Water Quality Assessment on Surface water and Groundwater at Tanah Merah and Tumpat

By

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

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DECLARATION

I declare that this thesis entitled "Water Quality Assessment on surface water and grorundwater at Tanah Merah and Tumpat" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submmited in candidature of any other degree.

Signature : ______________________________

Name : ______________________________

Date : ______________________________

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TABLE OF CONTENTS

LIST OF TABLE

LIST OF FIGURE

LIST OF ABBREVIATION

AN	Ammonical Nitrogen
BOD	Biochemical oxygen demand
COD	Chemical Oxygen Demand
D_1	Initial concentrations of DO
D_2	Final concentrations of DO
DO	Dissolved Oxygen
DOE	Department of Environment Malaysia
EC	Electrical conductivity
GPS	Global Positioning System
NWQS	National Water Quality Standard for Malaysia
TDS	Total Dissolved Solid
WHO	World Health Organization
WQI	Water Quality Index

LIST OF SYMBOL

°C	degree Celsius
%	Percent
mg/L	milligram per litre
NTU	Nephelometric Turbidity Units
µS/cm	microsiemens per centimetre
ppt	parts per thousand

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ABSTRACT

Water is an essential element for all living things and is considered as one of the most delicate parts of the environment. The objectives of this study is to determine the physico-chemical and microbiological parameters of surface water and groundwater in Tanah Merah and Tumpat, Kelantan. The quality of surface and groundwater is identified in terms of its physical, chemical, and biological parameters. Seven physical parameters (temperature, salinity, dissolved oxygen (DO), pH, total dissolved solids (TDS), electrical conductivity (EC) and turbidity) were measured directly in-situ using a multi parameters probe Model YSI 556 MPS while water samples were collected and analysed for biological parameter (total coliform and *Escherichia coli*). Study on water table in the study area was also conducted using resistivity method. Based on National Water Quality Standard, Malaysia (NWQS) classification, pH, TDS, salinity, EC and temperature on river water at Tanah Merah and Tumpat were under class I category, while DO under class III at both location and turbidity in class V at Tanah Merah and class II at Tumpat. For groundwater, TDS, salinity, EC, DO, turbidity, temperature and pH (Tumpat) were classified as class I. However, the pH at Tanah Merah was slightly acidic. According to WHO standard turbidity on surface water (Tanah merah and Tumpat), BOD, total coliform and faecal coliform on surface water and groundwater at both study area are exceed the acceptable limit. The water table at Tanah Merah does not found due to the condition of that site was slightly hilly area. While the water table at Tumpat was found within depth of 7 m to 13 m. Water quality on surface water and groundwater at Tanah Merah and Tumpat are safe for drinking, as long the residents boil the water first before used it.

Penilaian Kualiti Air di air permukaan dan air bawah tanah di Tanah Merah dan Tumpat.

ABSTRAK

Air merupakan satu keperluan penting dalam kehidupan dan aktiviti-aktiviti yang berkaitan dengan industri, pertanian, dan lain-lain manusia, dan ia dianggap sebagai salah satu bahagian yang paling sensitif alam sekitar. Objektif kajian ini adalah untuk menentukan parameter fizikal dan mikrobiologi ke atas air permukaan dan air bawah tanah di Tanah Merah dan Tumpat, Kelantan. Kualiti air permukaan dan air bawah tanah yang dikenal pasti dari segi fizikal, kimia, dan parameter biologi. Tujuh parameter fizikal (suhu, kemasinan, oksigen terlarut (DO), pH, jumlah pepejal terlarut (TDS), kekonduksian elektrik (SPR) dan kekeruhan) diukur secara langsung in-situ manakala sampel air telah diambil dan dianalisis untuk parameter biologi (jumlah koliform dan *Escherichia coli*). Kajian aras air di kawasan kajian juga telah dijalankan menggunakan kaedah kerintangan. Berdasarkan Interim National Standard Kualiti Air Malaysia (INWQS) klasifikasi, pH, TDS, kemasinan, EC dan suhu di atas air sungai di Tanah Merah dan Tumpat berada di bawah kelas I kategori, manakala DO bawah kelas III di kedua-dua lokasi dan kekeruhan di dalam kelas V di Tanah Merah dan kelas II di Tumpat. Untuk air bawah tanah, TDS, kemasinan, EC, DO, kekeruhan, suhu dan pH (Tumpat) telah dikelaskan sebagai kelas I. Bagaimanapun, pH di Tanah Merah adalah sedikit berasid. Menurut WHO kekeruhan standard pada air permukaan dan air bawah tanah di Tanah merah dan Tumpat, BOD, jumlah koliform dan koliform najis pada air permukaan dan air bawah tanah di kedua-dua kawasan kajian adalah melebihi piawaian. Aras air di Tanah Merah tidak dijumpai kerana keadaan tapak itu merupakan kawasan agak berbukit. Manakala aras air di Tumpat ditemui dalam kedalaman 7 m hingga 13 m. kualiti air di atas air permukaan dan air bawah tanah di Tanah Merah dan Tumpat adalah selamat untuk minum, selagi penduduk memasak air terlebih dahulu sebelum menggunakannya.

CHAPTER 1

INTRODUCTION

1.1 Background of study

Water is a unique property of the earth and it is important to all living organism. Of the world's total water supply, 97 % is found in the ocean and another 3 % is fresh water. Most of fresh water is in glaciers and ice caps form (68 %) whereas about 30 % is in the form of underground water and only 0.3 % in the form of surface water (Robert & Daniel, 2015). In many areas, river is the most important water resource use for irrigation, domestic water supply, industrial and other purposes (Fawaz *et al.*, 2013). But in certain rural areas where there is no adequate surface water or the surface water become polluted, groundwater is use as an alternative to fulfil the water demand.

Groundwater is one of the key natural resources of the world and it can be an alternative to water resources. Groundwater is the water that exists beneath the water table in the soils and geological formations that are fully saturated (Freeze & Cherry, 1979). In Malaysia, less than 10 % of the groundwater was used as drinking water especially in the states of Kelantan, Terengganu, Pahang, Perlis, Kedah, Sabah and Sarawak (Ong *et al.*, 2007). But in Kelantan, 70 % of the total water supply in this city is derived from groundwater (Abdullah, 2010). The people of north Kelantan, especially those living in villages use groundwater for domestic purposes. They normally get their water supply from the shallow aquifer through traditionally hand dug wells and boring system. Although groundwater is less polluted than surface water (river), but it can also contaminated by septic systems, storage tanks, landfills and atmospheric contaminant.

Surface water and groundwater are intimately connected to each other within the hydrologic cycle. In many situations, surface-water bodies gain water and solutes from groundwater systems and in others the surface water body is a source of groundwater recharge which causes changes in groundwater quality. As a result, withdrawal of water from streams can deplete ground water or conversely, pumping of ground water can reduce water in streams, lakes or wetlands.

Besides, pollution of surface water can cause degradation of groundwater quality and vice versa. Protecting the surface and groundwater from contamination is important in order to ensure that they are safe to consume by all living things. Thus, the assessment of water quality of surface water and groundwater has to be conducted to ensure the best quality of water is maintained for future generations

1.2 Problem Statement

The people in Kelantan state often use river water and bore water in their daily life. For example, the Kelantan River has been used heavily by the local people for domestic uses, transportation, agriculture, plantation irrigation, small scale fishing industries and also sand mining activities. All this activities have greatly influence the water quality of river in Kelantan especially in term of its turbidity. Moreover, the increasing number of sand mining industries and logging activities in the past years has cause high amount of suspended solids in many rivers (Tan & Rohasliney, 2013).

On the other hand, Kelantan state has been the largest groundwater operator in Malaysia especially in the north region of Kelantan (Malaysian Water Association, 2011). This groundwater has become the main source of fresh water for domestic purpose including agricultural activities. It also has become an alternative to public water supply since many years ago. Although it is less polluted than surface water but over exploitation may also deteriorate the quality of the water and make it unsafe to consume (Tan & Rohasliney, 2013).

Therefore, this research aims to determine the surface water and groundwater quality level at Kampung Kok Keli in Tumpat and Kampung Paloh in Tanah Merah, in term of their physico-chemical and microbial parameter. The values obtained were compared with national standard for drinking water quality by the Ministry of Health Malaysia and guidelines for drinking water quality by World Health Organization (WHO).

1.3 Objective

The objectives of this study are:

i. To determine the physio-chemical and microbiological parameter of surface water and groundwater in Tanah Merah and Tumpat.

ii. To determine surface water and groundwater quality result in Tanah Merah and Tumpat with World Health Organization water quality standard (WHO) and National Water Quality Standard (NWQS) standard.

iii. To determine the groundwater water table of Tanah Merah and Tumpat using resistivity method.

1.4 Significant of study

Surface water and groundwater is important the resources on the earth. All plant, animal, humans and microorganism also need water to survive. Therefore, it is important to determine the water quality of surface water and groundwater so that it is safe to use. In this study, the physicochemical and microbiological parameters were measured and compare with World Health Organization water quality standard (WHO) and National Water Quality Standard (NWQS). Therefore, this research will be the handful for the society and the management to know the standard of the surface water and groundwater quality that they use in their daily life.

CHAPTER 2

LITERATURE REVIEWS

2.1 Freshwater

Water is regarded as one of the most critical resources human have on earth. This is because water served as an essential need for human to carry out their daily activities in many fields namely industries, agriculture, domestic and others (Al-Badaii *et al.,* 2013). A parallel increase of human population and the demand for water made the concern on the quality and the quantity to rise abruptly (Aris *et al*., 2014).

