WATER QUALITY ASSESMENT OF PHYSICO-CHEMICAL AND MICROBIOLOGY PARAMETERS OF GROUNDWATER QUALITY AT KAMPUNG PALOH, TANAH MERAH, KELANTAN

By

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DECLARATION

I declare that this thesis entitled "Water Quality Assesment of Physico-Chemical and Microbiology Parameters of Groundwater Quality at Kampung Paloh, Tanah Merah, Kelantan"is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : ______________________________

Name : ______________________________

Date : ______________________________

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Water Quality Assesment of Physico-Chemical and Microbiology Parameters of Groundwater Quality at Kampung Paloh, Tanah Merah, Kelantan

Abstract

This study aims to examine the physico-chemical and microbiological of bore water at Kampung Paloh in Tanah Merah, Kelantan. The physical groundwater characteristic such as temperature, pH, turbidity, salinity, conductivity and total dissolve solids (TDS) were measured directly at the site just after the samples were collected using YSI multi-parameter. The biochemical oxygen dissolve BOD test and microbes were also conducted. Moreover, the water table of the study area was examined using resistivity method. Then, the water quality results were determine and World Health Organisation Standard and National Water Quality Standard of Malaysia was used as a guidelines. The analysis of the groundwater samples indicate that all the physico-chemical parameter results in under the permissible limit of WHO and National Water Quality Standard of Malaysia.

Keywords: groundwater, contamination, physico-chemical, microbiology

Penilaian Kualiti Air daripada parameter fiziko-kimia dan Mikrobiologi Kualiti Air Bawah Tanah di Kampung Paloh, Tanah Merah, Kelantan.

Abstrak

Kajian ini bertujuan untuk mengkaji fiziko-kimia dan mikrobiologi air boring di Kampung Paloh, Tanah Merah, Kelantan. Ciri-ciri air bawah tanah fizikal seperti suhu, pH, kekeruhan, kemasinan, kekonduksian dan jumlah pepejal larut (TDS) diukur secara langsung di kawasan kajian selepas sampel telah dikumpulkan dan diukur menggunakan YSI pelbagai parameter. Ujian BOD dan mikrob juga telah dijalankan. Selain itu, paras air di kawasan kajian telah diperiksa menggunakan kaedah kerintangan. Kemudian, keputusan kualiti air ditentukankan dengan Pertubuhan Kesihatan Sedunia (WHO) dan Standard Kualiti Air Kebangsaan Malaysia sebagai garis panduan. Analisis sampel air bawah tanah menunjukkan bahawa semua keputusan parameter fiziko-kimia di bawah had yang dibenarkan WHO dan Kualiti Air Standard Kebangsaan Malaysia.

Kata kunci : air bawah tanah, pencemaran, fiziko-kimia, mikrobiologi

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LIST OF ABBREVIATIONS

TDS	Total dissolved solid
DO	Dissolved oxygen
EC	Electrical conductivity
WHO	World Health Organisation
BOD	Biochemical Oxygen Demand
DO	Dissolve Solid

LIST OF SYMBOL

NTU	Nephelometric Turbidity Unit
°C	Degree celcius
mg/L	Milligram per litre
µS/cm	Micro siemens per centimetre

CHAPTER 1

INTRODUCTION

1.1 Background of study

Water is use for various types of demand namely for domestic (60%), industry (35%) and agriculture (5%). In industry, water is used for cleaning, heating and cooling and generating steam, as a solvent for transporting dissolved substances, and also as a constituent part of the industrial product itself. Water covers 70.9% of the earth's surface and it important to all life forms. On earth, 97.2% of the planet's water is found in oceans, 0.6% in groundwater and 2.1% in frozen water. Only 2.5% of the earth covers with freshwater and 98.8% of water is in ice and groundwater. Thus, groundwater provides the largest source of usable water especially during shortage of surface water and drought seasons.

Water in aquifers is brought to the surface naturally through a spring or can be discharged into lakes and streams. This water can also be extracted through a well drilled into the aquifer (Kumar & Singh 2015). A well is a pipe in the ground that fills with groundwater. This water then can be brought to the surface by a pump. Shallow wells may go dry if the water table falls below the bottom of the well. Some wells called artesian wells do not need a pump because of natural pressures that force the water up and out of the well (Kumar & Singh 2015).

In Malaysia, surface water is the main source of fresh water supply. But in rural areas where there is no water supply, groundwater is used for domestic purpose. According to Issa *et al.*, (2012), the state of Kelantan and Perlis are the biggest user of groundwater in Malaysia. The people of north Kelantan, especially those living in villages, use groundwater for their daily use (Samsudin *et al.*, 1997). They normally get their water supply from the shallow aquifer through traditionally hand-dug wells as well as from the surrounding rivers (Samsudin *et al.*, 1997). This is due to the low level of public water supply in Kelantan compared with other states in Peninsular Malaysia (Idrus *et al.*, 2014).

It is estimated that about 75% of the Kelantan residents living in the Lower Kelantan Basin are relied on groundwater for domestic water supply, agricultural and industrial activities (Sefie *et al.*, 2015). In the late twenties, a conventional groundwater supply distribution system came into existence with the establishment of Kota Bharu Waterworks Department which takes groundwater from much deeper aquifers (Samsudin *et al.*, 1997).

Although, groundwater can become an alternative to surface water but the quality of groundwater may deteriorate due to urbanisation (septic tanks, sewer and detergent), industrial wastewaters and agricultural activities (fertilisers and pesticides).Water becomes contaminated by pathogens such as coliform group bacteria, *Salmonella* and dysentery causing *bacilli* (Vyas *et al.*, 2015). Contamination of groundwater can result in poor drinking water quality (Mohamed Azwan *et al.*, 2010) which can affect a human health such as many types of diarrheal diseases, including Cholera, and other serious illnesses like Guinea worm disease, Typhoid, and Dysentery.

The major problem with the groundwater is that once it is contaminated, it is difficult to detect its quality. Therefore, the quality of groundwater is a major concern that needs to be addressed in order to meet the future demand of water supply in Kelantan.

1.2 Problem Statement

Groundwater can be an important source of water for domestic, industrial and agriculture needs especially if the present water supply is inadequate due to rapid increase in demand, industrial or agriculture expansion, low flow or bad quality of surface sources. In Kelantan, about 75% of people live in the Lower Kelantan Basin rely on groundwater for their daily used (Sefie *et al.*, 2015). Therefore, the quality of the groundwater is also important as much as surface water in order to ensure they are safe for use and to prevent any adverse effect. Besides, consumers especially the villagers are normally not aware if their boring water is polluted because the quality of the water cannot be justified with naked eyes.

Therefore, this research will determined the ground water quality in term of physico-chemical and biological parameters at Kampung Paloh in Tanah Merah, Kelantan. The water quality results 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). Besides, the water table in this study area were also determined in order to compare the water table with the well depth for the benefit of Kampung Paloh residents.

1.3 Objective of study

The objectives of this study are -:

a. To determine the water table using electrical imaging surveys at Kampung Paloh in Tanah Merah, Kelantan

b. To determine the physico-chemical and biological parameters of groundwater samples from five different bore hole at Kampung Paloh in Tanah Merah, Kelantan.
c. To determine the groundwater quality results with World Health Organization (WHO) and National Water Quality of Malaysia.

1.4 Significance of study

In Kelantan 75% of its water source is from groundwater (Sefie *et al.*, 2015). Although groundwater is less polluted than surface water but it can become contaminate when man-made products such as gasoline, oil, road salts and chemicals get into the groundwater and cause it to become unsafe and unfit for human use. The contaminations from the land's surface can move through the soil and end up in the groundwater. For example, pesticides and fertilizers can find their way into groundwater supplies over time. Toxic substances and untreated waste from septic tanks also can seep into groundwater and cause contamination. Therefore, the quality of groundwater is important especially to the residents of Kampung Paloh in Tanah Merah, Kelantan since there are many developments ongoing in that area and surroundings.

CHAPTER 2

LITERATURE REVIEW

2.1 Groundwater

When rain falls to the ground, the water does not stop moving on the surface of soil only but some of it flows along the surface in streams or lakes. Besides, some of it used by plants, some evaporates and returns to the atmosphere, and some sinks into the ground which is called groundwater (Figure 2.1). This water moves into the spaces between the particles of soil (Thomas *et al.*, 1998).

