UNIVERSITI PUTRA MALAYSIA

INVESTIGATION OF GROUNDWATER POTENTIAL AQUIFER USING GEOPHYSICAL TECHNIQUE AT SAWAH SEMPADAN, MALAYSIA

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By

FATHIN AYUNI BINTI AZIZAN

Thesis submitted to School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Master of Science

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Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Master of Science

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July 2015

Chairman: Mohamed Azwan bin Mohamed Zawawi
Faculty: Faculty of Engineering

Sufficient water supply is a vital process throughout the growth stages in all plants including paddy. Even though Malaysia has an annual rainfall around 2600 millimetres, which is above the global average, the distributions of rainfall are uneven which causes certain areas to face limited water supply. In addition to that, seasonal monsoons also affect the pattern of rainfall which leads to dry and wet season. Therefore, an alternative reliable resource of groundwater needs to be investigated with the aim of supplying water continuously over the years. Thus, identifying potential groundwater that can be extracted to irrigate the paddy field area is crucial. In this study, an approach of geophysical technique; 2D resistivity survey was applied. 2D resistivity survey was conducted to result a resistivity profile or familiarly called electrical resistivity tomography (ERT) which represents the subsurface media using RES2DINV software. Wenner-Schlumberger array and a layout of 5 metres electrode spacing for inner and 10 metres for outer cable were employed in all surveys of this study. The resistivity profiles of this study consist of three major lines and six minor lines. Each major line was formed from 7 surveys of 400 metres in length, which made up to 1.6 km after overlapping at 200 metres. SURFER software was used to create this major line resistivity profile. While minor line was made from a single survey of 400metre in length perpendicular to major lines at field. Using the ERT of major and minor lines, one can spot that there are few potential groundwater aquifer located throughout the profiles. Potential aquifer of resistivity profiles were identified based on comparison of geological log to resistivity survey made at that particular well location. The potential groundwater was acknowledged to be in the sand layer which ranges between 50 to 250 Ωm. There were five potential aquifer locations being pointed out at major lines and two at minor lines as on water quantity basis. The resistivity data with x-location of SURFER were later replaced by easting and northing data taken from the topography data using RTK GPS. A 3D skeleton model view of the groundwater potential aquifer at Block C Sawah Sempadan was created. This model shows the location of potential water aquifer spotted at the study area. The development of 3D model view of subsurface profile for selected field will act as reference for further study especially in developing

wells in extracting groundwater that is needed to be supplied as irrigation water to the field.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia
sebagai memenuhi keperluan untuk ijazah Sarjana Sains

SIASATAN POTENSI AKUIFER AIR BAWAH TANAH MENGGUNAKAN TEKNIK GEOFIZIKAL DI SAWAH SEMPADAN, MALAYSIA

Oleh

FATHIN AYUNI BT AZIZAN

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Bekalan air yang mencukupi adalah proses penting di seluruh peringkat pertumbuhan semua tumbuhan termasuk padi. Walaupun Malaysia mempunyai hujan tahunan sekitar 2600 milimeter, iaitu melebihi purata global, taburan hujan tidak sekata menyebabkan kawasan tertentu menghadapi bekalan air yang terhad. Selain itu, monsun bermusim juga memberi kesan kepada corak hujan yang membawa kepada musim kemarau dan hujan. Lantaran itu, satu sumber alternatif iaitu air bawah tanah perlu disiasat dengan tujuan membekalkan air secara berterusan untuk bertahun-tahun.Oleh itu, mengenal pasti potensi air bawah tanah yang boleh diekstrak untuk mengairi kawasan sawah padi adalah penting. Dalam kajian ini, pendekatan teknik geofizik; kajian keberintangan 2D telah digunakan. Kajian keberintangan 2D ini telah dijalankan untuk menghasilkan profil kerintangan atau dipanggil kerintangan elektrik tomografi (ERT) yang mewakili media subpermukaan menggunakan perisian RES2DINV. Protokol Wenner-Schlumberger dan susun atur 5 m bagi jarak elektrod untuk kabel dalaman dan 10 m untuk kabel luaran diaplikasikan dalam semua kajian selidik ini. Profil kerintangan di kawasan kajian ini terdiri daripada tiga baris utama dan enam baris sampingan. Setiap baris utama dibentuk dari 7 kajian yang panjang setiap satu adalah 400 m panjang, yang terdiri dengan 1.6 km selepas bertindih pada 200 m. Perisian SURFER telah digunakan untuk mencipta utama profil baris kerintangan ini. Manakala baris sampingan terdiri dari kajian tunggal 400m berserenjang dengan garis utama di lapangan. Dengan menggunakan ERT baris utama dan sampingan, beberapa potensi akuifer air bawah tanah di seluruh profil boleh dikesan. Profil kerintangan bagi akuifer berpotensi dikenal pasti berdasarkan perbandingan log geologi kepada kajian kerintangan dibuat di lokasi berhampiran. Air bawah tanah yang berpotensi telah diakui berada dalam lapisan pasir yang berkerintangan 50-250 Ωm. Lima lokasi akuifer berpotensi ditunjukkan di baris utama dan dua di baris sampingan atas dasar kuantiti air. Data kerintangan dengan lokasi-x dari SURFER kemudiannya digantikan oleh data timur dan utara yang diambil dari data topografi menggunakan RTK GPS. Rangka model pandangan 3D air bawah tanah yang berpotensi di Blok C