2.1.1 Surface water

Surface water is water on the surface of the planet such as in a river, lake, wetland, or ocean. Surface water can be contaminated by rainwater runoff from homes, businesses, roads and parking lots. Fertilizer and pesticide from lawns and gardens as well as fluids that leak from autos can all get washed into surface water supplies from rainwater runoff (Huang *et al.*, 2015). River plays a major role for communities especially in fisheries and as a source of water for people residing there.

Malaysia receives abundant rainfall averaging 3,000mm annually that contributes to an estimated annual water resource of some 900 billion cubic metres. About 97% of our raw water supply for agricultural, domestic and industrial needs are derived from surface water sources primarily rivers. Malaysia has 189 river basins, 89 in Peninsular Malaysia, 78 in Sabah and 22 in Sarawak. All the rivers originate and flow from the highlands (WWF, 2012).

2.1.2 Groundwater

Groundwater is the water that exists beneath the water table in the soils and geological formations that are fully saturated (Freeze & Cherry, 1979). Groundwater is stored in and moves slowly through layers of sand, soil and rocks which are called aquifer. Aquifer is able to function as the storage of water due to porous spaces and the connected voids that allow water to flow through it. Groundwater is one of the key natural resources of the world.

Groundwater use has fundamental importance to meet the rapidly expanding urban, industrial and agricultural water requirement, especially in arid areas where surface waters are scarce and seasonal. In the major cities and small towns in the world depend on the groundwater for water supplies, it due of its abundance, stable quality and also it because inexpensive to exploit (Morris *et al.*, 2003).

In Kelantan especially in Kota Bharu, groundwater plays a very important role in the public water supply system. 70% of the total water supply in this city is derived from groundwater (Abdullah, 2010). Groundwater is generally always moving where the movement that occurs from higher hydraulic head in recharge areas where precipitation is higher, to discharge areas of lower hydraulic head in spring, rivers, wells, wetlands and lakes. The gravity is driving forces that the moves of water from higher ground to the lower ground (Fetter, 1994). Some rural communities in the North Kelantan also use groundwater obtained from a shallow aquifers for drinking water and other domestic use (Islami *et al*., 2015). The Figure 2.1 shows the water from sources like precipitation and recharge ditches enters the unsaturated zone which is soil moisture and the saturated zone which is groundwater it enter through infiltration process. Groundwater flows slowly through water-bearing formations (aquifers) at different rates, then the end discharges to streams and the sea (Canada, 2013).

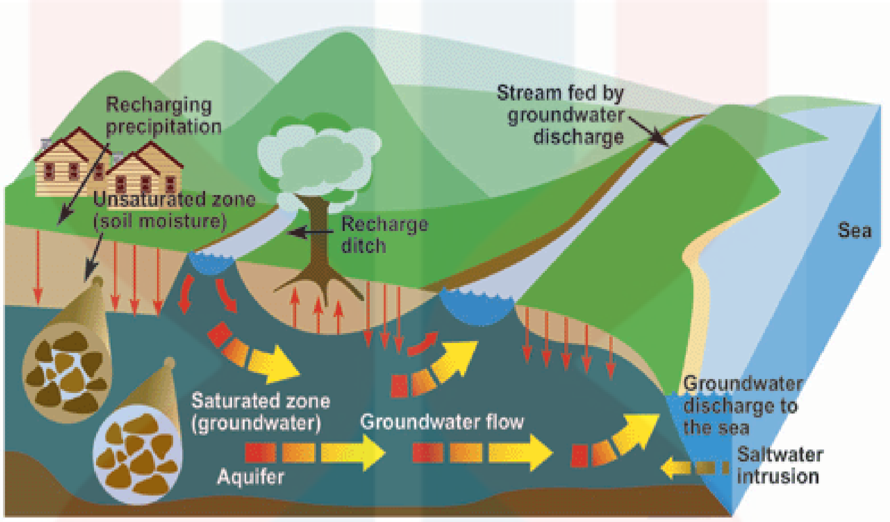

Figure 2.1: The movement of groundwater in the subsurface (Canada, 2013).

2.2 Water Quality

The increase of socio-economic activities in the areas had been accompanied by an even faster growth in pollution stress on water quality (Cleophas *et al.*, 2013). Water pollution can arise from both point and non-point sources. Most of the water pollution from point sources to the freshwater was originating from collection and discharge from domestic wasterwater, industrial waste or certain agricultural activities like farming (Cleophas *et al.*, 2013).

The quality of both surface and groundwater will be identified by studying its physical, chemical and biological parameters. In Malaysia, six chemical parameters are measured as standard to determine the water quality using the Water Quality Index (WQI) (Othman *et al.*, 2012). According to Cleophas *et al.*, (2013), this parameter includes pH, Biochemical Oxygen Demand (BOD), Chemical Oxygen

Demand (COD), Ammonical Nitrogen (AN), Suspended solids and Dissolved Oxygen. Other parameters that can describe the water quality was total coliform, *E.coli*, electrical conductivity, turbidity, temperature, salinity and total dissolved solid.

2.2.1 Physical Parameters

Physico-chemical water quality is the combination of physical characterization and water quality which will provide a clearer insight as to the ability river to support a healthy aquatic community and to the present of chemical and non-chemical stressors to the river ecosystem (Chin, 2006).

2.2.1.1 Dissolved Oxygen (DO)

Dissolved oxygen (DO) is a measure of the amount of oxygen freely available in the water through the diffusion from the surrounding air as waves crash along the riffles by aeration and a waste product of photosynthesis in the presence of light and chlorophyll. DO levels fluctuate seasonally and over a 24-hour period that they vary with temperature and atmospheric pressure. Basically, colder water will hold more oxygen but hold less at higher altitudes and low flow rate as less oxygen dissolve in warm water. When there are too many bacteria or organism in the river water and groundwater, they may use oxygen in a great amount (Karrr *et al.*, 1981).

2.2.1.2 Temperature

Temperature can impact both the chemical and biological characteristics of surface water and also groundwater. It affects the dissolved oxygen level in the water, metabolic rates of organisms, photosynthesis of aquatic plant at rivers and sensitivity of organisms to pollution and diseases. The temperature can varies according the location and time of the water. Normally, temperature fluctuation can occur in the afternoon its maximum temperature and in the night or in the morning its minimum temperature (Gerecht *et al.*, 2011). Theoretically, water in the deep parts usually cooler than water at the surface of the shallow of the river and also on the groundwater (Sophocleous, 2002).

2.2.1.3 pH

pH is a measure of the acidity of the solution through hydrogen ion concentration and is expressed as the molar concentration of the hydrogen ion as its negative logarithm (pH=-ion[H^+]) (Shipman *et al.,* 2012). It is important variable in the water quality assessment which is affected by respiration and photosynthesis and decomposition. Due to organisms are sensitive to pH changes, especially when it turns to acidity in water.

2.2.1.4 Turbidity

Turbidity is a measure of cloudiness in water. It is a visual characteristic of water and is an emphasis of the amount of light that is scattered by material in the water when a light is shined through the water sample (Bachman *et al.,* 1990). The higher the intensity of scattered light, then higher the turbidity. It is the condition from suspended solids in the water, including clay, silts, sewage, sand, plankton and industrial waste (Oram, 2014). On streams, increased sedimentation and siltation can happen and it can harm to aquatic life and organism. Particles also provide attachment places for other pollutants, particularly bacteria and metals. For this reason, turbidity readings can be used as an indicator of potential pollution in a water body (Oram, 2014).

2.2.1.5 Electrical Conductivity (EC)

Electrical conductivity (EC) is a measure of the ease with which electrical current can pass through water (Moore *et al.*, 2008). It can be measured accurately in the field using a portable conductivity probe and meter. It is an indicator of the amount of dissolved salts in a stream. Sodium, potassium and chloride ions can provide water for the ability to conduct electricity. The electrical conductivity of water is also a measurement of salinity of water. The electrical conductivity of water depends on the temperature of water (Ritzema, 2002).

2.2.1.6 Salinity

Salinity is the accumulation of salt in land and water to a level that impacts on both the natural and built environments. The impacts of salinity can affect native plants and animals, aquatic and terrestrial ecosystems, agricultural crops and pastures, water supplies and infrastructure such as roads and buildings (Dalton, 2013). Salt gradually accumulated on the surface of the soil through evaporation concentration during the dry session and then dumped into water or into the soil during the wet session. Surface water and shallow groundwater system becomes increasingly saline. Shallow saline groundwater seeps into the river as the base flow during dry session, further increasing their salinity (Dalton, 2013).

2.2.1.7 Total Dissolved Solid

Total dissolved solids (TDS) comprise inorganic salts (principally calcium, magnesium, potassium, sodium, bicarbonates, chlorides, and sulfates) and some small amounts of organic matter that are dissolved in water (Oram, 2014). TDS in drinking-water originate from natural sources, sewage, urban run-off, industrial wastewater, and chemicals used in the water treatment process, and the nature of the piping or hardware used to the plumbing (Oram, 2014).

2.2.2 Chemical Parameter

2.2.2.1 Biochemical Oxygen Demand (BOD)

Biochemical Oxygen Demand (BOD) is a measurement of the amount of dissolved oxygen (DO) that is used by aerobic microorganisms when decomposing organic matter in water. The BOD value is most commonly expressed in milligrams of oxygen consumed per litre of sample during five days of incubation at 20 °C and is often used as a surrogate of the degree of organic pollution of water (Clair *et al.*, 2003). After the five day period, sample is removed from the incubator and the dissolved oxygen reading can be taken.