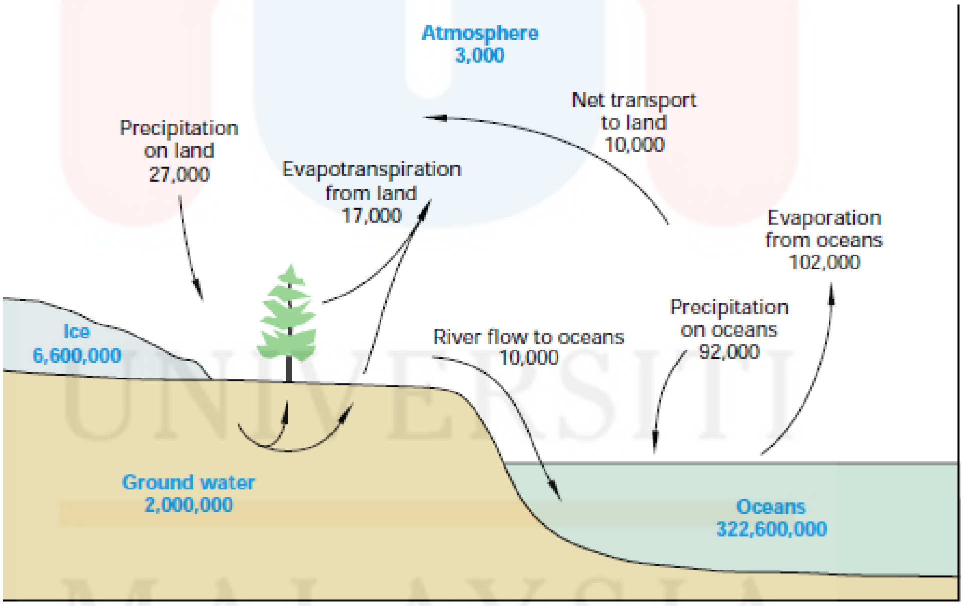

Figure 2.1: Process of hydrological cycle.

(Sources : Thomas et al., 1998).

Groundwater is water that is found underground in cracks and spaces in soil, sand and rocks. The area where water fills these spaces is called the saturated zone. The top of this zone is called the water table, the top of the water is the table. The water table may be only a meter below the ground's surface or it may be hundreds of meters down. Groundwater can be found almost everywhere (Kumar & Singh 2015). The water table may be deep or shallow and may rise or fall depending on many factors. For example is when heavy rains or melting snow it may cause the water table to raise, or an extended period of dry weather may cause the water table to fall (Kumar & Singh 2015). Groundwater is stored in and moves slowly through layers of soil, sand and rocks called aquifers.

The running of groundwater flows is depends on the size of the spaces in the soil or rock and how kind the spaces are connected among each other's. Aquifers usually contain of gravel, sand, sandstone or fractured rock, like limestone. These materials are permeable because they have large connected spaces that allow water to flow through. Water in aquifers will brought to the surface of soil typically like natural through a spring or can be discharged into lakes and streams (Shvartsman *et al.*, 2011). This water can also be extracted through a well which is drilled it from the aquifer. A well is a pipe in the ground that fills with groundwater to bring water onto the surface by a pump. Shallow wells may go dry if the water table falls below the bottom of the well. Some wells called artesian wells do not need a pump because of natural pressures that force the water up and out of the well (Shvartsman *et al.*, 2011).

2.2 Type of groundwater

The composition of the first aquifer (shallow groundwater) comprises of sand and gravel that extends from the ground level in some places or the base of the surface clay down to the next major clay bed. Generally, it lies between 5 to 15 metres depth below ground surface. In some places it is unconfined and in other places it is confined by the surface clay. In most places the shallow groundwater is fresh and of suitable quality but locally iron concentration can be in the range of 0.85 mg/L to 10.95 mg/L. The shallow groundwater is the most exploited source in the Kelantan groundwater basin (Eng Heng & Sing, 1989).

The groundwater contained in the aquifers beneath the shallow groundwater is collectively termed as "Deep Groundwater". Three main aquifer intervals in addition to the shallow aquifer have been recognised east of the Kelantan river and named the second, third and fourth aquifers respectively. The third aquifer which lies between 45 to 130 m depth contains the better quality water and thus has been developed at Tanjong Mas. The water in the second aquifer is brackish whereas it has been found to be saline in the fourth aquifer (Eng Heng & Sing, 1989).

2.3 Groundwater use

Groundwater is an important component of the natural water resources system and human beings have been utilized it ever since ancient days. The development of technology nowadays, which is in drilling and pumping technologies make the usage of groundwater easier, and this enables human beings to use the storage of very deep aquifers (UNEP 2013). Groundwater may be cheaper than the treated surface water. It has low turbidity and contains nutrients which are good for health. The utilization of groundwater can help to solve the water shortage in areas where surface water is limited. Approximately one-third of the world's population depend on groundwater for drinking purpose (UNEP 2013).

Groundwater is the world's largest accessible freshwater and important resource for drinking water supply, irrigation and industrial purposes as well as for global food security. Similarly, it can be used to supplement the surface water supplies. However, contamination of groundwater may restrict and affect the utilization of groundwater for potable uses (Mohamed & Ghazali, 2009) and drinking water sources (Mohamed Azwan *et al.*, 2010).

In Malaysia, the groundwater storage is estimated to be 5000 billion m^3 and only less than 2% of the present storage has been used (Azuhan, 1999). Besides, the exploitation of groundwater can help to meet parts of the increasing demand. Currently, groundwater is being used to meet various types of demand. The assimilation of surface water and groundwater management are needed to ensure a sustainable utilization of water resources (Mohamed & Ghazali, 2009). Groundwater potential and quality are of major concern to researchers because of increasing demand for fresh water coupled with climate change effects. Large amount of effluents generated from urban population, industries and agricultural activities may pollute soil and groundwater (Shirazi et al., 2015). The Figure 2.2 shows that the various demand for the exploited groundwater in Peninsular Malaysia.

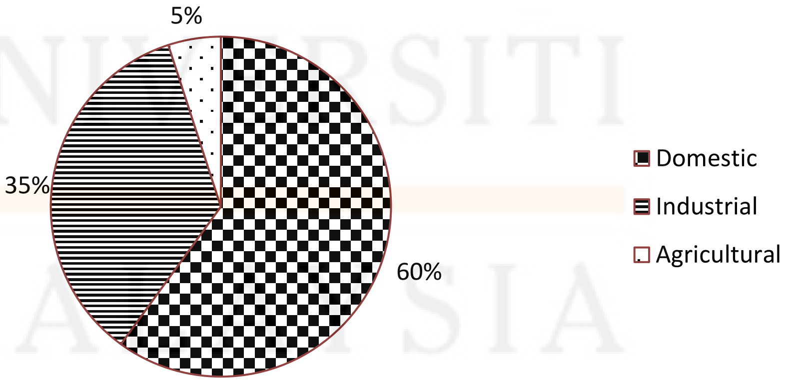

Figure 2.2: Various demands for the exploited groundwater in Peninsular Malaysia (Mohamed & Ghazali, 2009).

2.4 Groundwater contamination

Groundwater can become contaminated in many ways. If surface water that recharges an aquifer is polluted, the groundwater will also become contaminated. Contaminated groundwater can then affect the quality of surface water at discharge areas. Groundwater can also become contaminated when liquid hazardous substances soak down through the soil into groundwater (Patil *et al.*, 2012). Ground water problem is not only resulted from natural factors but discharge of industrial effluents, agricultural, domestic sewage and solid waste dump causes the groundwater to become polluted and created health problems. This problem is not only effect to human health but also for living organisms (Idrus *et al.*, 2014).

The groundwater resource of the Kelantan Plain is the most extensive in Malaysia and it is one of the sources of domestic and agricultural water supply for many farmers (ENEX 1977). There are many possible sources of groundwater contamination for example is routine agricultural uses of fertilisers and pesticides are recognised increasingly as significant sources (Goodrich *et al.* 1991). Two activities related to agriculture that are particularly relevant to the interaction of groundwater and surface water are irrigation and application of chemicals to cropland (WATER, 1998). Use of pesticides, particularly insecticides and herbicides in paddy plantation is usually required for the successful cultivation of rice. Insecticides such as BPMC, carbofuran, endosulphan, and lindane are commonly used, while 2,4-D, paraquat and molinate are some of the common herbicides used for weed control (Cheah *et al.*, 1996).

Besides, tillage of land changes the infiltration and runoff characteristics of the land surface, which affects recharge to ground water, delivery of water and sediment to surface-water bodies, and evapotranspiration. All of these processes either directly or indirectly affect the interaction of ground water and surface water. Agriculturalists are aware of the substantial negative effects of agriculture on water resources and have developed methods to alleviate some of these effects. For example, tillage practices have been modified to maximize retention of water in soils and to minimize erosion of soil from the land into surface-water bodies (WATER, 1998).

