UNIVERSITI PUTRA MALAYSIA

APPLICATION OF GEOELECTRICAL RESISTIVITY IMAGING TECHNIQUE FOR THE ESTIMATION OF SOIL WATER IN UNIVERSITI PUTRA MALAYSIA

ZEINAB ASRY

FPAS 2009 7

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By

ZEINAB ASRY

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

October 2009

DEDICATION

To family and my husband and my niece who make a difference.

Abstract of thesis presented to the Senate of University Putra Malaysia in fulfilment of the requirements for the degree of Master of Science.

APPLICATION OF GEOELECTRICAL RESISTIVITY IMAGING TECHNIQUE FOR THE ESTIMATION OF SOIL WATER IN UNIVERSITI PUTRA MALAYSIA

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October 2009

Chairman : Associate Professor Shaharin Ibrahim, PhD

Faculty : Environmental Studies

This study describes the application of electrical resistivity imaging technique in the estimation of soil water in UPM, Selangor, Malaysia. Electrical Resistivity Imaging surveys have been conducted in order to locate, delineate subsurface water resources and estimate its reserve. The resistivity imaging surveys carried out basically measures and maps the resistivity of subsurface materials. A 2-D geoelectrical resistivity technique was used. Resistivity measurement was carried out using an ABEM SAS 4000 terrameter with electrode selector system. A Wenner electrode configuration was employed. The field survey was conducted along thirteen profiles providing continuous coverage. Colour-modulated sections of resistivity versus depth were plotted for all lines, giving an approximate image of the subsurface structure. The field survey was accompanied by laboratory work. Resistivity of soil samples and groundwater was measured and the resistivity formation ratio was obtained. The porosity and water saturation of the same samples were calculated. A relationship between the porosity and the resistivity formation ratio as well as water saturation was established. The laboratory established relationship between moisture content and resistivity; the porosity against resistivity formation ratio and resistivity formation ratio against water saturation were used to estimate the volume of soil water above the bedrock within the study area. The porosity values were contoured and plotted. Depth to the bedrock for each line was obtained. A 2-dimensional and 3-dimensional representation of the subsurface topography of the area was prepared using commercial computer software. The use of the software also enabled the computation of the amount of soil water above the bedrock within the area investigated.

The results showed that the layers associated with the resistivities between 30Ω.m and 2000Ω.m is located at depths varying from 8 to 24m. The layer has porosity between 27% and 68%. The results obtained from the electrical resistivity profiles indicate that the net volume of soil was 1,619,467m^3 in Area 1 and 1,215,773m^3 in Area 2. The volume of soil water above the bedrock in Area 1 was 1,781.4 m^3 while in Area 2 the volume was 95.23 m^3.

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

PENGGUNAAN TEKNIK PENGIMEJAN KERINTANGAN ELEKTRIK DI DALAM PENGANGGARAN AIR TANAH DI ATAS BATU HAMPAR DI UNIVERSITI PUTRA MALAYSIA

Oleh

ZEINAB ASRY

October 2009

Pengerusi: **Profesor Madya Shaharin Ibrahim, PhD**

Fakulti: **Pengajian Alam Sekitar**

Tesis ini menghuraikan tentang penggunaan teknik pengimejan kerintangan elektrik di dalam penganggaran air bawah tanah di kawasan UPM, Selangor, Malaysia. Pengimejan kerintangan elektrik telah dijalankan untuk mengenalpasti kedudukan, menggambarkan sumber air bawah permukaan dan menentukan simpanannya. Penggunaan pengimejan kerintangan selalunya digunakan untuk mengukur dan memetakan kerintangan bahan-bahan di bawah permukaan. Teknik kerintangan geoelektrik 2-D telah digunakan. Pengukuran kerintangan telah diperolehi dengan menggunakan terrameter ABEM SAS 4000 dengan sistem pemilih elektrod. Konfigurasi elektrod Wenner telah digunakan. Ia dilakukan di sepanjang 13 profil yang memberikan liputan berterusan. Warna dimodulasi mengikut nilai kerintangan melawan kedalaman yang diplotkan pada semua garis, memberikan imej penganggaran struktur bawah permukaan. Kajian ini juga melibatkan kerja di dalam makmal. Kerintangan sampel tanah dan air bawah tanah yang diambil daripada

