Chapter 1
Introduction

1.1. Description of the Study Area

The study area is known as the North Kelantan Quaternary sediment lies within the latitude 5.83N and 6.23 N and longitude 102.14 E and 102.44 E. It is located in the northern portion of the State of Kelantan which is on the north-eastern coast of Peninsula Malaysia (Figure 1.1). The area covers approximately 487 Km^2 which of the surface elevation is less than 35 m above mean sea level.

Accessibility within the study area is averagely good. Kota Bharu is the State capital of Kelantan which linked to the city of Kuala Lumpur about 490 km away by a fairly good road. The quickest way is by air which takes only 45 minutes. The land uses are mainly for seasonal agricultural activities (tobacco and other vegetable) at the northern region. While in the middle region, paddy field dominates the area with a good artificial drainage system which also can be found in the north and the south region. At the southern region, palm oil plantation is found in almost all of the area which extends to upstream around 15 km away from the south border of study area.

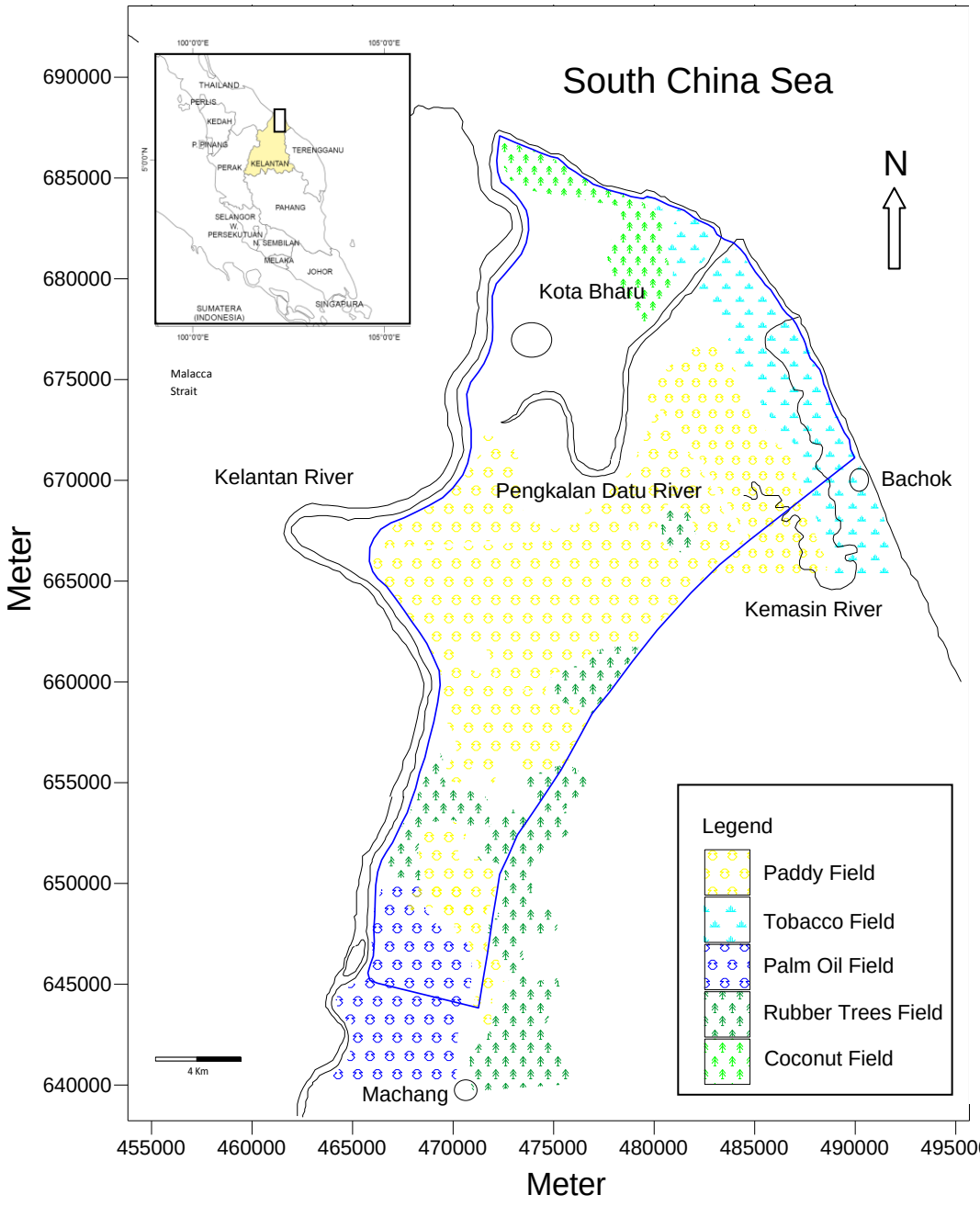

Figure 1.1. Location and land use map of study area. The RSO West Malaysia (Rectified Skew Orthomorphic West Malaysia) system and Kertau 1946 are used as the coordinate system and datum in the map.

