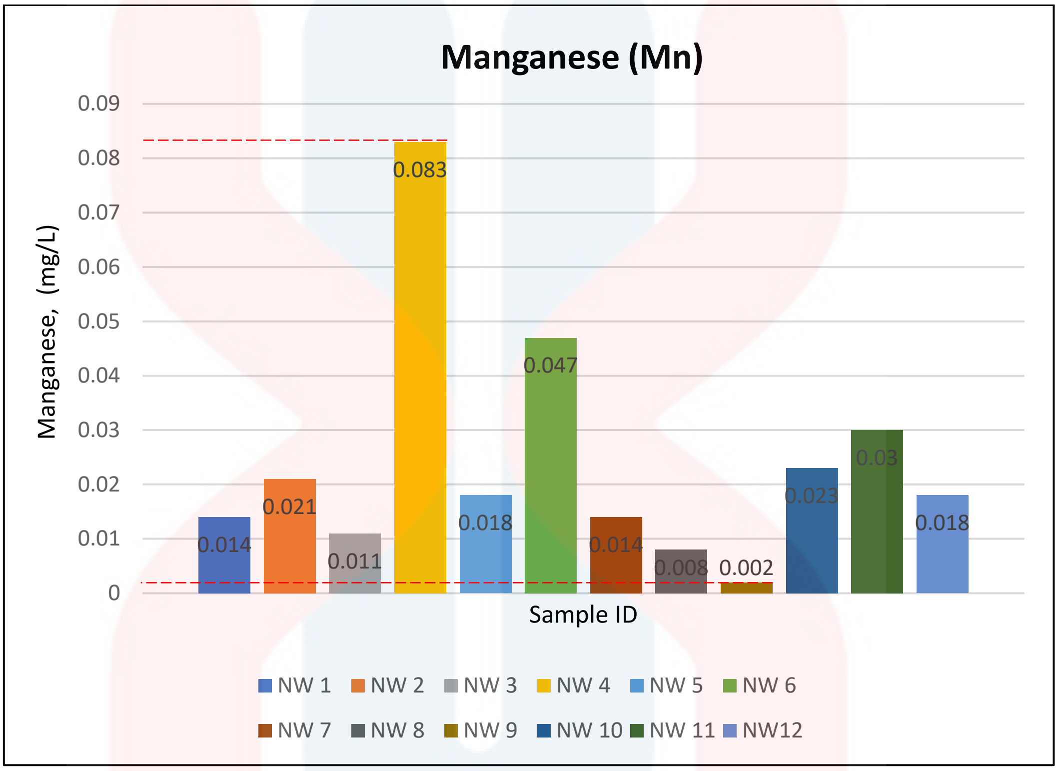

Figure 5.13: Manganese concentration in groundwater samples

The concentration of manganese in all groundwater sample around Kampung Ipoh is in range 0.002 mg/l to 0.083 mg/l. According to WHO (2011) guideline value, the concentration value of manganese that acceptable in drinking water is below than 0.4 mg/l. While for the MOH the concentration must not more than 0.1 mg/l. From this, it shows that all the water are safe to be use because it still not exceeds the standard value that has been given.