kawasan lapangan diukur dan nisbah kerintangan formasi diperolehi. Keronggaan dan kandungan ketepuan air bagi sampel yang sama telah dikira. Hubungan diantara keronggaan dan nisbah kerintangan formasi serta kaitan antara ketepuan air dengan nisbah kerintangan formasi telah pun dibuktikan. Hubungan diantara kandungan air dan kerintangan, nisbah kerintangan formasi melawan keronggaan dan nisbah kerintangan formasi melawan isipadu ketepuan air tanah diatas lapisan batu hampar bagi kawasan penyelidikan telah diperolehi. Kaitan antara kandungan air dan kerintangan elektrik, nisbah kerintangan formasi melawan keronggaan serta kaitan antara kerintangan formasi dengan peratusan ketepuan air telah di bentuk dan digunakan untuk mengira isipadu air tanah yang terdapat di dalam jujukan tanah antara permukaan bumi dengan batu hampar. Nilai keronggaan dikonturkan dan diplot. Kedalaman lapisan batu hampar bagi setiap kawasan telah diperolehi. Paparan 2-Dimensi dan 3-Dimensi menggambarkan topografi bawah permukaan kawasan dilakukan menggunakan perisian komputer. Penggunaan perisian juga membolehkan pengiraan jumlah air bawah tanah di atas lapisan batu hampar di kawasan penyelidikan diperolehi.

Hasil kajian menunjukkan bahawa lapisan yang mempunyai kerintangan antara 30 Ω.m dan 2000Ω.m adalah terletak antara kedalaman 8 hingga 24m. Lapisan-lapisan ini mempunyai keronggaan antara 27% hingga 68%. Hasil kajian Kerintangan elektrik juga menunjukkan bahawa isipadu tanah pada Kawasan 1 ialah 1,619,467m^3, manakala bagi Kawasan 2 ialah 1,215,773m^3. Isipadu air tanah yang berada di atas batu hampar adalah 1,781.4m^3 bagi Kawasan 1 dan 95.23m^3 bagi Kawasan 2.

ACKNOWLEDGEMENTS

I would like to thank my project supervisor, Prof. Madya Dr. Shaharin Ibrahim for his advice, guidance, technical support and discussions and his supervision and untiring patience throughout the course of this research. Similar gratitude must go to members of my supervisory committee, Prof. Madya Dr. Mohammad Wan Nor Azmin Sulaiman, and Prof. Madya Dr. Mohammad Firuz Ramli, for their guidance, understanding and invaluable advice offered to me throughout my research and preparation of this thesis.

I would like to thank my good classmate Siti Aishah Ismail for helping me in my work, and also to thank the officer of the laboratory Mr Ghafar who guided and helped me to run the instrument during my practical, right through the hot weather of Malaysia.

I would like to thank and be grateful to my husband and family, for helping me throughout my studies, so I could complete my work in success. I would also like to thank my niece in London, for assisting me in checking the language during the writing of my Thesis.

I certify that a Thesis Examination Committee has met on 29 October 2009 to conduct the final examination of Zeinab Asry on her Master of Science thesis entitled "Application of Electrical Resistivity Imaging Technique for the Estimation of Soil Water in Universiti Putra Malaysia" in accordance with Universities and University Colleges Act 1971 and Constitution of the Universiti Putra Malaysia [P.U. (A) 106] 15 March 1998. The Committee recommends that the candidate be awarded the Master of Science.

