



GEOLOGY OF JELI AND APPLICATION OF ZEOLITE IN WATER TREATMENT

by

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2023

DECLARATION

I declare that this thesis entitled " Geology of Jeli and Application of Zeolite in Water Treatment" is the result of my own research except as cited in this references. The thesis has not 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 of Jeli and Application of Zeolite in Water Treatment

ABSTRACT

The study area is located in Ayer Lanas, near the border of Jeli and Bukit Bunga, Tanah Merah, Kelantan. The research is focusing on the general geology of the study area with an area of 25km² that is located by the latitude of 5°46'36.38"N to 5°49'53.83"N and longitude of 101°52'51.22"E to 101°55'05.78"E and also the application of zeolite in water treatment. The main objective of this research is to update the geological map of Ayer Lanas with a scale of 1:25000 and to identify the effectiveness of zeolite in treating contaminated water. During geological mapping process, seven rock samples which consist of three granites, two siltstones and two quartzites have been collected from different outcrops throughout the study area. Petrography analysis of rock samples were analysed using optical microscope to observe minerals in higher magnification and to determine the type of rock. X-ray fluorescence (XRF) method was also used in this research to observe the major elements composition of the rock samples as well as zeolite sample. The data collected from the geological mapping was processed using ArcGIS 10.8 software and several maps such as geological map, lithology map, topographic map, drainage pattern map, and lineament map were produced. Based on the observation, the study area consists mainly of granite unit of Kemahang Formation, siltstone unit of Quaternary alluvium deposits unit and quartzite unit. For research specification, the water samples were collected several selected rivers and streams in Jeli district which are from a stream in UMK Jeli, Pergau River of different locations, Lanas River and also a stream in Jeli Town. Every water samples collected were labelled as ZS1, ZS2, ZS3, ZS4, ZS5 respectively according to the sampling location. In-situ analysis of the river water quality was carried out at every sampling location and the water samples collected were then brought to the laboratory to be treated with sand, zeolite and gravel layers. Then, the water samples were tested using atomic absorption spectroscopy (AAS) to analyse the concentration of selected heavy metal elements (i.e. cadmium, Cd, lead, Pb, copper, Cu and manganese, Mn) before and after water treatment process. The results obtained from the research shows that the application of zeolite in water treatment has successfully reduced the concentration of the heavy metal elements below the standard water quality of Ministry by Health Malaysia (MOH). Mn element in ZS1 has reduced a significant concentration of 0.131mg/L from 0.168mg/L to 0.037mg/L after water treatment process. Meanwhile, Cu element in ZS1 has reduced a total concentration of 0.093mg/L from 0.095mg/L to 0.002mg/L. Therefore, the application of zeolite in water treatment able to improve water quality for various purposes such as domestic, agriculture and industrial.

Keywords: Ayer Lanas, geology, water treatment, zeolite, heavy metals.

Geologi Jeli Dan Aplikasi Zeolit Dalam Rawatan Air

ABSTRAK

Kawasan kajian terletak di Ayer Lanas, berhampiran sempadan Jeli dan Bukit Bunga, Tanah Merah, Kelantan. Penyelidikan tertumpu kepada geologi am kawasan kajian dengan keluasan 25km² yang terletak pada garisan latitud 5°46'36.38"U hingga 5°49'53.83"N dan longitud 101°52'51.22"E hingga 101°55'05.78"E dan juga penggunaan zeolit dalam rawatan air. Objektif utama penyelidikan ini adalah untuk mengemaskini peta geologi Ayer Lanas dengan skala 1:25000 dan mengenal pasti keberkesanan zeolit dalam merawat air tercemar. Semasa proses pemetaan geologi, tujuh sampel batuan yang terdiri daripada tiga batu granit, dua batu lodak dan dua batu kuarzit telah dikumpulkan daripada singkapan berbeza di seluruh kawasan kajian. Analisis petrografi bagi sampel batuan dianalisis menggunakan mikroskop optik untuk memerhati mineral dalam magnifikasi yang lebih tinggi dan untuk menentukan jenis batuan. Kaedah sinar-X berpendarfluor (XRF) juga digunakan dalam penyelidikan ini untuk memerhatikan komposisi unsur-unsur utama bagi sampel batuan serta sampel zeolit. Data yang dikumpul daripada pemetaan geologi telah diproses menggunakan perisian ArcGIS 10.8 dan beberapa peta seperti peta geologi, peta litologi, peta topografi, peta pola saliran, dan peta lineamen telah dihasilkan. Berdasarkan pemerhatian, kawasan kajian terutamanya terdiri daripada unit batu granit daripada Formasi Kemahang, unit batu lodak daripada mendapan aluvium Kuaterner dan unit batu kuarzit. Untuk spesifikasi kajian, sampel air diambil dari beberapa sungai dan anak sungai terpilih di daerah Jeli iaitu dari anak sungai di UMK Jeli, Sungai Pergau di lokasi berbeza, Sungai Lanas dan juga anak sungai di Bandar Jeli. Setiap sampel air yang dikumpul masing-masing dilabel sebagai ZS1, ZS2, ZS3, ZS4, ZS5 mengikut lokasi pensampelan. Analisis in-situ kualiti air sungai telah dijalankan di setiap lokasi persampelan dan sampel air yang dikumpul kemudiannya dibawa ke makmal untuk dirawat dengan lapisan pasir, zeolit dan kerikil. Kemudian, sampel air diuji menggunakan spektroskopi serapan atom (AAS) untuk menganalisis kepekatan unsur logam berat terpilih (iaitu kadmium, Cd, plumbum, Pb, kuprum, Cu dan mangan, Mn) sebelum dan selepas proses rawatan air. Keputusan yang diperolehi daripada penyelidikan menunjukkan bahawa aplikasi zeolit dalam rawatan air telah berjaya mengurangkan kepekatan unsur logam berat. Kepekatan unsur Mn dalam ZS1 telah berurangkan dengan ketara sebanyak 0.131mg/L daripada 0.168mg/L kepada 0.037mg/L selepas proses rawatan air. Manakala kepekatan unsur Cu dalam ZS1 telah berkurangan sejumlah 0.093mg/L daripada 0.095mg/L kepada 0.002mg/L. Oleh itu, aplikasi zeolit dalam rawatan air mampu meningkatkan kualiti air untuk pelbagai tujuan seperti domestik, pertanian dan perindustrian.

Kata kunci: Ayer Lanas, geologi, rawatan air, zeolit, logam berat.

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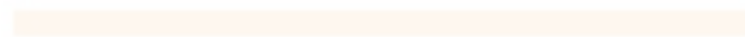
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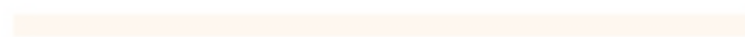
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LIST OF ABBREVIATIONS

Cd	Cadmium
Pb	Lead
Cu	Copper
Mn	Manganese
Ni	Nickel
Zn	Zinc
Fe	Iron
Ca	Calcium
Mg	Magnesium
NaOH	Sodium hydroxide
NH ₄	Ammonium
AAS	Atomic absorption spectroscopy
NaCl	Sodium chloride
HCl	Hydrochloric acid
HNO ₃	Nitric acid
SEM	Scanning electron microscopy
Na	Sodium
K	Potassium
N	North
S	South
NNE	North-north-east
SSW	South-south-west
FAAS	Atomic absorption spectrometry

WHO	World health organization
XRF	X-ray fluorescence
pH	Potential hydrogen
EC	Electrical conductivity
TDS	Total dissolved solids
DO	Dissolved oxygen
ORP	Oxidation reduction potential
km	Kilometre
cm	Centimetre
mL	Millilitre
ppm	Parts per million
%	Percent
mm	Millimetre
m	Meter
PPL	Plane polarized light
XPL	Cross polarized light
SiO ₂	Silicon dioxide
Al ₂ O ₃	Aluminium oxide
Ma	Million annum
mS/cm	MilliSiemens per centimetre
g/L	Gram per litre
mg/L	Milligram per litre
mV	Millivolts
MOH	MOH

LIST OF SYMBOLS

%	Percentage
°	Degree
σ	Sigma
°C	Temperature (degree Celsius)



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CHAPTER 1

INTRODUCTION

1.1 Background of Study

In this research, the applicability of zeolite in removal of heavy metal elements was investigated. Zeolite was used in this research because it is known as a good adsorbent that has ion exchange properties to adsorb the heavy metal elements. The main focus of this research is to update the geological information and geological map of Ayer Lanas, Jeli, Kelantan. Along with that, this research is also aimed to classify the selected heavy metal elements such as cadmium, copper, manganese and lead that exist in various rivers in Jeli district and to treat the water samples from different rivers using zeolite. The methodology involved in this research includes geological mapping, water sample collection and several laboratory tests such as petrographic analysis, water sample filtration, atomic absorption spectroscopy (AAS) and X-ray fluorescence (XRF) were carried out in order to complete this research.

1.2 Study Area

1.2.1 Location

The study area of this research is located at Ayer Lanas, Jeli, Kelantan, Malaysia. To be more specific, it is situated in the north-western part of Kelantan and located between the border of Jeli and Tanah Merah. In this research, 25km² of the study area was covered. It lies between latitude 5°43'46" N to 5°41'00" N and

longitude between 101°42'40" E to 101°45'30" E. The main river in this study area is Lanas River. Igneous and sedimentary rocks make up the lithology of the research region.

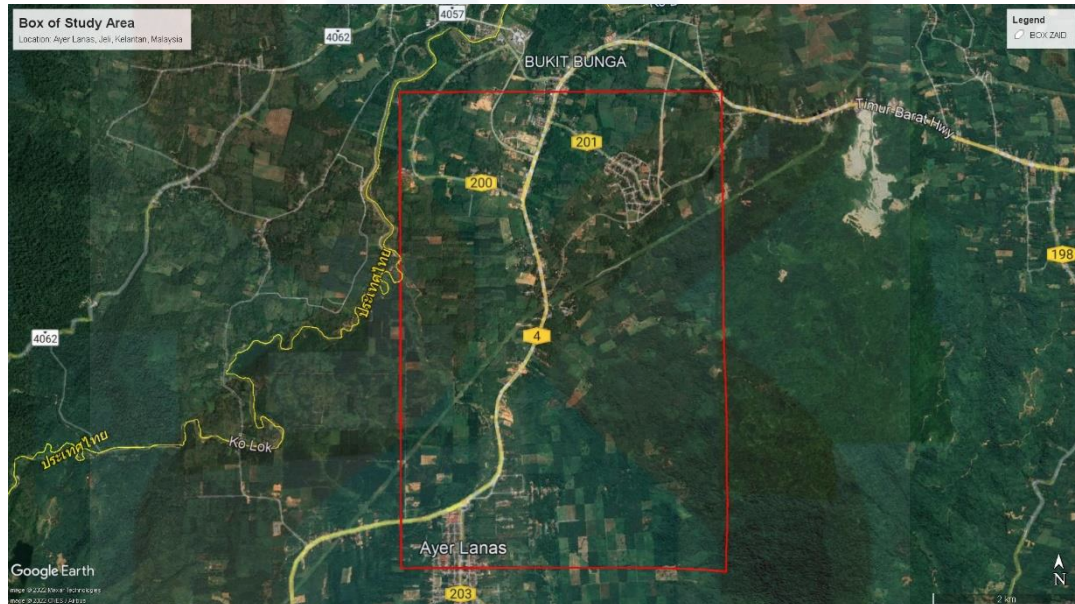


Figure 1.1: Study area at Ayer Lanas.

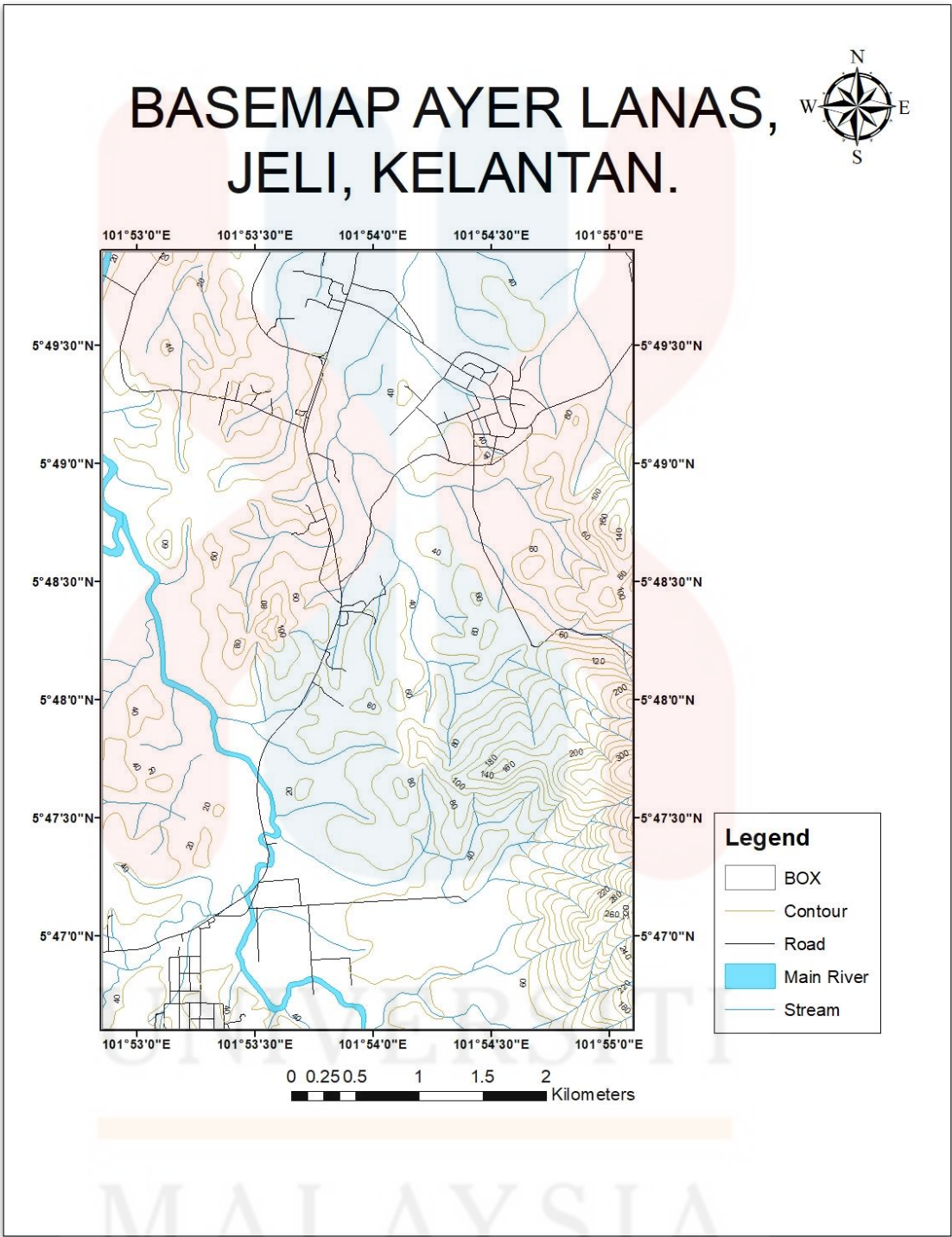


Figure 1.2: Basemap of study area at Ayer Lanas.

1.2.2 Accessibility

The main road connected to the study area Ayer Lanas is the Gerik–Jeli Highway. The main access to the study area is located within the small trail roads. Most of the roads are paved roads, but there are also unpaved roads or small trails that lead deep into rural areas where plantation areas are located such as rubber and palm oil plantations. Generally, most parts of the study area are easy to access where vehicles can pass through for economic and social purposes. In addition, there are also some of the study areas that cannot be accessed because of high elevation.

1.2.3 Demography

Jeli is the third largest district in the state of Kelantan. The district has many other sub districts. The area of the Jeli district is 1,280.21 km². People distribution in Ayer Lanas area is the second highest in Jeli as it is between two big towns which are Jeli and Tanah Merah. In 2010, out of 33,186 people lived in Jeli, Ayer Lanas recorded 3,271 residents. The population are divided into gender which are male and female. Among them, 1,610 are males and the balance 1,661 are females. Table 1.1 show the total population by sex, households and living quarters, district in Jeli district, Kelantan (Department of Statistics Malaysia, 2010).

Table 1.1: Total population in Kuala Krai and Jeli district in 2010.

Negeri : KELANTAN State					
Jajahan/ Kawasan Pihak Berkuasa Tempatan Jajahan/ Local Authority Area	Penduduk Population			Isi rumah Households	Tempat kediaman Living quarters
	Jumlah Total	Lelaki Male	Perempuan Female		
M.D. Kuala Krai	63,575	32,559	31,016	13,602	15,373
Kuala Krai & Guchil	15,503	7,835	7,668	3,389	3,710
Kuala Pahi	377	187	190	82	90
Kawasan selebih M.D. <i>Remainder of M.D.</i>	47,695	24,537	23,158	10,131	11,573
JELI					
M.D. Jeli	33,186	17,302	15,884	7,072	7,714
Air Lanas	3,271	1,610	1,661	714	796
Batu Melintang	2,383	1,195	1,188	516	536
Berdang	1,284	648	636	287	316
Bukit Lakota	608	297	311	127	134
Gemang	1,047	536	511	228	248
Jeli	3,810	2,012	1,798	937	1,023
Kalai	1,033	537	496	200	207
Kuala Balah	-	-	-	-	-
Tunku Abdul Rahman	2,939	1,486	1,453	690	736
Kawasan selebih M.D. <i>Remainder of M.D.</i>	16,811	8,981	7,830	3,373	3,718
<p>Nota : Angka di atas tidak disesuaikan kepada kadar kurang penghitungan. <i>Note : The above figures have not been adjusted for under-enumeration.</i></p>					

(Source: Tumpat District Council, 2010)

From the 3,271 residents, the record divided into three main races in Malaysia that are Malay, Chinese and India. There are also other races and non-Malaysian citizen recorded in the population. There are 3,189 Malays, one Chinese, eight Indians, and 68 other non-Malaysian citizens lived in Ayer Lanas in 2010. Table 1.2 shows the total population by ethnic group and district in Jeli district, Kelantan (Department of Statistics Malaysia, 2010).

Table 1.2: Total population in Kuala Krai and Jeli district by ethnic group in 2010.

Negeri : KELANTAN State									
Jajahan/ Kawasan Pihak Berkuasa Tempatan Jajahan/ Local Authority Area	Jumlah Total	Warganegara Malaysia Malaysian citizens							Bukan Warganegara Malaysia Non-Malaysian citizens
		Jumlah Total	Bumiputera			Cina Chinese	India Indians	Lain-lain Others	
			Jumlah Total	Melayu Malay	Bumiputera lain Other Bumiputera				
M.D. Kuala Krai	63,575	61,069	56,164	56,113	51	3,952	847	106	2,506
Kuala Krai & Guchil	15,503	15,147	12,077	12,063	14	2,784	232	54	356
Kuala Pahi	377	376	366	366	-	10	-	-	1
Kawasan selebih M.D. Remainder of M.D.	47,695	45,546	43,721	43,684	37	1,158	615	52	2,149
JELI									
M.D. Jeli	33,186	32,296	32,126	31,606	520	91	58	21	890
Air Lanas	3,271	3,203	3,190	3,189	1	1	8	4	68
Batu Melintang	2,383	2,374	2,362	2,270	92	10	-	2	9
Berdang	1,284	1,202	1,200	1,199	1	-	-	2	82
Bukit Lakota	608	606	606	606	-	-	-	-	2
Gemang	1,047	1,038	1,038	1,038	-	-	-	-	9
Jeli	3,810	3,735	3,687	3,685	2	38	9	1	75
Kalai	1,033	1,006	1,005	1,005	-	1	-	-	27
Kuala Balah	-	-	-	-	-	-	-	-	-
Tunku Abdul Rahman	2,939	2,908	2,903	2,899	4	5	-	-	31
Kawasan selebih M.D. Remainder of M.D.	16,811	16,224	16,135	15,715	420	36	41	12	587
Nota : Angka di atas tidak disesuaikan kepada kadar kurang penghitungan. Note : The above figures have not been adjusted for under-enumeration.									

(Source: Tumpat District Council, 2010)

1.2.4 Landuse

Ayer Lanas district covers an area of 339.68 km². There are agriculture sectors mostly developed for domestic purposes such as palm oil, rubber plantation and others. Residential areas, transport sectors such as roads and highways and commercial sectors such as shops, health and personal service are among the landuse developed in this area.

1.2.5 Social Economy

The social economy of the study area is primarily based on rubber tapping, palm oil harvesting and small-scale agriculture businesses such as vegetables and fruits. Furthermore, there are several shops in the study area, such as grocery stores, retail stores, and workshop. The residents of Ayer Lanas can also find raw foods at the

villagers' grocery store or wet market. Fresh vegetables and fruits agriculture, as well as raw foods such as chicken, are mostly raised by the villagers themselves. Aside from that, there is no developed industrial area or mining sector in the study area.

1.3 Problem Statement

The only latest geological map of Ayer Lanas, Jeli that can be found is from year 2016. The research was done by Nazarudin et al. (2016) however only focusing on the geophysical method for potential groundwater purpose in the study area. Therefore, this research was done in order to update the geological map of Ayer Lanas from several years ago because same changes in terms of general geology might have happened in the study area. For research specification, several rivers and streams in Jeli, Kelantan were chosen to be assessed in terms of their water quality. These rivers have undergone various changes throughout time as a result of urbanization, such as road constructions to accommodate rapid development of Jeli district. From the middle stream to the downstream, two-thirds of these rivers water quality is in the river class between III and IV (Juahir et al., 2014). Class III of the water pollutants classification indicates that the pollutants are coming from nutrients and agriculture runoff. Meanwhile, class IV of the water pollutants classification indicates that the pollutants consist of suspended solids and sediments. Therefore, this clearly shows that water bodies in Jeli is facing water pollution problem. Except for irrigation purposes, river water is unsuitable for any activity.