Sawah Sempadan telah diwujudkan. Model ini menunjukkan lokasi berpotensi akuifer air dikesan di kawasan kajian. Pembangunan pandangan model 3D profil sub-permukaan untuk kawasan ini akan bertindak sebagai rujukan untuk kajian lanjut terutama dalam membangun telaga bagi tujuan pengekstrakan air bawah tanah untuk bekalan air pengairan ke sawah.

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APPROVAL SHEET

I certify that a Thesis Examination Committee has met on (date of viva voce) to conduct the final examination of Fathin Ayuni bt Azizan on her thesis entitled "Investigation of Groundwater Potential Aquifer using Geophysical Technique at Sawah Sempadan, Malaysia" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Master of Science (Water Resources Engineering).

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TABLES OF CONTENTS

LIST OF TABLES

.LIST OF FIGURES

LIST OF ABBREVIATIONS AND SYMBOLS

m	: Meter
km	: Kilometer
Ωm	: Ohm meter
%	: Percentage
E	: Easting
N	: Northing
IADA	: Integrated Agricultural Development Area

CHAPTER 1

INTRODUCTION

1.1 General

All lives that exist in this world needs air, water and food to survive. Water is a very important part of source. All sources of water; oceans, river, lakes, groundwater, rainfall and snow have its own interaction to one another. They create a continuous recirculation movement of the water in the Earth which is known as hydrologic cycle.

The world's water consists of 97.5% saltwater and 2.5% freshwater. All of the total freshwater, glaciers and permafrost contributes to 69.5%, groundwater 30.1% and other surface and atmospheric water only contributes to 0.4% (Garrison, 2013). This makes the one of the stable, useable and highly contains large amount of freshwater form is groundwater.

Groundwater in Malaysia is an important resource that is yet to be exploited on a bigger scale to meet the increasing demand for various uses (Mohammed et al., 2009). The utilisation of groundwater can help to solve water shortage in areas where surface water is limited (Mohammed and Ghazali, 2007). The capacity and limitation of groundwater in Malaysian aquifer should be determined in knowing the groundwater storage available in the aquifer.

Due to an increase of cropping area and population in Malaysia and China respectively, Dor et al., 2011 and Song et al., 2011 concluded to the rapidly increasing of groundwater exploration for irrigation purposes. The water shortage is due to the drought season especially in Selangor, Malaysia will also need this solution. This resource of water has also been proven to be a resource that farmers exploit to offset droughts and shortfalls in surface water irrigation supplies (Chang et al., 2011).

However, the use of groundwater as source of irrigation has not been widely practised in Malaysia. The Department of Irrigation and Drainage of Kelantan (DID, 2009) has carried out underground irrigation project which uses groundwater conjunctively with surface water to irrigate paddy and other seasonal crops during off-season. The project were run at Pasir Mas and Meranti, Kelantan. This project utilised groundwater for irrigation with an aim to increase agricultural activity for double cropping.

To date as presented by Mohammed Hatta Abd Karim from Minerals and Geoscience Department in Malaysia, only three percent of all water suppliesuse groundwater as a source. In Malaysia, farmers are normally use surface water from canal as source of irrigation. Despite having the largest canal irrigation systems, the surface water is not sufficient to meet the

requirement of the crops. To overcome shortage of surface water, shallow groundwater resources can be exploited. However, such water without proper management and adoption of suitable technologies will harm the precious natural resources and also the environment itself.

Thus, developing a 3D groundwater models will give an additional insight into the complex system behaviour of the beneath subsurface media other than the assist in building conceptual understanding. Once it has been built up, it can estimate safe yield of groundwater exploration, forecast future groundwater behaviour and support decision making to preserve the source for long term sustainability.