1.1.1 Geology and Hydrogeology

The North Kelantan river plain is covered with Quaternary sediments overlying granite bedrock. It is drained mainly by short rivers and streams which flow into the South China Sea. The central part of the plain is drained by the largest river in the region, the Kelantan River, and in the South East, it is drained by Pengkalan Datu River. The thickness of the Quaternary deposits varies from 20 m inland to about 200 m near the coast. The loose quaternary sediments consist of alternating layers of coarse gravels to silts or mixtures of the two (Saim 1999). There are two main types of aquifers. The first aquifer is generally Shallow aquifers, mostly unconfined but occasionally confined or semi-confined, that has thicknesses 2-3 m and may reach up 15 m thick. The second type of aquifer present here are the Deep aquifers, mainly confined, with thicknesses of usually more than 15 m. These deep aquifers are comprised of three different layers, separated from each other by permeable clay strata (Saim 1999).

1.1.2. Groundwater Status

Groundwater is among the Nation's most important natural resources. It provides drinking water to urban and rural communities, supports irrigation and industry, sustains the flow of streams and rivers, and maintains riparian and wetland ecosystems. Being an important and integral part of the hydrological cycle, its availability depends on the rainfall and recharge conditions.

In State of Kelantan – Malaysia, especially in the North Kelantan, almost hundred percent urban and rural communities uses groundwater resource to fulfil their daily domestic use. In the area around Kota Bharu, domestic water for the communities is supplied by a water company (Air Kelantan Sdn Bhd). The company use mainly

water resources derived from groundwater, the rest is derived directly from the river. The company pump groundwater and apply some treatment for domestic supply (Ismail and Kiat, 1995). Meanwhile, in the southern and northeastern region of Kota Bharu, most of the communities use the groundwater of shallow aquifer derived from their conventional well (dug well) or borehole.

Groundwater quality depends on what cause of pollution, such as agricultural activity, its location close to the beach, or the natural process itself. The groundwater quality relate to agricultural contaminants such as nitrate and pesticides and also related with major chemical constituents, such as dissolved solids, hardness, and major ions such as sulphate, sodium, and iron (Kaushal et al., 2005; Almasri et al., 2004; Birkinshaw et al., 2000). In the coastal zone, there is a possibility of fresh groundwater contaminated by salt/brackish water. Groundwater resources along the coastal zone are vulnerable to saltwater intrusion. It is the movement of saline water into fresh-water aquifers, is most commonly caused by ground-water pumping near the coast (Carter et al., 2008; Samsudin et al., 2007; Leboeuf , 2004; Abdul Nasir et al., 2000).

One of the agriculture activities that might be contaminating groundwater within the area is chemical fertilizing with very high intensity and frequency including in palm oil and tobacco plantation area. A vast palm oil field covers approximately 42 km² of the upstream area of Kelantan River. Meanwhile tobacco plantation can be found 2 km wide along the beach line near Bachok and Tawang area. Within the area, mostly community use groundwater for their daily activities derived from their shallow dug wells.

An annual report from Mineral and Geosciences Department Malaysia indicate that high iron concentration in groundwater for certain area including Perol, Pintu Geng

pumping well station and other. Domestic water for community in the surrounding area to around Machang area is supplied from these pumping well stations.

1.2. Scope of the Study

Some of pioneering work using the geoelectrical resistivity imaging technique were carried out by Barker (1981), Griffiths et al. (1990), Griffiths and Barker (1993), Overmeeren van and Ritsema (1988) and Noel and Walker (1990). The usefulness of this method for solving a number of geoenvironmental problems is well introduced by Verma et al., (1983), Mazac et al., (1990), Barker (1990), Reynolds (1997), Banton at al., (1997), Loke (1999), Abdul Nassir et al. (2000), Leboeuf (2004), Samsudin et al. (2007; 2003; 1997) and Baharuddin et al. (2009), among other with different case studies. However, there has not been work on the application of the geoelectrical resistivity imaging to investigate chemical fertilizer in the agricultural area with different soil condition and heavy metal in the aquifer system. Moreover, a geoelectrical imaging survey has rarely been combined with laboratory measurements of soil and water samples taken from the investigated site, so that one can have a better guide to interpretation of the field values.

In this study, integrated methods of geoelectrical resistivity, hydrogeochemical and soil property analysis were used to conduct an investigation on groundwater and associated problem as the impact of land uses and natural condition of the fluvial and coastal plain. The results have the capability of exploring the groundwater potential and its associated problem within the study area. Besides to investigate the groundwater problem for the whole area, the study is also focusing on areas of particular interest. Several gamma ray borehole geophysics data and two new wells were used to assist on

geoelectrical resistivity interpretation. Hydrogeochemical method employed in-situ parameters (pH, temperature, total dissolved solid, conductivity and salinity) and main anion and cation analysis. Whilst, soil property analysis method used inversed auger method, moisture content and grain size analysis to obtain character of soil property. In order to obtain better result, all the data derived from each method were used for analysis and interpretation.