2.4.1 Microbial in groundwater

Coliform bacteria include a large group of many types of bacteria that occur throughout the environment. They are common in soil and surface water and may even occur on your skin. Large numbers of certain kinds of coliform bacteria can also be found in waste from humans and animals (Levine 1941). Most types of coliform bacteria are harmless to humans, but some can cause mild illnesses and a few can lead to serious waterborne diseases. Coliform bacteria are often referred to as “indicator organisms” because they indicate the potential presence of disease-causing bacteria in water. The presence of coliform bacteria in water does not guarantee that drinking the water will cause an illness (Levine, 1941). Rather, their presence indicates that a contamination pathway exists between a source of bacteria which is in surface water, septic system, animal waste and the water supply. Disease-causing bacteria may use this pathway to enter the water supply.

Specific types of coliform bacteria may be tested for, especially after a total coliform bacteria test is positive. These subgroups of coliform bacteria include fecal coliform and *Escherichia coli* or *E. coli*. Fecal coliform bacteria are specific to the intestinal tracts of warm-blooded animals, including humans, and thus require a more specific test for sewage or animal waste contamination. *E. coli* is a type of fecal coliform bacteria commonly found in the intestines of animals and humans. A positive *E. coli* result is much more serious than coliform bacteria alone because it indicates that human or animal waste is entering the water supply. There are hundreds of strains of *E. coli*. Although most strains are harmless and live in the intestines of healthy humans and animals, a few strains can produce a powerful toxin and can cause severe illness and death (Desai, 2012).

Contamination of groundwater can result in poor drinking water quality, loss of water supply, degraded surface water systems, high clean-up costs, high costs for alternative water supplies and also potential of health problems. Therefore, the groundwater quality assessment and monitoring is necessary in order to ensure sustainable use of water.

2.5 Effect of groundwater pollution

Groundwater contamination is normally results of human activities either from municipal, industrial, commercial or agricultural. Pesticide contamination of ground water and surface water has become a major environmental issue. Recent studies indicate that pesticides applied to cropland can contaminate the underlying ground water and then move along ground-water flow paths to surface water (Zawawi *et al.*, 2010). In addition, as indicated by the following examples, movement of these pesticides between surface water and ground water can be dynamic in response to factors such as bank storage during periods of high runoff and ground-water withdrawals.

Applications of pesticides and fertilizers to cropland can result in significant additions of contaminants to water resources. Some pesticides are only slightly soluble in water and may attach to soil particles instead of remaining in solution these compounds are less likely to cause contamination of ground water. Other pesticides, however, are detected in low, but significant, concentrations in both ground water and surface water (Fauziah *et al.,* 2014).

2.6 Physical parameter for water quality

To use water for daily used like drinking, domestic, agriculture or industrial, it is important and essential to test the water before consumed it. Water must be tested with the different physic-chemical parameters to know its quality. To test the water, we must know the purpose on how we are going to use the water and what extent we need its quality and purity. Water does content different types of floating, dissolved, suspended and microbiological as well as bacteriological impurities (Patil *et al.,* 2012). Some of the physical test should be performed to analysis water quality such as pH, temperature, dissolved oxygen, electrical conductivity, turbidity, total dissolved solid and salinity. Following different physical parameters are required for monitoring of the water quality.

2.6.1 pH

pH is essential for determining the corrosive nature of water. Lower the pH value is higher the corrosive nature of water. pH is used to measure the acidity of a solution of water. The pH scale commonly ranges from 0 to 14. For example, a solution with a pH of 6 is ten times more acidic than a solution with a pH of 7. Pure water is said to be neutral, with a pH of 7. Water with a pH below 7.0 is considered as acidic while water with pH greater than 7.0 is considered as basic or alkaline.

According to Gupta *et al.,* (2009), pH was positively correlated with electrical conductance and total alkalinity. The reduced rate of photosynthetic activity the assimilation of carbon dioxide and bicarbonates which are ultimately responsible for increase in pH, the low oxygen values coincided with high temperature during the summer month. Various factors bring about changes the pH of water. The higher pH values observed suggests that carbon dioxide, carbonate-bicarbonate equilibrium is affected more due to change in physico-chemical condition (Karanth, 1987).

2.6.2 Dissolved Oxygen (DO)

Dissolved oxygen is one of the most essential parameter for water quality. Its correlation with water body gives direct and indirect information such as bacterial activity, photosynthesis, availability of nutrients and stratification (Patil *et al.*, 2012). If the temperature higher, the values of dissolved oxygen will be decreased and due to higher of activity of microbial inside the water the dissolved oxygen decreased. A low DO which is less than 2 mg/L would point out poor water quality and thus would have difficulty in sustaining many sensitive aquatic lives.

2.6.3 Electrical Conductivity

Electrical conductivity is the ability of aqueous solution to carry on electrical current. The ability of the solution is depends on the presence of ions, total concentrations and the temperature of liquid. Usually, good conductors are resulted from the solution which is have most inorganic acids, bases and salts (Gorde & Jadhav, 2013). Besides, for conductivity of distilled water is less than µmhos/cm.

2.6.4 Turbidity

Turbidity may be due to organic and/or inorganic constituents. Organic particulates may harbour microorganisms. Thus, turbid conditions may increase the possibility for waterborne disease. Turbidity is caused by wide variety of Suspended particles (Tiwari, 2015).

2.6.5 Temperature

According to Najah *et al.*, (2003) physical conditions of water temperature change with climate change in the environment. This change occurs seasonally and its influenced by factors such as latitude, longitude, time, air convection, cloud cover and water. It can affect physical processes, chemical and biological processes affect the natural well water ecosystems.

2.6.6 Total Dissolved Solid (TDS)

Total dissolved solid are more vital measurements to be considered when examining water quality. TDS comprise inorganic salts and small amounts of organic matter that are dissolved in water. It determines the suitability of water for agriculture uses. Since total dissolved solids are not easily measured except under controlled conditions in reputable laboratories, and it was found there is a positive correlation existed between conductivity and dissolved materials (Patil *et al.*, 2012).

2.7 Water quality standard

One of the characteristics of water is to make it acceptable to the needs of particular purpose. Table 2.1 shows the WHO and National Water Quality Standard of Malaysia.

Table 2.1 Permisible limit of drinking water for WHO and National Water Quality Standard of Malaysia

Parameter	Unit	World Health Organisation (WHO)	National Water Quality Standard of Malaysia
pH	-	6.5-8.5	6.5-8.5
Temperature	˚C	25-30	25-30
Dissolve Oxygen	mg/L	7.5	7.0
Electrical conductivity	µS/cm	1000	1000
Turbidity	NTU	1	5
Total dissolve solid	mg/L	1000	500
Biochemical Oxygen Demand (BOD)	mg/L	1	1
Salinity	%	0.5	0.5
Faecal Coliform	Count/100ml	10	10
Total Coliform	Count/100ml	100	100

2.8 Groundwater study in Kelantan

Kelantan's climate is tropical monsoon, with stable temperatures ranging from 21 to 32 °C. Dry and warm weather with consistently high humidity on the lowlands ranging from 82 to 86 % are seen through January to April. It has an average yearly rainfall of 2,540 mm, with the wettest months being from November through January (Mohamed Azwan *et al.*, 2010).

The uses of public water supply in Kelantan were 1,086,840 (about 65%) out of Kelantan population (1,666,000) (Idrus *et al.*, 2014). The total number of population was recorded until December 2013 (Idrus *et al.*, 2014). The total population used the water supply include household that use two sources of water supply which is from public utilities and also alternative source of water supply such as groundwater and gravity feed system (GFS) (Idrus *et al.*, 2014). However, the rest of Kelantan population which is 35% are kindly depends on the alternative source of water supply (groundwater and Gravity Feed System) especially in rural area (Idrus *et al.*, 2014)

According to Zawawi *et al* (2010), their previous study was carried out to evaluate the influence of groundwater on nitrate-nitrogen concentration in a paddy field. Fertiliser if applied excessively can cause leaching into the soil and will penetrate deep into the soil and eventually contaminate the groundwater. Nitrates in groundwater is soluble hazardous to users. Their work was carried out at Ladang Merdeka Ismail Mulong, Kota Bharu, Kelantan to determine groundwater and nitrate-nitrogen flow using ArcGIS in a Geographical Information System (GIS) environment to produce groundwater level and nitrate concentration variation maps. The results showed that the average nitrate level was 4.81 mg/l with a maximum value of 17.16 mg/l. The groundwater levels in this area ranged from 3.75 to 6.52 meters above mean sea level with an average of 5.65 meters. In the paddy field, the nitrate levels variation was non uniform. In general, the nitrate levels in the paddy field were quite low.

CHAPTER 3

MATERIALS AND METHODS

3.1 Study area

The study area is located at Kampung Paloh in Tanah Merah, Kelantan. Five different houses using boring water was chosen for sampling locations in this study. The houses was marked as Location A, B, C, D and E and the coordinate for each locations was determined by Global Positioning System (GPS) as shown in Figure 3.1 and Table 3.1. A water table of the study area was also measured and its GPS location is shown in Table 3.2.