1.4 Objectives

- To update the geological map of Ayer Lanas, Jeli, Kelantan with scale of 1:25000.
- To determine the effectiveness of zeolite in adsorption of heavy metals (cadmium, Cd, lead, Pb, copper, Cu and manganese, Mn) in water treatment and improving the water quality.

1.5 Scope of Study

The scope of study in this research is focusing on producing geological map of Ayer Lanas, Jeli using ArcGIS software. In order to complete the main objective which is to produce the geological map, methods such as geological mapping and identification of type of rocks and their distributions in the study area must be done. Besides, the other objective of this research is to study the application of zeolite in water treatment. This research covers 25 km² of the study area.

1.6 Significance of Study

The significance of this study is to explore and get new information in the Ayer Lanas that can be a new contribution to the geology field research. Other than that, through this research updated geological map could be produced to conduct current and future research. There are many scientific studies that approve the advantages of zeolite in water treatment. Zeolites display bigger adsorption capacity of heavy metal ions such as Cr³⁺, Cu²⁺, Ni²⁺, Pb²⁺, Zn²⁺ and Cd²⁺. Another advantage is that zeolite has significantly larger pore size. Zeolites may purify water to produce potable water, and drinking water for example in Budapest, Hungary, and Tbilisi, Georgia.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The literature review of the research title and how to do research in the studied field were concentrated in this part. The objective of this literature review is to provide a guideline for writing the research proposal. This chapter has reviewed regional geology and tectonic setting, stratigraphy, structural geology, historical geology, and lastly petrography of zeolite which is the specification of this research.

2.2 Regional Geology and Tectonic Setting

Peninsular Malaysia is a part of South-East Asia piece and Eurasian Plate, that is also named as Sundaland (Hutchison, 1989). Peninsular Malaysia is separated into three parts which are Main Range, Western and Eastern. Granitic rocks make up almost up to 50% of the geology of Peninsular Malaysia. In context of stratigraphy, Peninsular Malaysia is split into western belt, central belt, and eastern belt.

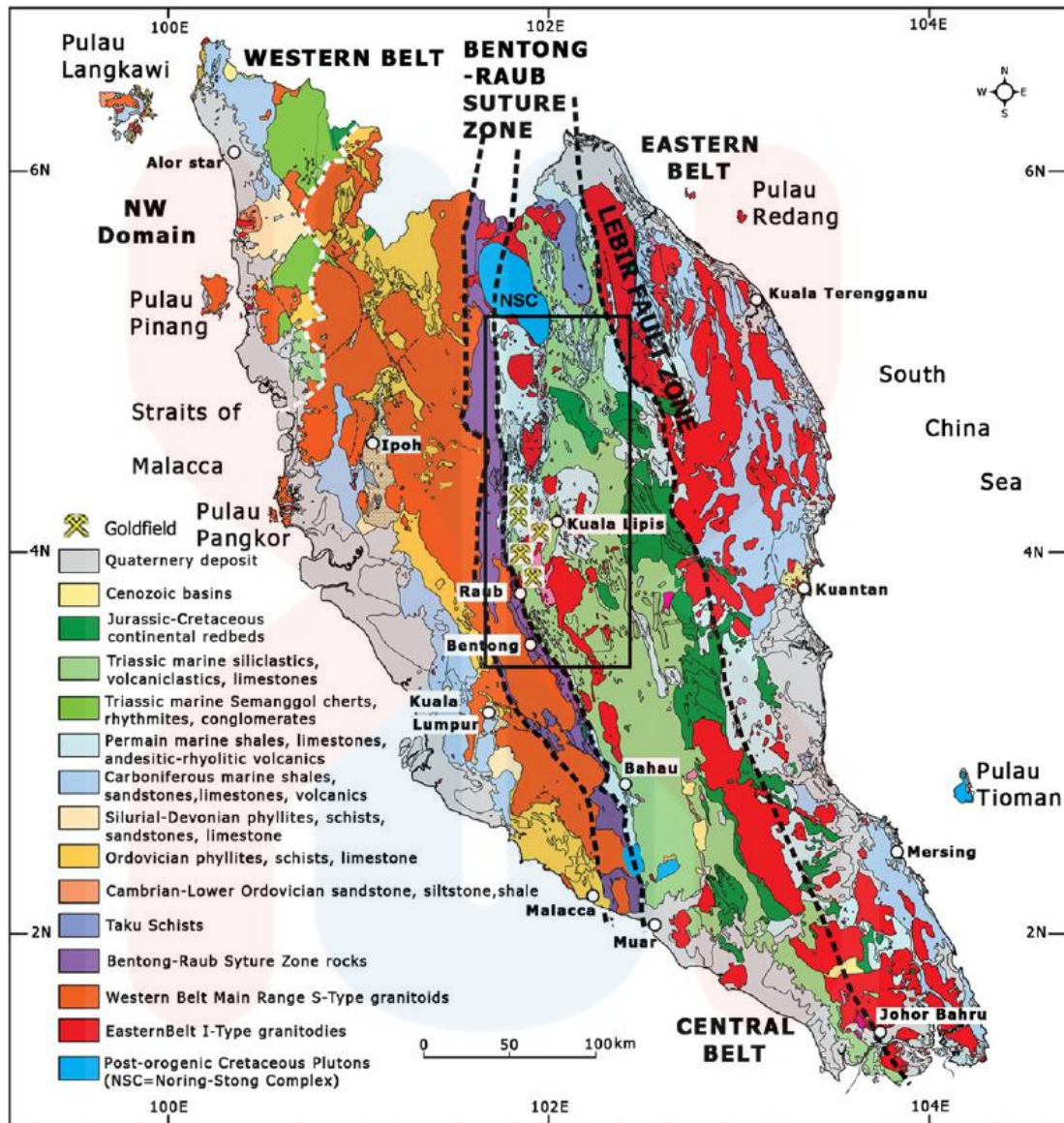


Figure 2.1: Geological map of Peninsular Malaysia (Metcalf, I., 2013).

2.3 Stratigraphy

Ayer Lanas stratigraphy is made up of granitic bodies and Quaternary alluvial deposits. Granitic outcrops are characterised by grey, medium to coarse-grained megacrystic granite porphyry with alkali feldspar as the phenocryst with an average length of 2 cm and a distinct preferred orientation, as well as abundant biotite (Nazaruddin et al., 2016). According to MT-JGSC (2006), the granitic bodies are part of the Triassic Kemahang Granite, which is a N-S trending mountainous area

composed of porphyritic granite as well as granodiorite with a gneissic texture. Meanwhile, unconsolidated sediments of alluvial deposits were deposited in generally flat and low-lying areas to undulating areas, and are dominated by gravel, sand, silt, and laterite.

2.4 Structural Geology

The formations of the Peninsular Malaysia are the result of a long and complex tectonic process that began during the Cambrian period and ended around the Cenozoic era (Hutchison, 1975). During the upper Triassic Indosinian Orogeny, the western Gondwana component of the Malay landmass (Sibumasu) is thought to have collided with the Indochina continental block (East Malaya). The effect of the suture zone is what makes the Bentong Raub line that can be seen now.

The Main Granite Range, also known as Malaysia's backbone or Titiwangsa Range, which has a distinct N-S lineament in the lower region eastern half of the main range and is also known as the Bentong Raub Suture. The Bentong-Raub suture has a north-northeast to south-southwest (NNE-SSW) extended shape that is mostly influenced by the Main Granite Range (Hutchison, 1989). The Lebir Fault Zone, which is the main fault zone in Kelantan, marks the boundary between the central and eastern belts. The Lebir fault zone is a large NNE-SSW curvilinear lineament that runs parallel to the Lebir River near Manik Urai, Kelantan. In the Ayer Lanas area, sedimentary successions are folded into a sequence of synclines and anticlines.

2.5 Historical Geology

The collision of Sinobur Malaya to the west and East Malaysia-Indonesia blocks to the east formed the Malaysia-Thailand transect region, which is part of the Jeli area. Bentong Raub Suture's collision zone extends northward into Thailand and southward into the Banka and Billiton Islands. The formation of Ayer Lanas resulted from Permian sedimentary rocks which consists of phyllite, slate, sandstone and limestone of Gua Musang Formation, Triassic sedimentary rocks which consists of shale, siltstone, sandstone, and limestone of Gunong Rabong Formation and also acid intrusive granitic rocks (Sulaiman et al., 2020).

2.6 Petrography of Zeolite

2.6.1 Structure, Properties and Occurrence of Zeolite

Zeolite is known as any of a class of hydrated aluminosilicate minerals that contain alkali and alkaline-earth metals. Its minerals are almost exclusively found as alteration products in sedimentary, metamorphic, and igneous rocks. Zeolites can develop as a result of volcanic glass alteration products in sedimentary rocks and act as a cementing factor in detrital rocks. They are also found in marine chemical sedimentary rocks. The bulk of zeolites found in sedimentary rocks usually finely crystalline, forming microscopic or sub-microscopic crystals (Hay & Sheppard, 2001). Naturally formed zeolites are also discovered in mafic volcanic rocks as cavity fills, most likely as a product of fluid or vapour deposition. Usually, zeolites can be found in large quantities in all oceans.

Zeolites are well-known for their ion-exchange properties as well as their reversible dehydration (Toshiyuki, 2022). They contain an interwoven framework

structure in which large metal cations and water molecules are housed. A zeolite's most important structural feature is a 3D tetrahedral framework in which each oxygen atom is shared with two tetrahedra. The framework is deemed neutral if all tetrahedra contained silicon. However, substituting silicon with aluminium causes a charge imbalance, and needs the inclusion of additional metal ions in relatively large cavities of the framework. These metal ions are usually monovalent or divalent ions found in naturally occurring zeolites, such as sodium, potassium, magnesium, calcium, and barium.

Natural zeolites are hydrothermal in nature and primarily volcanic in origin (Król, 2020). They can be found in crystallised forms in igneous and metamorphic rocks, also in sedimentary rocks where they accumulated in smaller-diameter grains. The examples of naturally occurring zeolites including clinoptilolite, mordenite, and chabazite (Razzak & Las, 2013). Metal ions and ammonium ions are highly selective in natural zeolites. As a result, zeolites have found important applications in environmental protection and agriculture. Zeolite-filled sorption columns can be used in heavy metal ions or radioactive isotopes removal from wastewater. Aside from its wide range of applications, natural zeolite has several drawbacks, including the presence of many impurities such as Na, K, Ca, Mg, and Fe, as well as poor crystallinity (Nusagri, 2020). The presence of these impurities can reduce zeolite activity. Therefore, activation and modification are typically performed first to improve the character of natural zeolites so that they can be used as catalysts, adsorbents, or in other applications.

Synthetic zeolites on the other hand are zeolites that have been engineered to have a better character than natural zeolites. The basic principle of synthetic zeolite production is its composition of silica and alumina, which allows it to be synthesised

from a variety of raw materials containing the two components. In the laboratory, the synthesis of zeolite to simulate hydrothermal processes can be attempted by elevating temperature or pressure, as well as natural raw materials and synthetic silicates. The synthesis reaction necessitates the use of appropriate equipment, clean substrates, and energy. As a result, the product's price may be significantly higher than the price of natural zeolite.

Clinoptilolite, analcime, heulandite, laumontite, and phillipsite are the most frequent zeolites found in sedimentary deposits. Chabazite, erionite, mordenite, and natrolite are some of the less common zeolites. The occurrence of zeolite facies in metamorphic rocks indicates the lowest grade of metamorphism (Alderton, 2021). Diagenetic responses combine with burial metamorphism as the sediment burial increases.

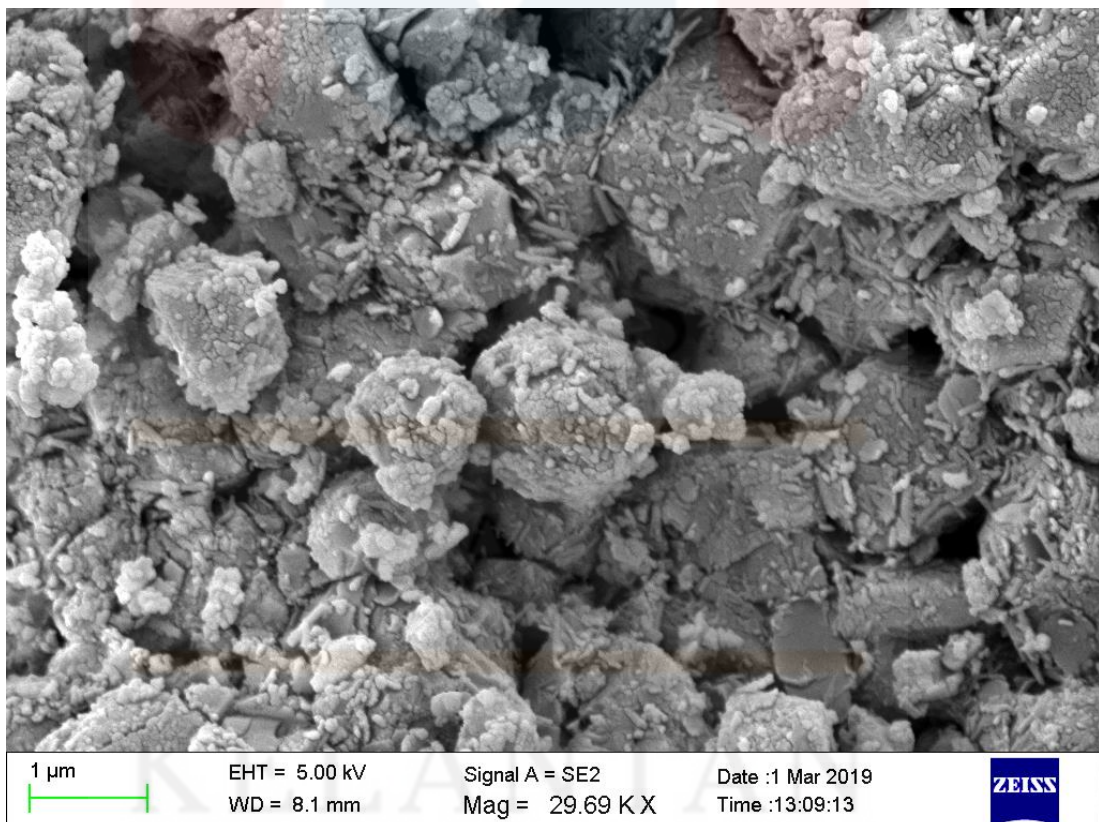


Figure 2.2: Example of SEM analysis of zeolite (Gayathri Devi, 2019)

2.6.2 River Water Quality in Jeli District

According to Juahir et al., (2014), rivers in Jeli district are considered polluted river due to several contaminants that have been classified are released into the river. Agriculture run-off, wastewater from the fertilizer industry, and sewage including high concentrations of nutrients like nitrogen and phosphorus are all classified as Class III water pollutants. These wastewaters provide nutrients to plants and may promote the growth of algae and other aquatic weeds in receiving waterways. As a result, the water body's quality suffers. Meanwhile, silt, sand, and minerals eroded from land are classified as water pollutants in Class IV. They enter the river by surface runoff during the rainy season and municipal sewers, where they can cause siltation. The abundance of suspended materials in the water can obstruct sunlight penetration, which is essential for photosynthesis by bottom plants. If the deposited materials are organic in origin, they will decompose, resulting in the formation of anaerobic conditions. Furthermore, finer suspended particles like silt and coal dust can harm fish gills and induce asphyxiation.

There are several parameters for water quality in Malaysia. Table 2.1 shows the National Water Quality Standards for Malaysia. Based on the table, water body that contain exceeding the amount of elements that shown is considered contaminated.

Table 2.1: National Water Quality Standards for Malaysia.

PARAMETER	UNIT	CLASS				
		I	IIA/II B	II F	IV	V
Al	mg/l	↑	-	(0.06)	0.5	↑
As	mg/l		0.05	0.4 (0.05)	0.1	
Ba	mg/l		1	-	-	
Cd	mg/l		0.01	0.01* (0.001)	0.01	
Cr (VI)	mg/l		0.05	1.4 (0.05)	0.1	
Cr (III)	mg/l		-	2.5	-	
Cu	mg/l		0.02	-	0.2	
Hardness	mg/l		250	-	-	
Ca	mg/l		-	-	-	
Mg	mg/l		-	-	-	
Na	mg/l	-	-	3 SAR	↑	
K	mg/l	-	-	-		
Fe	mg/l	1	1	1 (Leaf) 5 (Others)		
Pb	mg/l	0.05	0.02* (0.01)	5		
Mn	mg/l	0.1	0.1	0.2		
Hg	mg/l	0.001	0.004 (0.0001)	0.002		
Ni	mg/l	0.05	0.9*	0.2		
Se	mg/l	0.01	0.25 (0.04)	0.02		
Ag	mg/l	0.05	0.0002	-		
Sn	mg/l	-	0.004	-		
U	mg/l	-	-	-	↑	
Zn	mg/l	5	0.4*	2		
B	mg/l	1	(3.4)	0.8		
Cl	mg/l	200	-	80		
Cl ₂	mg/l	-	(0.02)	-		
CN	mg/l	0.02	0.06 (0.02)	-		
F	mg/l	1.5	10	1		
NO ₂	mg/l	0.4	0.4 (0.03)	-		
NO ₃	mg/l	7	-	5		
P	mg/l	0.2	0.1	-		
Silica	mg/l	50	-	-	↓	
SO ₄	mg/l	250	-	-		
S	mg/l	0.05	(0.001)	-		
CO ₂	mg/l	-	-	-		
Gross-α	Bq/l	0.1	-	-		
Gross-β	Bq/l	1	-	-		
Ra-226	Bq/l	< 0.1	-	-		
Sr-90	Bq/l	< 1	-	-		
CCE	μg/l	500	-	-		
MBAS/BAS	μg/l	500	5000 (200)	-		
O & G (Mineral)	μg/l	40; N	N	-		
O & G (Emulsified Edible)	μg/l	7000; N	N	-		
PCB	μg/l	0.1	6 (0.05)	-		
Phenol	μg/l	10	-	-		
Aldrin/Dieldrin	μg/l	0.02	0.2 (0.01)	-		
BHC	μg/l	2	9 (0.1)	-		
Chlordane	μg/l	0.08	2 (0.02)	-		
t-DDT	μg/l	0.1	(1)	-		
Endosulfan	μg/l	10	-	-		
Heptachlor/Epoxide	μg/l	0.05	0.9 (0.06)	-		
Lindane	μg/l	2	3 (0.4)	-		
2,4-D	μg/l	70	450	-		
2,4,5-T	μg/l	10	160	-		
2,4,5-TP	μg/l	4	850	-		
Paraquat	μg/l	10	1800	-		

Notes :
 * = At hardness 50 mg/l CaCO₃
 # = Maximum (unbracketed) and 24-hour average (bracketed) concentrations
 N = Free from visible film sheen, discolouration and deposits

Soetardji et al. (2015) tested the efficiency of the sodium hydroxide (NaOH) modified zeolite for ammonium removal in an adsorption investigation utilizing a real aquaculture system. Adsorption in a real system lowered the removal efficacy from 81 percent to 66.9 percent due to competition with other ions. Hamed et al. (2015) removed heavy metals (Fe³⁺, Ca²⁺, and Mg²⁺) from treated and untreated water using

NH_4^+ modified zeolite. The ideal pH for removal was discovered to be 4.5, with removal efficiencies of 98.0 percent, 97.0 percent, and 94.9 percent for Fe^{3+} , Ca^{2+} , and Mg^{2+} , respectively.

In comparison to other methods of water treatment, adsorption is considered to be an effective technique. The rate of pollutant removal is determined by zeolite modification procedures. According to Xiao et al. (2015), the ammonium removal efficiency of acid, alkali, salt, and thermal modified zeolite was 75.8 percent, 87.2 percent, 89.7 percent, and 81.3 percent, respectively. The best removal effects are achieved by alkali-modified zeolite and salt-modified zeolite. Tsade, (2016) conducted study on heavy metal concentrations using Atomic Absorption Spectroscopy (AAS). The water sample was obtained at random from the Kulufo River and tested for cadmium (Cd), chromium (Cr lead (Pb) and manganese (Mn). Flame Atomic Absorption Spectrometry (FAAS) was used to quantify the quantities of Cd, Pb, Cr, and Mn in the sample. The concentrations of Cd, Cr Pb and Mn in the examined river water ranges were found to be higher than those standardized by the World Health Organization (WHO).

CHAPTER 3

MATERIALS AND METHODS

3.1 Introduction

In this chapter, all materials and methods that were used to study the geology of Ayer Lanas, Jeli and analytical work for zeolite application in water treatment were discussed in detail. Materials that were used in this study can be classified into two types. The first type includes journals, previous research, books, articles and the internet. These materials are data sources for research purposes. The second type includes fieldwork equipment. Preliminary studies, field studies, analytical work, data processing, data analysis, and interpretation are all part of the methodology. Figure 3.1 show the research flowchart of this study.

3.2 Materials/Equipment

Table 3.1: Materials and apparatus that were used in the research

Materials /Equipment	Function
Garmin GPSMAP 64s	Provide information such as coordinate, navigation, tracking, elevation and timing for the user.
Brunton compass	To obtain directional with degree measurements. It also can be used to calculate geological structure, such as strike and dip of sedimentary layers.
Geological Hammer	To break the rock in order to get the fresh surface.