Members of the Thesis Examination Committee were as follows:

Latifah Abd Manaf, Ph.D
Faculty of Environmental Studies
Universiti Putra Malaysia
(Chairman)

Mohd Ismail Yaziz, Ph.D
Faculty of Environmental Studies
Universiti Putra Malaysia
(Internal Examiner)

W. Mohamad Daud Wan Yusoff, Ph.D
Faculty of Science
Universiti Putra Malaysia
(Internal Examiner)

Abdul Ghani Rafek, Prof
Faculty of Science and Technology
Universiti Kebangsaan Malaysia
(External Examiner)

BUJANG BIN KIM HUAT, PhD
Professor and Deputy Dean
School of Graduate Studies
Universiti Putra Malaysia

Date: 24 December 2009

This thesis submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirements for the degree of Master of Science. The members of the Supervisory Committee are as follows:

Shaharin Ibrahim, PhD
Associate Professor
Faculty of Environmental Studies
Universiti Putra Malaysia
(Chairman)

Mohammad Wan Nor Azmin Sulaiman, PhD
Associate Professor
Faculty of Environmental Studies
Universiti Putra Malaysia
(Member)

Mohammad Firuz Ramli, PhD
Associate Professor
Faculty of Environmental Studies
Universiti Putra Malaysia
(Member)

HASANAH MOHD GHAZALI, PHD
Professor and Deputy Dean
School of Graduate Studies
Universiti Putra Malaysia

Date: 14 January 2010

DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations, which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UPM or at any other institutions.

ZEINAB ASRY

Date: 10.11.2009

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LIST OF ABBREVIATIONS

%	Percentage
°C	Centigrade
2-D	Two dimensional
3-D	Three dimensional
A	Cross-Sectional
C_1	Current Electrode-1
C_2	Current Electrode-2
cm	Centimetre
cm^2	Centimetre square
ERI	Electrical resistivity imaging
g	Gram
I	Current
kg	Kilogram
km	Kilometre
L	Length
m	Meter
mm	Millimetre
P_1	Potential Electrode-1
P_2	Potential Electrode-2
R	Resistance
R^2	Strength of correlation

V	Voltage
ρ_a	Apparent resistivity
Ω.m	Ohm meter
e	Porosity
F	Formation Resistivity Ratio
ρ_b	Bulk density
ρ_d	Particle density
S	Saturation
θ_v	Volumetric water content
θ_w	Gravimetric water content
W_d	Dry weight
W_t	Total weight
V_t	Total Volume of sample
V_v	Total Volume of voids
V_s	Volume of the solid
RES2DINV	Rapid 2-D Resistivity Inversion programme
TPU	Taman Pertanian Universiti

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

The study of electric fields and currents in the earth is one of the youngest geophysical disciplines. Although the first step in applying geoelectrical method to geology has already been made more than 100 years ago (prospecting for sulphide deposits using the self-polarization method), the study of geoelectricity only began to develop at the beginning of last century. The Schlumberger brothers (1920) in France worked out the foundations of the method of equipotential lines and the telluric method, with which they were successful in ore and oil prospecting. Wenner (1916), an American developed the concept of apparent resistivity measurements and made uniform treatment of measurements on large surfaces possible. Of the several electrical methods, the one in most common use in engineering is the so-called resistivity method. Resistivity imaging provides continuously images of the subsurface in two or three dimensions, most commonly carried out as two-dimensional (2D) imaging for logistical and economical reasons (Dahlin et al., 2004).

1.2 PREVIOUS WORK

A study on the geology in Selangor area using electrical resistivity method was done by Hamzah et al. (2006a), Geophysical study was carried out in the Banting area of to delineate groundwater aquifer. A 2-D geoelectrical resistivity technique was used by Hamzah et al. (2006a). Resistivity images of all the subsurface material below the survey lines show similar pattern of continuous structure of layering or layers with some lenses with resistivity ranging from 0.1 to 50 Ω.m (Hamzah et al., 2006a).