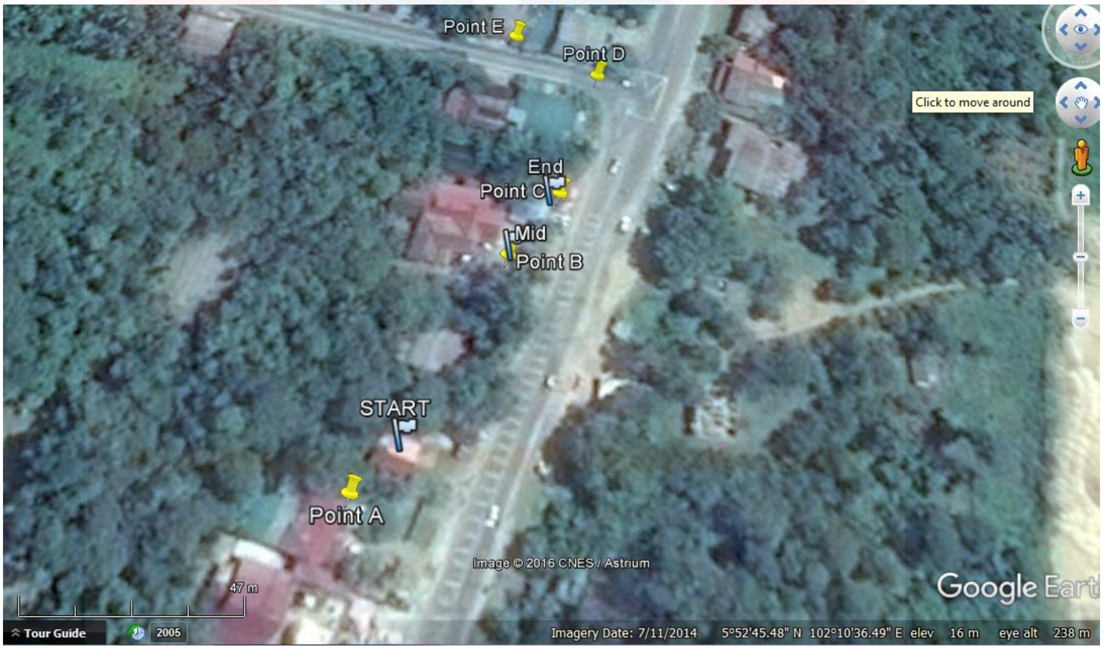

Figure 3.1: Geological map for boring water at Kg Paloh, in Tanah Merah, Kelantan.

Table 3.1: GPS location of boring water at Kampung Paloh.

GPS value / Location	Latitude/y	Longitude/x
A	5° 52' 41.988"	102° 10' 30.234"
B	5° 52' 43.881"	102° 10' 31.317"
C	5° 52' 44.4432"	102° 10' 31.7238"
D	5° 52' 45.588"	102° 10' 32.0442"
E	5° 52' 46.0014"	102° 10' 31.3422"

Table 3.2: GPS location of water table near Kampung Paloh.

GPS location / ABEM Point	Latitude/y	Longitude/x
Starting	5° 52' 42.384"	102° 10' 30.6294"
Centre	5° 52' 43.9324"	102° 10' 31.3998"
End	5° 52' 44.988"	102° 10' 31.71"

3.2 Materials and Methods

In this experiment, total five water samples were collected from five different dry wells at Kampung Paloh in Tanah Merah, Kelantan. All the samples were collected in sterilized bottles and were stored at 4°C within 24 hours. The analysis of water- quality parameters was carried out as per standard methods of WHO. Table 3.3 and 3.4 show the list of apparatus and reagents that were used in this study.

Table 3.3: List of apparatus.

NO.	APPARATUS
1.	Abem Terrameter LS Resistivity Imaging System
2.	YSI Multiparameter
3.	Glass bottle
4.	Global Positioning System (GPS)
5.	Hammer
6.	Measuring tape
7.	Ice box
8.	Incubator
9.	Sterile vessel
10.	Petri dish
11.	BOD bottle
12.	Microscope
13.	Clean glass slide
14.	Inoculating loop
15.	Bunsen burner
16.	Immersion oil
17.	Lens paper and lens cleaner

Table 3.4: List of reagents.

NO.	REAGENT
1.	Nutrient agar
2.	Iodine (Primary stain)
3.	Safranin (Mordant)
4.	Alcohol (Decolourization)
5.	Crystal violet (Secondary stain)

3.3 Geoelectrical resistivity survey

The geoelectrical resistivity survey was conducted to determine the thicknesses and water table of the aquifers in the study area. The resistivity measurements were carried out using ABEM terrameter as shown in Figure 3.2. The terrameter which consist of two separate units uses a low frequency alternating current (4 Hz) to measure the earth resistance. For all the soundings that were carried out, the Wenner array was used. A total of 41 soundings with current electrode separation of up to 100 metres were conducted.

Figure 3.2: ABEM Terrameter

3.4 In-situ analysis

For In-situ analysis, YSI multi-parameters as shown in Figure 3.3 were used to evaluate the current status of water quality performance for dissolved oxygen (DO), pH, turbidity, temperature and conductivity of the water samples. Distilled water was used to clean the probe to measurement. This test was conducted along with the sampling process where the water was collected in the bucket for testing procedure. YSI sensor meter that has been stabilized were placed into the bucket containing groundwater sample for at least 10 minutes. Then, all the data were recorded.

Figure 3.3: YSI multi-parameter

3.5 BOD test procedure

A specialized 300 mL BOD bottles designed to allow full filling with no air space and provide an airtight seal are used. The bottles are filled with the sample to be tested or dilution (distilled or deionized) water and various amounts of the wastewater sample are added to reflect different dilutions. At least one bottle is filled only with dilution water as a control or "blank."

A DO meter is used to measure the initial dissolved oxygen concentration (mg/L) in each bottle (DO_i). Each bottle in then placed into a dark incubator at 20°C for five days. After five days the DO meter is used again to measure a final dissolved oxygen concentration (mg/L) (DO_f).

The final DO reading is then subtracted from the initial DO reading and the result is the BOD concentration (mg/L). If the wastewater sample required dilution, the BOD concentration reading is multiplied by the dilution factor.

$$BOD_5 = \frac{DO_i - DO_f}{\frac{V_b}{V_s}} \quad \text{(Eq 3.1)}$$

BOD_5 = Biochemical oxygen demand at t days (mg/L)

DO_i = initial dissolved oxygen in the sample bottle (mg/L)

DO_f = final dissolved oxygen in the sample bottle (mg/L)

V_b= sample bottle volume. 300 ml

V_s= sample volume (ml)

Note that the $\frac{V_b}{V_s}$ is the sample dilution

3.6 Microbiological Sampling procedure

For precaution step, icebox were used to maintain a sample temperature of 4 degree celcius. All the samples were labelled with location, name, data and time. For microbiological test, the sterilized vessels without sodium thiosulphate were used to collect the water sample. While dark glass bottle samples were used for BOD test. The other precaution step is, before collecting the sample, all the pipe connected to the bore holes were cleaned and flamed by using Bunsen burner. Then, the pipe was open for several minutes before sample water is collected to clear the service line. Lastly, sample water were capped and stored in ice box until before reach laboratory for microbiological and BOD analysis.

3.7 Microbial test

This method is based on isolation and gram staining method. In isolation method there are five steps procedure which is described as below.

3.7.1 Step 1: Diluting the original sample

1 mL of the original sample was added to 9 mL of sterile diluent and the samples were mixed together. The new sample (dilution 1) has a cell concentration (number of cells/ml) $1/10^{th}$ of the original sample (i.e. it is a 1 in 10 or 10^{-1}dilution). Dilution 1 contains the cells in 1 mL of the original sample now spread through the

10 mL of dilution 1. Thus, each 1 mL of dilution 1 contains 1/10th the number of cells in each ml of the original sample as illustrated in Figure 3.4.

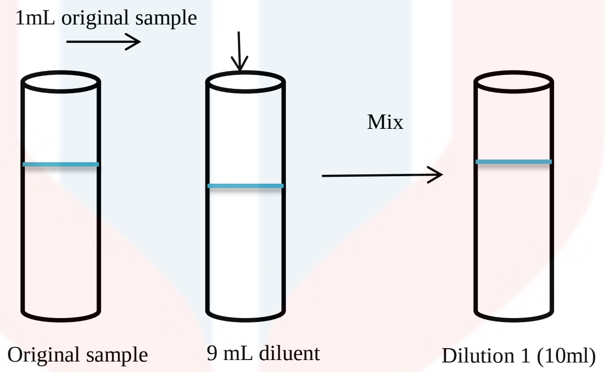

Figure 3.4: Process diluting the original sample

Next, 1 mL of dilution 1 is added to 9 mL of diluent to make dilution 2. Now, dilution 2 has a cell concentration 1/10th of that of dilution 1 and so has a cell concentration of 1/100th that of the original sample. Dilution 2 is a 1 in 100 or 10^{-2} dilution of the original sample. The dilution process was repeated until a series of dilutions were prepared as illustrated in Figure 3.5.