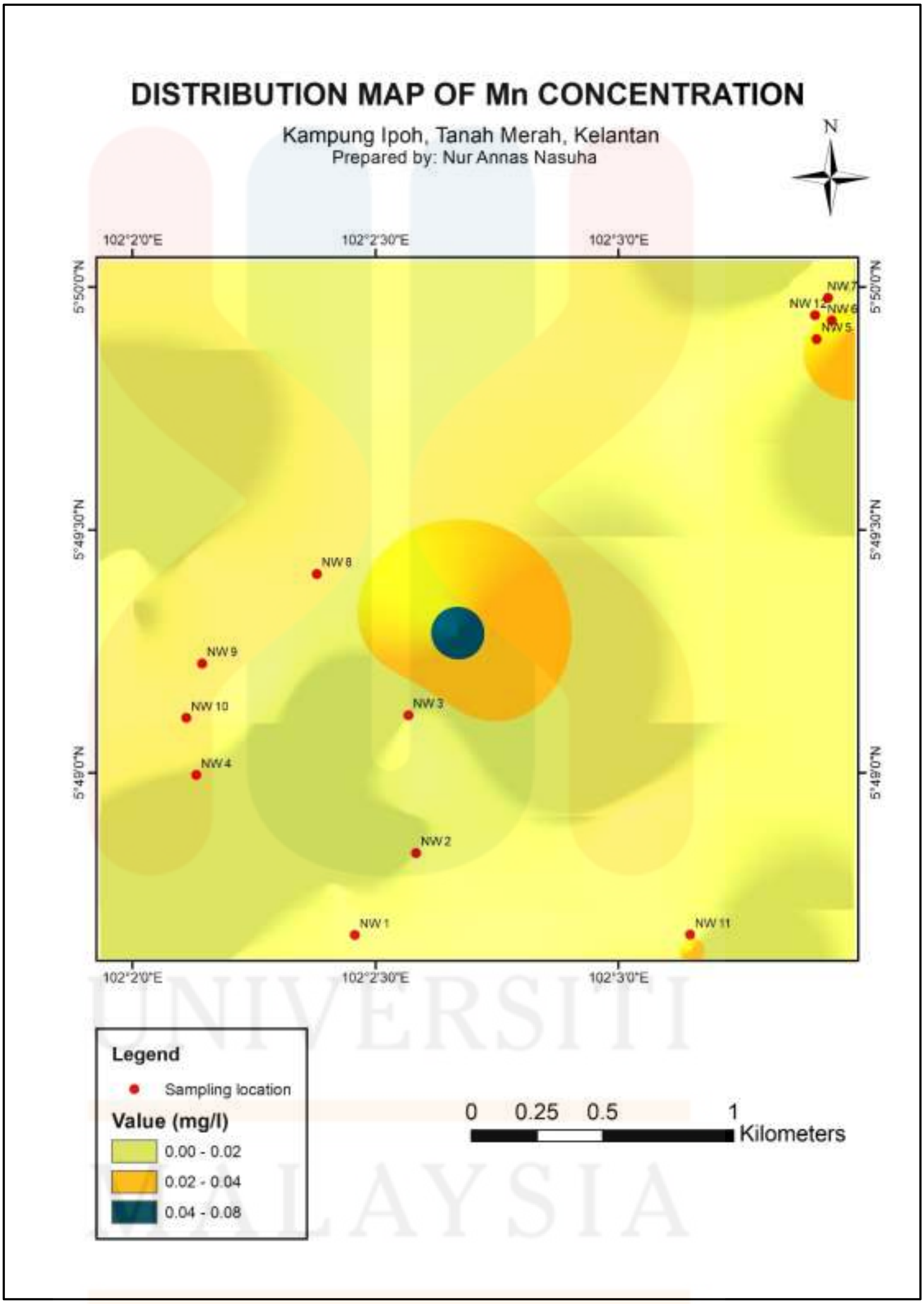

Figure 5.14: Distribution map of Manganese concentration

ii) Iron

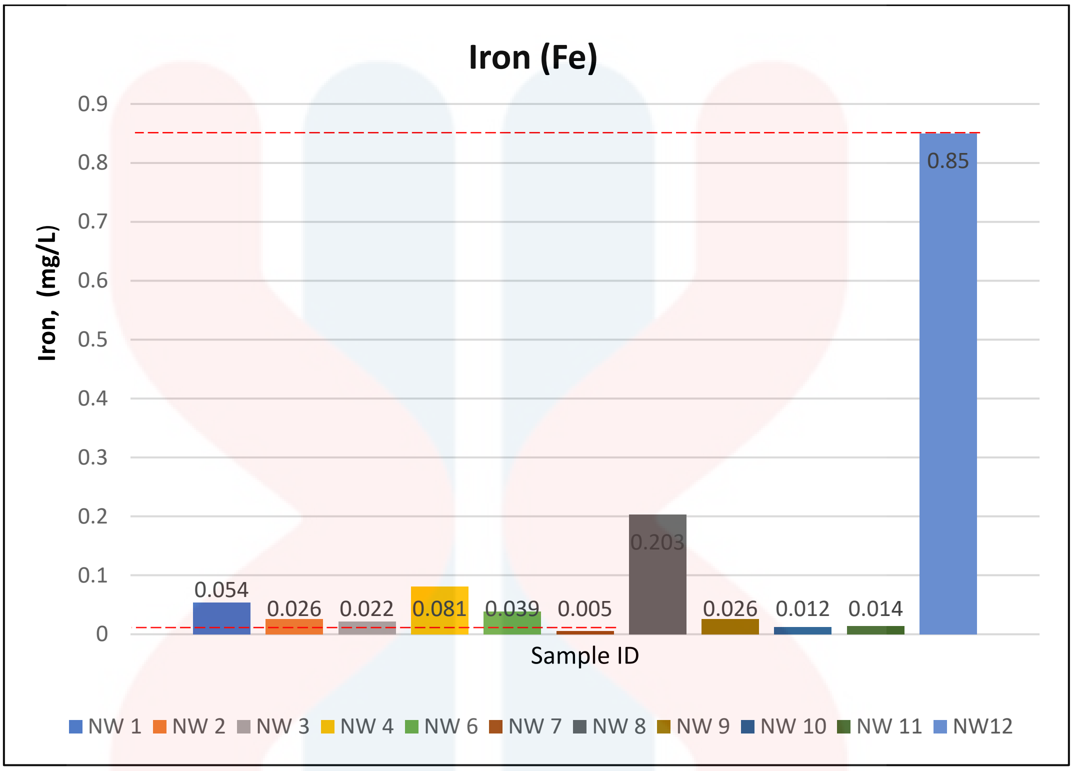

Figure 5.15: Iron concentration in groundwater samples

The graph above show that the highest reading for iron concentration is NW 12 with 0.850 mg/l concentration which across limit standard value of MOH and WHO. A high amount of iron in drinking water may not lead to any health risk. However, it will give an effect to the taste of water. Iron may give drinking water a worst taste which taste like a metallic and can effect food taste too. If it used for other purpose like cleaning purpose, it will change and give a stain on dishes and laundry because of the colour from the water. However, for other well, the water still can be use for drinking and other purpose. For NW5, there is no iron concentration has been found.