A study of the geology, using electrical resistivity, from Serdang to Sungai Besi was done by Hago (2000).The current study area is located in the Universiti Putra Malaysia main campus and Taman Penyelidikan University (TPU). Thirteen Wenner electrical resistivity imaging surveys were conducted throughout the study area. Resistivity data obtained from these imaging surveys were analyzed to determine the aquifer boundaries and estimate its soil water reserve. Resistivity of the hard rock varied from, 39 Ω.m to 1238 Ω.m, whereas in soil the resistivity varies between 9 Ω.m and 83 Ω.m.

According to Hago (2000), laboratory investigations on the porosity, resistivity and hydraulic conductivity indicated that the hard rock within the study area have porosity ranging from 3.9% to 14%, while the soil porosity is between 35% and 44%.

Combination of the 2-D resistivity images obtained from the thirteen lines, with the results of the laboratory measurements, boreholes information (the boreholes were located near to the study area) and geological data shows general agreement and suggests that electrical imaging surveys can be used as a fast and efficient exploration tool to determine the aquifer boundaries and estimate its reserve (Hago, 2000).

1.3 SIGNIFICANCE OF STUDY

Resistivity methods can be used to investigate the boundary between crystalline and sedimentary rocks, compact quartzite rocks with schist or phyllite, etc. Electrical resistivity surveys have been used for many decades in hydro geological, mining and geotechnical investigations. More recently, it has been used for environmental surveys. The results of this study can be used for to geological and hydro-geological assessment such as wells location and agricultural activity. The geoelectrical resistivity method plays a significant role in the exploration of natural resources like groundwater and mineral deposits. The resistivity imaging surveys can be used to help in delineating the bedrock.

One of the major points which is stressed in this thesis is the use of electrical resistivity imaging method for the identification of different layers of the earth, the types of bedrock rock, the depth of the water and the recognition of the electrical resistivity in the layers of the earth and the estimation of the amount of soil water between the top of bedrock and the surface of the ground. It can also be used to find the most suitable location to dig a well for agriculture purpose.

1.4 PROBLEM OF STATEMENT

Water is very important in life support systems. In agriculture, knowledge of amount of water available in an area and the location in which water exist is very important and this area important in agriculture activity so, can find the good location for digging with geoelectrical method and want to define the water location in the field work. This research has been directed quantity the amount of water which exists in the soil column and also on the location where water exists.

1.5 STUDY AREA

The study area is located in the University Putra Malaysia compus complex in Serdang, Selangor. It is approximately 22km south of Kuala Lumpur by road. It is bounded by latitudes 2° 59’ 12.99” N to 2° 59’ 48.18” N and longitudes 101° 42’ 22.33” E to 101° 42’ 42.77” E and the topography of the area is shown in Figure 1.1. The study area is located in a flat region with elevations between 49m to 51m for Area 1, and between 50m to 52m for Area 2 above the mean sea level. Accessibility to the study area is easy as the roads are well maintained. Grass, low bush, and trees, cover the land.