2.2.3 Microbial Parameters

2.2.3.1 Total Coliform

Total coliform bacteria are a group of relatively harmless microorganisms commonly found in the intestines of warm-blooded organisms and cold. Part of this group is the fecal coliform which originally could come only from warm-blooded animals and is distinguished by its ability to grow at high temperatures. Some of total coliforms can be found in the soil or vegetation, while the fecal coliform are bacteria that normally live in the intestines of warm-blooded animals and making them as an indicator of fecal contamination. Outside of the intestines of warm-blooded animals, those fecal coliform bacteria can survive for extended time periods (Campbell *et al.*, 2011).

In Standard Methods for the Examination of Water and Wastewater Part 9221 and 9222 (APHA et al., 1998), coliform group members are described as (1) all aerobic and facultative anaerobic, gram-negative, non-spore-forming, rod-shaped bacteria that ferment lactose with gas and acid formation within 48 h at 35^{o}C. (2) all aerobic and many facultative anaerobic, Gram-negative, non-spore forming, rod-shaped bacteria that develop a red colony with a metallic sheen within 24 h at 35 ^{o}C on an Endo-type medium containing lactose.

Pathogenic microbes can also be found in fecal material along with coliform bacteria. In addition, the presence of fecal coliform in the aquatic environment shows that water pollution occurs through the bacteria. Therefore, their presence in rivers and groundwater shows that the potential health risk exists for individuals to use water.

2.2.3.2 *Escherichia coli (E.coli).*

Escherichia, a member of *Enterobacteriaceae*, are oxidase-negative catalase-positive straight rods that ferment lactose (Cabral, 2010). *Escherichia coli (E. coli)* are a natural and essential part of the bacterial flora in the gut of humans and animals. *Escherichia coli* have been isolated from humans, farm animals, wild animals, milk, water and environmental samples (Adzitey *et al.*, 2015). Most *E. coli* strains are non-pathogenic and reside harmlessly in the colon. However, certain serotypes do play a role in intestinal and extra-intestinal diseases, such as urinary tract infections (Scheutz&Stockbine, 2005)

E. coli is an important zoonotic pathogen. *E. coli* O157:H7 one of serotype the *Escherichia coli* that was first recognized in 1982. *E. coli* O157:H7 as a human pathogen and cattle have been identified as a major source of infection of human but it is not pathogenic in cattle and present in the feces of healthy cattle (Elder *et al.*, 2000). In addition, *E. coli* isolation reveals fecal coliform contamination in the combined-sewer outflows (Perez *et al*., 2000). Thus, it is necessary to emphasize the detection of *E. coli* from river and groundwater that may cause severe illness in animals and birds as well as in human being.

2.2.4 National Water Quality Standard (NWQS)

Water quality standard serves as the basic of environmental assessment of water in relation to pollution load categorization of class of beneficial uses that provided under National Water Quality Standard (NWQS) for Malaysia. Table 2.1 below shows that classification of standard of water quality parameters under Department of Environment Malaysia (DOE) and National Water Quality Standard (NWQS).

Besides that, DOE has establish guideline on interim national water quality standards with comprising five classes based on it quality of each water bodies (MIHP, 2007). Class I represents the excellent quality water bodies. The standards are set for the conservation of natural environment in its undisturbed state. It can be found at national park area and in the highland where strictly no discharge of any kind of pollution. In this category meet the most severe requirements for human health and aquatic life protection. Class IIA is set for the criteria development for protection of sensitive aquatic species known to exist to this class of water, conventional treatment and for human health (DOE, 2010).

Class IIB has similar quality from class IIA but in this it's more specialized for recreational use body contact. Class III represents a class that which protects common and moderate tolerant aquatic species of economic value. This class can be used for water supply with advance treatment and it also can be used for livestock drinking needs (DOE, 2010).

Class IV expresses a state of water quality permitted to major agriculture irrigation activities which may not cover minor application to sensitive crops Finally, Class V represent of the class that not listed in the above classes (DOE, 2010).

Table 2.1: National Water Quality Standard for Malaysia (NWQS) (DOE, 2010).

Parameters	Unit	Class				
		I	II	III	IV	V
Biochemical Oxygen Demand (BOD)	mg/l	1	3	6	12	>12
Dissolved Oxygen (DO)	mg/l	7	5-7	3-5	<3	<1
pH	-	6.5-8.5	6-9	5-9	5-9	-
Electrical Conductivity (EC)	µS/cm	1000	1000	-	6000	-
Salinity	%	0.5	1	-	2	-
Total Dissolved Solid (TDS)	mg/l	500	1000	-	4000	-
Total Suspended Solid (TSS)	mg/l	25	50	150	300	300
Temperature	°C	-	Normal +2 °C	Normal +2 °C	-	-
Turbidity	NTU	5	50	50	-	-
Total Coliform	Count/100 ml	100	5000	50000	50000	>50000
Fecal Coliform	Count/100 ml	10	100	400	5000 (20000)a	5000 (20000)a

2.2.5 World Health Organization (WHO) drinking water quality standard

Access to safe drinking-water is important as a health and development issue at national, regional and local levels. In some regions, it has been shown that investments in water supply and sanitation can yield a net economic benefit, as the reductions in adverse health effects and health-care costs outweigh the costs of undertaking the interventions. Table 2.2 show the guideline that provide by World Health Organization (WHO) in fourth edition for the guideline to all people at around the world to monitoring the quality of their water.

Table 2.2: World Health Organization (WHO) drinking water quality standard (WHO, 2011).

	Index Range		
	Clean	**Slightly Polluted**	**Polluted**
Biochemical Oxygen Demand (BOD)	1-3	4-12	>12
Dissolved Oxygen (DO)	7	6-1	<1
pH	7	6.5-8.5	1-6,9-12
Electrical Conductivity (EC)	<1000	-	>6000
Salinity	<0.5	0.5-2	>2
Total Dissolved Solid (TDS)	<450	450-2000	>2000
Temperature	27 ±2	-	-
Turbidity	<5	5-50	>50
Total Coliform	<100	100-5000	>5000
Fecal Coliform	<10	10-500	>500

2.3 Surface and Groundwater Water Quality in Kelantan

Domestic sewage and industrial effluent appears to be the major contributors to water pollution in the Kelantan River which one of the main water resources for the paddy field at Lading Merdeka Mulong Lating, Kota Bharu, Malaysia (Mahdi *et al.,* 2015). The polluting industrial activities include the processing of agricultural products, textiles, leather production and carpets (Mahdi *et al.,* 2015). The Kelantan River has been used by the local people for domestic uses, transportation, agriculture, plantation irrigation, small scale fishing industries and also sand mining activities (Tan & Rohasliney, 2013). According to Ambak & Zakaria, (2010) the Kelantan River's water has been turbid since the early 1990s because of the high amount of suspended solids, turbidity and siltation. These were caused by logging activities in the upstream areas of Lojing Highlands and sand mining activities at that river itself.

In the North Kelantan, groundwater is the major water resources used for daily activities that is supplied by domestic water company. In Bachok, season crops planting, such as tobacco, corn, chili, and other vegetable plants, is the dominant agricultural activity. In the Pengkalan Chepa and Sabak areas, the dominant agricultural activity is the production of coconuts (Islami *et al.,* 2015). Mostly in agricultural activities using chemical fertilizers to increase agricultural production but it would cause a groundwater contamination. By vertical transport of pollutants through the sandy soil profile occurs from excess precipitation, irrigation water and infiltration process (Ahmad *et al.*, 1994).

K.Y Lum (1994) studies showed that the groundwater under both rice and tobacco agrosystems was contaminated by coliform bacteria in Kota Bharu, Kelantan. For tobacco agro systems, out of 357 number of sample, percentage of total coliform violations recorded was 46.77%. Meanwhile for rice agro systems, out of 404 number of sample, percentage of total coliform violations recorded was 42.82% (K.Y Lum, 1994). According to the previous study by Idrus *et al* (2014) the presence of *E.coli* was found in groundwater at nine district (Tumpat, Kota Bharu, Pasir Mas, Tanah Merah, Bachok, Pasir Puteh, Machang, Kuala Krai and Gua Musang). From all 454 samples about 14% (65/454) samples were contaminated with *E.coli* with concentrations ranging from 5.09 ± 30.8MPN/100ml that has been contaminated with the human waste in nature (Idrus *et al.*, 2014).

CHAPTER 3

MATERIALS AND METHOD

3.1 Study Area

In this study, Tanah Merah and Tumpat were chosen for surface water and groundwater sampling locations. Tanah Merah covers three districts namely dareah Bukit Panau, daerah Ulu kusial dan daerah Jedok. In this study, sampling was conducted in Kampung Paloh where the village is located in Bukit Panau district. On the other hand, Tumpat is a district and a parliamentary constituency in Kelantan. Tumpat is the northernmost constituency in Kelantan, bordering Thailand across the Golok River to the west, Kota Bharu across the Kelantan River to the east, and Pasir Mas to the south. There are 30 districts in Tumpat and the sampling was conducted in one of Tumpat district which is in Kampung Kok Keli area. Figure 3.1 and 3.2 shows approximately 500 m x 500 m of study area at the both sites.

In this research there were 4 sampling point where two samples were collected at Tanah Merah and another two samples from Tumpat. At each location the river and groundwater samples were examined. The coordinates of all sampling's location were determined by Global Positioning System (GPS) as shown in Table 3.1.