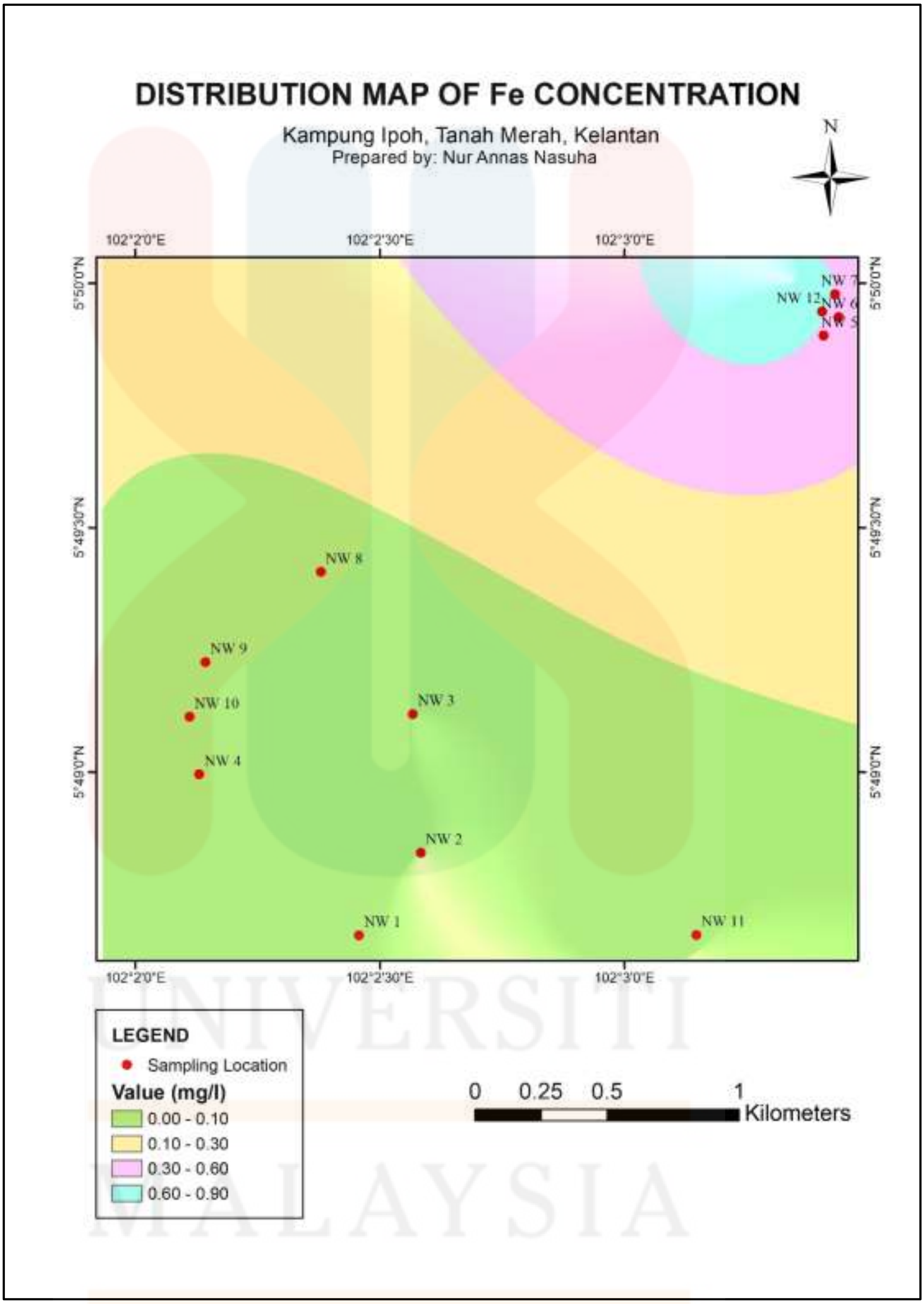

Figure 5.16: Distribution map of Iron concentration

iii) Copper

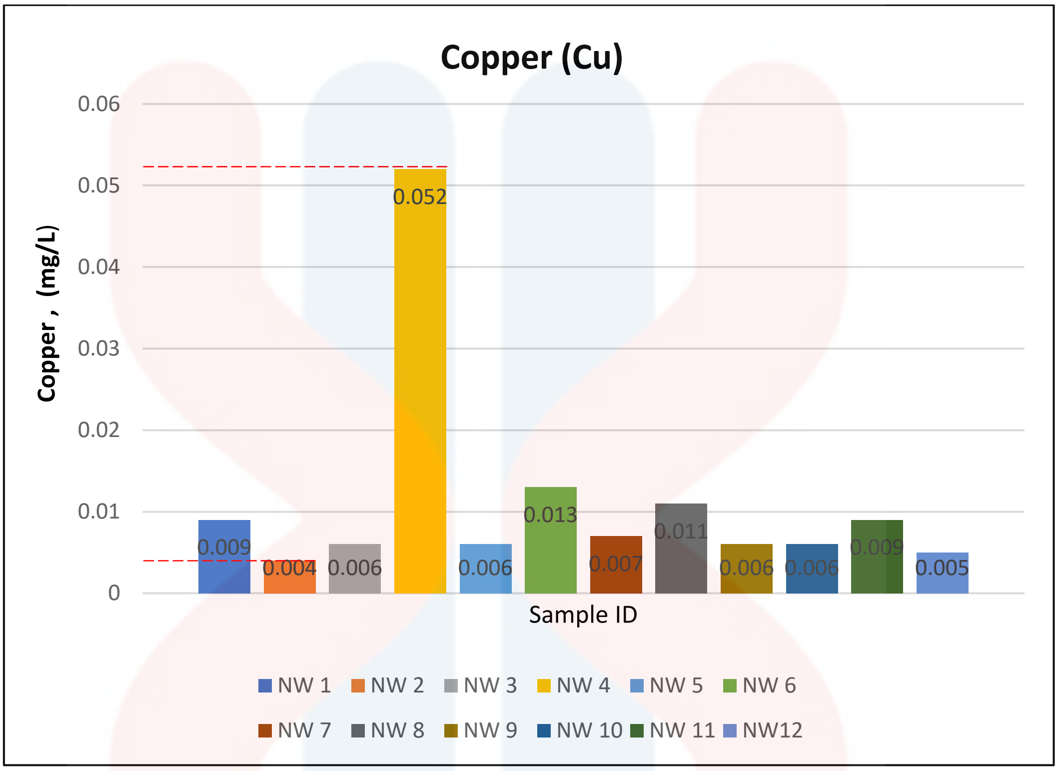

Figure 5.17: Copper concentration in groundwater samples

According to WHO guideline value, there no specific value for cooper in drinking water, but MOH classify that the copper must not more than 1.0 mg/l. 0.004 mg/l to 0.052 mg/l is the ranges of copper concentration in the groundwater sample in Kampung Ipoh. The highest reading is at NW4 0.052 mg/l while the lowest is 0.004 mg/l at NW2. It show that all of the sample are safe for daily use since it still in MOH standard value.