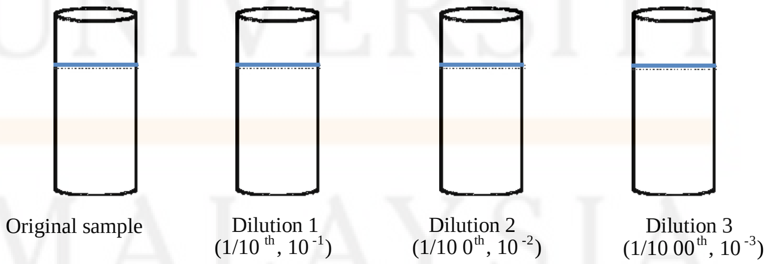

Figure 3.5: Dilution Process

3.7.2 Step 2: Plating the dilution series

This step was done in order to estimate their cell concentrations.1 mL of a dilution 1 was pipetted on to the surface of an agar plate and spread evenly using a sterile glass rod as illustrated in Figure 3.6. The step was repeated for dilution 2 and dilution 3.

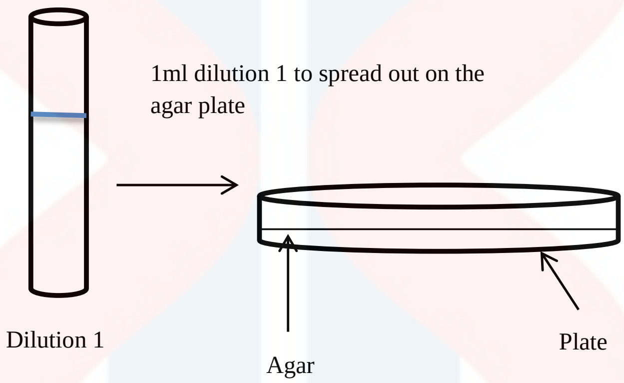

Figure 3.6: Process of spread out the dilution on the agar plate.

3.7.3 Step 3: Incubating the plates

The plates were incubated at 37 °C in incubator for 24 hours before. During incubation of the agar plates, each viable cell (invisible to the naked eye) that was spread to a discrete position on the agar surface will grow and divide many times to form a visible colony of microorganisms. Thus, incubating the plates enables to estimate the number of cells that were present in the 1 ml of the sample spread on the plate.

3.7.4 Step 4: Counting the colonies

After 24 hours of incubation, the plates were taken out in order to count the colonies of the bacteria that were presence. The incubated agar plates have different numbers of colonies on them depending on the dilution of the sample**.**

3.7.5 Step 5: Gram staining procedure

To prepare the slide, a sterile cooled loop was used, a drop of sterile water or saline solution on the slide was placed. The loop was sterilized and cools again and a very small sample of a bacterial colony was picking up and gently stirred into the drop of water/saline on the slide to create an emulsion. For the Gram Staining procedure, four types of solution were used. Firstly, crystal violet stain was added over the fixed culture. The prepared slide was let for 10 to 60 seconds. The stain was pouring off and gently rinsed the excess stain with a stream of water from a plastic water bottle. Note that the objective of this step is to wash off the stain, not the fixed culture. Next, the iodine solution was added on the smear, enough to cover the fixed culture. The slide was let for 10 to 60 seconds. The iodine solutions were pouring off and rinsed the slide with running distilled water. The excess water from the surface was shaken off. A few drops of alcohol were used as decolorizer so the solution trickles down the slide. After 5 seconds rinsed it with distilled water. When the solvent is no longer coloured it is the exact time to stop as it flows over the slide. Further delay will cause excess decolorization in the gram-positive cells, and the purpose of staining will be defeated. Lastly, the safranin was used to counter-stain and let stand for 45 seconds. Tilt the slide slightly and gently rinse with tap water or distilled water using a wash bottle. The smear was view using a light-microscope under oil-immersion.

CHAPTER 4

RESULT AND DISCUSSION

In this chapter the results are shown in tables and graphs followed by detailed discussion. The in situ parameters of groundwater samples from Kampung Paloh, Tanah Merah will be discussed and the obtain values will be compared with National Water Quality Standard and WHO Standard in order to observe physical and microbiological parameters. On the other hand, the depth of the water table obtained from LS Resistivity Imaging System will also be presented in order to compare with the depth of the residence's boring water system.

4.1 Water quality analysis

For complete analysis and discussion of the research on the water quality at Kampung Paloh in Tanah Merah, Kelantan, several parameters of water quality have been used to determine its quality.

4.1.1 Physico-chemical analysis

YSI-Multiparemeter was used in order to determine pH**,** temperature, dissolved oxygen (DO), electrical conductivity, turbidity, total dissolved solid and salinity of the water sample.

4.1.1.1 pH

Figure 4.1 shows, the pH of groundwater samples at five locations in Kg Paloh. Based on the results, all the samples were found slightly acidic. The highest pH reading is 5.27 at point A and the lowest pH is 5.01 at point E which is lower than the normal range of pH for groundwater system which is 6.5 to 8.5.

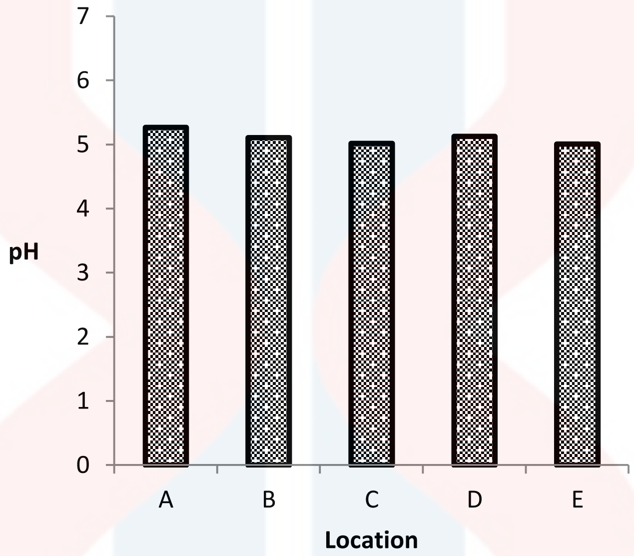

Figure 4.1: Distribution of pH in groundwater at five different locations at Kampung Paloh,Tanah Merah, Kelantan.

The pH of groundwater varies depending on the materials contains in the groundwater like the composition of the rocks and sediments that surround the travel pathway of the recharge water infiltrating. A low pH in this case may be attributed by the reaction of carbon dioxide from surrounding before the water samples were tested. According to National Center for Biotechnology Information (2010), the acidity of some drinking water has potential to cause acidosis in the body. Acidosis can cause irreversible cell damage, lower bone density and immune body response.

4.1.1.2 Temperature

The temperatures of water for all sampling locations were the range of 26.0 to 27.99 °C as shown in Figure 4.2. Temperature is a regulator of the solubility of gases and minerals (solids) or the amount of these materials could be dissolved in water. The solubility of important gases, such as oxygen and carbon dioxide increases as temperature decreases (Boundless, 2016).

Based on the figure, the temperatures are more or less similar and there are no significant differences of temperature between the locations. Besides, the temperatures for all locations are within the standard level of National Water Quality Standard and WHO drinking water quality standard as refer to Table 2.1 and in Chapter 2.

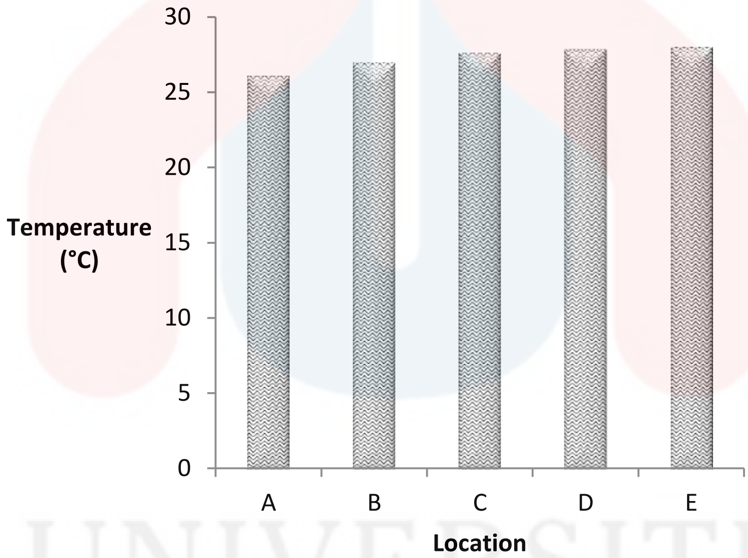

Figure 4.2: Distribution of temperature in groundwater at five different locations at Kampung Paloh in Tanah Merah, Kelantan.