Figure 3.1: Locations sampling point and water table at Tanah Merah. (Source: Google Earth)

Figure 3.2 Locations sampling point and water table at Tumpat. (Source: Google Earth)

Table 3.1: The coordinates of sampling point at Tanah Merah and Tumpat

Sampling Point	**Coordinates**
River Tanah Merah	5° 52' 45.9582"N, 102° 10' 31.335"E
River Tumpat	6° 10' 25.4604"N , 102° 12' 14.7846"E
Groundwater Tanah Merah	5° 52' 34.9644"N , 102° 10' 49.4934"E
Groundwater Tumpat	6° 10' 31.5294"N , 102° 12' 16.4586"E

3.2 Material and Reagents

The list of materials acquired to conduct in-situ and ex-situ analysis which are Global Positioning System (GPS) was used to determine the exact coordinates for each sampling point, Lamotte water sampler was used to collect water sample, YSI 556 Multiple Parameters was used to collect data of water quality parameters, ABEM Terrameter LS was used to determine water table, HACH model 2100Q Portable Turbimeter was used to determine the turbidity parameter, HACH HQ40d BOD measurement package was used to determine the BOD parameter, Microscope was used to determine microbial parameters, ice box was used to preserve the samples, sample bottle plastic bag, beakers, glass slide, bunsen burner, petri dish, inoculating loop, and laminar flow.

The list of reagents acquired to conduct isolated bacteria and gram staining method includes nutrient agar (NA), distilled water, crystal violet, iodine, ethyl alcohol, and safranin and immersion oil. Table 3.2 shows all the material and reagent used in this study.

Table 3.2: The equipment and reagent was used in this study

Test	Material and Reagent
In-situ	Global Positioning System (GPS)
	Lamotte water sampler
	YSI 556 Multiple Parameters
	ABEM Terrameter LS
	HACH model 2100Q Portable Turbimeter
	ice box
	sample bottle
Ex-situ	HACH HQ40d BOD measurement package
	Microscope
	petri dish
	glass slide
	nutrient agar (NA)
	crystal violet, iodine, ethyl alcohol, and safranin
	laminar flow

3.3 Water Sampling and Preservation

Before sampling, icebox was completely filled with ice. All the bottles samples were labelled with the sampling point, name and date. For the Total coliform and *E.coli* sample, sterilized vessels were used to collect the water sample. While the dark glass bottle samples were used for BOD tests.

As for the precaution step, all the pipes connected to the bore holes were cleared and flamed to avoid any microorganism or bacteria infect the sampling water. Then the pipes were open for water flow for a few minutes before the water sample was collected, this step are done to ensure the water sample that collected is directly from underground (water table). Then, water sample were capped, covered with plastic bag and stored in ice box until reach to the laboratory for the analysis of BOD, Total coliform and *E.coli*. This step is vital to prevent unwanted changes in the groundwater samples. For river sampling, water sampler (as shown in Figure 3.3) was used to collect the water sample. As for precaution step, water sampler was rinse using distilled water to avoid any microorganism or bacteria infect the sampling water.

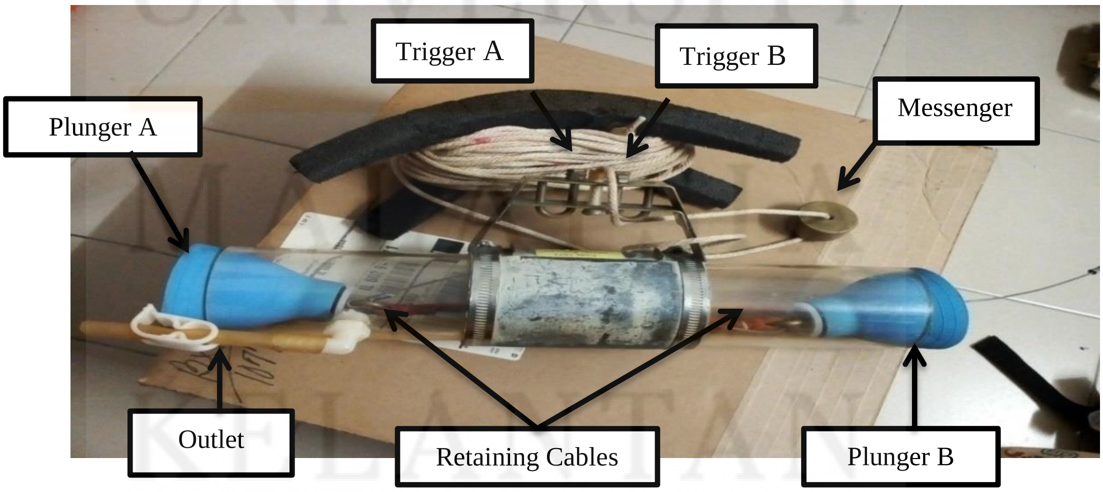

Figure 3.3: Water Sampler

3.4 Water Quality Analysis

3.4.1 In-situ test

In-situ measurement is the procedure in extent which is applied directly in the sampling point. There are few in-situ parameters which conducted on river water and groundwater in the sampling point. These parameters where pH, dissolve oxygen (DO), temperature, turbidity, electrical conductivity, salinity and total dissolved solid (TDS). These parameters were measured using YSI 556 MPS Multi-parameter. These parameters were conducted on-site to avoid any inaccuracy due to the environmental factors. At the beginning of each sampling point, the probe for in-situ measurements were checks using the appropriate standard solutions. The measurements of in-situ surface water and groundwater was made at mid-depth for 10 minutes. After that, the reading was recorded on the table.

3.4.2 Ex-situ test

The sample that was collected at each point was taken to the laboratory for biochemical oxygen demand (BOD) and coliform and faecal coliform (*Escherichia coli*) test.

3.4.2.1 BOD test

Firstly, buffer solution was prepared by placing one pack of pillow buffer into media bottle. Three litre of distilled water were measure by using measuring cylinder and poured into the media bottle that contain pillow buffer. The mixture solution was gently shaken until the solution was completely dissolved. Then, the solution was placed in incubator at 20 ^{o}C.

For the BOD test 10 ml of water sample was placed into BOD bottles. Buffer solution that had been prepared before was added into BOD bottle that contain pillow buffer with no air bubbles in it. After that, the initial concentrations of DO (D_1) of each sample were measured carefully by inserting self-stirring sensor into the BOD bottle. The BOD bottles were sealed with aluminium foil and it was placed into incubator at 20 ^{o}C for five days. After five days, BOD bottles were removed from incubator and the final concentration of DO (D_2) were measured. The BOD_5 was calculated from the reduction of DO and the volume of samples using Equation 3.1(Delzer & McKenzie, 2003).

$$\mathrm{BOD(mg/L)} = \frac{D1-D2}{P} \quad \text{(Eq. 3.1)}$$

where: D1= the initial DO_1 of the sample

D2= the final DO_5 of the sample after 5 days

P= the decimal volumetric fraction of sample used

3.4.2.2 Isolation method

Isolation and gram staining method was conducted to test the present of these bacteria (Panneerselvam and Arumugam, 2012). There are four steps to obtain the present of bacteria. First, the media was prepared by weighting 14 g of nutrient agar. Then, 500 mL of distilled water was poured in bottle that contain nutrient agar. The content of bottle was heated and gradually brings to a boil to dissolve the agar. The bottle was placed into autoclave at 121 °C for 15 minutes. After that, the medium in the bottle was poured into petri-dish.

For the spread method, 1 mL of the sample was poured into petri-dish and inoculates the dish by gently streaking the entire of agar surface without tearing into it. Then the petri dish was covered with parafilm and stored in a sterile cabinet at ideally environment around 37 °C and were kept away from the sunlight.

Next, the loop was sterilized using Bunsen burner and was allowed to cool for several seconds. Then, a single colony of the bacteria in the petri dish was taken and the loop was gently dragged into the new petri dish that contain agar. First quadrants at petri dish was making and continue to streak the second quadrant of the plate in a similar zig-zag manner from the outer edge of the plate inward. After that, the loop was sterilized and let it cool. Then, drag the loop through the second quadrant once and zig-zag streak the third quadrant of the plate from the edge inward. Then, the step was repeated for making fourth quadrant. This steps as shown in figure 3.4. After done streaking, the plate was leave for 24 hours.

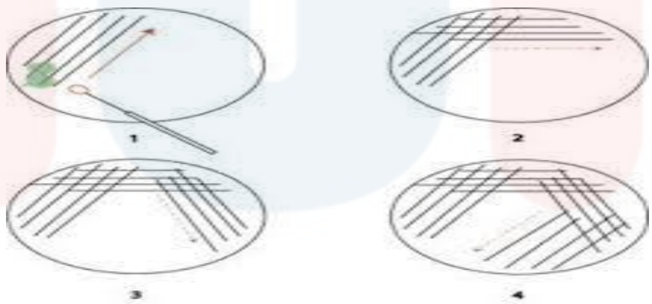

Figure 3.4: The streaking technique

In gram staining method involve 4 chemical which is crystal violet, gram’s iodine, ethanol and safranin. Firstly, the slide was sterilizing using alcohol for remove the contaminant on the slide. A drop of distilled water was placed on the slide. The loop was sterilizing by heat the loop to the flame and let it cool for a several second. Then, the bacteria colony was taken from the plate and placed on the slide. The slide was heated by just passing the flame for a few second. After that, a drop of crystal violet was applying on the slide and leaves it for a 1 minute. Then, the slide was rinsed with distilled water. This step was repeated using gram's iodine, ethanol and safranin. The low power lens (10X) was used for a good field. A drop of oil was added and immerses the 100X oil immersion lens into the oil by rotating the nosepiece. The fine adjustments were used to bring the image into clear focus.

3.5 Water Table Investigation

A horizontal line of 200 m length was selected at Tanah Merah study area and 80 m at Tumpat. The selections of sites to conduct this resistivity survey were based on availability of the area to contain all the resistivity equipment and horizontal line. The area must be free from the building and obstacle in order to run the resistivity test. Wenner configurations were used in this study.