<p>Specimen bottle</p>	<p>To put the water sample during transportation to the laboratory for data analysis.</p>
<p>Chemical solution</p> <p>i. HNO₃</p> <p>ii. Distilled water</p>	<p>To be used in water sample preservation and preparation before AAS analysis.</p>
<p>Laboratory apparatus</p> <p>i. 50mL measuring cylinder</p> <p>ii. 500mL volumetric flask</p> <p>iii. Pipette</p> <p>iv. 1mL pipette tips</p> <p>v. 100mL beakers</p> <p>vi. Syringe</p> <p>vii. 0.45µm syringe filter</p> <p>viii. Glass rod</p> <p>ix. 50mL and 15mL centrifuge tubes</p> <p>x. Water treatment cylinder</p>	<p>To carry out water sample preparation and water treatment process during the laboratory test.</p>
<p>Instrument</p> <p>i. X-ray fluorescence (XRF)</p> <p>ii. Atomic Absorption Spectroscopy (AAS)</p> <p>iii. YSI Multiparameter</p>	<p>- To analyse the chemical and structural formula of zeolite samples</p> <p>- To detect the elements that exist in the water sample.</p> <p>- To measure the pH, temperature, conductivity, total dissolved solids (TDS), salinity, dissolved oxygen</p>

	(DO) and oxidation reduction potential (ORP) for in-situ analysis
<p>Filtering medium</p> <ul style="list-style-type: none"> i. Gravels ii. Zeolite iii. Sand iv. 55mm filter paper 	<ul style="list-style-type: none"> - To filter contaminated water samples from fine impurities and large particles - To treat the contaminated water samples from heavy metal ions
<p>Glove</p>	To protect hands from chemical reagents during laboratory test
<p>Software</p> <ul style="list-style-type: none"> i. ArcGIS ii. Global Mapper iii. GeoRose 	<ul style="list-style-type: none"> - To produce different types of maps - To create cross section in geological map - To produce rose diagram

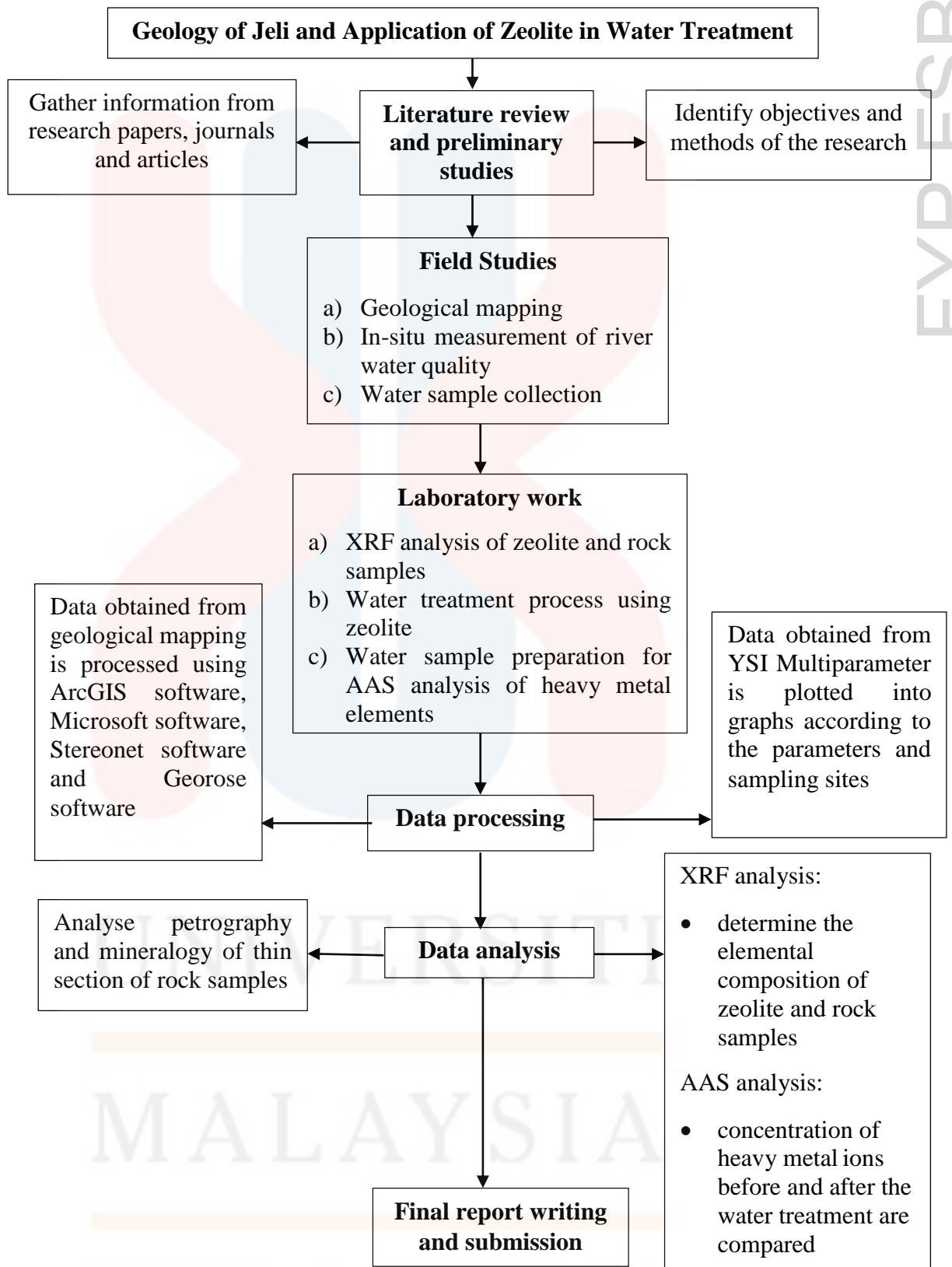


Figure 3.1: Flow chart of the research

3.3 Methodology

3.3.1 Preliminary Studies

This research has been started in March 2022. The previous geological map of the study area was thoroughly studied to get an idea roughly of the important types of rock and other significant geological features of the study area. A few previous researches, important journals and articles were studied properly as a reference so that they would help in the field.

3.3.2 Field Studies

a) Geological Mapping

The study area of this research is located at Ayer Lanas, Jeli, Kelantan. To complete this study, data must be obtained using appropriate methods. Geological mapping, traversing, field measurement, and rock sampling are all examples of field studies. Geological mapping was carried out in order to discover the geologic features of the study area, such as rock types, contact, age relations, and structural patterns. The data was recorded in accordance with the objectives of this study. Walking through a more or less predetermined route from one point on the map to another, plotting the geology along the way, is how traversing was done. Traversing is a method of thoroughly covering the ground across the study area. Garmin GPSMAP 64s was used to mark the coordinate of each outcrop and other geological features found during traversing. Brunton compass in measuring the geological structure such as bedding, fault, cleavage, foliation, and joints was applied during field study. Structures was observed, fresh rock samples were collected with a hammer, and lastly sketches and

photographs of the outcrop and other geological features was. All of this data was useful in producing a geological map.

b) In-Situ Measurement of River Water Quality

In-situ analysis is one of the physicochemical measurements that can be done on-site before collecting the water samples (Burden et al., 2002). There are several parameters that was decided for measuring the water quality selected river (i.e. Pergau River, Lanas River, UMK River). The parameters are pH, temperature, electrical conductivity (EC), total dissolved solids (TDS) dissolved oxygen (DO), salinity and oxidation reduction potential (ORP) (Riduan et al., 2009). YSI Multiparameter is an instrument that was used to carry out this method. To carry out the in-situ analysis, one site from every polluted river was selected. At the selected site, the YSI Multiparameter must be turned on first to start every new calibration. Then, the casing of the sensor that was connected to the YSI Multiparameter is removed. The sensor was first rinsed with distilled water and then submerged into the river. The measurement of each parameter was recorded from the meter when the reading is static. The sensor was then rinsed with distilled water and inserted back into the casing to avoid any error to the next measurement.



Figure 3.2: In-situ measurement of river water quality

c) Water Sample Collection

The condition planned for sample collection is during broad daylight where the sampling day was estimated outside of the rainy seasons. This is because, during the rainy season, the concentration of contaminants that are released in the river water will be reduced. To ensure the data from the collected water sample is valid, it is better safe to do the sample collection during the hot weather. The location for sample collection was set to be taken near the residential area and industrial area. This is because, residential area and industrial area are among the contributors to the contamination of the river water. For water sampling, 3 sampling bottles of 500mL was used to collect the contaminated water sample from every selected river. The sampling bottles was closed tightly to prevent evaporation and oxidation. Then, 1mL of concentrated nitric acid (HNO_3) was added into every sampling bottle and preserved in the chiller (Figure 3.3).



Figure 3.3: Water samples from every sampling location were preserved with HNO_3 and bottled up in sampling bottles.

3.3.3 Laboratory Work

a) XRF Analysis of Zeolite and Rock Samples

X-ray fluorescence (XRF) is a non-destructive chemical analyses used to determine the elemental composition of materials such as rocks, minerals, sediments and fluids. It is a widely used method for analysis of major and trace elements in the materials. The zeolite and rock samples were crushed into small pieces with weight approximately 4 grams. The chemistry of a sample is determined by measuring the fluorescent X-ray emitted from it when excited by a primary X-ray source. XRF analyse the elements quantitatively and qualitatively in concentrations ranging from parts per million (ppm) up to 100%.

b) Water Sample Preparation for AAS Analysis

50mL of preserved water sample from each site was transferred into 50mL beaker. After that, the water sample was filtered using 0.45 μ m syringe filter and transferred into 50mL centrifuge tube (A). From centrifuge tube (A), 15mL of the water sample was extracted using pipette and transferred into centrifuge tube (B). Then, another two centrifuge tubes were prepared and labelled as centrifuge tube (10^{-1}) and centrifuge tube (10^{-2}). Both centrifuge tubes (10^{-1}) and (10^{-2}) were added with 13.5mL of concentrated HNO₃. Next, 1.5mL of water sample from centrifuge tube (B) was extracted and added into centrifuge tube (10^{-1}). The mixture of the water sample and nitric acid in centrifuge tube (10^{-1}) is shaken well. Then, 1.5mL of the mixture from centrifuge tube (10^{-1}) was extracted and added into centrifuge tube (10^{-2}). The mixture in centrifuge tube (10^{-2}) is shaken well. These procedures are called water sample dilution before the samples are ready to be analysed using AAS (Figure 3.4). These procedures were repeated using 50mL of preserved water sample from each site. Finally, the samples were all prepared and ready for AAS analysis of heavy metals concentration before the water treatment process.

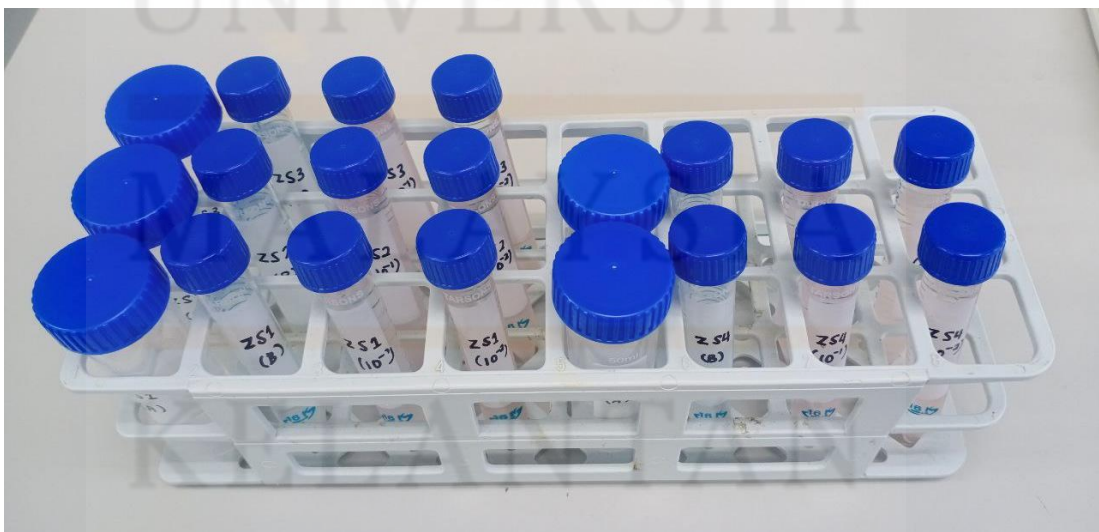


Figure 3.4: Water samples from every sampling location were prepared into centrifuge tube of 50mL (A) and 15mL (B), (10^{-1}) and (10^{-2}).

c) Water Treatment Process Using Zeolite

Filtering mediums such as gravels, zeolite and sand are washed thoroughly before running the water treatment procedure. A water treatment cylinder with a volume of 748cm^3 is filled with gravels, zeolite and sand layer by layer (Figure 3.5). A piece of 55mm filter paper was placed at the bottom-most part of the cylinder. Then, the cylinder was added with a sand layer of 6cm height. The function of the sand is to filter out fine impurities and supply minerals to the water. Next, a zeolite layer of 6cm height was added on top of the sand layer to treat the water from heavy metal ions such as Cu^{2+} , Pb^{2+} , Mn^{2+} and Cd^{2+} and any other harmful chemicals. For the uppermost part of the cylinder, 6cm height of gravel layer was added on top of the zeolite layer to remove any large particles from the water. All these filter medium layers are permeable so that water can flow easily across the medium.

After that, distilled water was allowed to flow inside the cylinder for a few seconds to wash away any chemicals and impurities left before treating the contaminated water. Then, a 100mL beaker was put under the cylinder to collect the treated water coming out from the bottom of the cylinder. Next, 100mL of the contaminated water sample was measured and poured into the cylinder. Treated water that was coming out from the bottom of the cylinder was collected inside the beaker. The time taken for the treated water to flow into the beaker was recorded.

Lastly, the filtering mediums inside the cylinder were once again rinsed with distilled water to remove the chemicals and impurities. This procedure was repeated by replacing the contaminated water sample from different sites every time. After the treated water samples from every site were collected, they were diluted again for the AAS analysis to get the after-treatment concentration of heavy metal ions.

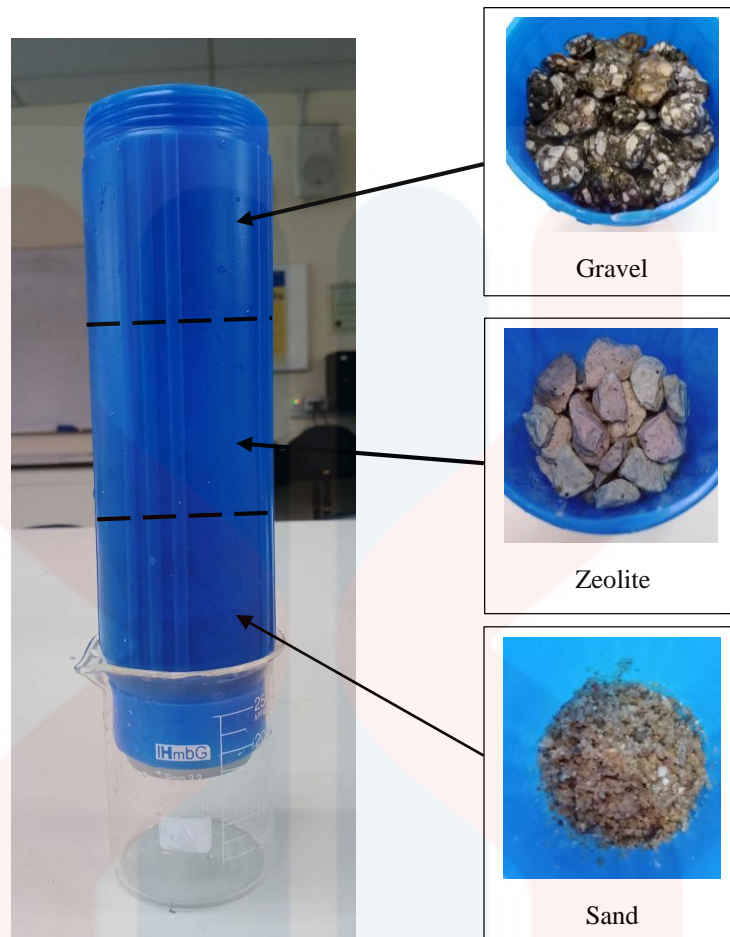


Figure 3.5: The set-up of water treatment procedure and its components.

3.3.4 Data Processing

Data processing is the conversion of data obtained from the field studies into usable and desired form. The data collected in physical form by writing in notebooks, papers or any other physical form was transferred, processed and stored in digital form. Data processing was done using several online software such as ArcGIS software, Microsoft software, Stereonet software and Georose software. Using the various types of software helps to obtain a variety of formats of output files. Maps, tables and graphs are the examples of different types of output that were obtained in this study.

Other than that, to process the data obtained from YSI Multiparameter, all the data were plotted into graphs according to the parameters and sampling sites to make profiles for river water quality across the Jeli district.

3.3.5 Data Analysis and Interpretation

The thin section of each rock sample was analysed in order to complete and update the lithology in the geological map. Petrography and mineralogy of the rock sample were observed and interpreted in detail based on the thin section. Meanwhile, the results obtained from XRF analysis of zeolite and rock samples were observed and interpreted in terms of their element compositions and concentration. The data obtained from the AAS analysis before and after the treatment process of contaminated water samples were presented in graph form. The concentration of Cu, Pb, Mn and Cd elements before and after the water treatment are compared to prove the effectiveness of zeolite in water treatment.

CHAPTER 4

GENERAL GEOLOGY

4.1 Introduction

The study area is specified in Ayer Lanas which has the area of 25km². The coordinates of the study area are 05°46'36" N to 05°49'53" N latitude and 101°52'51" E to 101°55'05" E longitude. The geological aspects of the study area such as geomorphology, lithostratigraphy, structural geology and historical geology are discussed in this chapter.

4.1.1 Accessibility

Study area is located in Ayer Lanas, Jeli, Kelantan, Malaysia and has the accessibility to the main road. The main road connected to the study area is the Gerik–Jeli Highway. The distance of the study area from UMK, is around 6.2km and can be accessed by car in 7 minutes. Most of the roads are paved roads, but there are also unpaved roads or small trail roads that lead deep into rural areas where plantation areas are located such as rubber and palm oil plantations.

4.1.2 Settlement

There are several settlement or residential areas or situated in the study area including Kampung Rahmat, Kampung Jakar, Kampung Buyong, Kampung Chedok

and Kampung Gertak Panjang. All these villages are located along or near the main road. This is because it is easy for the local people to get access to the nearby shops and public sectors.

4.1.3 Vegetation

From the observation during the geological mapping, 60% of the study area is covered with vegetation. Among the vegetation that can be seen in abundance are rubber tree and palm oil tree. This is because majority of the land use in the study area are rubber and palm oil plantations. There is also low hill forest on the east side of the study area.



Figure 4.1: Rubber plantation in the study area.

KELANTAN



Figure 4.2: Palm oil plantation in the study area.

4.1.4 Traverse and Observation

During the geological mapping, traverse was mostly done along the main road and also the trail road that lead into the villages and plantation area. There was not much outcrop that can be found along the river due to the alluvium landform of the river. The outcrops that were found within the study area are mainly igneous and sedimentary rock. The hand specimen sampling of the rock was carried out at different site throughout the study area.

4.2 Geomorphology

Geomorphology is the study of landforms and their origin, evolution, form, and distribution across the physical landscape. Geomorphological processes provide

various information on the formation of different structures and features in landscapes around the world (Briney, 2021).

4.2.1 Topography

Topography is the study of the earth surface created due to various natural processes. Topography such as mountains, valleys, rivers, or craters on the surface is what makes a landscape. Topographic map displays the contours and shading the heights and lows surface of certain areas. There are several classification of geomorphological unit done by Van Zuidam (1985) according to the elevation of the earth topography such as low plain, slightly sloping plain, sloping hill, steep hill, very steep hill and extremely steep hill (Table 4.1).

According to the Figure 4.3, the study area can be classified into low plain, slightly sloping plain, moderately sloping hill, steep hill classification. The low plain area covers the elevation of 50m and below that covers almost 60% of the study area. Next, slightly sloping plain shows the elevation range from 50m to 100m that covers about 15% of the study area. The elevation that range from 100m to 200m indicate moderately sloping hill that cover 15% of the study area. The highest elevation in the study area is 310m and it is classified as steep hill as the elevation for steep hill is range from 200m to 500m. Steep hill covers 10% of the study area. The classification of slightly sloping plain, moderately sloping hill, steep hill dominate the east part of the entire study area. The hilly area is named Kemahang Hill and it is trending N-S direction. The steepness of certain surface can be seen in the topographic map. The closer the contour line indicates the higher steepness compared to contour line with bigger gap that indicates lower steepness.