1.2 Problem Statement

In every crop field, the presence of water is significantly required throughout the growth stages including paddy. Up till now, the surface water from nearby water body is still limited and cannot afford to supply water for a huge area of field at a time (IADA, 2009). Consequence from that scenario, the nearest filed to the canal will definitely receive the supply first compared to the far ones due to distance and gravity flow process. This creates a large interval time to fill up the whole area.

Since most of crop field was placed to form a small estate under several agricultural agencies, they are bond to those planting schedule released by the agency, these will automatically force them to follow the schedule tightly as the need to harvest yield in approximately the same time due to harvester's rental by the agencies itself. Consequently, there will be some plots harvested with matured rice and others with immature rice which certainly affects the quality of the rice.

In a real situation, the study area was placed under IADA Barat Laut Selangor. The irrigation scheme is called Sawah Sempadan Irrigation, which is one of the eight compartments of Kuala Selangor Irrigation scheme. The entire crop planted there are paddy. IADA is the agency that is responsible to advise, monitor and manage all the activities of paddy including irrigation. The area has a better–equipped irrigation for paddy compared to other parts of Malaysia.

The water was originally collected from the main water supply station of Bernam River which is then diverted to a feeder canal before flowing into Tengi River and then to the main canal. The Sawah Sempadan distribution system comprises of main canal and secondary canals. The water from the main canal will flow into the secondary canal through constant head orifice before running into the paddy plot. The function of this structure is to reroute a required amount of water to secondary canals based on a fixed irrigation schedule. These canals are spaced apart at approximately 400 metres apart.

Although the system is well developed, through those 30 years that has past, the main canal and tertiary canal have faced several problems. The main canal side structure has been damaged due to logging activity which also caused

swamp water from the nearest forest to merge into the water in the main canal. The secondary canal features some leakage and sludge formed at the bottom of the canal itself. All those problems occurred has decreased the water supply distribution system to 67% of efficiency (IADA Barat Laut Selangor).

Other than the problem stated above, the quantity of the water in main canal also varies from time to time depending on the seasons. This was obviously affected by the amount of water flowing onto the last receiver, paddy plot. The study of water depth in paddy plot at this study area by Deraman(2004) shows that the actual water depth in the paddy plot did not reach the requirement water level as recommended by DOA,2010. In addition to that, the results revealed a high level of water in the paddy plot yield a high amount of rice harvested in that research season. Few researchers such as Mostajeran et al., 2009 has also proven that low yield of rice produced is due to the water stress (less of water supply during planting). In order to solve this problem, the study of groundwater as an alternative source for irrigation purpose is urgently needed.

The groundwater stored in an aquifer can directly be used for irrigation as the ground surface and upper subsurface membrane act as filter membrane to the infiltrate surface water. This infiltration process, water body seepage, along with human activity affects the groundwater systems. Therefore, targeted aquifer needs to be placed under continuous management to maintain the condition of groundwater resources within acceptable limits, while providing desired economic and social benefits.

With the aim of managing the water resource, a 3D model that captures the whole sight of the study area should be developed in order to locate potential groundwater. A 3D model was chosen as it presents a real site of subsurface view.

1.3 Objectives

The main objective of this study is to investigate the potential of Sawah Sempadan aquifer for irrigation purposes using geophysical techniques as an alternative source. This study will be conducted systematically by following the order of specific objectives. The specific objectives of this study are;

1. To create a resistivity profile across/along the secondary canal.
2. To analyse the potential number of aquifer in resistivity profile from quantity aspect, and
3. To develop a 3D view of the groundwater potential model for the study area.

1.4 Focus of the study

In this study, groundwater potential aquifer of selected site is being researched using geophysical technique. The focus of the groundwater potential is more on quantity rather than quality itself. This is because the need of water for irrigation only requires class IV water as in table 1 below. Therefore, the quantity of the potential groundwater aquifer is more crucial while performing this study.

Table 1: Water Classes and uses (Environment Quality Report, 2006)

CLASS	USES
Class I	Conservation of natural environment. Water Supply I - Practically no treatment necessary. Fishery I - Very sensitive aquatic species.
Class IIA Class IIB	Water Supply II - Conventional treatment. Fishery II - Sensitive aquatic species. Recreational use body contact.
Class III	Water Supply III - Extensive treatment required. Fishery III – Common of economic value and tolerant species; livestock drinking.
Class IV	Irrigation
Class V	None of the above.

This study is focused more towards groundwater aspects rather than the geological structure of the study area. Due to cost and time constraints also, a resistivity survey were carried out at existing borehole logging near to study area within same geological formation even though most researchers did the reverse technique.

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