3.5.1 Arrangement for ABEM system

The arrangement for ABEM Terrameter LS resistivity was made according to the sketch in Figure 3.5. The Lund imaging cable one was placed at near with the first steel electrode and the second of Lund imaging cable was placed at the middle. Each of the Lund cables measures 100 meters in the length. 42 of the electrodes were planted into the ground and 5 m spacing between the electrodes along the horizontal line.

The cables was connected to the each of the electrodes and then to the ABEM terrameter LS. Lastly, ABEM Terrameter was connected with the battery. ABEM Terrameter was used to record resistivity data from geophysic analysis. To run ABEM Terrameter, first the instrument was set up following its procedure. Figure 3.6

show the flow of this experiment. Figure 3.7, 3.8 and 3.9 show the setup of resistivity method at the field in Appendix A.

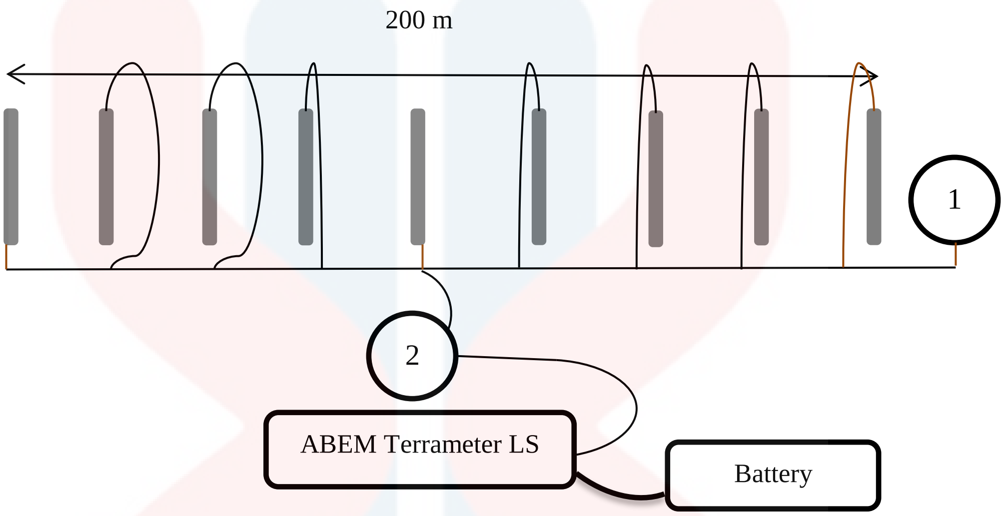

Figure 3.5: The arrangement for ABEM Terrameter LS

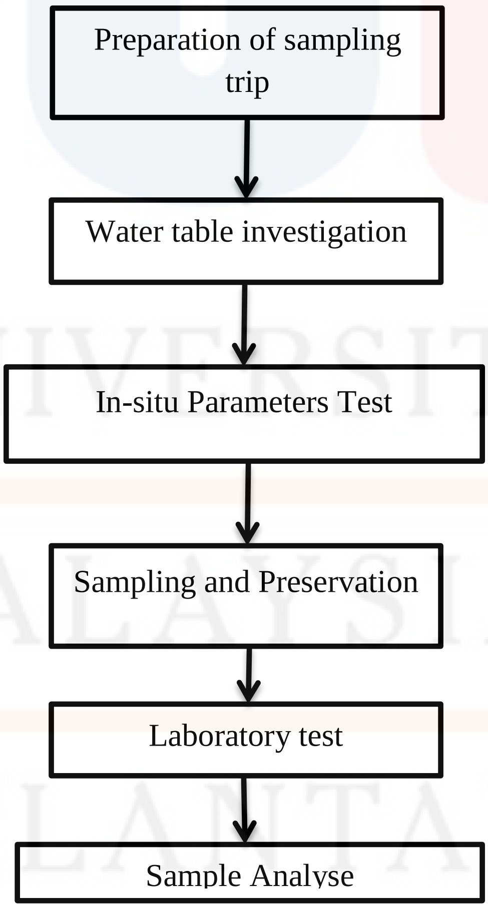

Figure 3.6: Flow of the Experiment

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 Physico-chemical Parameters

4.1.1 Dissolve Oxygen (DO)

DO measurement are expressed as concentration in miligrams per litre (mg/L) which indicates the amount of the oxygen in the water. Furthermore, DO is the actual amount of oxygen available in dissolved form in the water. Figure 4.1 shows that the average results of DO concentration on surface water and groundwater.

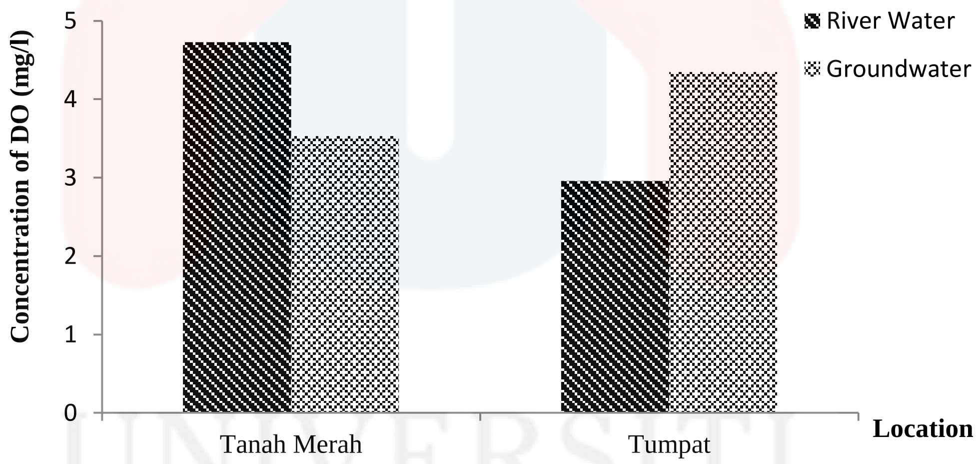

Figure 4.1: Concentration of DO on surface water and boring water at different locations.

The highest average of DO concentration was at Tanah Merah river (4.73 mg/L), followed by boring water at Tumpat (4.35 mg/L), boring water at Tanah Merah (3.53 mg/L) and river at Tumpat (2.96 mg/L). Basically, the higher concentration of DO in the water, the better the quality of the water is. Therefore, DO concentration at river in Tanah Merah was in good quality compared with others points. This was particularly due to the condition of sampling site, type of water which is surface water and groundwater and temperature of the water.

Concentration of DO at Tanah Merah's river was higher than in Tumpat, due to fewer disturbances of human activities in Tanah Merah. In Tumpat, the sampling site was congested with fishing activities which make the DO lower. Meanwhile, the concentration of DO on boring water at Tumpat was higher than Tanah Merah. This is due to the depth of boring systems at Tanah Merah are deeper than at Tumpat accordance to the villagers at both study area. Based on WHO and NWQS standard acceptable limit of DO is greater than 7 mg/L, so the concentration of DO on surface water and groundwater at both places are less than the acceptable limits.

4.1.2 Temperature

Temperature of water is a crucial parameter to be determined due to water temperature may be affecting almost all other parameters. Temperature will affect especially dissolved oxygen (DO). Basically, colder water hold more DO than warm water as colder water molecules are less active (Sophocleous, 2002). Besides that, temperature also affects the rate of photosynthesis by aquatic plants. As temperature increases plant grow and die faster and leaving behind matter that need oxygen for decomposition (Sophocleous, 2002). Figure 4.2 show the temperature at different type of water in different locations.

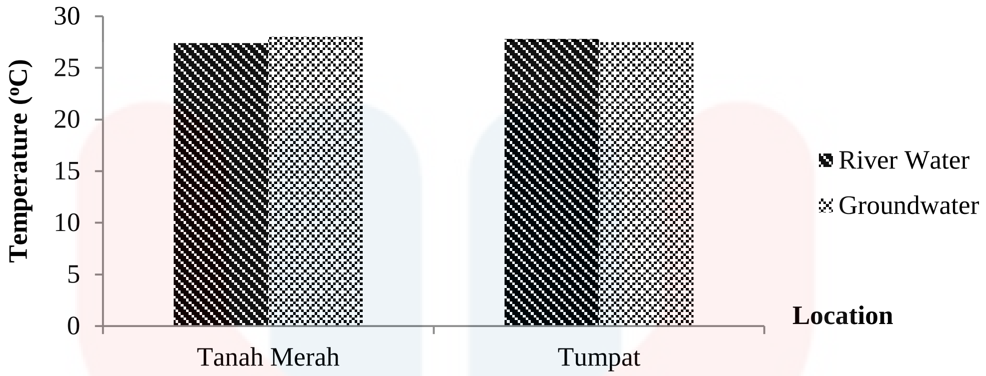

Figure 4.2: The temperature on surface water and boring water at different locations

The highest average of temperature was at Tanah Merah's boring water (28 ^{o}C), followed by river water at Tumpat (27.8 ^{o}C), boring water at Tumpat (27.5 ^{o}C) and river at Tanah Merah (27.4 ^{o}C). According to WHO and NWQS standard temperature on surface water and groundwater at normal temperature (27 ^{o}C) for both places are within the acceptable limits.

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4.1.3 pH

pH is a measure of the relative amount of hydroxyl ions and free hydrogen present in the water (Shipman *et al.*, 2012). pH commonly measured in the first place as it may indicate the conductivity level of the water. Some of organisms can survive at specific level of pH and it may die when slight changes happen. Figure 4.3 shows the pH values in different type of water at different locations. The average pH at Tanah Merah's river is 7.59, 6.27 in river water at Tumpat, 6.23 in groundwater at Tumpat and 5.13 in groundwater at Tanah Merah. The pH value in groundwater at Tanah Merah is slightly acidic. This may be due to the accumulation of acidic rain water. Besides that, acid generating salts and frees carbon dioxide gas also might lower the pH values of groundwater. WHO standard and NWQS standard acceptable limit of pH is in range of 6.5 to 8.5. So, based on the result surface water and groundwater at Tumpat and Tanah Merah were within acceptable limit of WHO standard and NWQS standard except for groundwater at Tanah Merah which is slightly acidic.