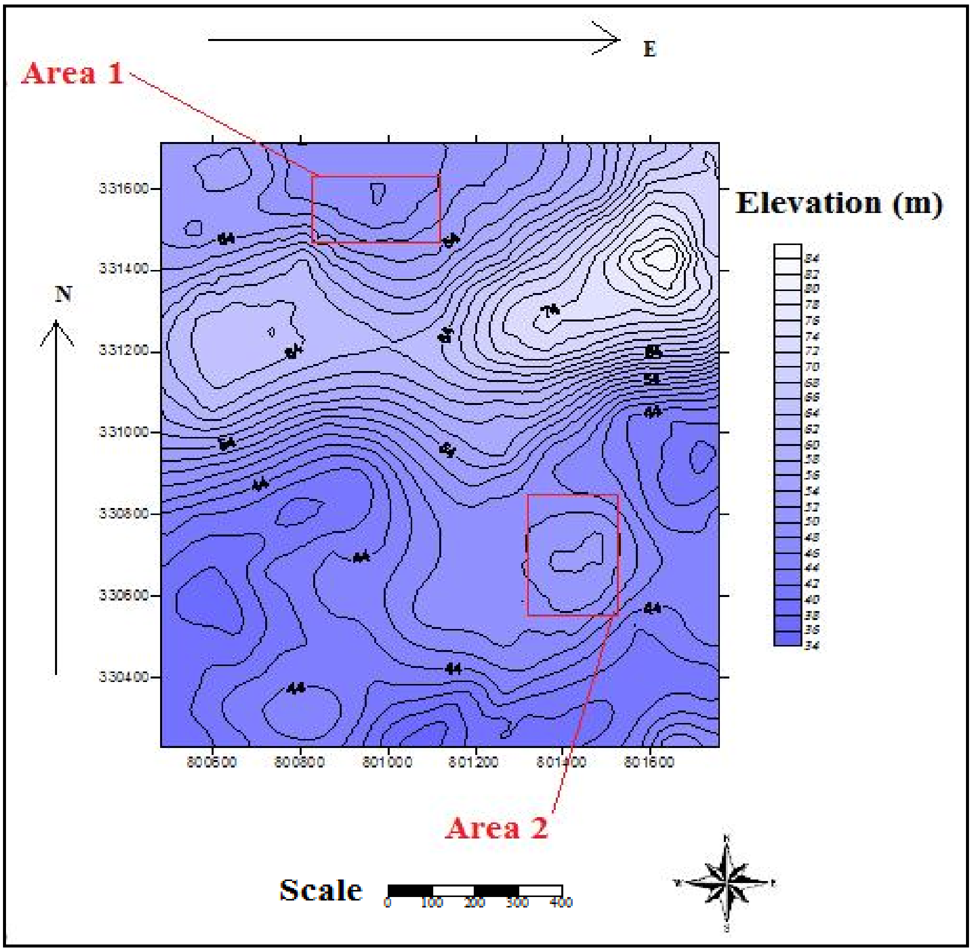

Figure 1.1: Topographical map of study Area 1and 2

1.6 CLIMATE

The Malay Peninsula has a typical equatorial climate characterized by constantly high annual temperatures and heavy rainfall. While the temperature range is practically the same all over the Malay Peninsula throughout the year and is only governed by the height of the land above sea level, there are important differences in the amount and seasonal distribution of the rainfall in different parts of the country. Many studies have been made on the climate of Peninsular Malaysia. Most of these studies have been compiled by (Ooi and Chia 1974). They have analysed the climatic elements and the factors contributing to climatic variations in different parts of the peninsula. From November to February monsoon clouds from the northwest cross the Malay Peninsula bringing rain to eastern Malaya and the eastern part of the Main Range. From May to August, south westerly monsoon winds bring rainfall to the western region of the Peninsula. The areas experience a tropical humid climate with seasonality in rainfall distribution. The climate of the study area, like most other parts of Peninsular Malaysia, is warm and humid or has an equatorial type of climate with high temperature and rainfall throughout the year. Malaysia is subjected to both South-West as well as North-East monsoons. The former lasts from April to September and brings with it rains to fall on the West Coast and some part of the interior, while the latter, developing from high pressure trough originating in Siberia, always brings the moisture-laden clouds from the South China Sea to rain on the East Coast states and their vicinity from October to March.

Eight years (2000-2007) mean average rainfall for the study areas was about 2489 mm, distributed throughout the year, with the bulk of the rains concentrated in the months of October and November, and it rains comparatively less in May to September (dry season) than October to April (wet season).

The annual variation of temperature was less than 2°C in the study site. April and May were the months with the highest average monthly temperature and December and January are the months with the lowest average monthly temperature. Temperature departure from the annual average was not marked throughout a year. Mean daily dry season (May–August) and wet season (November–February) temperatures typically ranged from about 31 to 33°C and 29 to 32°C, respectively.