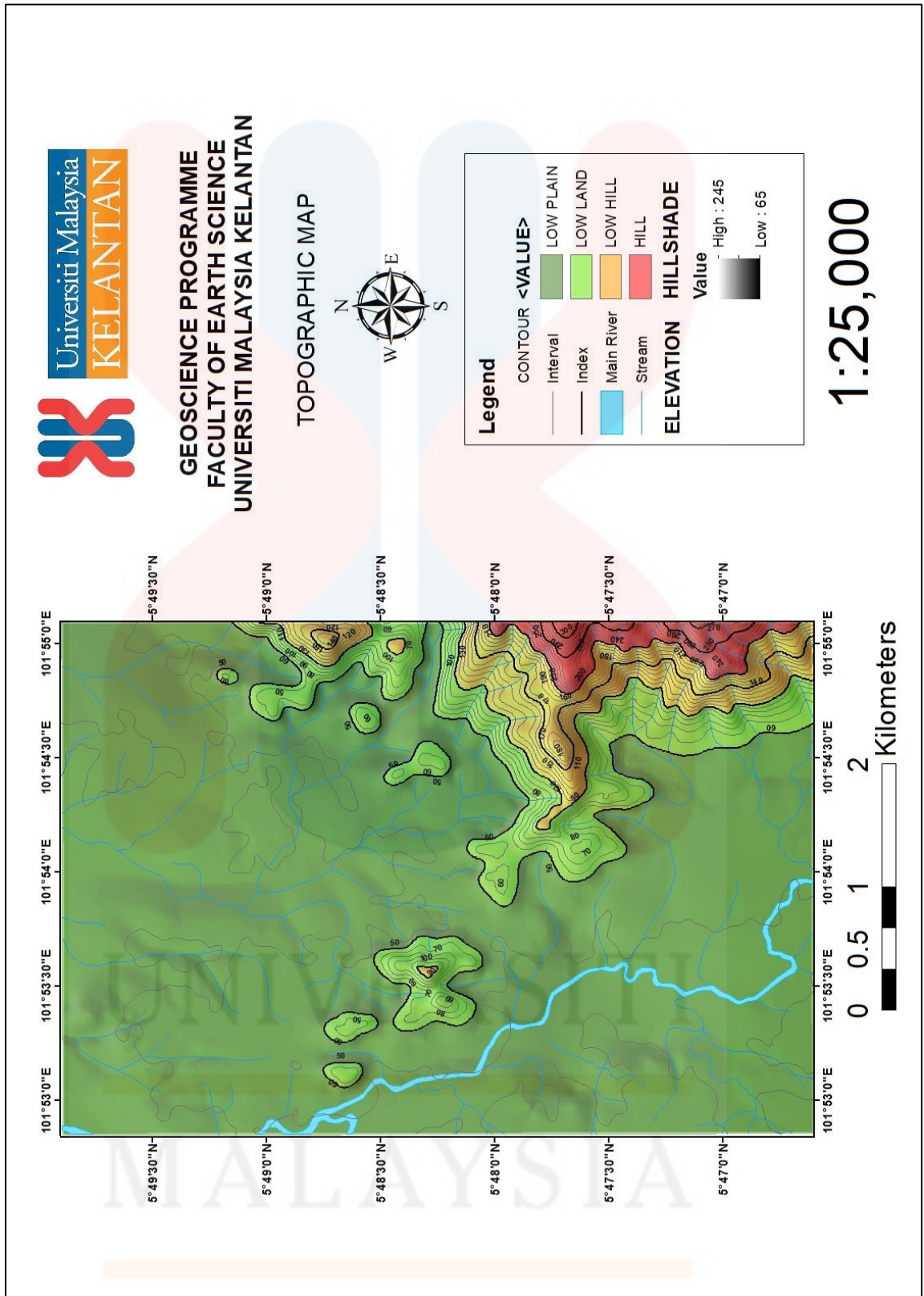


Figure 4.3: Topographic map of study area.

Table 4.1: Slope Classification from Zuidam.

Classification	Slope		Elevation Difference (m)
	Percent (%)	Degree (°)	
Flat	0-2	0-2	<5
Gently Slope	2-7	2-4	5-25
Sloping	7-15	4-8	25-75
Moderately Steep	15-30	8-16	75-200
Steep	30-70	16-35	200-500
Very Steep	70-140	35-55	500-1000
Extremely Steep	>140	>55	>1000

Other than that, river is also an element of topography. The main river in the study area is the Lanas River. It flows to the south direction. Lanas River acts as water catchment because it has the lowest elevation in the entire study area which is below 50m. Streams that run down the hilly area help uplift and tilting of the stratified rocks as well as transport the sediments to flow and deposit into the main river. In rainy season, streams also flow the rain water into the main river.

4.2.2 Weathering

Weathering is the breakdown or dissolution of rocks and minerals on the Earth surface. Weathering agents include water, ice, acids, salts, plants, animals, and temperature changes. (Evers, 2022). The example of weathering processes are plant roots growing and pushing through it, ice expanding in cracks, abrasion from wind and water-pushed sediment, and chemical breakdown of rock such as limestone (Briney, 2021). Weathering process are divided into three which are physical, chemical and biological weathering.

For physical weathering in the study area, Figure 4.4 shows the granite outcrop that has broken apart due to the action of water. Water flowing through a stream into a rock can eventually erode the rock. When the water in a river or stream moves quickly, it can uplift the rock from the river or stream bed. Water can seep into cracks and crevices in rock. When the rocks fall back down, they collide with other rocks, causing tiny pieces of the rocks to break apart.



Figure 4.4: The effect of physical weathering that causes the granite outcrop to break apart.

Chemical weathering occurs when water interacts with minerals to create various chemical reactions that change the rock composition. Example of chemical weathering that can be found in study area is oxidation. Figure 4.5 shows the sedimentary outcrop that has chemically weathered and form rust on its surface due to the exposure to the atmosphere. The process occurs when oxygen from air and water reacts with rock that contain iron to form iron oxides or rust. This process not only change the composition of the rock, but also weakening and crumbling the rocks.



Figure 4.5: Oxidation process as chemical weathering has form the rusty layer of iron in the sedimentary rock.

Lastly for biological weathering, it is a type of weathering occurs by plants, animals and microbes to break rocks apart or degrade the minerals in them. From Figure 4.6, biological weathering process occurs whereby plants grow on the granite rock surface. Algae also can be seen grow on rock surfaces because of particularly humid areas.



Figure 4.6: The growth of plant and algae as biological weathering on the granite outcrop.

4.2.3 Drainage Pattern

Drainage system is the pattern formed by the streams, rivers, and lakes in a specific drainage basin. They are influenced by the land's topography. Streams are considered as part of drainage basins. There are several main types of drainage pattern classified by geomorphologist. They are dendritic, trellis, rectangular, parallel, radial, centripetal, deranged and angular. However, the type of drainage patterns that can be classified in the study area are dendritic and trellis pattern.

Lanas River is the main river in the study area and its flows towards south. Based on Figure 4.8, dendritic pattern which looks like branching pattern of tree roots, dominates the north and east part of the study area, where the hilly areas located. The streams from dendritic pattern mostly flows down the hilly area, join together at acute angles and flow towards the north. By referring to the drainage pattern map, the dendritic pattern streams are not connected to the main river, Lanas River.

Trellis pattern on the other hand dominates the along Lanas River. Trellised drainage patterns form where there is strong structural control over streams due to geology (Pidwirny, 2006). A pattern like this formed when tributaries of major rivers flow parallel to one another and secondary streams join them at right angles. (Amruta, 2022). Streams from this pattern can be found in the low plain area whereby the elevation is lower than 60m. These streams joined together with Lanas River at almost right angle and flow toward the south.



Figure 4.7: Lanas River as the main river in the study area.

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DRAINAGE PATTERN MAP



Legend

- Main River (Blue line)
- Dendritic Pattern (Red line)
- Trellis Pattern (Yellow line)



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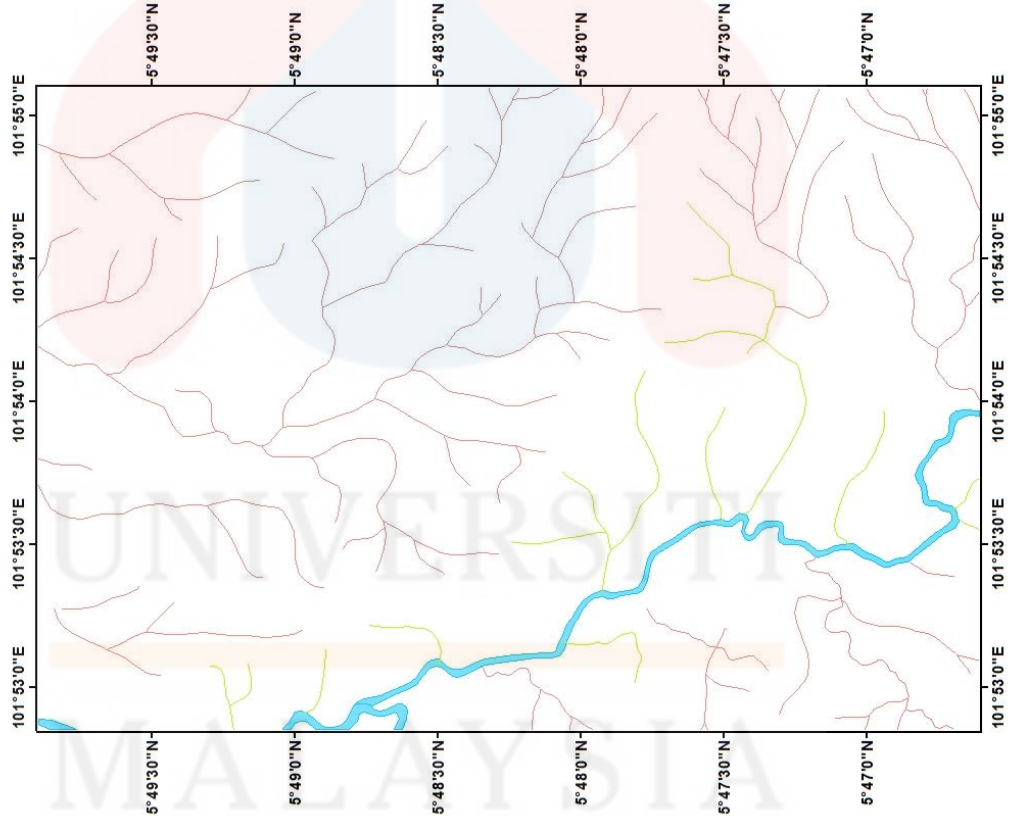


Figure 4.8: Drainage pattern map of study area

4.3 Stratigraphy

4.3.1 Lithostratigraphic Unit

(a) Simpang Formation

Simpang Formation (Hutchison & Tan, 2009) consist of unconsolidated to semi-consolidated gravel, sand, clay, and silts that dominate the quaternary deposits. This formation covers the north of the Kelantan river valley. The silty and clay deposit with depth of 13 m to 15 m is relatively young (Zakaria, 1972), whereas the thickness of alluvium can reach more than 200 m towards the seas (Suratman, 1997).

(b) Kemahang Granite Formation

The Kemahang granite of is a granitic mass in north-west Kelantan close to the Thai border and known as one of the biggest granitic body in Malaysia. Based on the age determination by MacDonald (1967), the age of Kemahang granite is from Middle Triassic. Kemahang granite is from an acidic type of composition. The granite contains different varieties of granitic rocks. The predominant type is medium- to coarse-grained, grey in colour, with large feldspar phenocrysts, abundant biotite, marked lineation of feldspar phenocrysts at a number of localities. Kemahang distributed at Jeli Hill, Kemahang Hill, Kusial Hill and other smaller hills.

Table 4.2: Lithostratigraphic column in study area.

Era	Period	Formation	Lithology Unit	Colour
Cenozoic	Quaternary	Simpang Formation	Alluvium deposit (Siltstone)	Yellow
Mesozoic	Middle Triassic	Kemahang Granite Formation	Acid intrusive (Granite)	Pink

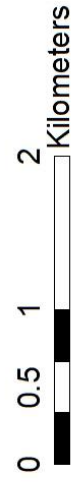
Based on Figure 4.9, the boundaries of the lithology were determined based on the contour patterns. Granite unit is more intrusive and resistant towards weathering. Therefore, it appears to have closer contour lines and bare contrary to the surrounding unit in the map. From Figure 4.10, weathered exposures of siltstone unit in ZCP 5 was observed close to the granite unit in ZCP6. The siltstone unit forms at lower topography which increases towards the boundary with the granite unit. The boundary zone is estimated close to the bottom slope of resistant granite unit.

LITHOLOGY MAP



Legend

 Main River
 Stream
 Acid intrusives (Granite)
 Alluvium deposit
 CONTOUR
 Interval
 Index



1:25,000

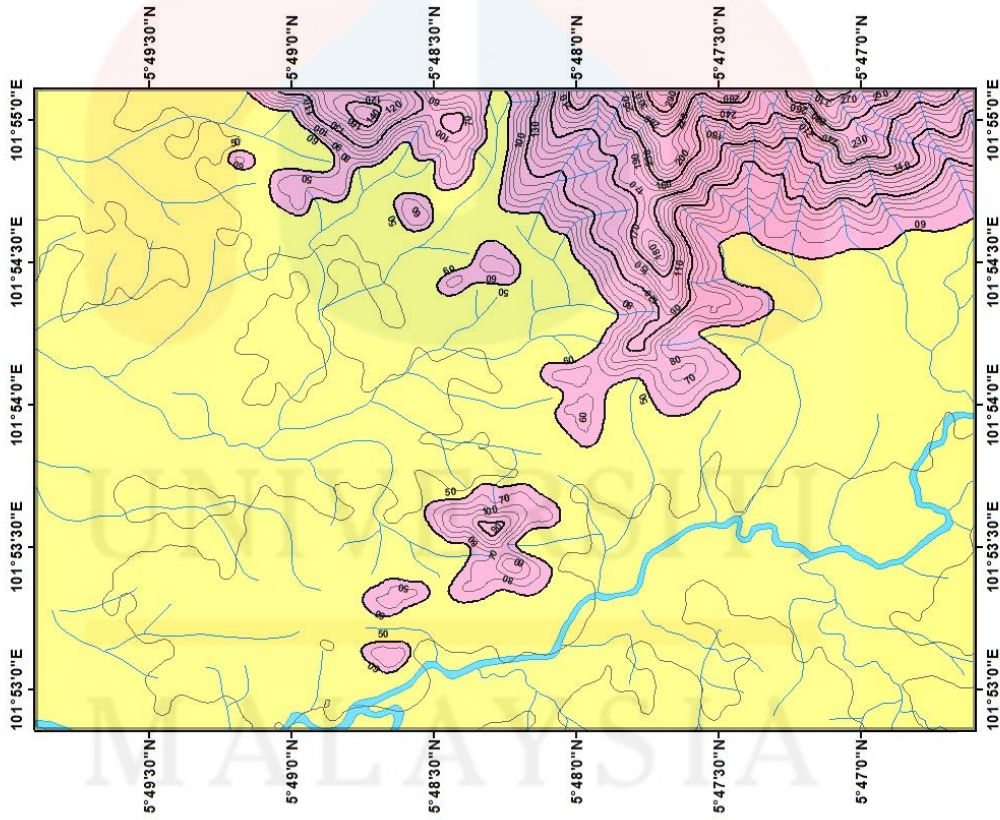


Figure 4.9: Lithology map of study area.

4.3.2 Unit explanation

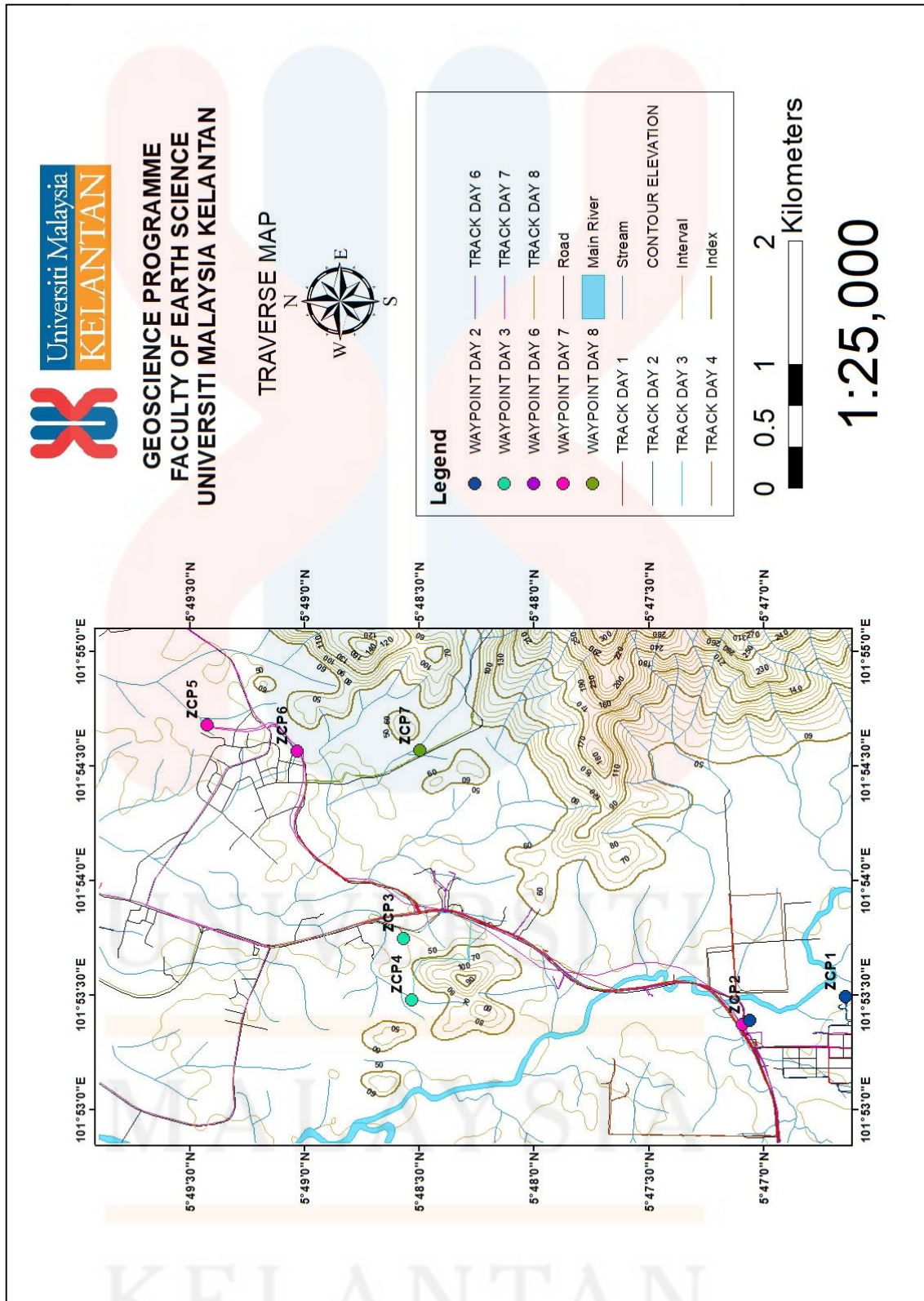


Figure 4.10: Traverse map of study area.

(a) Siltstone Unit

There were two localities of siltstone unit found within the study area. The first locality is ZCP3 located at coordinate N 05°48'34.2" E 101°53'44.7". This outcrop was found on August 23, 2022 at 11:30AM. It has the elevation of 51m and azimuth 94° from north. This outcrop is exposed into cut slope due to excavation process. It is highly weathered whereby the rock materials have all discoloured. The lithology of this outcrop is also almost unidentified due to the high weathering. However, the original structure and texture of this rock is still visible. It has white, grey, black, red and brown colour, silty texture, has slump fold structure and interbedded with sandstone.

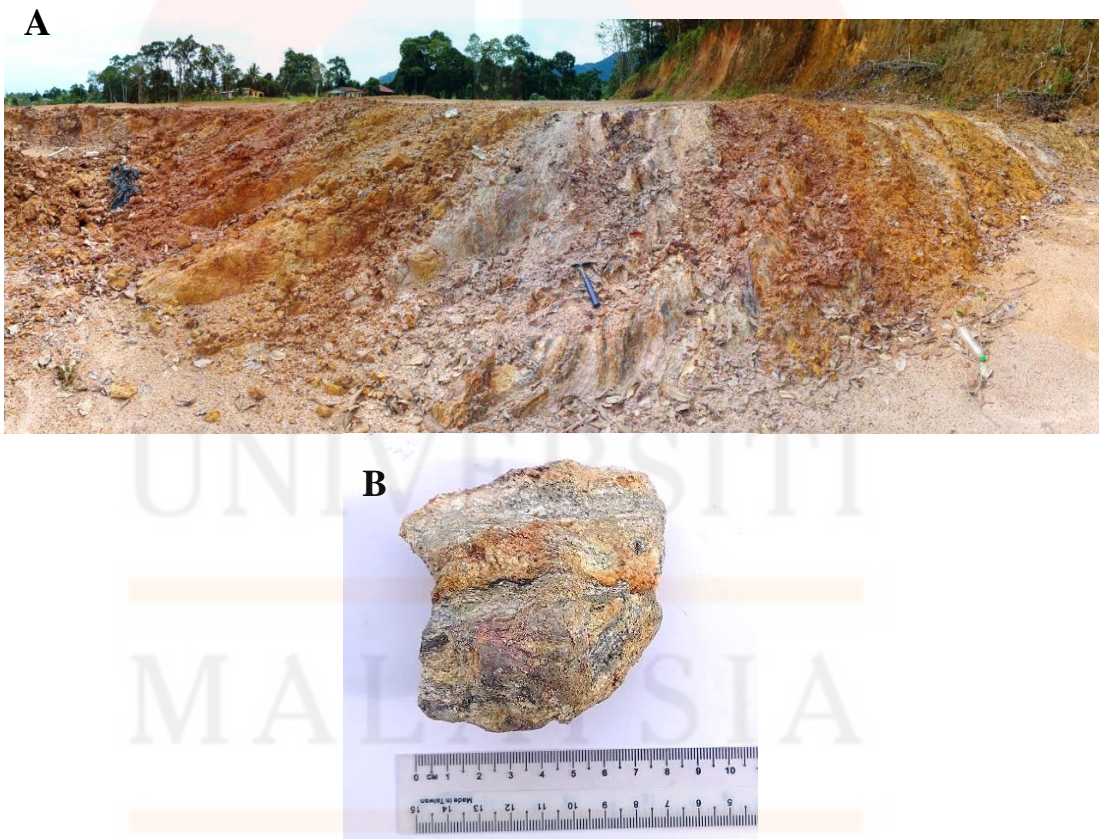


Figure 4.11: (A) Siltstone outcrop and (B) hand specimen of ZCP3.