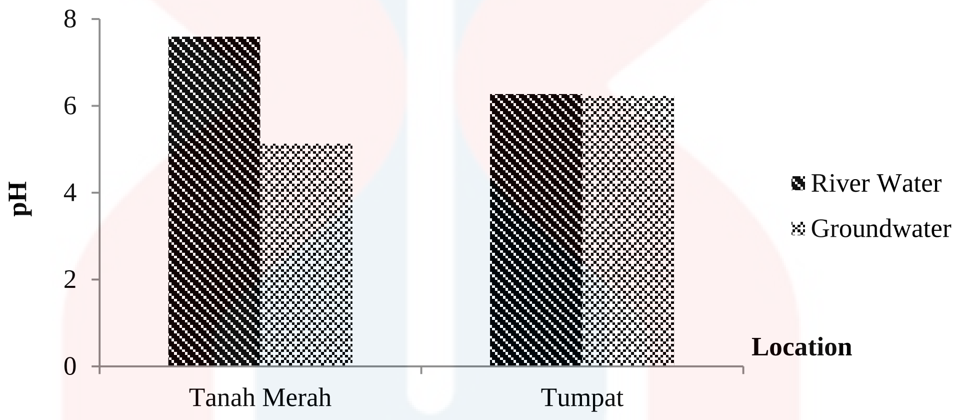

Figure 4.3: pH levels on surface water and groundwater at different locations.

4.1.4 Turbidity

Turbidity is a measure of clarity of water that was caused by particles dissolved in the water that scatter light making the water appear cloudy (Bachman *et al.,* 1990). Turbidity is affected by several factors in the water such as presence of dissolved solid and composition of the particle. Figure 4.4 shows the average turbidity of river water at Tanah Merah and Tumpat. Turbidity at Tanah Merah river higher than Tumpat river.

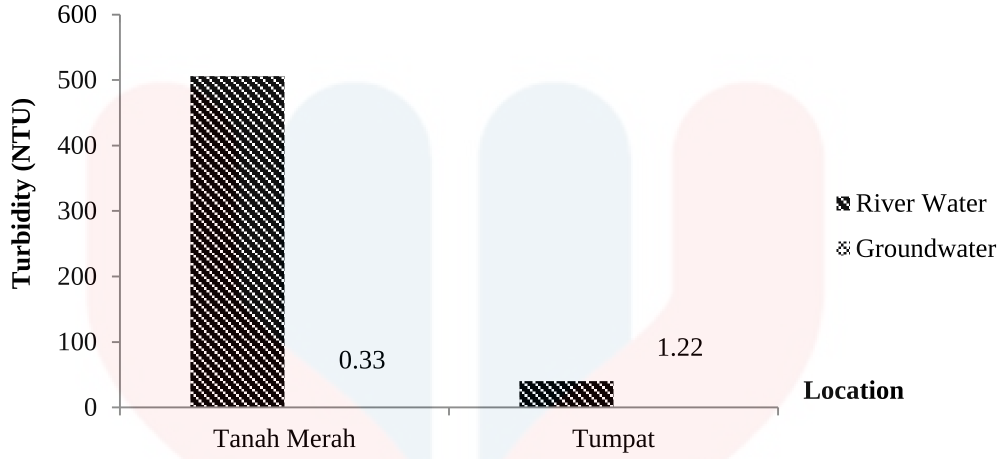

Figure 4.4: The turbidity on surface water and groundwater at different locations.

From the results, average of turbidity are 506 NTU at Tanah Merah's river , 40 NTS at Tumpat's river, 0.33 NTU at Tanah Merah's groundwater and 1.22 NTU at Tumpat's groundwater (1.22 NTU). Based on the result, Tanah Merah's river has the highest turbidity. This might be due to sand mining which is currently operating on that river. The sand mining activity has changed the colour of water into a brownish colour. Besides that, a higher turbidity maybe because of the soil erosion, river flow, presents of sources of organic pollution and run off factors.

According to WHO and NWQS standard, the acceptable limit of turbidity is less than 5 NTU. Therefore, the groundwater for both study area are within the acceptable limit. However, for surface water at both study area, the values have exceeded the standard.

4.1.5 Electrical Conductivity (EC)

Electrical conductivity is a measurement of water's ability to conduct an electric current which depend on concentration of ions and temperature of the water. It estimates the amount of TDS in the water and also related with the pH in water. Electrical conductivity depend on the water temperature, which when temperature higher, then electrical conductivity also higher. Figure 4.5 shows the average of electrical conductivity in different type of water at different locations.

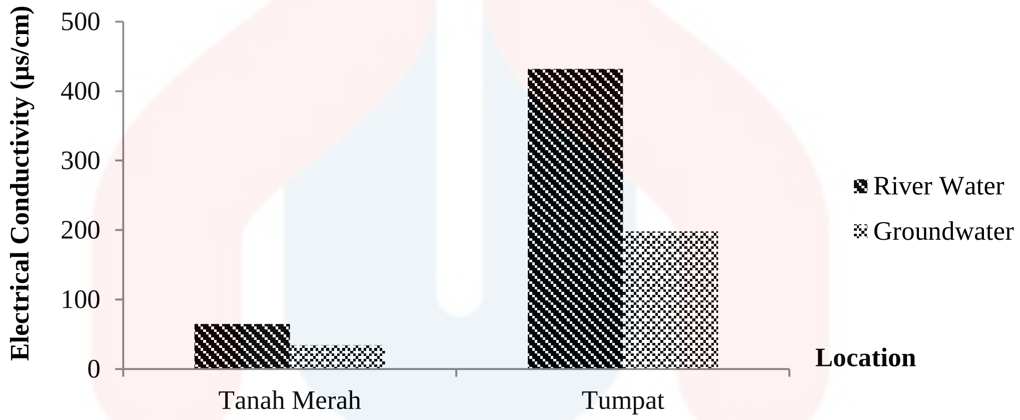

Figure 4.5: The electrical conductivity on surface water and groundwater at different locations.

The highest of electrical conductivity in this study was located at Tumpat's river water (432 µs/cm) while the lowest of EC at Tanah Merah's groundwater (34.3 µs/cm). EC value at surface water higher than EC value on the groundwater this might due to the runoff of ions-contained particle into the river is higher than to the infiltration process entry the groundwater. EC value at Tumpat's river water higher than Tanah Merah's river water this occurs due the value of TDS, temperature, pH and salinity at Tumpat's river higher than Tanah Merah's river because EC is related with those parameters.

According to WHO on surface water and groundwater are within the acceptable limits which are less than 1000 µs/cm and NWQS standard of EC on surface water and groundwater in class I (<1000 µs/cm).

4.1.6 Salinity

Salinity is the measure of all the salts dissolved in water. Salinity is usually measured in parts per thousand (ppt) (Dalton, 2013). Salinity is an ecological factor of considerable importance, influencing the types of organisms that live in a body of water. As well, salinity influences the kinds of plants that will grow either in a water body or by a groundwater (Kalcic *et al.*, 2011). Figure 4.6 shows that the average percentage of salinity level at both locations.

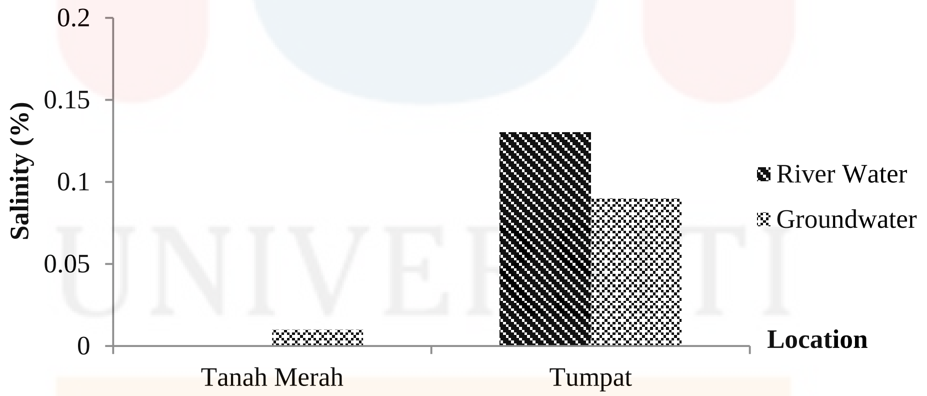

Figure 4.6: The salinity on surface water and groundwater at different locations.

The higher salinity was recorded at Tumpat's river (0.13%) and the lowest which is at Tanah Merah's river (0%). There is zero percentage of salinity at Tanah Merah's river due to high in turbidity. High turbidity that means there is a lot of particle of sand and silt in water that can trap the salinity particle (Hakanson, 2005).

Besides that, salinity also related with EC, when higher level in EC then level of salinity will increase. According to WHO standard acceptable limit is less than 0.5 %, then value of salinity on surface water and groundwater were recorded on the study area are within acceptable limit and for NWQS standard salinity on surface water and groundwater in class I (< 0.5 %).

4.1.7 Total Dissolved Solid (TDS)

Total dissolved solids (TDS) are a measure of the combined content of all inorganic and organic substances contained in a liquid in molecular, ionized or micro-granular (colloidal sol) suspended form. Figure 4.7 show that the average of TDS at both location.