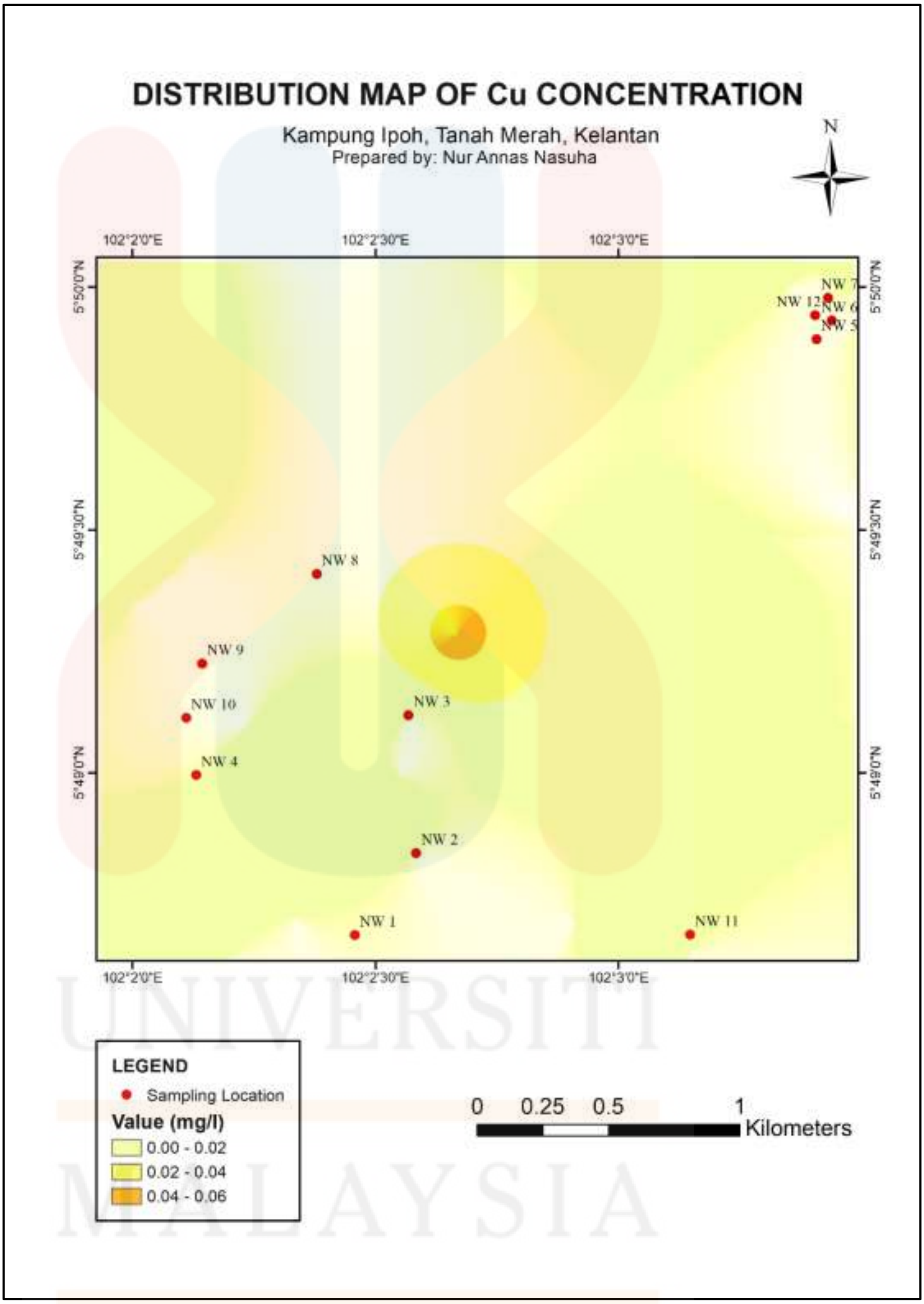

Figure 5.18: Distribution map of Cooper concentration

vi) Zinc (Zn)

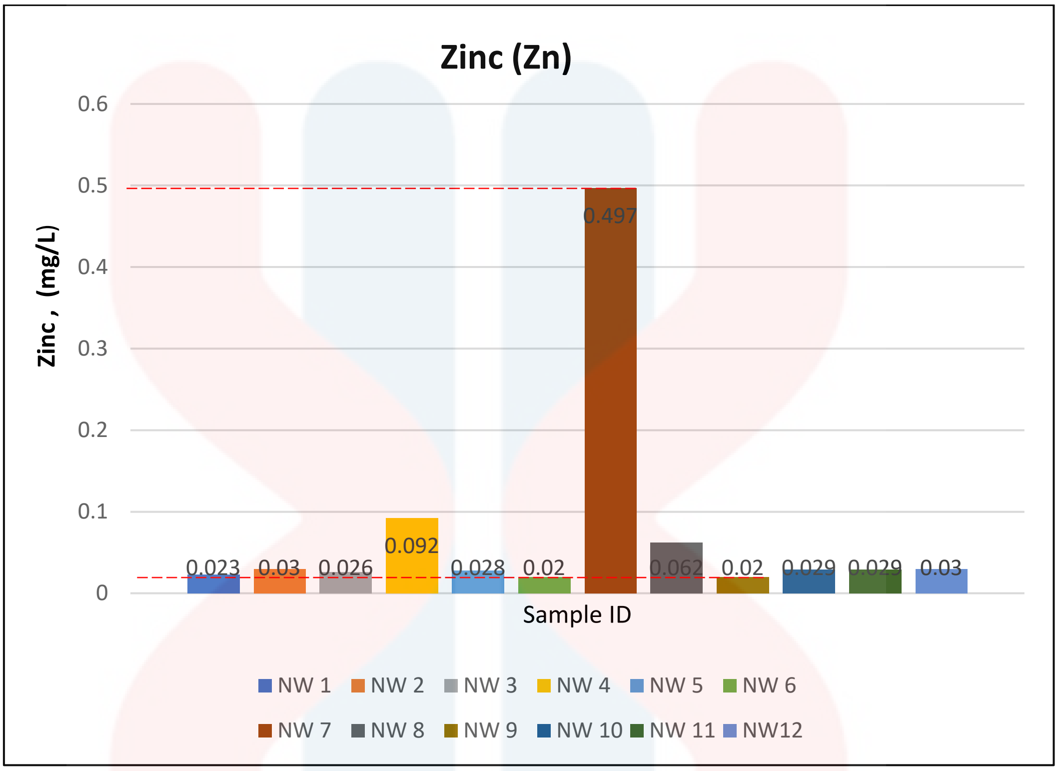

Figure 5.19: Zinc concentration in groundwater samples

A high concentration of zinc in drinking water will lead to intestinal irritant which causing nausea and vomiting. However, from the graph it show the zinc concentration in twelve water sample in range 0.02 mg/l to 0.497 mg/l and still follow the World health Organization (WHO) and Ministry of Health (MOH) standard value. So, it will not give a bad effect to the consumer.