1.3. Importance of the Study

The groundwater in the southern area is most probably undergone pollution due to the agricultural activities. Consequently, an area located below this area is prone to contamination. Furthermore, most of the communities within the area utilize the shallow groundwater for their domestic uses. Exact information of the area has been contaminated and the possibility of its flow pattern is needed. (?)

In the middle part of the study area, the information of polluted groundwater by natural processes are important due to the area has a good storage for groundwater. The map of unpolluted fresh water potential aquifer is needed due to increasing fresh water demand.

In the northern part, occurrence of salt/brackish water in the subsurface is important to be detected. This is necessary because the water resources for urban area to the north are obtained from groundwater around this area. High pumping rate may cause extensive movement of salt/brackish water to the landward. In addition, the impact of high agricultural activity is needed to be investigated.

I.4. Aim and Objective

In the North Kelantan delta, there is no study to investigate groundwater characteristics using integration of geoelectrical resistivity, hydrogeochemical and soil property analysis. The aim of this study is to investigate the applicability of these combined methods to solve groundwater problem and its associated problem. The main research objectives are:

1. To explore the possibility of using geoelectrical resistivity method to study nitrate groundwater contamination.
2. To evaluate and monitor the chemical fertilizer (especially nitrate) concentration within the soil water and the specific mechanism of nitrate infiltration through the soil for specific soil property characteristics.
3. To study the subsurface boundary as control of groundwater movement.
4. To explain heavy metal in the soil that is related to the high heavy metal concentration in the groundwater.
5. To study correlation of resistivity and variation of the salt water content in soils that has different characteristics.
6. To study potential salt/brackish water in the aquifer and its associated problem.

1.5. Organization of Thesis

In order to gain a better insight of the groundwater characteristics and its associated problem, an independent field investigations and data collection of the area was carried out from March 2008 to November 2009. It is desirable that in any hydrogeological investigation a full support from geoelectrical resistivity, borehole geophysics, hydrogeochemical and soil property analysis methods is necessary in order to obtain subsurface information of the area concerned. However, some subsurface information was obtained from boreholes drilled by the Geological Survey (gamma ray data of several wells). Other information related to the present study such as rainfall data were obtained by the courtesy of Malaysian Meteorological Department (MMD, 2008). Some information on hydrology and water quality was kindly provided by Jabatan Mineral dan Geosains Malaysia – Kelantan.

The writing of this thesis is divided into seven chapters.

Chapter 1 is the introduction of the research

Chapter 2 is the physical environment of study area. This chapter deals mainly with the geological, hydrological and hydrogeologcal of the study area. The first is the brief of the previous research that has been done by other researcher. The next is providing the general geology background derived from several references. The division of study area into three areas, Area 1, Area 2 and Area 3 followed by the description of each area are presented in this chapter. Hydrology and hydrogeology of the study area is presented at the last of this chapter. This includes the rainfall, aquifers, source of groundwater, its uses and groundwater contamination.

Chapter 3 is the methodology and data acquisition. All methodologies used in this research is provided in this chapter including geophysical (geoelectrical resistivity and

borehole geophysics), hydrogeochemical and soil property analysis methods. The geoelectrical resistivity theory, equipment test, data acquisition and processing is the first presentation, followed by borehole geophysics, hydrogeochemical and soil property analysis methods.

Chapter 4 is the result and discussion of Area 1. In this chapter, the possibility of using geoelectrical resistivity method to detect nitrate in the soil water are examined. The next discussion is on the detail groundwater problem in Area 1 especially due to nitrate pollution from the agriculture activities. The discussion on the time lapse chemical fertilizer monitoring at the palm oil plantation and its associated problem is presented at the end of this chapter.

Chapter 5 is the result and discussion of Area 2. The searching of geoelectrical resistivity anomaly for the whole Area 2 is reported in this chapter. It is followed by the anomaly explanation and heavy metal delineation in aquifer system.

Chapter 6 is the result and discussion of Area 3. In this chapter, the study of the groundwater characteristics for whole Area 3 will be discussed. The first discussion is on the soil resistivity correlation with different soil characteristic and different percentage of sea water content. This result is useful in the geoelectrical interpretation especially emphasized on occurrence of salt/brackish water in the deeper aquifer. The last discussion is focused in time lapse chemical monitoring in the Bachok area where the fertilization activities is ongoing.

Chapter 7 is the conclusion and recommendation. This chapter will be more on conclusion derived from the study and followed by some recommendations for the future work.