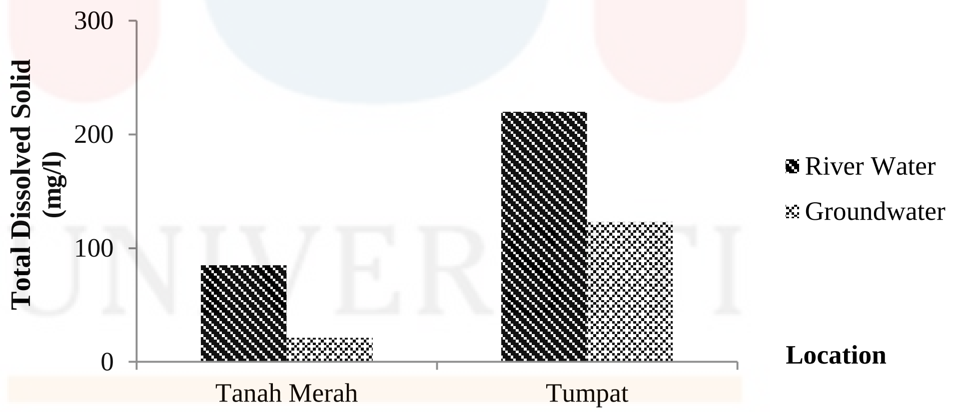

Figure 4.7: The total dissolve solid on surface water and groundwater at different locations

The higher TDS value was located at Tumpat's river (220 mg/L) and the lowest which is at Tanah Merah's groundwater (21.3 mg/L). Parameters of EC, temperature, pH and salinity will give effect on level of TDS on water. TDS level at Tumpat's river higher than Tanah Merah's river due to higher in level EC at Tumpat's river water. When there is a lot of particle in the water, then it can increase the water temperature on that surface and groundwater as well. According to WHO the acceptable limit is less than 450 mg/L, so the value the were get on the study areas on surface water and groundwater are within acceptable limit and for NWQS standard TDS on surface water and groundwater in class I (<500 mg/L).

4.1.8 Biochemical Oxygen Demand (BOD) parameter.

Figure 4.8 show that the average of BOD at both location. The higher BOD value was located at Tanah Merah's river water (6.7mg/l) and the lowest which is at Tanah Merah's groundwater (0.9mg/l). BOD level at Tanah Merah's river water higher due to the high difference between DO_1 (7.95mg/l) and DO_5 (7.72mg/l) as BOD represent the amount of oxygen that consumed by microorganism while the process of decomposition of organic matter under aerobic conditions in the water. The lower in BOD level indicate the good condition on the water that which means there is less of microorganism in the water. According to WHO standard the acceptable limit is less than 1 mg/L, then the result that were get in study area on surface water and groundwater are exceed the limit except for groundwater at Tanah Merah and for NWQS Malaysia Tanah Merah's river water can be classify in class IV (12 mg/L), river water and groundwater at Tumpat in class III (6 mg/L) and groundwater at Tanah Merah in class I (1 mg/L).

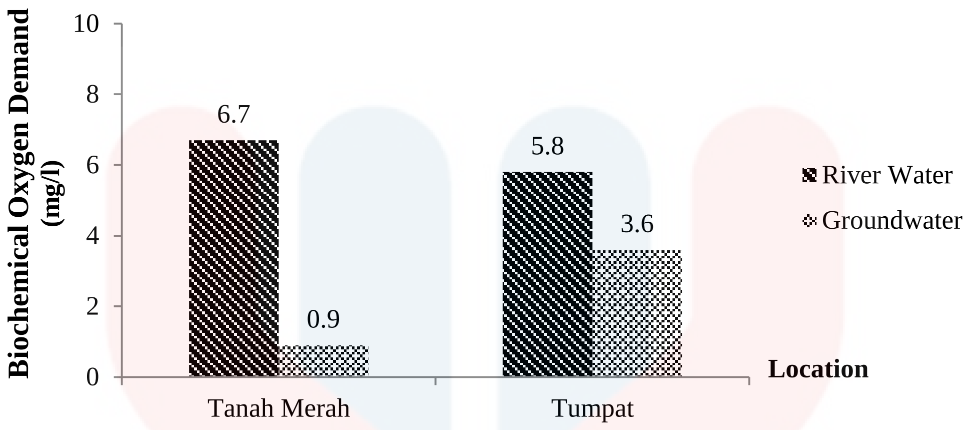

Figure 4.8: The Biochemical Oxygen Demand (BOD) on surface water and groundwater at different locations.

4.1.9 Summary

Table 4.1 show the average result of surface and groundwater at Tanah Merah and Tumpat. From the result that were get on the study area on surface water and groundwater when compare with the standard they can categorized into 3 part which is less than acceptable limit, within the acceptable limit and exceed the acceptable limit. Dissolved oxygen (DO) on surface water and groundwater for both study area was less than acceptable limit part. Temperature, TDS, pH (on surface water at Tanah Merah) and BOD (on groundwater at Tanah Merah) were within acceptable limit part. While pH (on surface water at Tumpat and groundwater at both study area), turbidity (on surface water at both study area), BOD (on groundwater at Tumpat and surface water at both study area), Total coliform and Faecal coliform for both study area were exceed acceptable limit part.

Table 4.1: The average values on surface water and groundwater at Tanah Merah and Tumpat

	Unit	Tanah Merah		Tumpat		WHO	NWQS
		River water	Grounwater	River water	Groundwater		
DO	mg/l	4.73	3.53	2.96	4.35	>7	>7
Temperature	^{o}C	27.4	28.0	27.8	27.5	27 +2	27 +2
pH	-	7.59	5.13	6.27	6.23	6.5-8.5	6.5-8.5
Turbidity	NTU	506	0.33	40.0	1.22	<1	<5
EC	µs/cm	65	34.3	432	198	<1000	<1000
Salinity	%	0	0.01	0.13	0.09	<0.5	<0.5
TDS	mg/l	85	21.3	220	123	<450	<500
BOD	mg/l	6.7	0.9	5.8	3.6	1	1
Total Coliform	CFU	86.7×10^{5}	73×10^{5}	158.8×10^{5}	80×10^{5}	<100	<100
Faecal Coliform	CFU	36.3×10^{5}	11.3×10^{5}	55.7×10^{5}	50×10^{5}	<10	<10

4.2 Microbiological Analysis

In this study, isolation and gram staining method was conducted to determine and identical the total coliform and faecal coliform (*Escherichia coli*). Result that was found on plate there two colour of colony which is white and yellow as shown in Figure 4.9. In order to identical those two colour gram staining method was conducted. The result found under microscope are white colony representing of total coliform and yellow colony represent *E.coli* as shown in Figure 4.10 and 4.11.

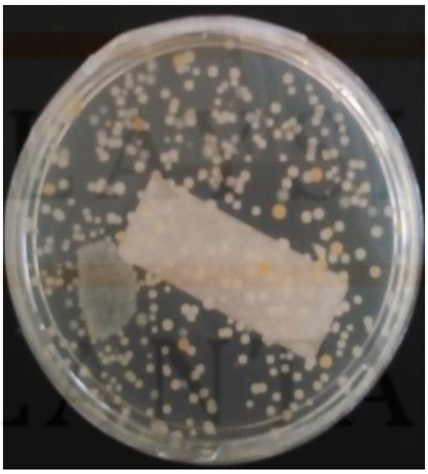

Figure 4.9 : Bacteria growth in the plate with yellow and white colony.

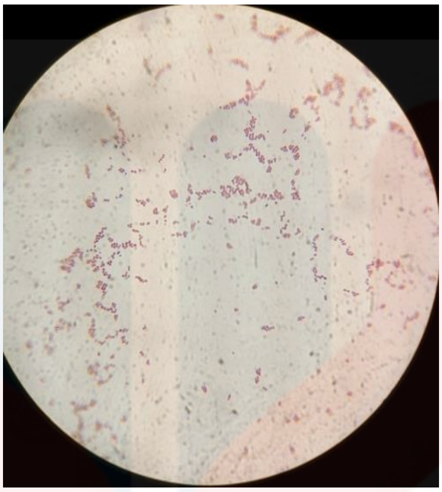

Figure 4.10: Total coliform that observed under 100 x microscopes with immerse oil.

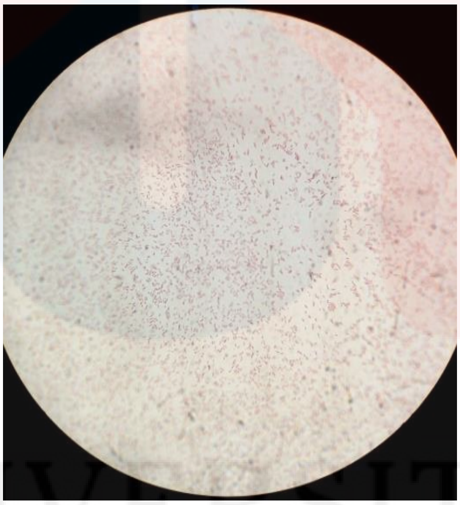

Figure 4.11: *Escherichia coli* that observed under 100 x microscopes with immerse oil

Figure 4.12 shows the average value of total coliform that was found on surface water and groundwater at Tanah Merah and Tumpat. From the study areas the average of total coliform was recorded at Tanah Merah's river water is 86.7×10^5 CFU, Tanah Merah's groundwater (73×10^5 CFU), Tumpat's river water (158.8×10^5 CFU) and Tumpat's groundwater (80×10^5 CFU). Based on the result that were getting Tanah Merah's river water was the higher value among others this may be due to the human activities such as fisheries activities, near with residential area and food store.

WHO standard and NWQS standard acceptable limit for total coliform is less than 100 CFU, so based on the result that were get the value of total coliform on surface water and groundwater were exceed the acceptable limit of WHO standard and NWQS standard.