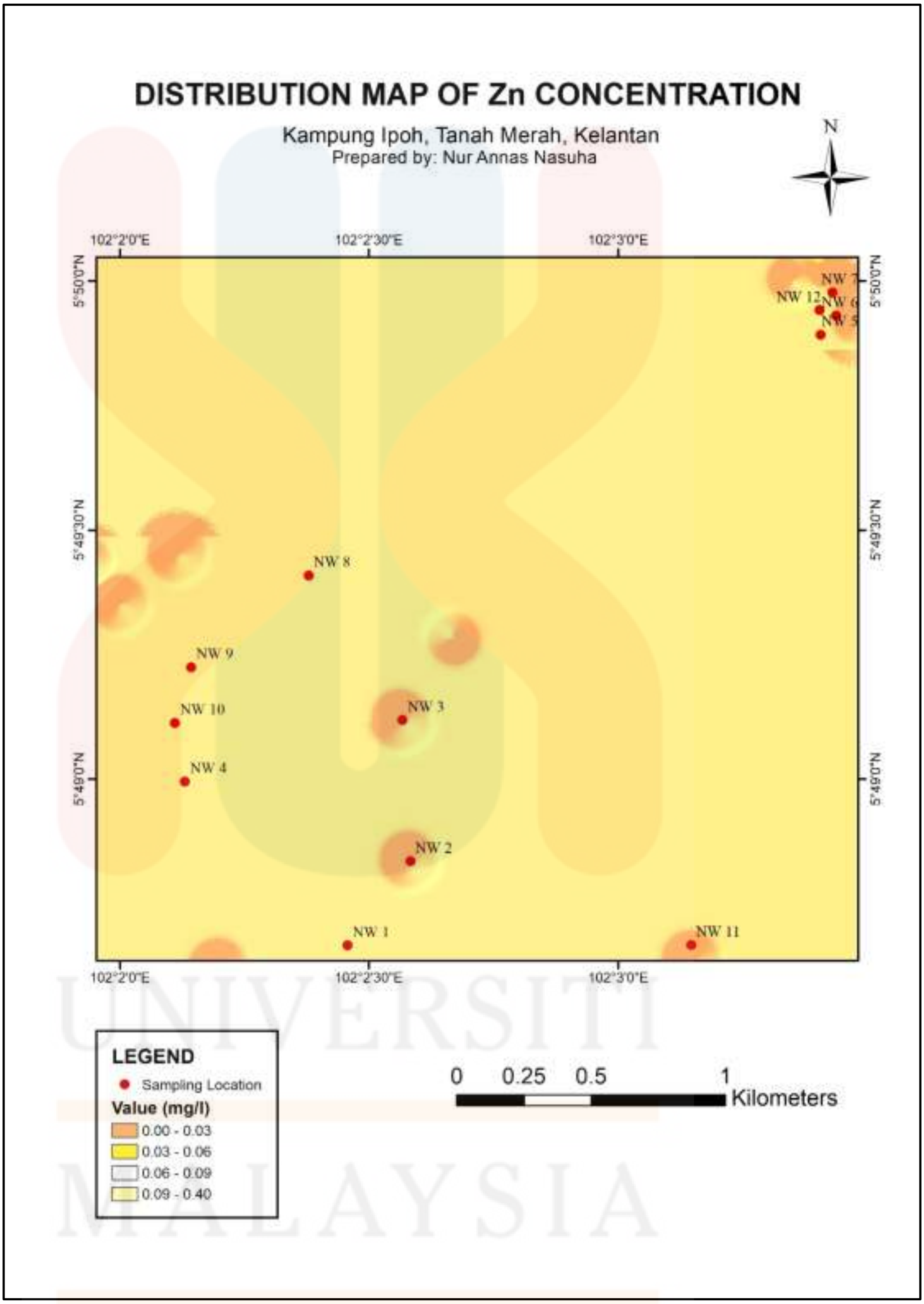

Figure 5.20: Distribution map of Zinc concentration

vii) **Chromium (Cr)**

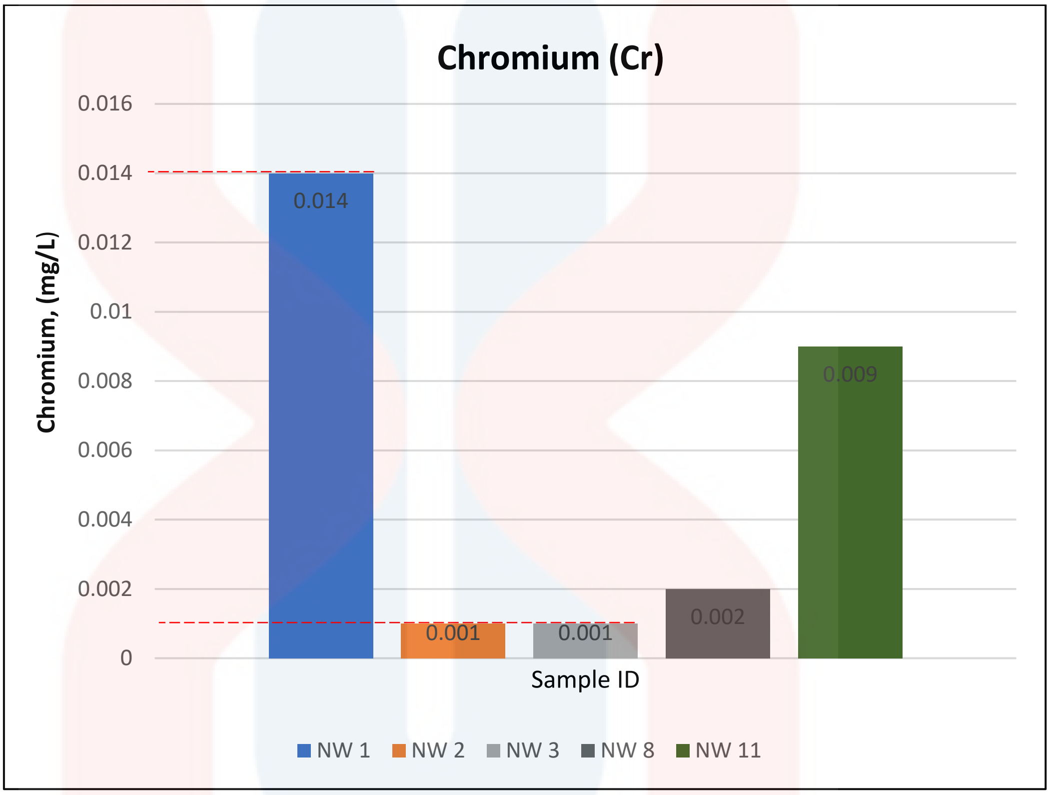

Figure 5.21: Chromium concentration in groundwater samples

There are only five wells contain a numbers of Chromium concentration which are well NW1, NW2, NW3, NW8 and NW11. The ranges of chromium concentration are from 0.001 to 0.014 which NW1 shows the highest reading (0.014 mg/l) and the lowest reading is NW2 and NW3 (0.001 mg/l). MOH state the amount of chromium in drinking water is not more than 0.05 mg/l. So, it can conclude that this five well is safe to use. For the other seven wells, there is no chromium element detected in the water sample based on the analysis result.

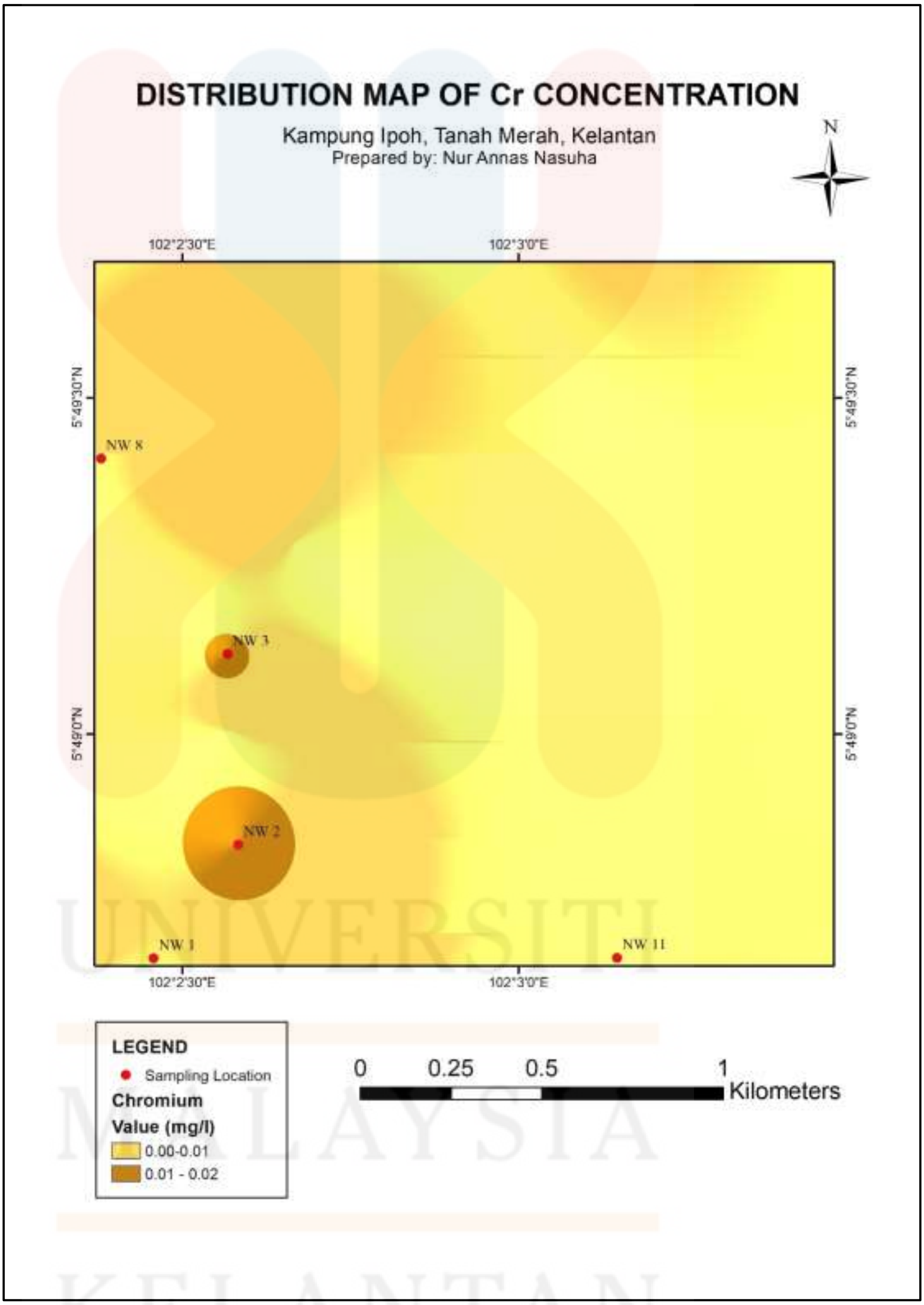

Figure 5.22: Distribution map of Chromium concentration

v) Lead (Pb)

Based on the laboratory assessment of all water sample, the amount of lead is not detected. It will not give any problem since based on the standard by MOH and WHO also, only 0.01 mg/l of Pb are accepted in drinking water. The amounts more than it might cause serious health problems like lead poisoning, which can severely affect mental and physical development *(Mayo Clinic,2021).* According to The Safe Drinking Water Act (SDWA) by EPA and the Centers for Disease Control and Prevention (CDC) in United States, they are in progress to reduce the maximum can be an example for us to make sure the concentration of lead in our drinking water also is free. However, from the sampling and water analysis in Kampung Ipoh, this condition are already complied with the act that has shown by EPA and CDC.