4.1.1.3 Dissolved oxygen (DO)

Figure 4.3 shows the DO of five locations in Kg Paloh. Based on figure it is concluded that the of DO concentration is below the required Standard of National Water Quality Standard and WHO which recommended 7.5 mg/L and 7.0 mg/L respectively. The highest DO concentration recorded was 4.39 mg/L at location A. Oxygen may be present in water due to direct diffusion from air and photosynthetic activity of autotrophs. Concentration of DO is one of the most important parameters to indicate water purity and to determine the distribution and abundance of various algal groups. Overall DO value in study area is under permissible limit of WHO.

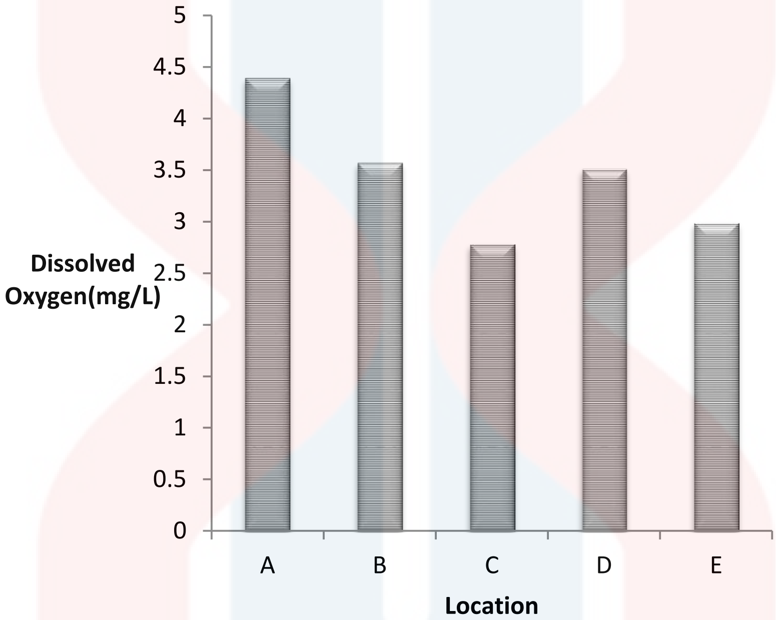

Figure 4.3: Distribution of dissolved oxygen (DO) in groundwater at five different locations in Kg Paloh,Tanah Merah, Kelantan.

4.1.1.4 Conductivity

Electrical conductivity is a measure of water capability to transmit electric current and also it is a tool to assess the purity of water. The conductivity of all locations was illustrated in Figure 4.4. Based on figure electrical conductivity found in the range 32 to 42 (µS/cm). The highest conductivity recorded were at Location A which is 42 µS/cm whereas Location C has the lowest conductivity which is 32 µS/cm. This amount shows that the groundwater sample can be safely used for drinking purpose. The more salts in water, the better conductor it becomes. The National Water Quality Standard and WHO standard required for conductivity is 1000µS/cm respectively.

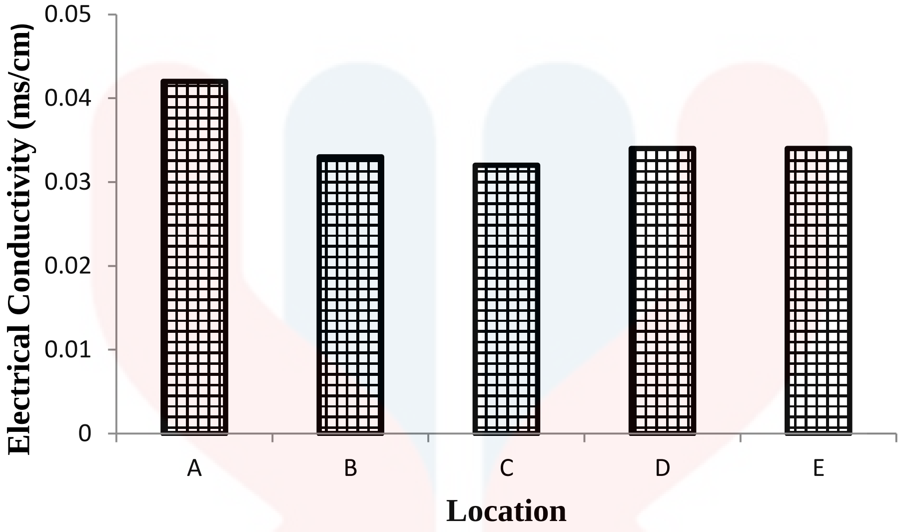

Figure 4.4 Distribution of electrical conductivity in groundwater at five different locations in Kg Paloh,Tanah Merah, Kelantan.

4.1.1.5 Turbidity

Turbidity is measure of the amount of particulate matter and dissolved colour that is suspended in water. Water that has high turbidity appears cloudy. High turbidity can cause high temperature of water because of suspended particles absorb more heat and can also reduce the amount of light penetrating the water. Turbidity can range from less than 1 NTU to more than 1,000 NTU (Falconer, 2003). At 5 NTU, water is visibly cloudy at 25 NTU, it is murky.

Figure 4.5 shows the turbidity of five locations in Kampung Paloh. Based on the figure Point A has the highest turbidity which is 1.84 NTU while the lowest turbidity recorded is 0.34 NTU at Point D. The standard turbidity value for drinking water based on National Water Quality for Malaysia is 5 NTU which is for Class 1. For this research, this value is higher from the permissible limit of WHO but can still be accepted because the highest value is 1.79 NTU which is before filtering. After filter the value might be under 1.0 NTU which is suitable for drinking water and safe to human health. As the Table 4.2 shows the value of reference point which is the value of turbidity is 0.53 NTU after filtering. Turbidity of water is caused by suspended matter such as clay, silt, and organic matter (Falconer, 2003).

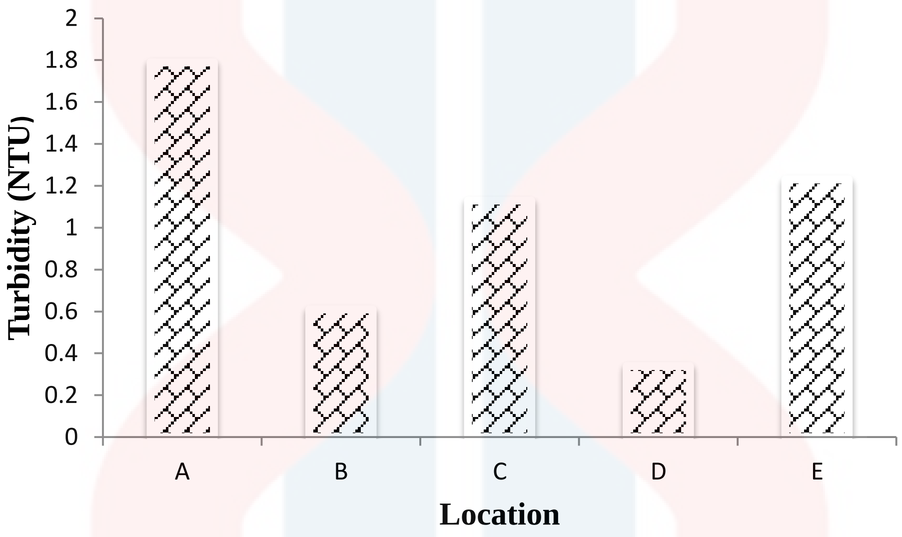

Figure 4.5: Distribution of turbidity in groundwater at five different locations in Kg Paloh,Tanah Merah, Kelantan.

4.1.1.6 Total Dissolved Solid

Total dissolved solids is measure in miligrams per liter (mg/L) of the amount of dissolved materials in water. Ions such as potassium, sulfate, calcium, and magnesium is contributed to the dissolved solids in groundwater (Gupta *et al*, 2009). For the TDS, permissible limits is 1000 mg/L by using WHO drinking water quality standards and for National Water Quality standard for Malaysia is 500 mg/L. Figure 4.6 shows TDS result at five locations in Kampung Paloh. Based on the results the highest TDS value is at Point A which is 26 mg/L. All the values show the permissible value limits of WHO for TDS. High TDS values in water will be resulted in a salty taste of the water. Groundwater often has higher levels of dissolved solids than surface water because of its contact with aquifer geologic material and more time to dissolve rock and mineral materials (National Center for Biotechnology Information, 2010).