Another locality for siltstone unit is ZCP5 that is located along a new road in Kampung Jakar at coordinate N 05°49'25.6" E 101°54'40.8". This outcrop was found on August 23, 2022 at 11:30AM. It has the elevation of 40m and azimuth 64° from north. The condition of this outcrop is almost the same to the outcrop at ZCP3 whereby it is highly weathered. The colour of this outcrop is white, grey, black, red and brown and it also has silty texture. Joint structures can be seen at this outcrop and the strike and dip reading of the reading was taken here.

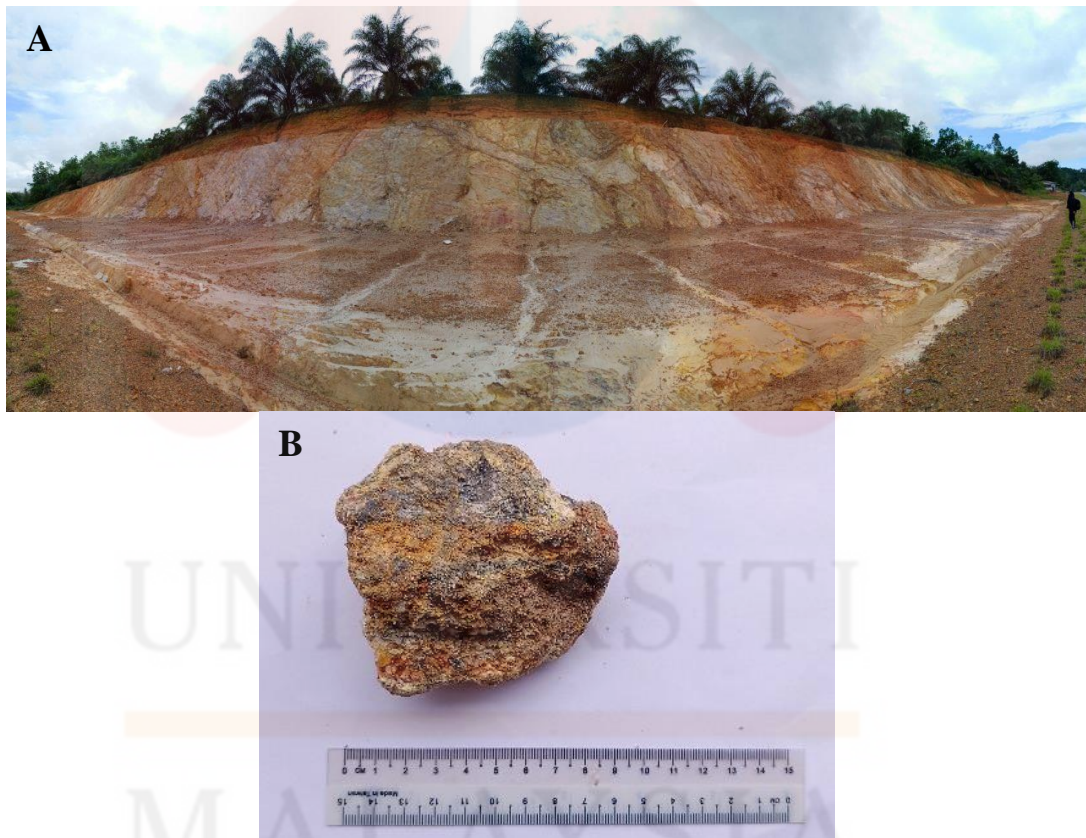


Figure 4.12: (A) Siltstone outcrop and (B) hand specimen of ZCP5.

This siltstone unit represents the Simpang Formation during Quaternary period. It has a relatively wide distribution that it covers almost 60% of the study area. The siltstone unit can be correlate to Simpang Formation in terms of the properties of

the rock. The rock of siltstone unit is the argillaceous succession from unconsolidated to semi-consolidated gravel, sand, clay, and silts from the formation.

i. Petrographic Analysis

Petrography is a sub discipline of petrology that studies and discusses detailed descriptions of rocks in thin sections observed under microscope with two types of polarised light which are plane polarized light (PPL) and cross polarized light (XPL). Petrographic analysis determines a rock's origin, whether igneous, sedimentary, or metamorphic, as well as its mineral content. Hand specimens collected during geological mapping were processed into thin sections in order to determine their composition and mineralogy. The names of rocks were given based on the abundance minerals observed under a microscope.

Sample ZCP3

These photomicrographs of siltstone sample show aphanitic texture and is composed of quartz, biotite and orthoclase. Figure 4.13(A) shows biotite mineral with brown colour, has perfect cleavage and shows deformation which is bent cleavages. The percentage amount of biotite in this sample is 10%. In Figure 4.13(B), quartz mineral can be seen in crossed polarized light (XPL). It shows milky colour, no cleavage and has subhedral shape. However, the quartz is not visible in the plane polarized light (PPL). The percentage amount of quartz is 20%. The orthoclase shows greyish and whitish colour with subhedral shape. It is colourless in the plane polarized light (PPL). The percentage amount of orthoclase in this sample is 70%.

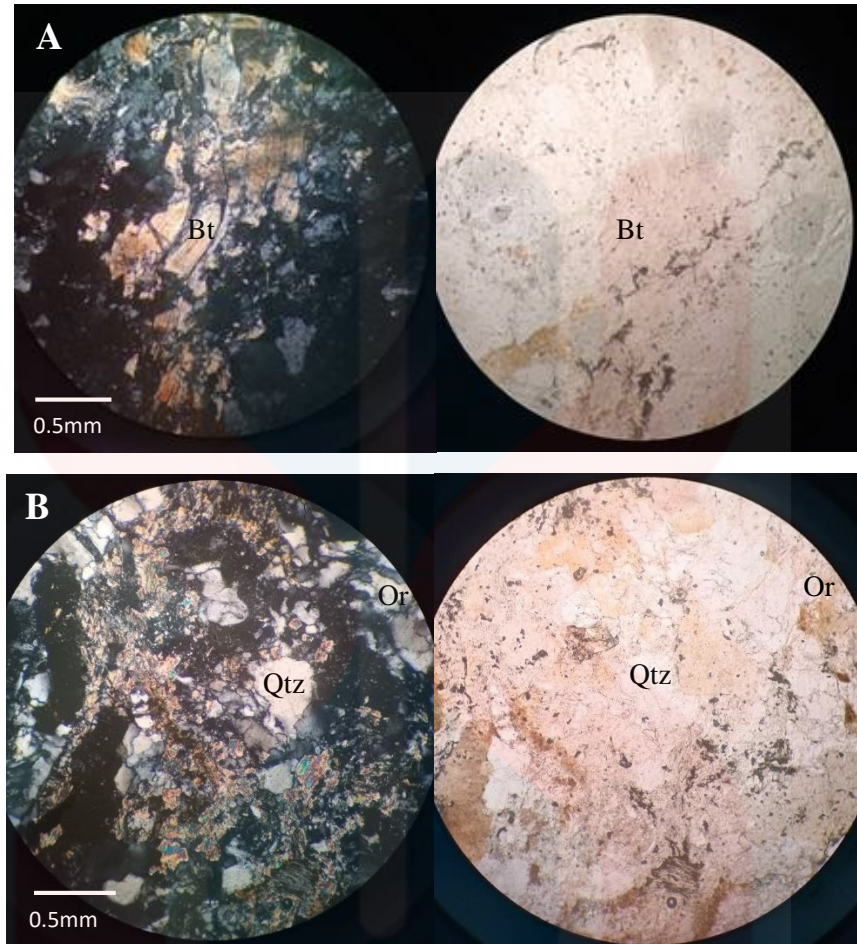


Figure 4.13: The minerals in siltstone of ZCP3 under crossed polarized light (XPL) and plane polarized light (PPL). (A) Deformed biotite into bent cleavages. (B) Quartz and orthoclase shows subhedral shape. (Qtz = Quartz, Bt = Biotite, Or = Orthoclase).

(b) Granite Unit

The granite unit was found as three different localities throughout the study area. Granite at ZCP1 was found on August 8, 2022 at 9:30AM. This granite outcrop located at a point in the Lanang River with coordinate N 05°46'38.3" E 101°53'29.7" and elevation of 36m at azimuth 340° from north. By observing the hand specimen in Figure 4.16, it can be seen that the rock has phaneritic texture as the minerals can be seen by naked eyes. It has white, black and grey colour. The quartz and biotite mineral can be seen clearly. This outcrop has undergone biological weathering due to the growth of algae on its surface.

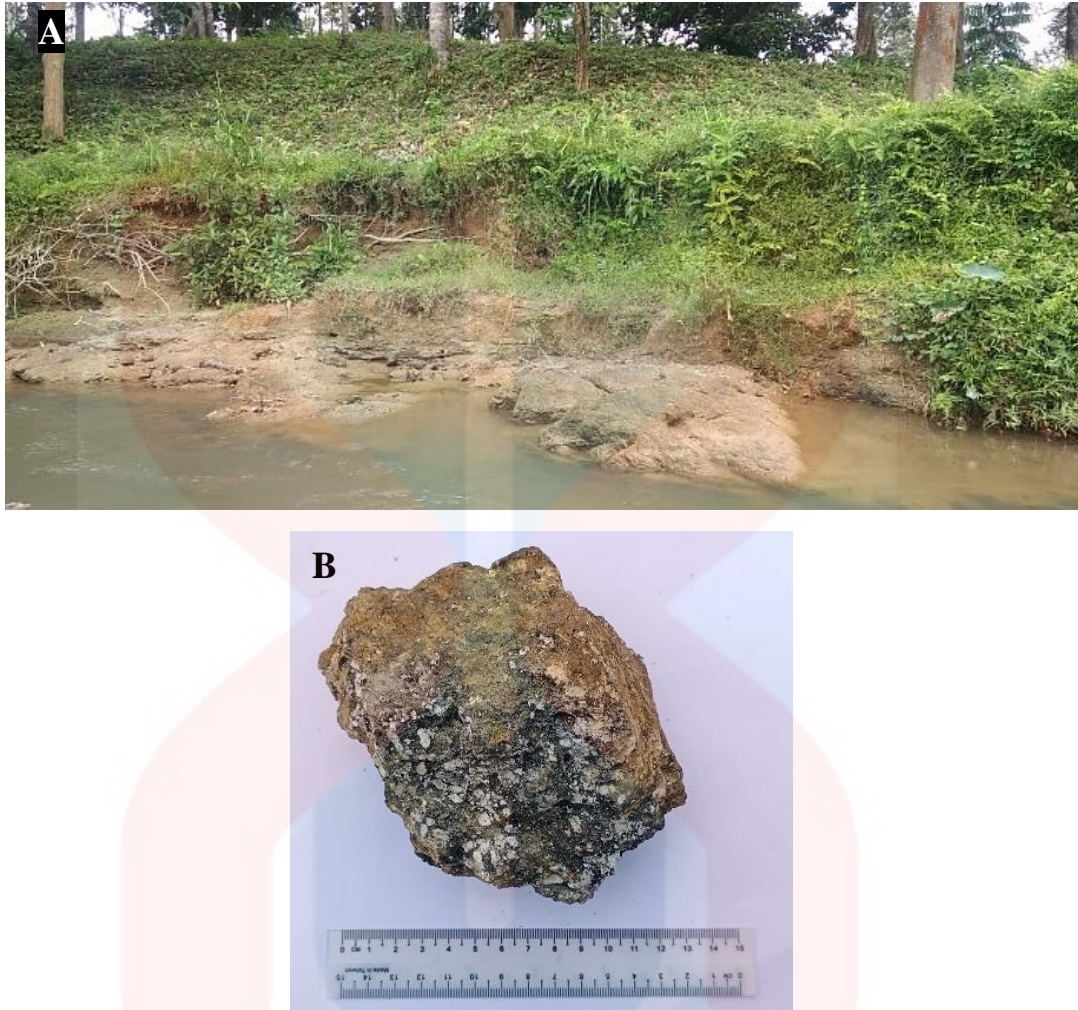


Figure 4.14: (A) Granite outcrop and (B) hand specimen of ZCP1.

Another granite unit was found at ZCP6 on August 30, 2022 at 11:40AM. The location of this outcrop is in Kampung Jakar on the road side with the coordinate N $05^{\circ}49'02.0''$ E $101^{\circ}54'33.9''$, azimuth 127° and elevation of 48m from north. This rock has porphyritic texture with phenocrysts up to 3cm in size. The colour of this rock is grey, black and white.

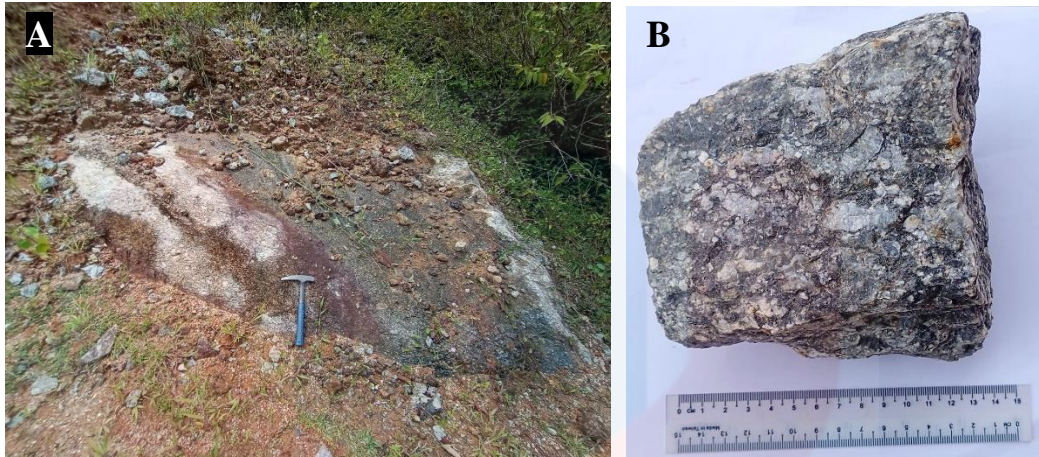


Figure 4.15: (A) Granite outcrop and (B) hand specimen of ZCP6.

The last granite unit found in the study area was at ZCP7 on September 9, 2022 at 12PM. This outcrop is located by the stream in hilly area, east part of the study area at coordinate N 05°48'29.8" E 101°54'34.0" with elevation 44m and azimuth 68° from north. This rock also has a very clear porphyritic texture with quartz phenocrysts up to 4cm in size. It has white, yellow, grey in colour as it has moderately weathered due to the existence of water body near it.

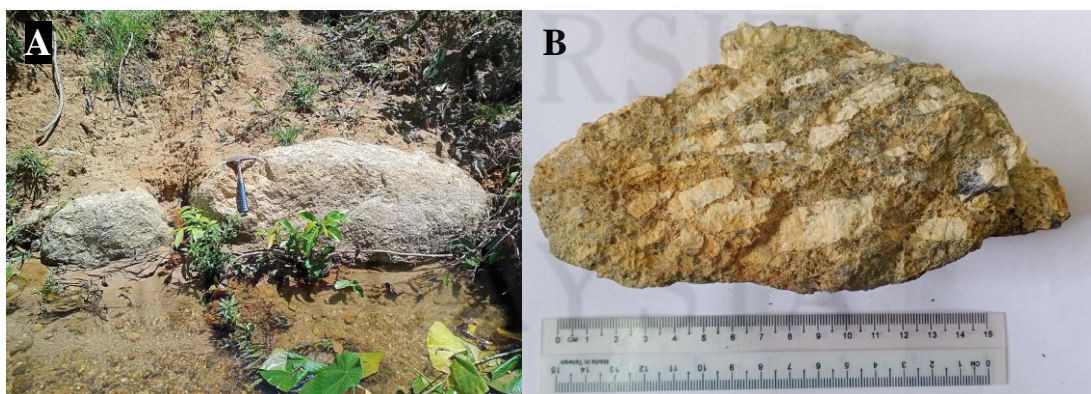


Figure 4.16: (A) Granite outcrop and (B) hand specimen of ZCP7.

This granite unit represents the Kemahang Granite Formation during Middle Triassic. It has a wide distribution that it covers mostly the east part of the study area

in N-S trending. The granite unit can be correlate to Kemahang Granite Formation in terms of the properties of the rock. The rock of granite unit that have been found mostly medium- to coarse-grained, grey in colour and have abundance of biotite and feldspar minerals.

i. Petrographic Analysis

Sample ZCP6

These photomicrographs of granite rock sample show porphyritic texture and is composed of quartz, plagioclase, biotite and orthoclase. Figure 4.19(A) The groundmass is composed mainly of plagioclase feldspar that shows albite or polysynthetic twinning. The percentage amount plagioclase feldspar in this sample is 50%. Meanwhile the phenocrysts are composed of biotite and quartz. In Figure 4.19(B), the biotite phenocryst shows brown colour with perfect cleavage. It has a size of 0.29mm and subhedral shape. Quartz phenocryst however shows whitish grey colour and smaller size than biotite. Quartz is colourless under plane polarized light (PPL). The percentage amount of biotite and quartz are 10% and 20% respectively. Orthoclase in Figure 4.19(C) shows greyish to whitish colour, has equant and subhedral grains, has extinction due to absorption of light when the plate is rotated. Orthoclase is also colourless under plane polarized light (PPL). The percentage amount of orthoclase is 20%.

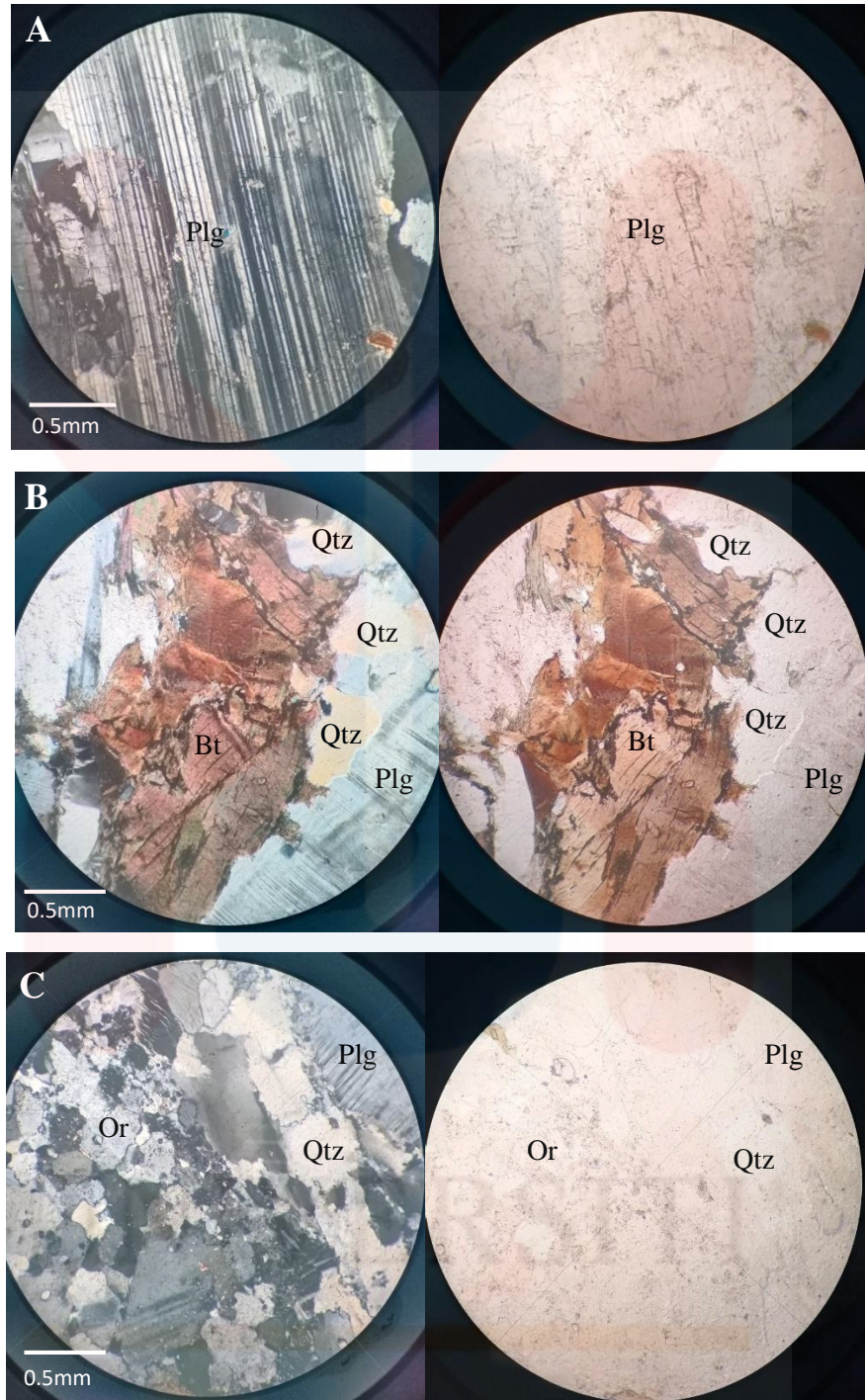


Figure 4.17: The minerals in granite rock pf ZCP6 under crossed polarized light (XPL) and plane polarized light (PPL). (A) Plagioclase feldspar shows albite twinning. (B) Biotite phenocryst and quartz phenocryst on plagioclase groundmass. It has a size of 0.29mm and subhedral shape. (C) Orthoclase, quartz and plagioclase have equant and subhedral grains and colourless under PPL. (Plg = plagioclase, Qtz = Quartz, Bt = Biotite, Or = Orthoclase).