5.5 DISCUSSION

According to the result and heavy metal concentration analysis from twelve different water sample around study area, all of the groundwater in Kampung Ipoh, Tanah Merah, Kelantan is in a good quality. It can be used as a drinking water instead of for domestic usage since all human activities towards social-economic developments depend on the availability of water. However, for the NW 7 domestic well, which located at the coordinate 05°50'00.4"N 102° 03'21.4"E it need to be filter in proper way if it used for drinking water since the concentration of zinc element is quite high. Unless it only used for other purpose like for agriculture, livestock activities and other.

In terms of in-situ analysis, there is no problems for temperature, dissolved oxygen and total dissolved solid parameters. All of these three parameters still follow the guideline that has been provided by Ministry of Health (MOH) and World Health Organization (WHO). The problem was only occur for pH and turbidity parameters.

Most of the groundwater samples that has been taken at the study area has a pH value less than 6.5 which are below the standard value of World health Organization (WHO) and Ministry of Health (MOH). Basically, it is very not recommended to drink the water which pH below 6.5 because it can be considered as acidic water. In research from McGrane, acidic water will give a bad effect to the human for example, diarrhea, abdominal pain, suppression of the immune system and organ damage after consumption, (2020).

An acidic water can be recover by neutralized it using a neutralizing filter that containing calcite or ground limestone (calcium carbonate) or magnesium oxide, the hardness of the water also can be increase (*UMass Extension, 2007*). In spite of that, NW 9 and NW 12 still have a good pH and exceed the guideline.

In terms of turbidity, land use, water flow and point source pollution are the example of natural factor that affect the turbidity. The highest turbidity in the water sample of the study area is in NW 9, NW 4, and NW 12. It can be proved, when the turbidity reading already exceeding 5 NTU. From the sampling process, it has been identified the factor that trigger the increasing numbers of turbidity for these three areas is because of the agriculture and animal breeding activities. Farms discharge which consists of agrochemicals, organic matter, sediments and saline will drainage into water bodies and lead to groundwater contamination occur. This can be correlate to the research that show about 70 percent of water abstraction happened because of agriculture plays a major role in water pollution (UNEP, 2016).

Geologically, dissolved oxygen is the common parameter which strongly influenced geological process. The presences of dissolve oxygen in water will trigger the biological weathering. This condition can be proved when an aquatic organism like algae and phytoplankton occur. A high amount of dissolved oxygen will make the algae able to do a photosynthesis. Other than that, the turbidity of groundwater also increase due to the presence of clay mineral in the shallow well in the study area.

Figure 5.23: Example of well with high turbidity

CHAPTER 6

CONCLUSION AND RECOMMENDATION

6.1 Conclusion

Conclusively, the main objective of this research which are to produce and updated the geological map on the 1:25,000 scale is achieved. The general geology of Kampung Ipoh, Tanah Merah District, Kelantan, Malaysia is divided into two major units of lithology which are schist and quartzite. Schist was found dominant lithology that can be found mostly at the eastern part of study area.

For the specification research, the groundwater around Kampung Ipoh, Tanah Merah, mostly has a good quality and the parameters value of the locations shows a reading within the value permitted by WHO and MOH like pH and turbidity. A high level of pH will give a bad effect to the human health like nausea, diarhea and might damage certain tissue in our body. Even the heavy metal is a micronutrient for living system, it also can be persisted due to the environmental pollutant that can give a big effect to the most of living thing in our earth.

So, both of these parameters need to be monitored periodically in Kampung Ipoh, Tanah Merah since the groundwater is very high demand due to the increasing number of populations.

6.2 Recommendation

Based on the current research, the recommendations for the next study must be improved significantly in geological mapping. The purpose of the improvement is to obtain more accurate data and give an excellent result at the end of the research. For geological mapping, the process must be start on time or might be early so that the problem such as the insufficient in the collection of data can be avoided. The general knowledge in mapping also needs to be improved. The geology knowledge including structural geology, lithologies and other more. An advanced geology information will make the mapping become more easier to determining and identifying the exact rock unit in the study area.

For the specification, groundwater monitoring can be done periodically. This is to increase the quality of groundwater. Groundwater well monitoring can be done by go through a few processes, which are boring process, geologic log and the process of casing and screening installation. Other than that, with the advanced of technology, the parameter of groundwater can also be observed periodically. Monitoring telemetry system where the probe that inserted to the water sample give a signal to the Model 3004 Neon Datalogger can be use. All of the data like pH will be transported to the web server and view of water level, water quality will be generated in a graphs format.

All of these recommendations can be used for the next geological mapping and groundwater monitoring purpose. A good geological mapping will produce a good geological map which can avoid the hazardous occur and a good monitor of groundwater can ensure the water quality of groundwater.

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