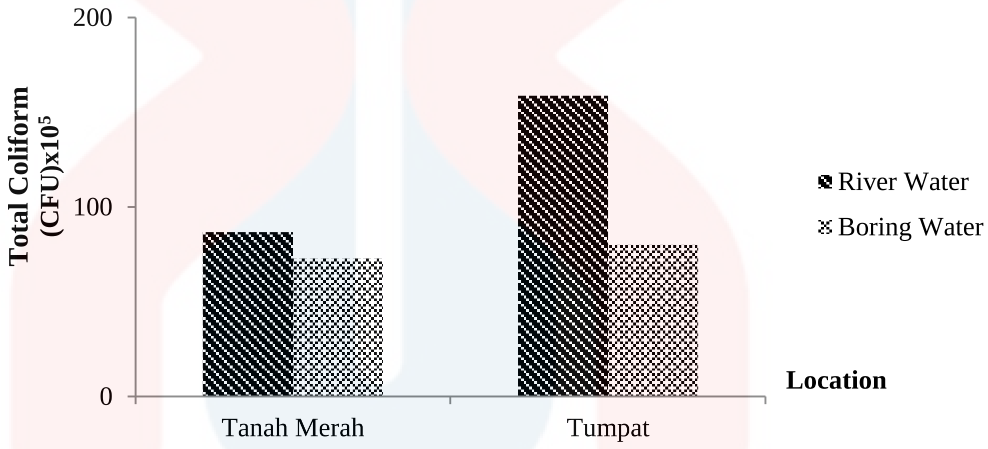

Figure 4.12: The total coliform on surface water and boring water at different locations

Figure 4.13 shows the average of faecal coliform (*E.coli*) that was found on surface water and groundwater at Tanah Merah and Tumpat. From the study areas the highest of faecal coliform (*E.coli*) was recorded at Tumpat's river water is 55.7×10^5 CFU, followed by Tumpat's groundwater (50×10^5 CFU), Tanah Merah's river water (36.3×10^5 CFU) and Tumpat's groundwater (11.3×10^5 CFU). Based on the result that were getting Tumpat's river water was the higher value among others this may be due to the human activities such as food store, fisheries activities and near with residential area.

WHO standard and NWQS standard acceptable limit for faecal coliform (*E.coli*) is less than 10 CFU, so based on the result that were get the value of faecal coliform (*E.coli*) on surface water and groundwater were exceed the acceptable limit of WHO standard and NWQS standard.

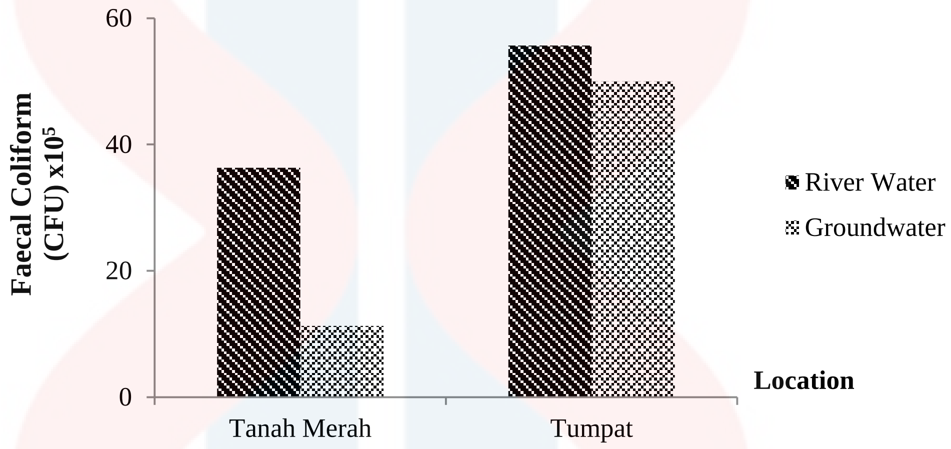

Figure 4.13: The *E.coli* on surface water and groundwater at different locations.

4.3 Water Table Analysis

Wenner array method that was used in determines the groundwater table at Kampung Paloh, Tanah Merah. The following figures show the data that was generated using Terrameter LS Toolbox software. Figure 4.14 show the result of ABEM that was gain at Kampung Paloh, Tanah Merah. At depth 32 m there is no water was found, to compare with the boring water that the villagers was done. They were found groundwater at depth of 24m. This is due to the condition of place that runs the resistivity method was close to the river but it’s a slightly hilly area. Besides that, at the river there are sand mining operation this could might the water table to be lowered and it can be classified it as deep groundwater type.

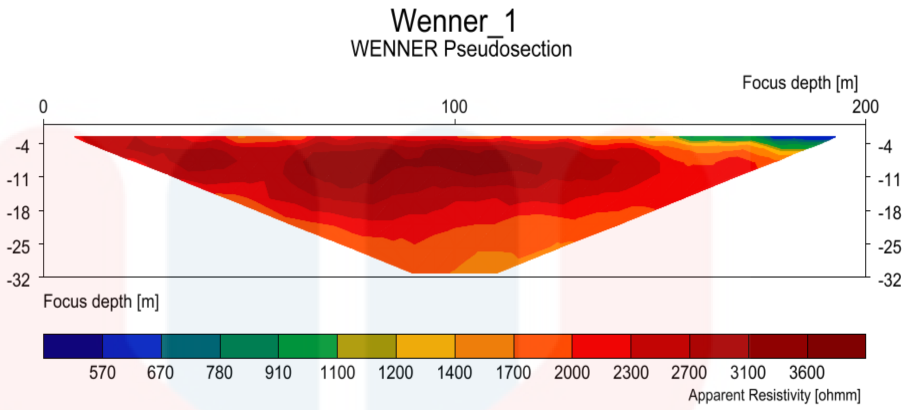

Figure 4.14: Resistivity data at Kampung Paloh, Tanah Merah

Figure 4.15 show the result of ABEM that was gain at Kampung Kok Keli, Tumpat. The lowest resistivity reading is at 40 ohm meter. This low resistivity reading of light blue to dark blue colour is considered as groundwater water table. The groundwater can be classified to be an unconfined aquifer. Unconfined aquifers are sometimes also called water table. Groundwater has low resistivity value due to its character which is can highly conduct electricity. The groundwater water table was found within depth 7 m to 13m. According to the villagers their bore well system are around depth 12 m to 15m so groundwater at Tumpat can be classified as shallow type groundwater.

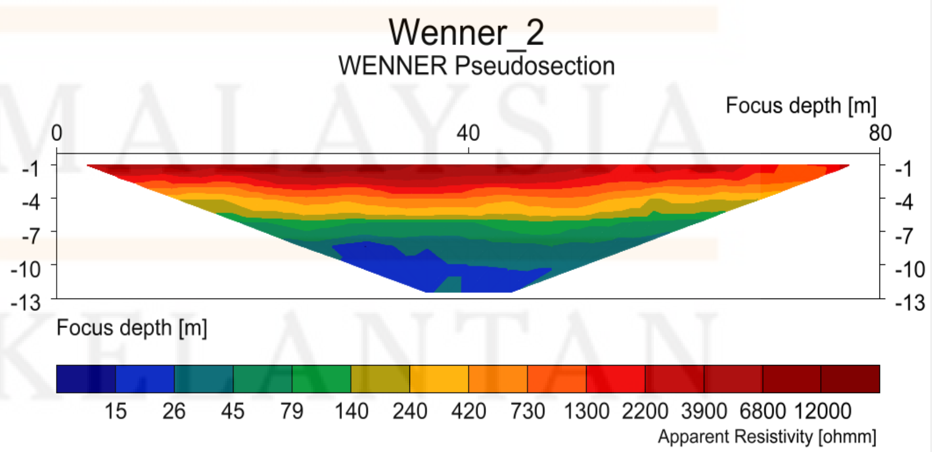

Figure 4.15: Resistivity data at Kampung Kok Keli, Tumpat

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

As for conclusion, water quality in both surface and ground water in Tanah Merah and Tumpat are safe for drinking based on the result of physico-chemical parameters where all the parameters are within the acceptable limit. However, for microbiological parameters, there is a present of total coliform and *E.coli* on surface water and groundwater at Tanah Merah and Tumpat which exceeded the limit of WHO and INWQS standard. Therefore, the residents need to boil the water first before drinking so that the water is safe. If they consume the raw water without boiling, it can be harmful to their health.

On the other hand, water table at Tumpat site was found within the depth of 7 to 13 m below surface which is accordance with depth of bore well system of the villagers. However, in Tanah Merah the water table was not detected even up to 32 m depth although the sampling location is located by the river. This could be the result of excessive sand mining which happen at the location that causes the water table to be lowered. Therefore, the groundwater in Tumpat can be classified as shallow type groundwater, while in Tanah Merah is classified as deep groundwater.

5.2 Recommendation

It is recommended that for next research all the chemical parameters such as nitrate, ammonia, phosphorus, ferum and manganese will be included to get more accurate information of the water quality in the study area. By measuring all these parameters, a clear view of the water quality status can be obtained. If only physical and biological parameters are measured, it is a little bit difficult to gauge the impact of their life when consume that water. The combination of the data can be used to generate essential information for managing sustainable water resources for the benefit of future generations. For the resistivity method, find the place that can added the length of meter in the horizontal line, in other to get more data on the depth of water table. Data that were getting from ABEM device can be extract more data using software, so that can get more detail about the water table.

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APPENDIX A

Figure 3.7: place the electrode on the ground

Figure 3.8: Horizontal line of resistivity method

Figure 3.9: Run of ABEM at the study area