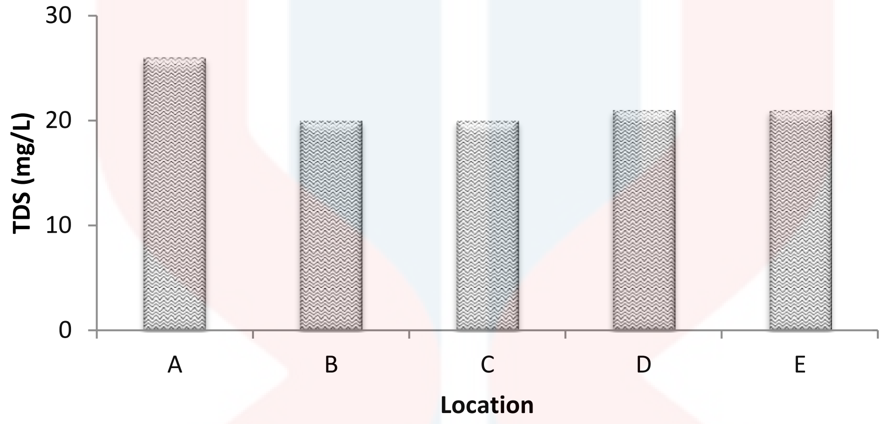

Figure 4.6: Distribution of total dissolved solid in groundwater at five different locations in Kg Paloh,Tanah Merah, Kelantan.

4.1.1.7 Salinity

Salinity is the saltiness or dissolved salt content of a body of water and also soil salinity. Salinity is an important factor in determining many aspects of the chemistry of natural waters and of biological processes within it, and is a thermodynamic state variable that, along with temperature and pressure, governs physical characteristics like the density and heat capacity of the water (National Center for Biotechnology Information, 2010). Figure 4.7 shows the salinity results for five locations at Kampung Paloh. Based on the figure salinity is found highest at Point A which is 0.02 mg/L. The WHO and National Water Quality Standard required for salinity is 0.5% .

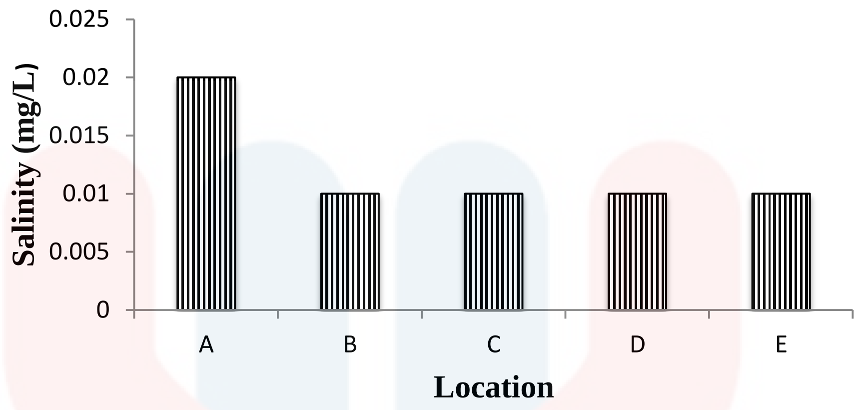

Figure 4.7: Distribution of salinity in groundwater at five different locations in Kg Paloh,Tanah Merah, Kelantan.

4.1.1.8 Biochemical Oxygen Demand (BOD)

The amount of oxygen required to completely oxidize the organic compounds to carbon dioxide and water through generations of microbial growth, death and decay is total biochemical oxygen demand (total BOD). Figure 4.8 shows BOD results of five locations at Kampung Paloh. Based on the figure, the highest BOD reading is at Point C which is 0.27mg/L. The standard BOD value for drinking water based on National Water Quality for Malaysia is 1mg/L which is for Class 1. All the values show the permissible value limits of National Water Quality for Malaysia for BOD.

Generally, when BOD levels are high, there is a decline in DO levels. This is because the demand for oxygen by the bacteria is high and they are taking that oxygen from the oxygen dissolved in the water. If there is no organic waste present in the water, there won't be as many bacteria present to decompose it and thus the BOD will tend to be lower and the DO level will tend to be higher (National Center for Biotechnology Information, 2010).

Table 4.1: Biochemical Oxygen Demand (BOD) reading

Location	Dissolved oxyen (DO_i)(mg/L)	Dissolved oxygen (DO_f)(mg/L)	Biochemical Oxygen Demand (BOD)(mg/L)
A	7.93	7.84	0.27
B	7.89	7.84	0.15
C	7.78	7.74	0.12
D	7.92	7.86	0.18
E	7.90	7.86	0.12

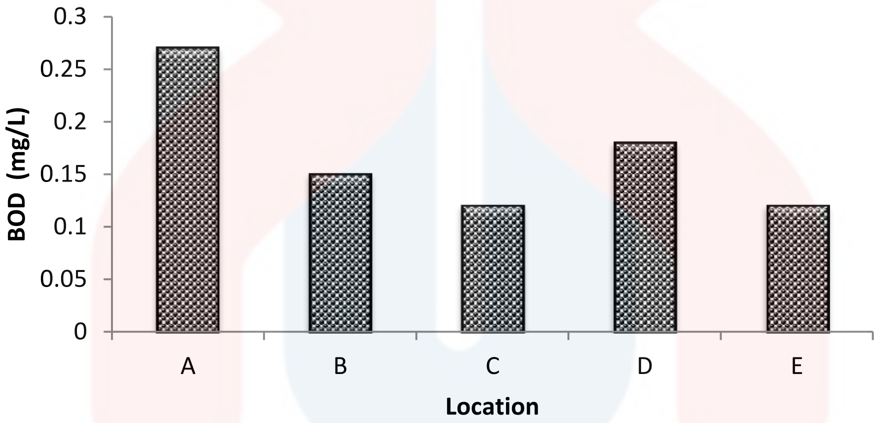

Figure 4.8: Distribution of BOD in groundwater at five different locations in Kg Paloh,Tanah Merah, Kelantan.

4.1.2 Microbiological analysis

Microbiological analysis was performed to check the present of total Coliform and *E. Coli* in the sample. This test was conducted using gram staining where the result obtained is interpreted based Figure 4.9 and Figure 4.10. Coliform bacteria are a commonly used indicator of sanitary quality of foods and water.

Gram-positive cells have a thick peptidoglycan cell wall that is able to retain the crystal violet-iodine complex that occurs during staining, while Gram-negative cells have only a thin layer of peptidoglycan. Thus Gram-positive cells do not decolorize with ethanol, and Gram-negative cells do decolorize. This allows the 09Gram-negative cells to accept the counter stain safranin. Gram-positive cells will appear blue to purple, while Gram-negative cells will appear pink to red.

From the results, all the samples show that the Coliform and *E. Coli* bacteria are present. Based on Figure 4.9 it can be seen that the gram-negative bacilli *E. Coli* present in a rod shape. However, the results also indicates the presence of gram-positive cocci *Staphylococcus Aureus* in a sphere shape.

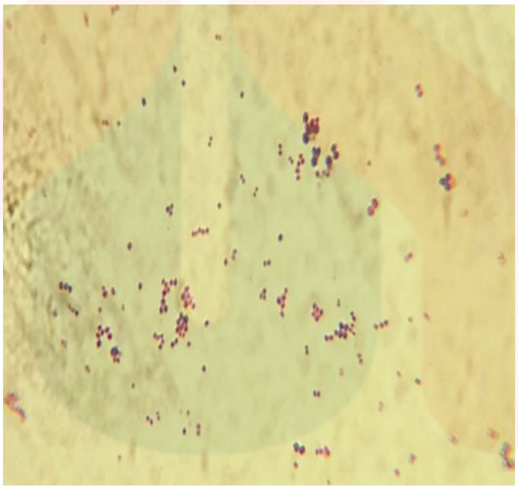

Figure 4.9: Gram-positive cocci *Staphylococcus Aureus* (sphere shape)

Figure 4.10: Gram-negative bacilli *Escherichia Coli* (rod shape)

4.1.3 Summary

Table 4.2 below shows the summary of values obtained for each parameter from the tests carried out on the five samples of groundwater taken at Kg Paloh, Tanah Merah, Kelantan. The result shows the average reading (three times reading) for each parameter and also the reference point which is the value of water sample after filtering. The tests were conducted as an In-situ analysis. The YSI multi-parameter was used for conducting this test.