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ii. XRF Analysis

Sample ZCP1

X-ray fluorescence (XRF) method was used to analyse the chemical and structural formula of rock samples ZCP1 and ZCP6. From Table 4.3, elements or compounds with the major composition in rock sample ZCP1 are silicon dioxide (SiO_2) and aluminium oxide (Al_2O_3). The composition of each element or compound in this rock sample are 62.503% and 16.306% respectively. This rock sample is classified as granite rock as it has typical chemical compositions that granite usually have whereby 70-77% silica and 11-13% alumina.

Table 4.3: The results from XRF analysis that shows the concentration of elements or compounds in rock sample ZCP1.

Element/Compound	Composition (%)
MgO	0.768
Al ₂ O ₃	16.306
SiO ₂	62.503
P	0.176
K ₂ O	0.892
Ca	0.363
Ti	0.416
V	0.020
Mn	0.034
Fe	3.018
Ni	0.003
Cu	0.004
Zn	0.005
Ga	0.002
Rb	0.010
Sr	0.018
Y	0.003
Zr	0.028
Nb	0.001
Ba	0.035
Pb	0.001

Sample ZCP6

From Table 4.4, elements or compounds with the major composition in rock sample ZCP6 are silicon dioxide (SiO₂), aluminium oxide (Al₂O₃), iron (Fe), potassium oxide (K₂O), magnesium oxide (MgO) and calcium (Ca). The composition of each element or compound in this rock sample are 53.744%, 7.084%, 6.404%, 3.059%, 2.389% and 1.202% respectively. This rock sample is also classified as granite rock as it has relatively high composition of SiO₂ and Al₂O₃ even though not as much as general chemical compositions of granite.

Table 4.4: The results from XRF analysis that shows the concentration of elements or compounds in rock sample ZCP6.

Element/Compound	Composition (%)
MgO	2.389
Al ₂ O ₃	7.084
SiO ₂	53.744
P	0.067
K ₂ O	3.059
Ca	1.202
Ti	0.896
V	0.036
Cr	0.012
Mn	0.093
Fe	6.404
Ni	0.004
Cu	0.001
Zn	0.008
Ga	0.002
Rb	0.027
Sr	0.013
Y	0.004
Zr	0.030
Nb	0.004
Sn	0.005
Ba	0.014
Ce	0.013
Pb	0.001
Th	0.006
U	0.002

(c) Quartzite Unit

Quartzite unit was found at two different localities which are ZCP2 and ZCP4. Outcrop of ZCP2 was found on August 12, 2022 at 11:20AM. It is located in the middle of Lanas River at coordinate N 05°47'03.5" E 101°53'23.4" of elevation 31m and azimuth 73° from north. This outcrop has only slightly weathered on the surface whereby it discoloured into brown colour and algae grow on the surface as the rock is located in the river. However, the original mass structure is perfectly preserved. This rock has white colour on the inside when it was struck by hammer. This rock mass did not react to HCl which indicates that it neither consists of calcite mineral nor it is a limestone rock mass.



Figure 4.18: (A) Quartzite outcrop and (B) hand specimen of ZCP2.

Another outcrop of quartzite unit was found on August 23, 2022 at 1:00PM. It is located in the palm oil estate at coordinate N 05° 48' 32.13" E 101° 53' 30.19" of elevation 59m and azimuth 244° from north. This outcrop also has only slightly weathered on the surface that it discoloured into brown colour. When struck by hammer, this rock was broken into pieces with perfect cleavage. Same as outcrop at ZCP2, this outcrop also did not react to HCl.



Figure 4.19: (A) Quartzite outcrop and (B) hand specimen of ZCP4.

This quartzite unit has a small distribution throughout the study area that it covers certain locations in the west part and southwest part of the study area. From the literature review, there is not any research paper that explain about quartzite unit in the Ayer Lanas or surrounding area. Therefore, this unit cannot be correlated to other geological formation as there is lack of information about this unit.

4.4 Structural Geology

Structural Geology is the study of deformation within rock mass in order to understand the past geological events such as tectonic movements history and environments that could have deformed them. Discontinuity is physical break within a rock mass which causes the tensile strength across the plane to be lower than that of the rock material. The examples of discontinuities are fractures, faults, shear planes, joints, cleavages, foliations, bedding lineament and fissures. Discontinuities can explain the deformation of the rock such as extension strain, compression and tension stress.

4.4.1 Fold Analysis

Fold is one of secondary structures. Secondary structures are discontinuities that formed after the rock mass formation. Type of fold that can be found at the study area is slump fold. Slump fold form when a layer sequence separates from other layers below or above it and begins to move downward. The movement causes the soft layers to bend and fold, resulting in structures within an otherwise undisturbed sequence of bed layers.



Figure 4.20: Slump fold that can be found at study area.

4.4.2 Lineament Analysis

Lineament is a linear feature that is thought to reflect an underlying geological structure, such as a fault. In a photograph, map, or model, a lineament is a pattern in a factual representation of the Earth's surface or a subsurface datum. The term "subsurface datum" refers to stratigraphically, structurally, and geophysically defined data. In this study, by comparing the terrain map between ArcGis and Google Terrain map software to find the lineaments, it was possible to get a rough idea of the direction of force that was exerted in the study area. The orientation of lineaments in the lineament map is determined by the hill shade and contour pattern.

LINEAMENT MAP



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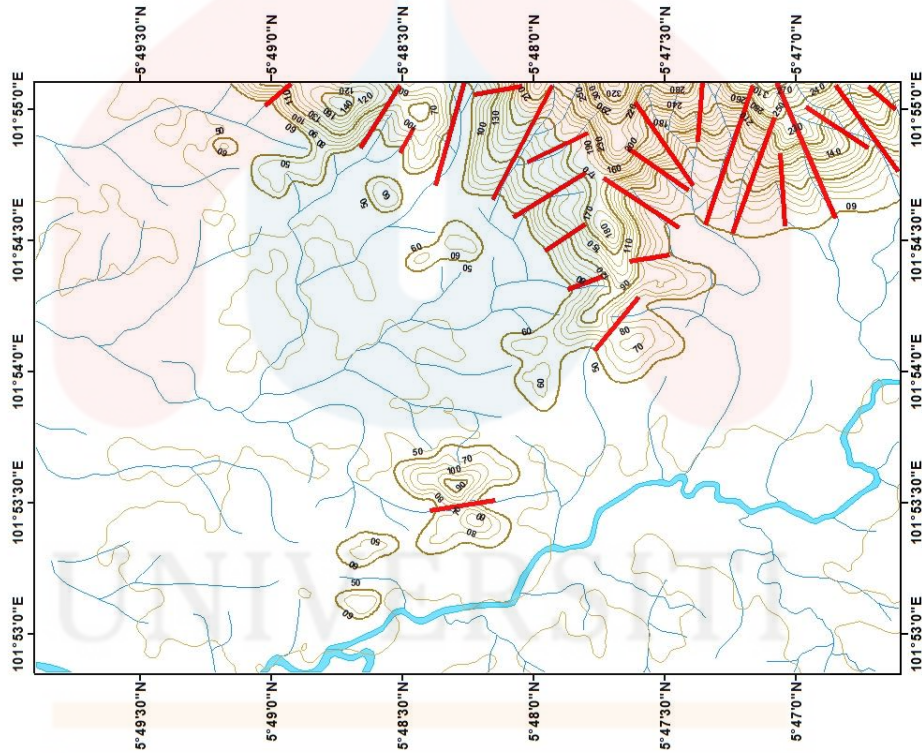


Figure 4.21: Lineament map of the study area.

4.4.3 Joint Analysis

Joint is also a secondary structure that deformed the rock mass. Joint can be recognised by the small cracks structure. Rock mass tend to break along the joint. Joint also acts as water channel as water can seep into the rock through joint. Joint data was taken at ZCP5 with coordinate N 05°49'25.6" E 101°54'40.8". From the joint data obtained, rose diagram of joint analysis was made using GeoRose software and the principal stress was identified. There are three types of principal stress which are σ_1 , σ_2 and σ_3 . By referring to Figure 4.22, σ_1 is classified as 315° which indicates the maximum tensile stress. Next, σ_2 is classified as 275° which indicates the intermediate principal stress. Lastly, σ_3 is classified as 40°, 290° and 350° which indicate the minimum principal stress.



Figure 4.22: The sedimentary outcrop where the joint data is taken.

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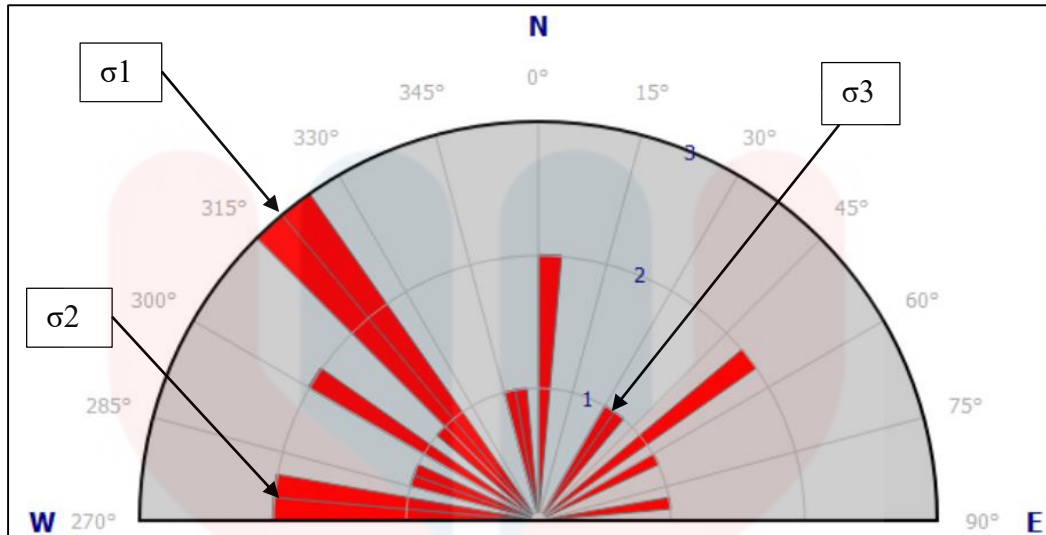


Figure 4.23: Rose diagram of joint analysis.

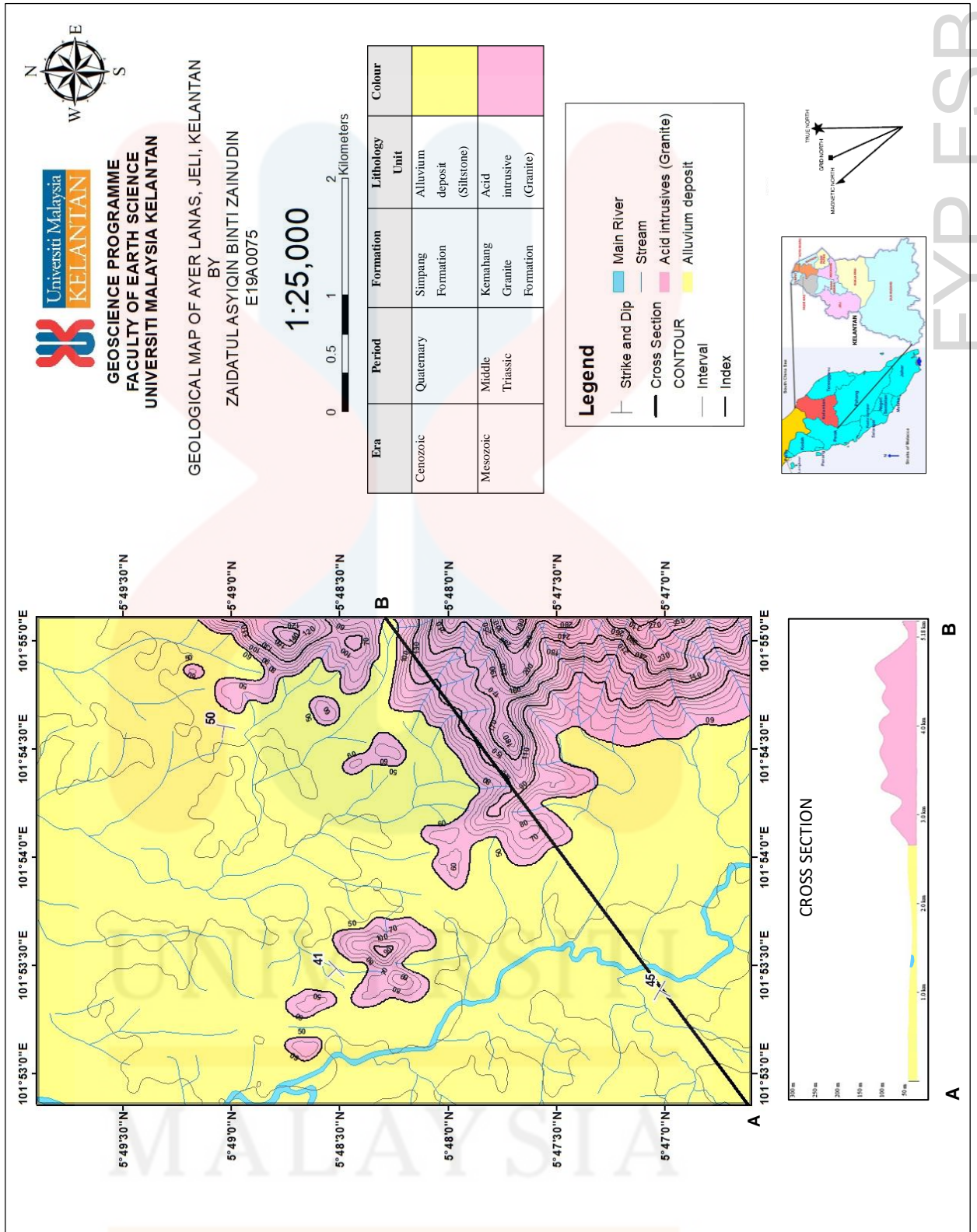


Figure 4.24: Geological map of the study area.

4.5 Historical Geology

From the geological mapping, Ayer Lanas is consist of three types of rock which are granite, quartzite and also alluvium deposits. The alluvium deposits from the Quaternary age of Simpang Formation composed unconsolidated to semi-consolidated gravel, sand, clay, and silts of covers a wide area within Ayer Lanas. This formation overlies the Kemahang Granite Formation of Middle Triassic age. Kemahang distributed at Jeli Hill, Kemahang Hill, Kusial Hill and other smaller hills.

However, based on the literature review, Jeli district is generally composed of three types of rock, (Sulaiman et al., 2020). The oldest lithology is Permian sedimentary rocks which consists of phyllite, slate, sandstone and limestone. This lithology is from Gua Musang Formation of age approximately 251.2 - 247.2 Ma. The second oldest lithology is Triassic sedimentary rocks which consists of sandstone, shale, siltstone, and limestone. They are from Gunong Rabong Formation that aged approximately 242 - 237 Ma. Other than that, the youngest lithology in this area is granitic rocks (acid intrusive).

CHAPTER 5

APPLICATION OF ZEOLITE IN WATER TREATMENT

5.1 Introduction

This chapter explained about the results obtained from the specification methods. To be able to determine the application of zeolite in water treatment, there are several data from different methods need to be analyse. For example, In-situ measurement of river water quality, XRF analysis of zeolite, Water treatment process using zeolite and AAS analysis of water samples. The description of every water sample is described in the section below.

5.2 Sample Description

Water samples were collected from different streams and rivers across Jeli district (Figure 5.1). Sample from ZS1 was taken from stream near the administration building of UMK Jeli. Sample ZS2 was collected from Pergau River near a homestay D Pergau Inn. Sample ZS3 was collected from Pergau River at Kampung Lawar, Batu Melintang, Jeli. Sample ZS4 was taken from Lanas River and lastly sample ZS5 was collected from a stream near TS Timber Industries in Jeli Town. All water samples collected were treated in the laboratory using layers of treating materials such as sand, zeolite and gravel with 6cm height for each layer (Figure 5.2). From Table 5.1, it can be seen that all water samples have lower turbidity or seemed clearer after being treated.



Figure 5.1: Map of water sampling location in Jeli district.

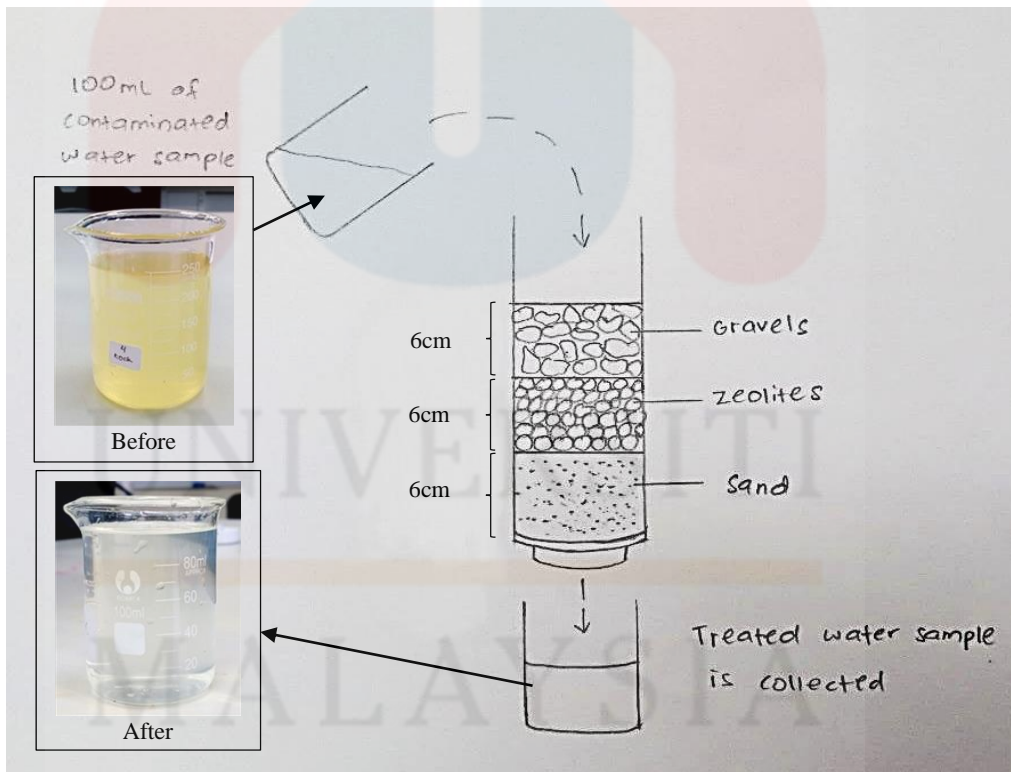






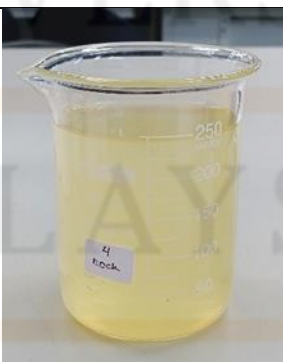
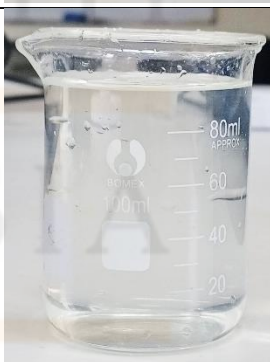




Figure 5.2: Set up layout for water treatment process.

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Table 5.1: Description of water samples taken at different places around Jeli district.

Sample ID	Coordinate	Figure of water sample before treatment	Figure of water sample after treatment	Observation
ZS1 (28/8/2022)	N 05°44'42.9" E 101°52'01.4" (60m)			Water sample before treatment is clear and has low turbidity
ZS2 (29/8/2022)	N 05°42'33.0" E 101°46'51.2" (81m)			Water sample before treatment is slightly cloudy and has low turbidity
ZS3 (29/8/2022)	N 05°40'14.6" E 101°41'58.6" (114m)			Water sample before treatment is clear and has low turbidity
ZS4 (30/8/2022)	N 05°47'05.4" E 101°53'22.4" (34m)			Water sample before treatment is cloudy and has high turbidity

ZS5 (30/8/2022)	N 05°41'12.0" E 101°50'44.4" (69m)			Water sample before treatment is slightly cloudy and has low turbidity
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5.3 Result

In this part, all the results from in-situ measurement of river water quality, XRF analysis of zeolite and water treatment process using zeolite and AAS analysis of water samples were covered in detail.

5.3.1 In-Situ Measurement of River Water Quality

In-situ measurement of river water quality was done at every sampling location using YSI Multiparameter to measure different parameters of water quality (Table 5.2). The parameters that are measured are temperature, pH, dissolved oxygen (DO), total dissolved solids (TDS), conductivity (EC), salinity and oxidation reduction potential (ORP). From the table, ZS3 can be seen having the highest pH and DO which are 8.53 and 9.57mg/L respectively. ZS5 has the highest TDS (0.045 g/L) and EC (0.074 mS/cm) due to its location situated near the sawmill that give the primary source of the TDS. For salinity, all sampling locations have average salinity which is 0.02%. ORP is the ability of a water body to cleanse itself or breakdown waste products by exchange of electron potential that relates to active oxidant or reductant. If the reading is negative, the substance is a reducing agent and if the reading is

positive means that the substance is an oxidizing agent. From the observation, all sampling locations are reducing agents because of the negative reading.

Table 5.2: Different parameters taken for the in-situ analysis of river water quality at different locations.

Parameters	Sample ID				
	ZS1	ZS2	ZS3	ZS4	ZS5
Temperature (°C)	27.62	26.48	25.31	26.76	28.74
pH	7.86	7.78	8.53	8.30	7.97
DO (mg/L)	7.06	8.69	9.57	8.53	7.42
TDS (g/L)	0.038	0.025	0.019	0.027	0.045
EC (mS/cm)	0.062	0.039	0.029	0.043	0.074
Salinity (%)	0.03	0.02	0.01	0.02	0.03
ORP (mV)	-33.6	-45.9	-90.7	-105.0	-175.4

5.3.2 XRF Analysis of Zeolite

X-ray fluorescence (XRF) method was used to analyse the chemical and structural formula of zeolite samples. From Table 5.3, elements or compounds with the highest composition in zeolite is silicon dioxide (SiO₂) and aluminium oxide (Al₂O₃). Zeolite is made of aluminosilicate framework. Therefore, both compounds are the has higher in composition compared to other elements or compound. Georgiev et al. (2009) has given the chemical formula for zeolite which is $M_{x/n}[(AlO_2)_x(SiO_2)_y].wH_2O$. From this formula, M is referred to as an alkaline earth cation, x and y are the total number of tetrahedra per unit cell, n referred to as the valence of the cation and w is the number of water molecules per unit cell. By referring to the composition of elements or compounds, zeolite that is used in this experiment can be classified as Zeolite H type that has typical oxide formula of

$K_2O \cdot Al_2O_3 \cdot 2SiO_2 \cdot 4H_2O$ (Table 5.4). However, there were some unknown errors occur during the XRF analysis of zeolite that caused the results of the composition exceeding the total of 100%.

Table 5.3: The results from XRF analysis that show the concentration of elements or compounds in zeolite composition.

Element/compound	Composition (%)
MgO	1.253
Al_2O_3	11.494
SiO_2	92.437
K_2O	2.946
Ca	1.361
Ti	0.079
Cr	0.007
Mn	0.014
Fe	0.736
Cu	0.001
Zn	0.006
Ga	0.001
Rb	0.016
Sr	0.022
Y	0.001
Zr	0.011
Nb	0.001
Pd	0.001
Ba	0.012
Hf	0.000
Pb	0.001
U	0.000

Table 5.4. Typical oxide formula of some synthetic zeolites.

Zeolites	Typical oxide formula
Zeolites A	$\text{Na}_2\text{O} \cdot \text{Al}_2\text{O}_3 \cdot 2\text{SiO}_2 \cdot 4,5\text{H}_2\text{O}$
Zeolites N-A	$(\text{Na}, \text{TMA})_2\text{O} \cdot \text{Al}_2\text{O}_3 \cdot 4,8\text{SiO}_2 \cdot 7\text{H}_2\text{O}$ TMA – $(\text{CH}_3)_4\text{N}^+$
Zeolites H	$\text{K}_2\text{O} \cdot \text{Al}_2\text{O}_3 \cdot 2\text{SiO}_2 \cdot 4\text{H}_2\text{O}$
Zeolites L	$(\text{K}_2\text{Na}_2)\text{O} \cdot \text{Al}_2\text{O}_3 \cdot 6\text{SiO}_2 \cdot 5\text{H}_2\text{O}$
Zeolites X	$\text{Na}_2\text{O} \cdot \text{Al}_2\text{O}_3 \cdot 2,5\text{SiO}_2 \cdot 6\text{H}_2\text{O}$
Zeolites Y	$\text{Na}_2\text{O} \cdot \text{Al}_2\text{O}_3 \cdot 4,8\text{SiO}_2 \cdot 8,9\text{H}_2\text{O}$
Zeolites P	$\text{Na}_2\text{O} \cdot \text{Al}_2\text{O}_3 \cdot 2 - 5\text{SiO}_2 \cdot 5\text{H}_2\text{O}$
Zeolites O	$(\text{Na}_2, \text{K}_2, \text{TMA}_2)\text{O} \cdot \text{Al}_2\text{O}_3 \cdot 7\text{SiO}_2 \cdot 3,5\text{H}_2\text{O}$; TMA – $(\text{CH}_3)_4\text{N}^+$
Zeolites Ω	$(\text{Na}, \text{TMA})_2\text{O} \cdot \text{Al}_2\text{O}_3 \cdot 7\text{SiO}_2 \cdot 5\text{H}_2\text{O}$; TMA – $(\text{CH}_3)_4\text{N}^+$
Zeolites ZK-4	$0,85\text{Na}_2\text{O} \cdot 0,15 (\text{TMA})_2\text{O} \cdot \text{Al}_2\text{O}_3 \cdot 3,3\text{SiO}_2 \cdot 6\text{H}_2\text{O}$

5.3.3 Water Treatment Process Using Zeolite and AAS Analysis of Water

Samples

Every water samples that have been treated were once again tested for water quality using the same parameters as before. This procedure was done in the laboratory and is called ex-situ analysis of water sample quality. There are some increasing and decreasing values depending on the parameter (Table 5.5).

Table 5.5: Different parameters taken for the ex-situ analysis of water sample quality after treatment with zeolite.

Parameters	Sample ID				
	ZS1	ZS2	ZS3	ZS4	ZS5
Temperature (°C)	22.50	21.8	21.1	20.9	20.3
pH	6.33	6.29	6.22	6.17	6.11
DO (mg/L)	9.75	9.12	9.41	9.55	9.23
TDS (g/L)	0.035	0.024	0.016	0.026	0.021
EC (mS/cm)	0.2147	0.4383	0.5780	0.8020	0.5500
Salinity (%)	0.011	0.022	0.030	0.043	0.030
ORP (mV)	477.1	524.2	519.5	494.1	487.9

From the results in Table 5.6, it can be seen that zeolites are able to remove quite plenty of heavy metal elements during water treatment process. To give a clearer view on the difference of heavy metal concentration before and after water treatment, four bar graphs were constructed according to the type of heavy metal elements (Figure 4.9, Figure 4.19, Figure 4.11 and Figure 4.12). After water sample was treated and analysed using AAS method, heavy metal elements which are Cd, Cu, Mn, Pb shows decrease in concentration. This is due to the adsorption process that occur during the water treatment process. Zeolite bind together with the heavy metal elements to remove them from the water samples.

Table 5.6: AAS result Heavy metal elements concentration before and after water treatment using zeolite.

Sample ID	Concentration of heavy metals before and after water treatment using zeolite (mg/L)							
	Cd		Cu		Mn		Pb	
	Before	After	Before	After	Before	After	Before	After
ZS1	0.012	0.006	0.095	0.002	0.168	0.037	0.052	0.012
ZS2	0.011	0.007	0.043	0.003	0.104	0.051	0.011	0.002
ZS3	0.010	0.008	0.037	0.003	0.065	0.024	0.029	0.014
ZS4	0.012	0.009	0.063	0.001	0.129	0.070	0.027	0.010
ZS5	0.011	0.009	0.046	0.001	0.136	0.117	0.022	0.004

5.4 Discussion

5.4.1 Water Quality Parameter

Figure 5.3 shows the decrease in temperature of water samples after the water treatment process. This is due to the surrounding cool temperature in the laboratory

that influence the water sample temperature to reduce. The decrease in temperature also influenced the DO values in certain ways.

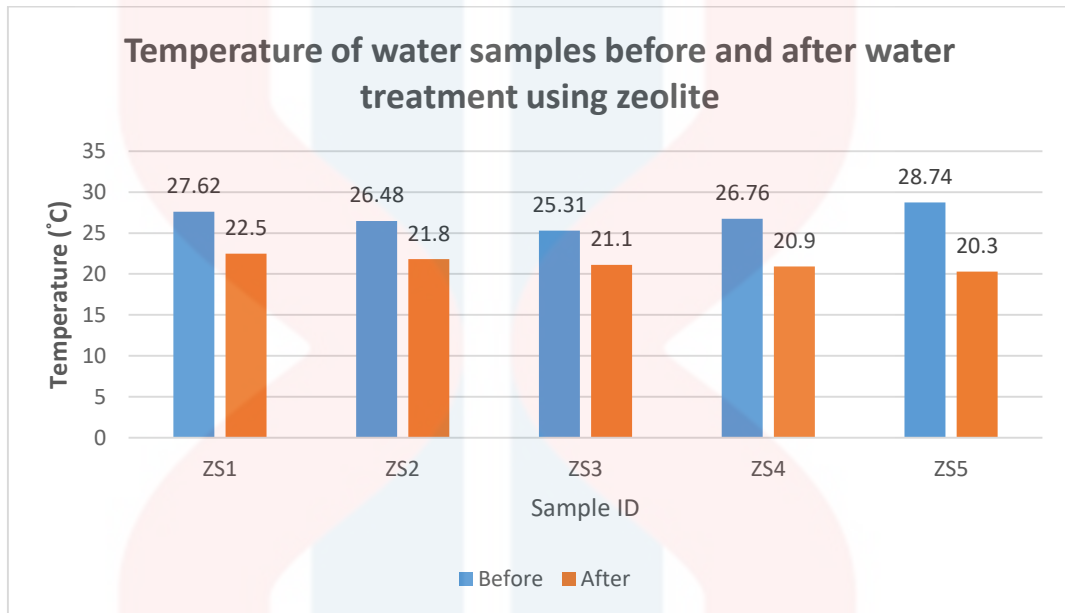


Figure 5.3: Temperature of water samples before and after water treatment using zeolite.

Figure 5.4 represents the pH of water samples before and after water treatment. The pH shows decreasing values for each water samples. The pH of ZS3 shows the most significant reduction which is from 8.53 to 6.22 because this type zeolite has acidic properties. Therefore, during water treatment process, the zeolite exchanges ions with water samples.

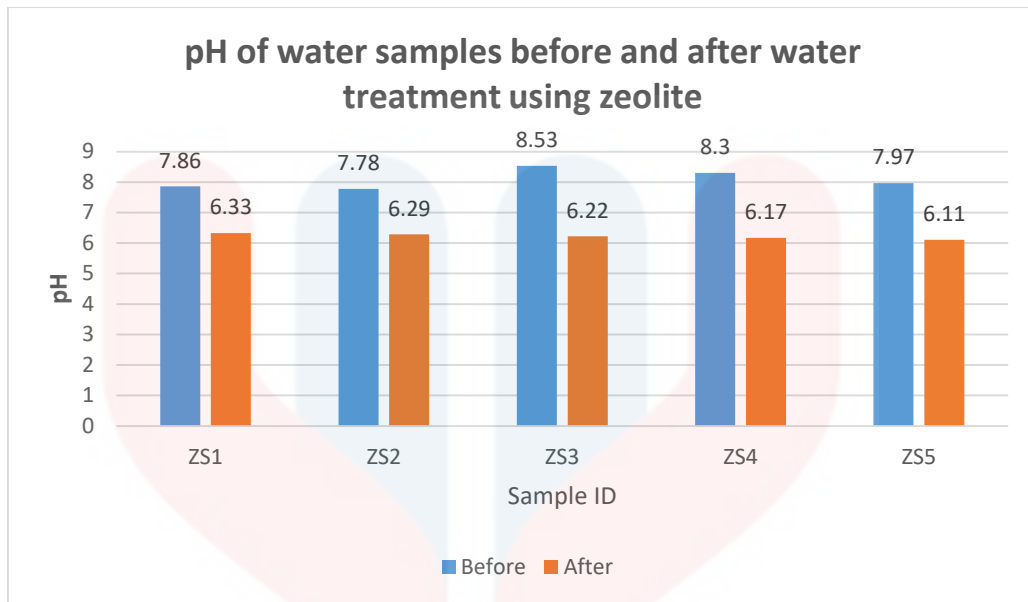


Figure 5.4: pH of water samples before and after water treatment using zeolite.

Figure 5.5 shows the increasing concentration of dissolved oxygen (DO) in every water samples after being treated with zeolite. The increase in DO is due to the decreasing temperature of water samples. The relationship between DO and temperature is inversely proportional. Increasing DO also indicates the increasing solubility of oxygen in the water samples.

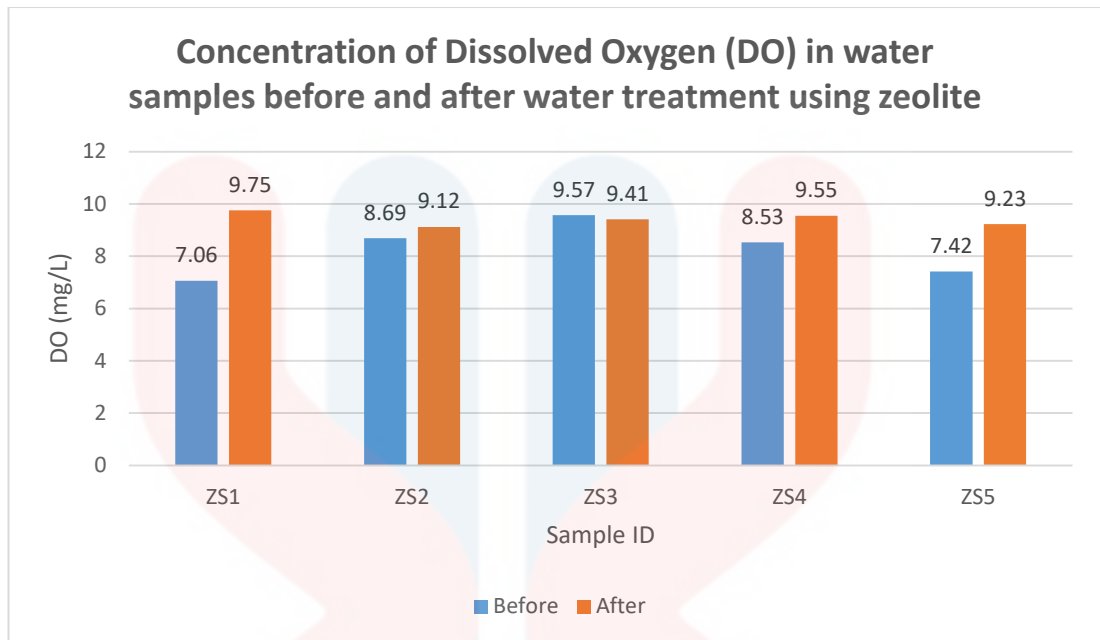


Figure 5.5: Concentration of Dissolved Oxygen (DO) in water samples before and after water treatment using zeolite.

Figure 5.6 represents the concentration of Total Dissolved Solids (TDS) in the water samples. Before being treated with zeolite, water samples record low values where the highest reading is 0.045mg/L for ZS5. Meanwhile, after being treated, TDS concentration values of all water samples decreased where the highest value is only 0.035mg/L for ZS1. However, the highest reading is still in safe state because the maximum value of TDS for Raw Water Quality Criteria set by Ministry of Health Malaysia (MOH) is 1500mg/L.

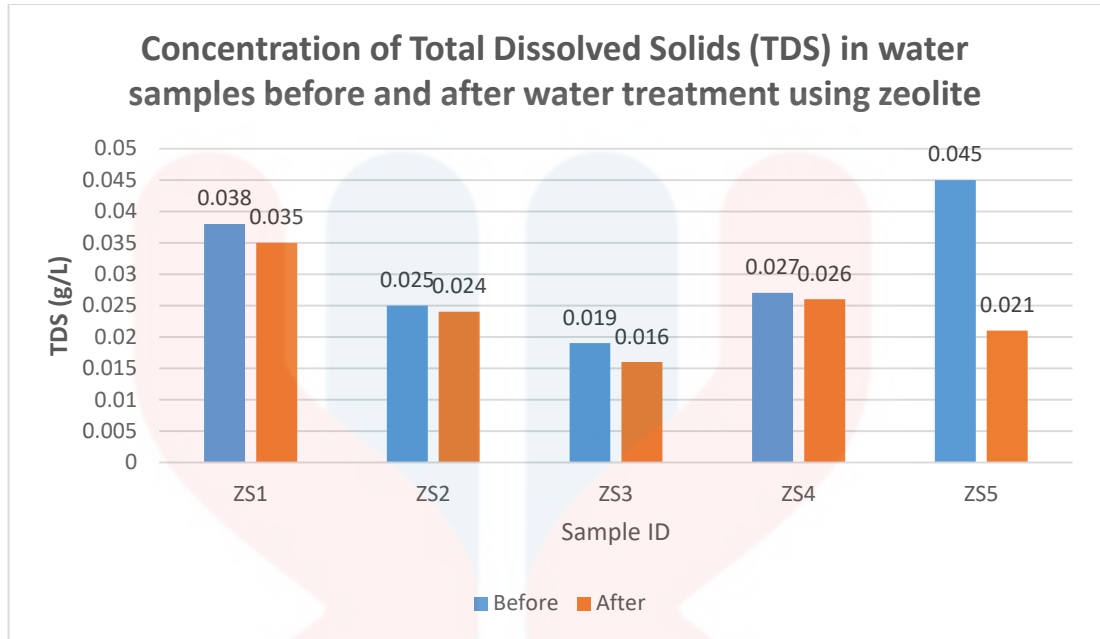


Figure 5.6: Concentration of Total Dissolved Solids (TDS) in water samples before and after water treatment using zeolite.

Figure 5.7 shows the Electrical Conductivity (EC) of each water samples. The values of EC before water treatment process also record low readings for each water samples. After being treated, all samples show increasing values of EC with the highest reading by ZS4 at 0.802mS/cm. However, the EC values for all water samples are still normal for river or stream conductivity. Middle range conductivity of river ranges from 200 μ S/cm to 1000 μ S/cm. Meanwhile, high conductivity ranges from 1000 μ S/cm to 10000 μ S/cm. Water with high conductivity value indicates the saline condition and not suitable for aquatic organisms.

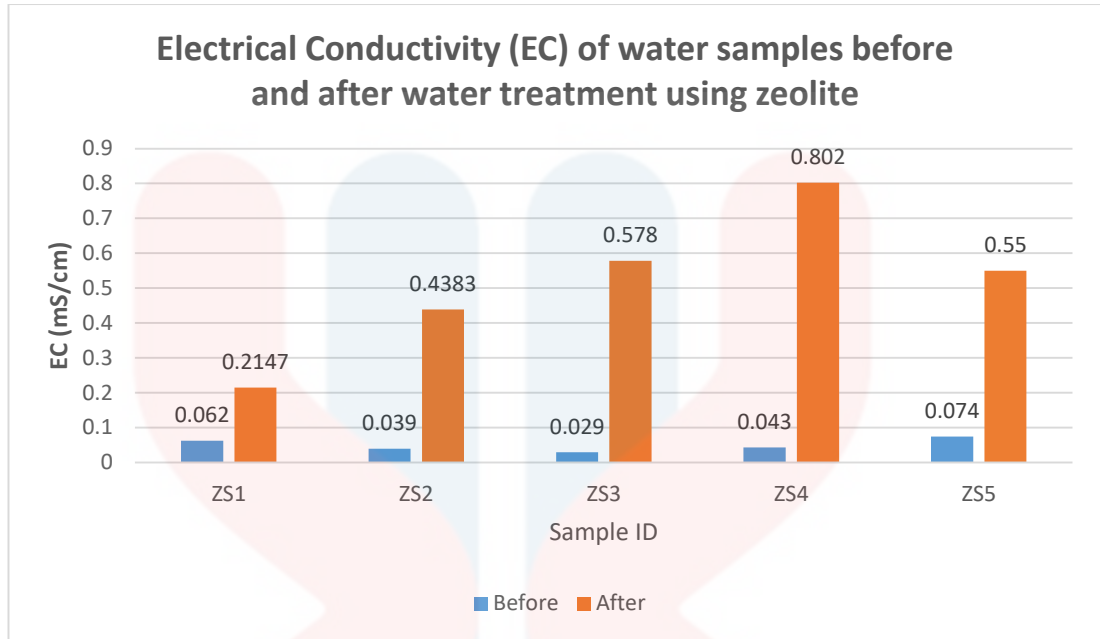


Figure 5.7: Electrical Conductivity (EC) of water samples before and after water treatment using zeolite.

For salinity parameter, ZS1 recorded decreases in salinity from 0.03% to 0.011% after being treated (Figure 5.8). Water samples ZS2, ZS3 and ZS4 show increasing salinity at 0.022%, 0.030% and 0.043% respectively. Sample ZS5 shows constant salinity at 0.003%. Salinity values of water samples for both before and after water treatment have normal value for river water quality which is around 0.012%.