Table 4.2: Average reading of the parameter

Parameter	WHO drinking water quality	Groundwater sampling location					Reference Point
		A	B	C	D	E	
pH	6.5-8.5	5.27	5.11	5.02	5.13	5.01	7.25
Temperature	25-30	26.08	26.95	27.63	27.85	27.99	27.32
DO (mg/L)	7.5	4.39	3.57	2.78	3.51	2.99	6.73
Conductivity (µS/cm)	1000	42	33	32	34	34	291
Turbidity (NTU)	1	1.79	0.61	1.13	0.34	1.23	0.53
TDS mg/L	1000	26	20	20	21	21	210
Salinity (%)	0.5	0.02	0.01	0.01	0.01	0.01	0.1
BOD (mg/L)	1	0.12	0.15	0.27	0.18	0.12	-
Total Coliform	Count/100	103x10^3	79.3x10^3	70x10^3	19.33x10^3	15x10^3	-
Faecal Coliform	Count/100	1.67x10^3	9.3x10^3	2.67x10^3	1x10^3	2.3x10^3	-

4.1.4 Water table analysis

Figure 4.11 below shows the geo-electrical pseudosections which indicate the distribution of apparent resistivity of groundwater table in the study area. A total of

42 soundings with current electrode separation of up to 100 metres were conducted by using Abem Terrameter LS Resistivity Imaging System. For all the soundings that were carried out, the Wenner array was used.

Based on the Figure 4.11, a resistivity value ranging between 29 ohmm and 310 ohmm is observed from the surface level to a depth of around sixteen metre. This result indicates that there is no water found from the surface to 16 m depth due to invisible of blue colour detection. However, at the upper layer on the left side, there is a spot of blue colour which might be due to the drainage appear at that point.

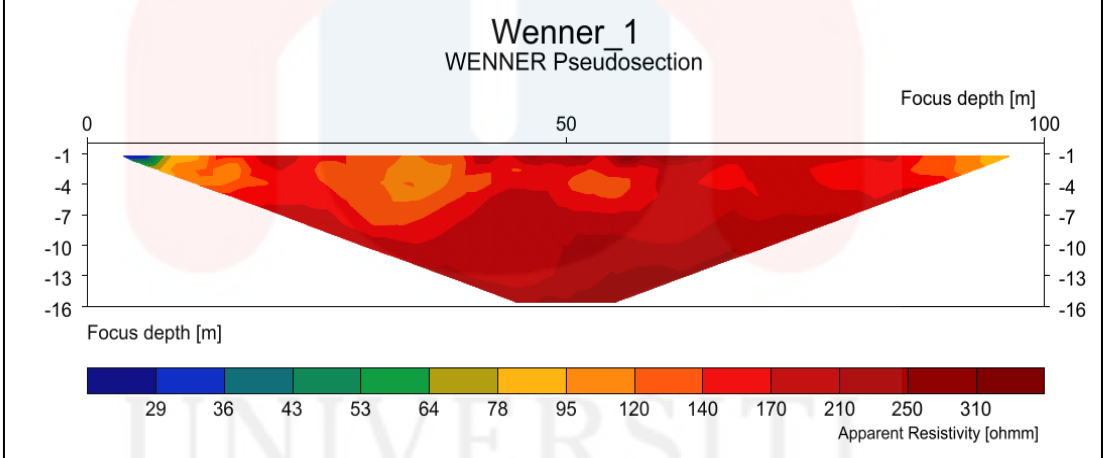

Figure 4.11: Water table analysis result

Figure 4.12 below show the resistivity data analysis based on the type of rock and mineral that contains inside the aquifer. The blue colour represents the water presence inside the groundwater table. Red colour represents massive sulphides which is graphite and graphitic rocks.

From this research, the data recorded that a lot of massive sulphides inside the water table. Because of that, the water table only can be found at sixteen metre and above. Apart from that, the construction like sand mining around the study area also contributes to the depth of water table.

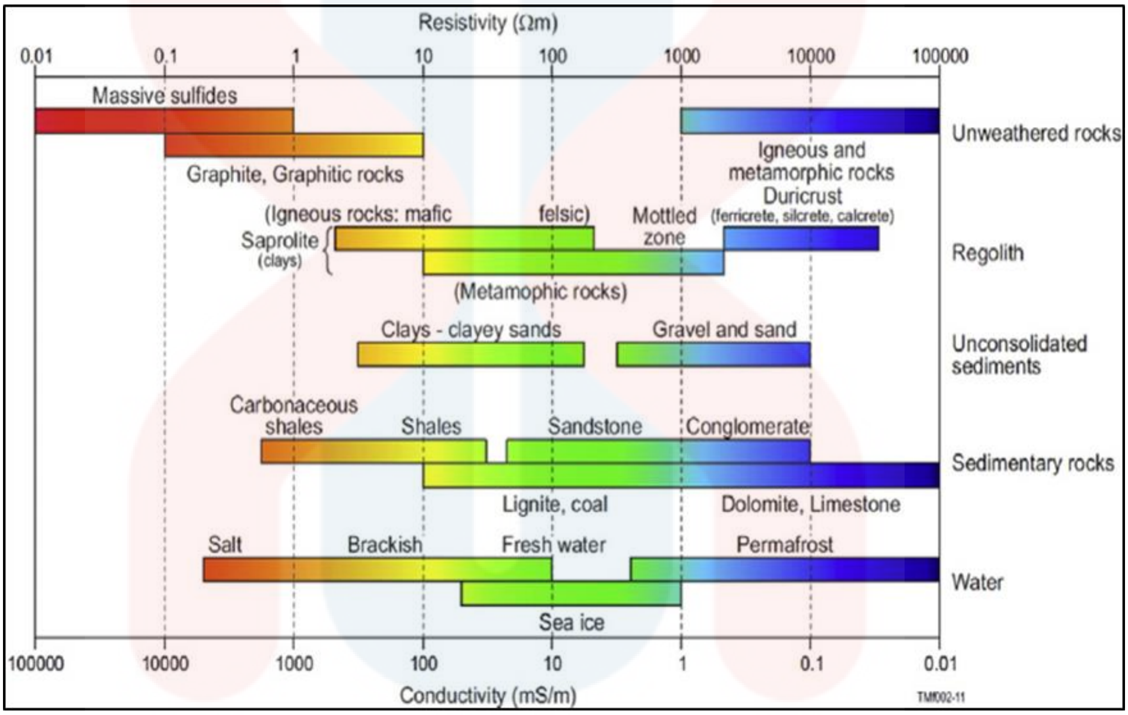

Figure 4.12 : Resistivity data analysis

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

Based on the objectives of the research that have been stated in Chapter 1 and the result that have been discussed in chapter 4, we can conclude that the groundwater in the study area is suitable for drinking water and other household purposes. Most of the elements that have been analysed are under the permissible limit of WHO and Malaysia National Water Quality Standard. After comparing results with WHO and Malaysia National Water Quality Standard, all the samples for physical and microbiological parameter which is pH, temperature, dissolved oxygen, electrical conductivity, turbidity, total dissolved solid and salinity were accepted for drinking water purposes.

By using ABEM Terrameter, the water table at the Kampung Paloh were determined. Residences used the bore hole around eighty to ninety feet (25 metre) of the water table. From this research, the depth of water table that could found which is sixteen metre only. Due to this reasons, water supply used by the local peoples are follow the water table level.

The physico-chemical and microbiological parameters of groundwater also recorded. All the physico-chemical parameter that has been tested is under the permissible limit of WHO and National Water Quality Standard of Malaysia. Apart from that, the value that has been tested was before filtering, but it still under permissible limit of WHO and National Water Quality Standard. So that, after filtering the quality of the water will be more better.

As the research only checked for physical and microbiological parameter, the chemical contains inside the water is unknown. For example, for total dissolved solid, we just determined the values of TDS but we cannot know the type of chemicals inside the water.

5.2 Recommendation

From this research, some recommendations are made in order to improve future research for better understanding of groundwater quality in Kelantan. Since this research only determined the physico-chemical and microbiological parameter thus, only little information can be extracted from the groundwater quality. Therefore, for further research it is recommended that the chemical parameters such as metals and organics content can be examined. This is because the groundwater usually contains calcium, magnesium, iron, aluminium and etc.

In the current research, only five locations were selected for groundwater sampling. So, the results obtained from this study cannot represent Tanah Merah as a whole. Therefore, it is suggested that more locations will be added in the in order to get more reliable data information on the groundwater quality in Tanah Merah, Kelantan or any other part in this state.

Lastly, for the geoelectric resistivity, only the raw data was interpreted. This data should be further analysed using special software in order to extract more data about the groundwater aquifers such rocks or nutrients that contains inside the groundwater. We can also know the type of watershed and type of groundwater like shallow or deep based on rocks contains inside the aquifers.

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