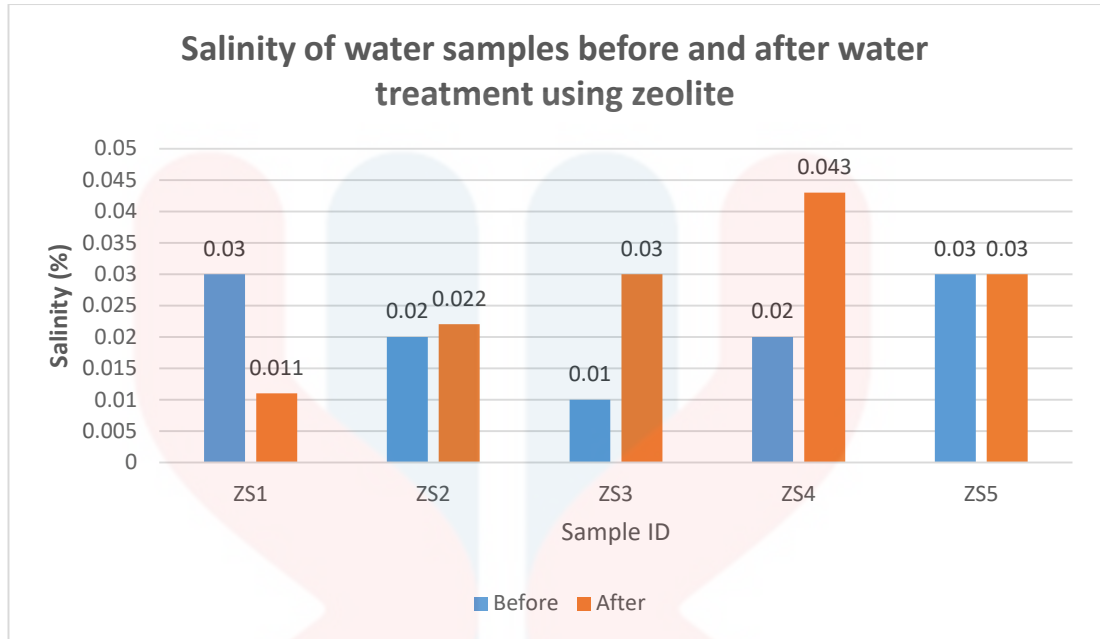


Figure 5.8: Salinity of water samples before and after water treatment using zeolite.

5.4.2 AAS Analysis of Heavy Metals in Water Sample Before and After Treatment Using Zeolite

Figure 5.9 is a graph of Cd element concentration that shows decreases in Cd concentration in every water sample after being treated. ZS1 decreased in Cd concentration from 0.012mg/L to 0.006mg/L, ZS2 decreased from 0.011mg/L to 0.007mg/L, ZS3 decreased from 0.01mg/L to 0.008mg/L, ZS4 decreased from 0.012mg/L to 0.009mg/L and lastly ZS5 decreased from 0.011mg/L to 0.009mg/L. However, the concentration of Cd after the water treatment process is still higher than Raw Water Quality Criteria set by Ministry of Health Malaysia (MOH) standard which is 0.003 mg/L (Table 5.7). This is due to the differences in affinity for sorption sites and metal characteristics of Cd (Shaheen et al., 2012). Affinity means the strength of an element to bind with its intended receptor. Cd has lower affinity which means its strength of to bind with the receptor is low. Therefore, zeolite adsorbed lesser concentration of Cd compared to other elements.

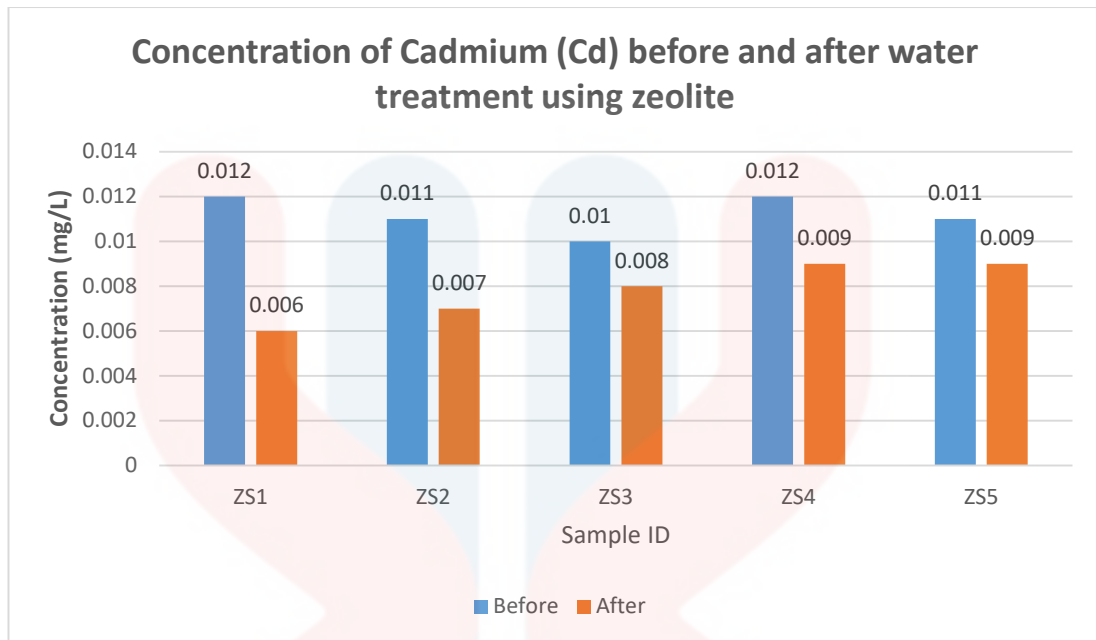


Figure 5.9: Graph of AAS result of Cadmium (Cd) concentration before and after water treatment using zeolite.

Figure 5.10 is a graph of Cu element concentration that shows drastic decreases in Cu concentration in every water sample after being treated. ZS1 has reduced the most Cu element among all samples which is from 0.095mg/L to 0.002mg/L. ZS2 reduced from 0.043mg/L to 0.003mg/L of Cu element. ZS3 reduced from 0.037mg/L to 0.003mg/L. ZS4 reduced from 0.063mg/L to 0.001mg/L and lastly ZS5 reduced from 0.046mg/L to 0.001mg/L. In general, every water sample that have been tested for Cu concentration indicate that they have safe amount of Cu. This is because the acceptable value for Cu concentration in raw water that follows the MOH standard is 1.0mg/L (Table 5.7).

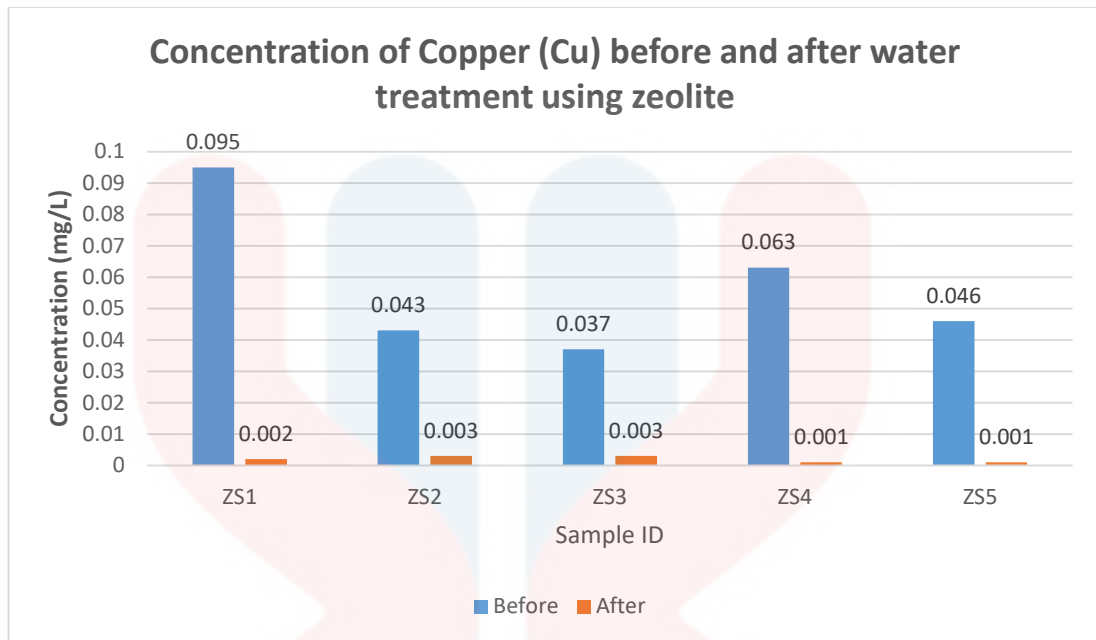


Figure 5.10: Graph of AAS result of Copper (Cu) concentration before and after water treatment using zeolite.

Next is the analysis of Mn element concentration. Except for ZS3, Mn is the most dominant element compared to Cd, Cu and Pb in almost every water sample. ZS1 has the most reduction after water treatment process with zeolite which is from 0.168mg/L to 0.037mg/L (Figure 5.11). ZS2 decreased from 0.104mg/L to 0.051mg/L. ZS3 and ZS4 decreased from 0.065mg/L to 0.024mg/L and 0.129mg/L to 0.07mg/L respectively. ZS5 shows the least reduction in Mn concentration after water treatment process with zeolite which is from 0.136mg/L to 0.117mg/L. However, the concentration of Mn in every water sample before and after water treatment process with zeolite shows values that below than 0.2mg/L (Table 5.7). This means that during water sampling process, every sampling location did not contaminated with Mn element that could be harmful to health even though it is the most dominant heavy metal element.

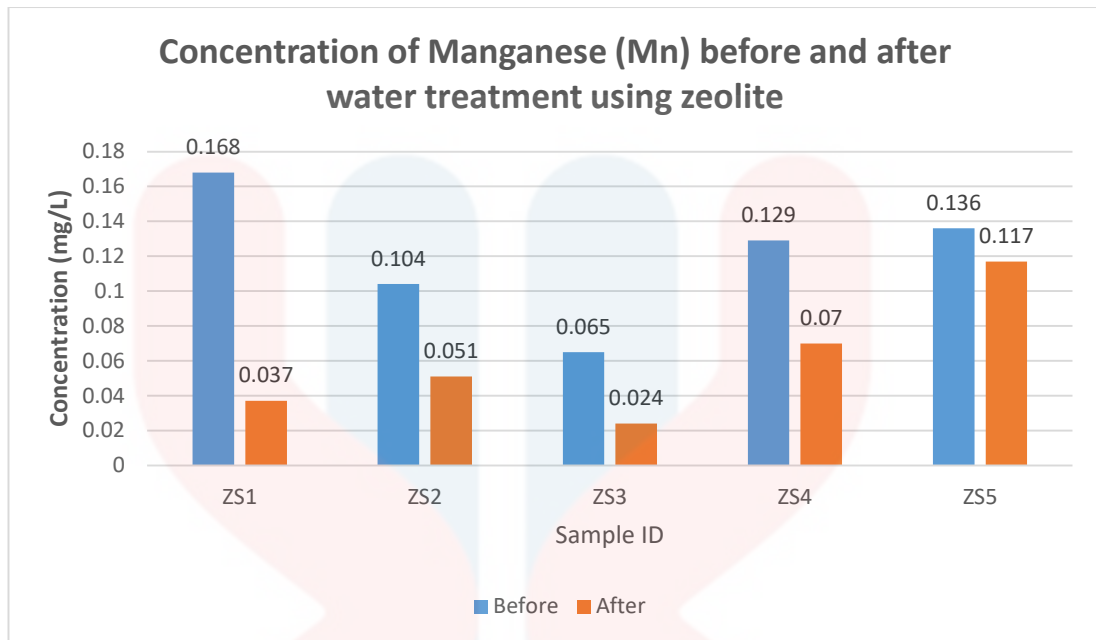


Figure 5.11: Graph of AAS result of Manganese (Mn) concentration before and after water treatment using zeolite.

Lastly, Figure 5.12 represents the difference of Pb element concentration before and after water treatment process with zeolite. ZS1 has the highest concentration of Pb before being treated which is 0.052mg/L, slightly exceeds the MOH water quality standard at 0.05mg/L (Table 5.7). However, after being treated, the concentration of Pb reduced to a safe value at 0.012mg/L. ZS2 that has the least concentration of Pb also reduced from 0.011mg/L to 0.002mg/L after water treatment process. ZS3 and ZS4 decreased in Pb concentration from 0.029mg/L to 0.014mg/L and 0.027mg/L to 0.01mg/L respectively. Finally, ZS5 decreased in Pb concentration from 0.022mg/L to 0.004mg/L after being treated with zeolite.

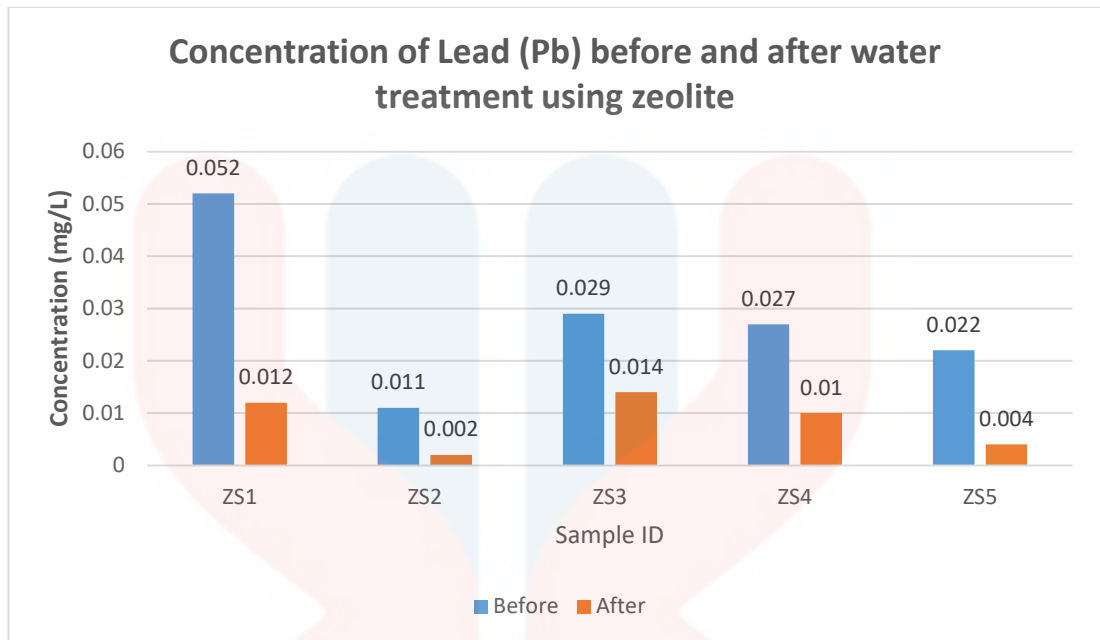


Figure 5.12: Graph of AAS result of Lead (Pb) concentration before and after water treatment using zeolite.

Table 5.7: Recommended Raw Water Quality Criteria by Engineering Services Division, Ministry of Health Malaysia.

No	Parameters	Unit	Acceptable value	Frequency to be monitored			Ref.
				Surface	Ground	Direct Impounding	
Group I							
1	Total Coliform	cfu/100 ml	5000.0	W	M	M	WHO1
2	Turbidity	NTU	1000.0	W	M	M	WHO2
3	Colour	TCU	300.0	W	M	M	WHO1
4	pH	-	5.5-9.0	W	M	M	MAL
Group II							
1	Total Dissolved Solids (TDS)	mg/l	1500.0	M	Y/4	Y/4	WHO1
2	Biochemical Oxygen Demand(BOD)	mg/l	6.0	M	Y/4	Y/4	WHO1
3	Chemical Oxygen Demand (COD)	mg/l	10.0	M	Y/4	Y/4	WHO1
4	Chloride (Cl)	mg/l	250.0	M	Y/4	Y/4	MAL
5	Anionic Detergent, MBAS	mg/l	1.0	M	Y/4	Y/4	WHO1
6	Ammonia (as N)	mg/l	1.5	M	Y/4	Y/4	WHO1
7	Nitrate (as N)	mg/l	10.0	M	Y/4	Y/4	MAL
8	Total Nitrogen (as N)	mg/l	1.0	M	Y/4	Y/4	WHO1
9	Iron (Fe)	mg/l	1.0	M	Y/4	Y/4	WHO1
10	Fluoride (Fl)	mg/l	1.5	M	Y/4	Y/4	WHO1
11	Hardness	mg/l	500.0	M	Y/4	Y/4	MAL
Group III							
1	Mercury (Hg)	mg/l	0.001	Y/4	Y/4	Y/4	MAL
2	Cadmium (Cd)	mg/l	0.003	Y/4	Y/4	Y/4	MAL
3	Selenium (Se)	mg/l	0.01	Y/4	Y/4	Y/4	WHO1
4	Arsenic (As)	mg/l	0.01	Y/4	Y/4	Y/4	WHO1
5	Cyanide (CN)	mg/l	0.07	Y/4	Y/4	Y/4	MAL
6	Lead (Pb)	mg/l	0.05	Y/4	Y/4	Y/4	MAL
7	Chromium (Cr)	mg/l	0.05	Y/4	Y/4	Y/4	WHO1
8	Silver (Ag)	mg/l	0.05	Y/4	Y/4	Y/4	MAL
9	Copper (Cu)	mg/l	1.0	Y/4	Y/4	Y/4	MAL
10	Manganese (Mn)	mg/l	0.2	Y/4	Y/4	Y/4	MAL
11	Magnesium (Mg)	mg/l	150.0	Y/4	Y/4	Y/4	MAL
12	Sodium (Na)	mg/l	200.0	Y/4	Y/4	Y/4	MAL
13	Zinc (Zn)	mg/l	3.0	Y/4	Y/4	Y/4	WHO1
14	Sulphate (SO ₄)	mg/l	250.0	Y/4	Y/4	Y/4	WHO1
15	Mineral Oil	mg/l	0.3	Y/4	Y/4	Y/4	MAL
16	Phenol	mg/l	0.002	Y/4	Y/4	Y/4	WHO1

MALAYSIA

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Group IV							
	Organochlorine Pesticides:	mg/l	0.00003	Y/4	Y/4	Y/4	MAL
1	Aldrin/Dieldrin	mg/l	0.0002	Y/4	Y/4	Y/4	MAL
2	Chlordane	mg/l	0.002	Y/4	Y/4	Y/4	MAL
3	DDT	mg/l	0.0003	Y/4	Y/4	Y/4	MAL
4	Heptachlor & HeptachlorEpoxide	mg/l	0.001	Y/4	Y/4	Y/4	MAL
5	Hexachlorobenzene	mg/l	0.002	Y/4	Y/4	Y/4	MAL
6	Lindane	mg/l	0.02	Y/4	Y/4	Y/4	MAL
7	Methoxychlor						
	Herbicides:	mg/l	0.03	Y/4	Y/4	Y/4	MAL
1	2,4-D (DichlorophenoxyaceticAcid)						
Group V							
	Radioactivity:	Bq/l	0.1	Y	Y	Y	MAL
1	Gross α	Bq/l	1.0	Y	Y	Y	MAL
2	Gross β						

Note: WHO1 : International Standards For Drinking Water 1963.
 WHO2 : Guidelines For Drinking Water Volume 1 & 2 1984.
 MAL : Values adopted For Malaysian Conditions.
 W : Indicates parameters to be monitored at least once a week.
 M : Indicates parameters to be monitored at least once a month.
 Y/4 : Indicates parameters to be monitored at least once in 3 months.
 Y : Indicates parameters to be monitored at least once a year.

(Source: Sanichem, 2022)

To conclude this chapter, the application of zeolite gives more benefits in water treatment process. As discussed above, zeolite can increase the water quality in terms of many aspects mainly pH, DO, TDS and turbidity. Zeolite is known for its ion exchange and molecular sieve properties whereby it binds and filter the elements in order to treat the water. Hence, it can reduce the concentration of heavy metal elements such as Cd, Cu, Mn and Pb. During the water treatment process, zeolite was able to reduce the concentration of Cu, Mn and Pb in the water samples to a safe condition which means below the standard water quality by MOH. Other than that, zeolite also was able to reduce the concentration of Cd in the water samples. However, the concentration after the water treatment was still above the standard water quality by MOH for Cd element due to the reasons discussed above.

CHAPTER 6

CONCLUSION AND RECOMMENDATION

6.1 Conclusion

As a conclusion, the geological map of Ayer Lanas, Jeli, Kelantan with scale of 1:25000 has been updated. From this research, several geological aspects such as geomorphology, geological structures, lithology and stratigraphy have been studied. Several maps were produced according to every aspect to further understand the geology of the study area. The study area consists mainly of granite, alluvium deposits and quartzite. For research specification, zeolite is effective in removing heavy metal element from contaminated water body. As discussed in the Chapter 5, aside from Cd element, zeolite has successfully proven to reduce the concentration of Cu, Mn and Pb elements up to 0.093mg/L, 0.131mg/L and 0.04mg/L respectively, indicate the values below the MOH standard. Therefore, the application of zeolite in water treatment able to improve water quality. However, the effectiveness of the zeolite in water treatment also influenced by several aspects such as characteristics of ion exchange properties and affinity of the receptor elements or zeolite itself in reducing the heavy metal elements.

6.2 Recommendation

In terms of geological mapping, more geological knowledge should be implanted so that students are fully ready to map their study area. For example, before going to the field, students should have a clear view on how they should take the structural readings of an outcrop using compass because some of the students are still confused on this part. Knowledge in petrographic analysis and software handling are also important as students need to explain in detail the petrography and crystal structure of the rock samples and also to create a high quality geological map using software. In terms of water quality measurement, another method should be added which is the turbidity of water. Turbidity value of water can be measured by turbidity meter and it can be used for in-situ and also ex-situ analysis. This approach is important as the accurate turbidity value can be obtained and compared at the end of research.

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